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GEORGIA'S
GREENHOUSE GAS INVENTORY
1990 - 2015

National Inventory Report

Under the United Nations Framework Convention on Climate Change

2019

Ministry of Environmental
Protection and Agriculture
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GHGs National Inventory Report of Georgia

1990-2015

Tbilisi, 2019

The National Inventory Report of GHG emissions to the UNFCCC was prepared by a group of decision makers, experts and other stakeholders, representing: The Ministry of Environmental Protection and Agriculture of Georgia and its LEPL Environmental Information and Education Centre (EIEC), Ilia State University, independent national and international sector experts.

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Abbreviations and Symbols

AD – Activity Data
AWDS – Animal Waste Disposal Site
BOD – Biological Oxygen Demand
COD – Chemical Oxygen Demand
COP – Conference of Parties (of the UNFCCC)
CRF – Common Reporting Format
DOC – Degradable Organic Carbon
EF – Emission Factor
EIA – Environmental Impact Assessment
FAOSTAT – Food and Agriculture Organization Statistics Office
GAM – Global Average Method
GEOSTAT – National Statistics Office of Georgia
GHG – Greenhouse Gas
GPG – Good Practice Guidelines
IEA – International Energy Agency
IPCC – Intergovernmental Panel on Climate Change
KfW – German Development Bank
LULUCF – Land Use, Land-Use Change and Forestry
MCF – Methane Correction Factor
MEPA – Ministry of Environmental Protection and Agriculture of Georgia
MSW – Municipal Solid Waste
NG – Natural Gas
NIR – National Inventory Report of GHGs emissions
NMVO – Non-Methane Volatile Organic Compounds
SNC – Second National Communication
TNC – Third National Communication
UNFCCC – United Nations Framework Convention on Climate Change

C – Carbon
CaO – Lime
CH_4 – Methane
CO – Carbon Oxide
CO_2 – Carbon Dioxide
HFC – Hydrofluorocarbons
N_2O – Nitrous Oxide
PFC – Perfluorocarbons
SF_6 – Sulphur Hexafluoride
SO_2 – Sulphur Dioxide
Gg – Gigagram (10^9 gram=1000 ton)
hl – Hectoliter (100 Liter)
PJ – Peta Joule (10^{15} Joule)
TJ – Tera Joule (10^{12} Joule)

Content

List of Tables

List of Figures

1 Executive Summary

1.1 Overview

Georgia joined the United Nations Framework Convention on Climate Change (UNFCCC) in 1994 and the parliament ratified the Kyoto Protocol in May 28, 1999 with the resolution N 1995. "The ultimate objective of this Convention is to achieve stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner."

On June 7, 2017, Georgia ratified Paris Agreement and started preparing its Nationally Determined Contribution (NDC) document to submit by 2020. Simultaneously, the Ministry of Environmental Protection and Agriculture of Georgia develops "Climate Action Plan 2021-2030" with the technical assistance of GIZ which will be ready by 2020.

The ability of the International Community to achieve the set objective, by reducing Greenhouse Gases (GHGs) emission, depends on of the knowledge and understanding of the trends in GHG emissions. According to Article 4(1) (a) and Article 12(1) (a) of the Convention, all parties are required to provide the supreme body of the Convention – the Conference of the Parties[1] – information about national GHGs emissions and sources of removal. Up to 2010[2], the main reporting mechanism for Non-Annex 1 countries of the Convention was National Communication. A decision[3] taken by the 16th Conference of the Parties held in Cancun (2010), requires all countries, starting 2014, to present a biennial independent and complete report (BUR- Biennial Update Report) including the trends of national GHG emissions.

In Georgia, the first GHG inventory was performed based on the 1980-1996 data, as part of the preparation of the First/Initial National Communication (FNC, during 1997-1999). The Second National Communication (SNC, during 2006-2009) comprised the period of 1997-2006. The 2007-2011 GHG inventory was performed as part of the Third National Communication (TNC, during 2012-2015). The First Biennial Update Report (FBUR, during 2015-2017) of Georgia to UNFCCC comprised the period of 2012-2013. The 2014-2015 GHG inventory was prepared for the Second Biennial Update Report (SBUR, during 2018-2019) of Georgia to UNFCCC. In the latest national GHGs inventory the results were recalculated for the following years 1990, 1994, 2000, 2005, 2010-2013 in all sectors, due to the use of IPCC 2006 guidelines.

The present report describes the results of the Fifth National Inventory of greenhouse gases for the period 2014-2015. The Inventory is based on the Intergovernmental Panel on Climate Change (IPCC) Methodology that is comprised of the following key documents (hereafter jointly referred to as the IPCC methodology). These are:

- 2006 IPCC Guidelines for National Greenhouse Gas Inventories[4] (hereafter referred to as IPCC 2006);

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[1] Conference of the Parties (COP) - is the supreme decision-making body of the Convention. All States that are Parties to the Convention are represented at the COP.

[2] In 2010, 16th Conference of the Parties of the UNFCCC was held in Cancun, Mexico, at which the decision was made to have separate reporting on inventories and climate change mitigation activities.

[3] 1/CP16; http://unfccc.int/resource/docs/2010/cop16/eng/07a01.pdf#page=2.

[4] IPCC 2006: 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme, Egleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds). Published: IGES, Japan. http://www.ipcc-nGgip.iges.or.jp/public/2006gl/index.html

- 2003 IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry (hereafter referred to as IPCC GPG-LULUCF);
- Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories[5] (hereafter referred to as IPCC 1996);
- IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (2000)[6] (hereafter referred to as IPCC GPG).

For the compilation of the inventory, Inventory Software Ver 2.54 (released on 6 July 2017)[7] and excel based worksheets were used. According to the Common Reporting Format (CRF) of the IPCC Methodology, inventories cover five sectors, as follows:

Energy;
Industrial Processes and Product Use;
Agriculture;
Land use, Land- Use Change and Forestry (LULUCF);
Waste.

The UN Framework Convention on Climate Change requires reporting the gases listed below:

Carbon Dioxide (CO_2);
Methane (CH_4);
Nitrous Oxide (N_2O);
Hydrofluorocarbons (HFCs);
Perfluorocarbons (PFCs);
Sulphur Hexafluoride (SF_6).

The Fifth National Inventory of Georgia reviews all the above-listed direct gases stipulated by the Convention and indirect greenhouse gases, such as: Nitrogen Oxides (NO_X), Carbon Monoxide (CO), Non-Methane Volatile Organic Compounds (NMVOCs) as well as Sulphur Dioxide (SO_2).

According to the UNFCCC reporting guidelines on annual inventories[8], the Global Warming Potentials (GWP) provided by the IPCC in its Second Assessment Report (“1995 IPCC GWP Values”) based on the effects of GHGs over a 100-year time horizon was used for expressing GHG emissions and removals in CO_2 equivalents. The values of the GWP of greenhouse gases are shown in the Table below[9].

Table 1-1 Global Warming Potential (GWP) of Direct Greenhouse Gases

Gas	Lifetime, Years	100-years Horizon GWP
CO_2	variable (50-200)	1
CH_4	12±3	21
N_2O	120	310
HFC:		
HFC-23	264	11.700
HFC-32	5.6	650
HFC-125	32.6	2.800
HFC-134a	10.6	1.300
HFC-227ea	36.5	2.900
HFC-236fa	209	6.300
HFC-245ca	6.6	560
PFC:		
PFC, CF_4	50000	6.500
PFC-116, C_2F_6	10000	9.200
PFC-218, C_3F_8	2600	7.000
PFC 31-10, C_4F_{10}	2600	7.000

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[5] IPCC, 1997: Revised 1996 IPCC Guidelines for National Greenhouse Gas Emission Inventories. Reference manual. IPCC/OECD/IEA. IPCC WG1 Technical Support Unit, Hadley Centre, Meteorological Office, Bracknell, UK. http://www.ipcc-nGgip.iges.or.jp/public/gl/invs1.html

[6] IPCC, 2000: Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, IPCC-TSU NGGIP, Japan. http://www.ipcc-nGgip.iges.or.jp/public/gp/english/

[7] https://www.ipcc-nggip.iges.or.jp/software/index.html

[8] Guidelines for the preparation of national communications from Parties not included in Annex I to the Convention, III B.

[9] IPCC Second Assessment - Climate Change 1995. IPCC, Geneva, Switzerland. pp 64

HFC-143a	48.3	3.800
HFC-152a	1.5	140
PFC 51-14, C_6F_{14}	3200	7.400
SF_6	3200	23.900

In the Tables, containing inventories results, following IPCC's recommendations, the following prefixes were adopted for the units of amounts of greenhouses gas emissions.

K (Kilo) - 10^3

M (Mega) -10^6

G (Giga) -10^9

T (Tera) -10^{12}

P (Peta) -10^{15}

Examples: 1 Gigagram (Gg) =10^9 Grams= 10^6 Kilograms (kg) =10^3 Tones (t)

1 Gigajoule (GJ) = 10^9 Joules (J)

1 Terajoule (TJ) =10^{12} Joules (J) =10^3 Gigajoules (GJ)

1 Petajoule (PJ) = 10^{15} Joules (J) = 10^6 Gigajoules (GJ)

Institutional Framework of the National GHG Inventory

The Government of Georgia is a responsible body to the UNFCCC. The Ministry of Environmental Protection and Agriculture of Georgia elaborates and implements the policy in climate change[10]. The structural unit of the Ministry is the Department of Environment and Climate Change and its subunit is a Climate Change Division. Along with other functions, the Division is responsible for coordination of periodic compilation of inventory report and its submission to the Convention Secretariat.

There is an independent non-commercial legal entity under public law of Georgia, the LEPL Environmental Information and Education Centre[11], in the structure of the Ministry of Environmental Protection and Agriculture. One of the functions of this Entity is creation of a unified environmental data base and support of its publicity. Furthermore, the Centre prepares National Greenhouse Gas Emissions Inventory reports with the help of independent international and local experts.

This NIR has been prepared under the project: "the Fourth National Communication and Second Biennial Update Report to the UN Framework Convention on Climate Change". The Climate Change Division of the Ministry of Environmental Protection and Agriculture leads and coordinates the report preparation. UNDP Georgia operates as an implementing agency for the Global Environment Facility (GEF) project and assists Georgia during the whole program implementation, also monitors and supervises the project on behalf of the GEF. An executive council was formed at the initial phase of the project. The council consists of the representatives of the Ministry of Environmental Protection and

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[10] The resouliton of Government of Georgia – on approval the statute of Ministry of Environmental Protection and Agriculture of Georgia ,N112, 6 March, 2018.

[11] www.eiec.gov.ge

Agriculture, the Ministry of Economy and Sustainable Development, UNDP, GIZ, Greens Movement (NGO). The council makes important decisions about the project, reviews and submits the work plans and changes in the budget; it is responsible for timely implementation and the quality of the project.

There is an active cooperation on data exchange between the Ministry of Environmental Protection and Agriculture and National Statistics Office of Georgia based on the MoU singed in 2014.

The LEPL Environmental Information and Education Centre is an implementing entity of the project - "Global Environmental Monitoring and Improving its Knowledge of Information Management and Harmonization of Georgia" (supported by UNDP and GEF). The main output of the project is setting up Environmental Information and Knowledge Management System. The system is integrated into an online inventory program that is adapted to the IPCC inventory program.

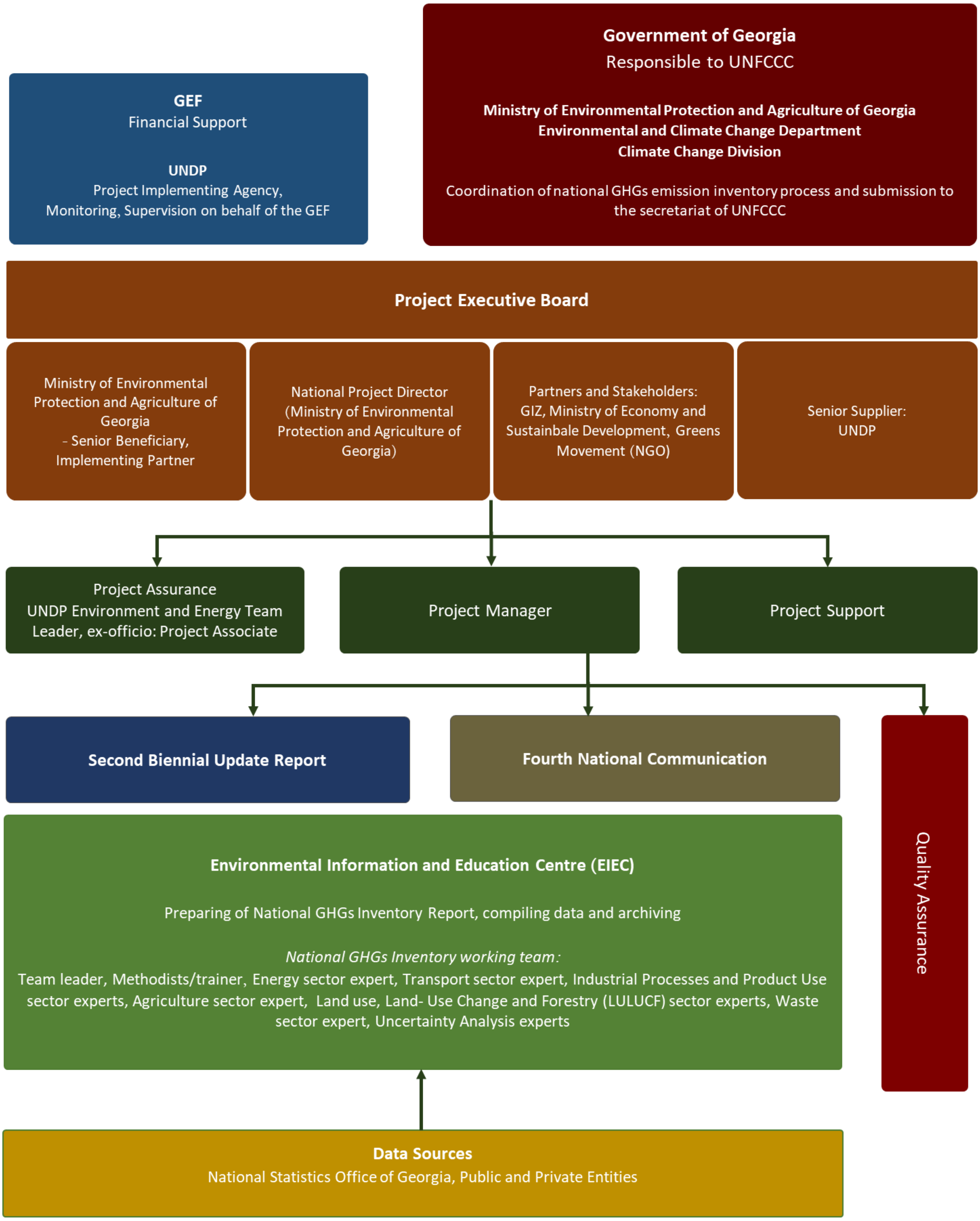

Figure 1-1 Institutional Framework of the National GHG Inventory in Georgia

1.2 Key Source Categories

Chapter 4 of 2006 IPCC Guidelines for the National GHG Inventories provides rules for methodological choice and identification of key categories. According to the guideline, “a key category is one that is prioritized within the national inventory system because its estimate has a significant influence on a country’s total inventory of greenhouse gases in terms of the absolute level, the trend, or the uncertainty in emissions and removals. Whenever the term key category is used, it includes both source and sink categories.”

This sub-chapter provides the analysis of key source/sink of GHG emission/removals in Georgia for the period 1990-2015, for absolute values of emissions/removals (level analysis), as well as for the trends.

For the identification of key source/sink categories, the share of individual categories (converted to CO_2 eq.) in total emissions/removals is calculated according to absolute level of emissions/removals (level assessment). Following the calculation of percentage contribution of each source/sink category, they are summed in descending order of magnitude, adding up to 95% of the sum of all key categories.

According to the trend assessment method, a source/sink category is considered a key category if they significantly contribute to the total trend of national emissions and removals. For this assessment, the trend of a source-category is calculated for each source/sink category as the difference of the values of emissions/removals derived from this source/sink category, between current and base years for the inventory, divided by the value of current year emission/removal. Furthermore, the trend of total value of inventory is calculated by dividing the difference between the total emissions of current and base years, by current year total emission.

To assess the actual significance of the difference between source-category and total trends in the outcomes of the overall inventory, these differences are weighed according to the assessment of the share of absolute value of a source-category emission, i.e., a level assessment is performed. Specifically, the total emission trend is subtracted from the assessed source-category trend and is multiplied by the value of the level (share), obtained for this source-category by the “level assessment” calculated for the base year. Derived values for all source-categories are summed and the share of each category, as part of this total, is calculated. Thus, a key source-category would include a source-category for which the difference between the total inventory trend and the source category trend, according to the source-category “level” in the base year, is significant.

The current inventory was conducted for the 1990-2015 period. Hence, 1990 has been used as a base year for trend assessment. The derived results were arranged in a descending order and cumulative totals were calculated. The sources of which the cumulative total is equal to, or higher than 95% of the overall emission (in CO_2 eq.) were determined to be a key source-category in terms of the trend. The identified key source-categories are presented in Table below.

Table 1-2 Key Source-Categories of Georgia’s GHG Inventory According to Level and Trend Assessment Approaches

IPCC Category Code	IPCC Category	GHG	Level Assessment 1990	Level Assessment 2015	Trend Assessment 1990-2015	Reason to Select as Key- category
1A3b	Road Transportation - Liquid Fuels	**CO_2**	8%	**19%**	**0.06**	**Level, Trend**
1B2	Fugitive Emissions from oil and natural gas transmission and	**CH_4**	12%	**11%**	**0.15**	**Level, Trend**

IPCC Category Code	IPCC Category	GHG	Level Assessment 1990	Level Assessment 2015	Trend Assessment 1990-2015	Reason to Select as Key- category
	distribution					
4A	Enteric Fermentation	CH_4	4%	9%	0.02	Level, Trend
1A4b	Residential - Gaseous Fuels	CO_2	6%	8%	0.07	Level, Trend
1A1	Electricity and Heat Production - Gaseous Fuels	CO_2	10%	8%	0.14	Level, Trend
6A	Solid Waste Disposal Sides	CH_4	1%	5%	0.02	Level, Trend
1A2	Manufacturing Industries and Construction - Solid Fuels	CO_2	8%	5%	0.11	Level, Trend
1A3b	Road Transportation - Gaseous Fuels	CO_2	0%	4%	0.02	Level, Trend
2A1	Cement Production	CO_2	1%	4%	0.01	Level, Trend
4D1	Direct Soil Emissions	N_2O	2%	4%	0.03	Level, Trend
2B1	Ammonia Production	CO_2	1%	3%	0.01	Level, Trend
2C2	Ferroalloys Production	CO_2	0%	2%	0.01	Level, Trend
1A4a	Commercial/Institutional - Gaseous Fuels	CO_2	1%	2%	0.01	Level, Trend
1A1	Heat Production and Other Energy Industries - Solid Fuels	CO_2	2%	2%	0.03	Level, Trend
4B	Manure Management	N_2O	1%	2%	0.00	Level
2B2	Nitric Acid Production	N_2O	0%	1%	0.00	Level
1A2	Manufacturing Industries and Construction - Gaseous Fuels	CO_2	5%	1%	0.07	Level, Trend
1A3c	Other Transportation	CO_2	0%	1%	0.00	Level
4D3	Indirect Soil Emissions	N_2O	1%	1%	0.01	Level, Trend
6B2	Domestic Waste Water Handling	CH_4	1%	1%	0.00	Level
2F	Consumption of Halocarbons and Sulfur Hexafluoride (Refrigeration and Air Conditioning Equipment)	HFC[12]	0%	1%	0.003	Level
1B1	Fugitive Emissions from Solid Fuel Mining and Transformation	CH_4	2%	1%	0.02	Level, Trend
4B	Manure Management	CH_4	0%	1%	0.00	Level
1A4b	Residential	CH_4	0%	1%	0.00	Level
1B2	Fugitive Emissions from Oil Extraction	CH_4	0%	1%	0.00	Level
1A4b	Residential - Liquid Fuels	CO_2	2%	0%	0.03	Level, Trend
1A4a	Commercial/Institutional - Liquid Fuels	CO_2	2%	0%	0.03	Level, Trend
1A2	Manufacturing Industries and Construction - Liquid Fuels	CO_2	5%	0%	0.07	Level, Trend
2C1	Cast Iron and Steel Production	CO_2	4%	0%	0.07	Level, Trend
1A1	Electricity and Heat Production - Liquid Fuels	CO_2	18%	0%	0.30	Level, Trend

Table 1-3 shows the results of key source-categories of Georgia's GHG inventory for 1990 and 2015 years including LULUCF sector.

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[12] Baseline year for HFC is 2001.

Table 1-3 Key Source-Categories of Georgia's GHG Inventory According to Level and Trend Assessment Approaches (Including LULUCF)

IPCC Category Code	IPCC Category	GHG	Level Assessment 1990	Level Assessment 2015	Trend Assessment 1990-2015	Reason to Select as Key- category
5A	Forest Land	**CO_2**	12%	**21%**	**0.08**	**Level, Trend**
1A3b	Road Transportation - Liquid Fuels	**CO_2**	6%	**12%**	**0.04**	**Level, Trend**
5C	Grassland	**CO_2**	5%	**10%**	**0.03**	**Level, Trend**
5B	Cropland	**CO_2**	6%	**7%**	**0.05**	**Level, Trend**
1B2	Fugitive Emissions from Oil and Natural Gas Transmission and Distribution	**CH_4**	9%	**7%**	**0.11**	**Level, Trend**
4A	Enteric Fermentation	**CH_4**	3%	**5%**	**0.02**	**Level, Trend**
1A4b	Residential - Gaseous Fuels	**CO_2**	5%	**5%**	**0.05**	**Level, Trend**
1A1	Electricity and Heat Production - Gaseous Fuels	**CO_2**	8%	**5%**	**0.10**	**Level, Trend**
6A	Solid Waste Disposal Sides	**CH_4**	1%	**3%**	**0.01**	**Level, Trend**
1A2	Manufacturing Industries and Construction - Solid Fuels	**CO_2**	6%	**3%**	**0.08**	**Level, Trend**
1A3b	Road Transportation - Gaseous Fuels	**CO_2**	0%	**3%**	**0.01**	**Level, Trend**
2A1	Cement Production	**CO_2**	1%	**3%**	**0.01**	**Level, Trend**
4D1	Direct Soil Emissions	**N_2O**	2%	**2%**	**0.02**	**Level, Trend**
2B1	Ammonia Production	**CO_2**	1%	**2%**	**0.01**	**Level, Trend**
2C2	Ferroalloys Production	**CO_2**	0%	**1%**	**0.01**	**Level, Trend**
1A4a	Commercial/Institutional - Gaseous Fuels	**CO_2**	0%	**1%**	**0.00**	**Level**
1A1	Heat Production and Other Energy Industries - Solid Fuels	**CO_2**	2%	**1%**	**0.02**	**Level, Trend**
4B	Manure Management	**N_2O**	1%	**1%**	**0.00**	**Level**
2B2	Nitric Acid Production	**N_2O**	0%	**1%**	**0.00**	**Level**
1A2	Manufacturing Industries and Construction - Gaseous Fuels	**CO_2**	4%	**1%**	**0.05**	**Level, Trend**
1A3c	Other Transportation	**CO_2**	0%	**1%**	**0.00**	**Level**
4D3	Indirect Soil Emissions	**N_2O**	1%	**1%**	**0.01**	**Level, Trend**
6B2	Domestic Waste Water Handling	**CH_4**	0%	**1%**	**0.00**	**Level**
2F	Consumption of Halocarbons and Sulfur Hexafluoride (Refrigeration and Air Conditioning Equipment)	**HFC**[13]	0%	**1%**	**0.002**	**Level**
1B1	Fugitive Emissions from Solid Fuel Mining and Transformation	**CH_4**	1%	**0%**	**0.02**	**Trend**
1A4b	Residential - Liquid Fuels	**CO_2**	2%	**0%**	**0.03**	**Level, Trend**
1A4a	Commercial/Institutional - Liquid Fuels	**CO_2**	1%	**0%**	**0.02**	**Trend**
1A2	Manufacturing Industries and Construction - Liquid Fuels	**CO_2**	4%	**0%**	**0.05**	**Level, Trend**
2C1	Cast Iron and Steel Production	**CO_2**	3%	**0%**	**0.05**	**Level, Trend**
1A1	Electricity and Heat Production - Liquid Fuels	**CO_2**	14%	**0%**	**0.22**	**Level**

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[13] Baseline year for HFC is 2001.

1.3 GHG Emission Trends 1990-2015[14]

Greenhouse gases (CO_2, CH_4, N_2O, HFCs and SF_6) emission trends for 1990-2015, without consideration of the LULUCF sector, are provided in Table 1.4 (Gg CO_2 eq.). In 1990, these emissions totaled 45,606 Gigagrams in CO2 equivalent. Due to the breakup of the economic system of the Soviet period, emissions started to fall sharply. In 2015, GHG emissions amounted 17,588 Gg. CO2 equivalent.

During this inventory GHG emissions and removals calculated using 2006 IPCC guidelines for 2014 and 2015 and recalculated results for the following years 1990, 1994, 2000, 2005, 2010, 2011, 2012, 2013. For other years GHG emissions and removals were interpolated using Compound Annual Growth Rate. Exception is the IPPU sector where GHG emissions were recalculated for all previous years.

Table 1-4 GHG Emission Trends in Georgia During 1990-2015 (Gg CO2 eq.) excluding LULUCF

Gas/Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
CO_2	34,098	25,829	18,931	13,763	10,257	8,991	7,923	6,929	6,091	5,506	4,874	4,607	4,636
CH_4	9,049	7,076	5,623	4,547	3,742	3,740	3,742	3,748	3,759	3,774	3,793	3,836	3,879
N_2O	2,459	2,173	1,880	1,664	1,418	1,477	1,562	1,601	1,642	1,752	1,813	1,741	1,813
HFC-134a	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.11	0.46
HFC-125	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.05	0.19
HFC-143a	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.06	0.20
HFC-32	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.00	0.01
SF_6	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Total	**45,606**	**35,078**	**26,434**	**19,974**	**15,417**	**14,208**	**13,227**	**12,279**	**11,492**	**11,031**	**10,479**	**10,184**	**10,329**

Gas/Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
CO_2	4,667	4,739	4,760	5,236	5,761	6,198	6,316	7,027	8,918	9,341	8,732	9,609	10,277
CH_4	3,923	3,968	4,013	4,068	4,130	4,197	4,272	4,353	4,849	5,237	4,511	4,505	5,088
N_2O	1,838	1,862	1,901	1,885	1,846	1,810	1,776	1,773	1,732	1,877	2,139	2,041	2,084
HFC-134a	1.46	2.43	4.59	4.69	5.31	7.81	12.84	26.41	30.54	56.77	65.07	68.38	77.83
HFC-125	0.64	1.42	2.33	2.22	2.14	3.09	4.07	12.86	17.31	19.06	21.33	30.71	37.61
HFC-143a	0.47	0.99	1.73	1.53	1.45	2.71	3.61	13.91	14.54	15.01	15.24	16.94	17.98
HFC-32	0.07	0.17	0.27	0.27	0.26	0.30	0.39	0.89	1.82	2.14	2.62	4.52	5.97
SF_6	NE	NE	NE	NE	NE	NE	NE	0.22	0.25	0.27	0.28	0.30	0.32
Total	**10,431**	**10,574**	**10,682**	**11,198**	**11,745**	**12,219**	**12,385**	**13,206**	**15,563**	**16,548**	**15,487**	**16,276**	**17,591**

1.4 Emission Trends by Sectors

Emission trends by sectors over 1990-2015 are provided in the Table 1.5. As can be seen from the table, energy is the dominant sector, and it accounts for more than half of total emissions over the entire period, excluding LULUCF. Following the breakup of the Soviet Union, the contribution of the agricultural sector in total emissions grows gradually, and it ranks second over the period 1990-2015. IPPU and Waste sectors are on the third and fourth places in ranking, excluding LULUCF.

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[14] The discrepancies may appear in total values due to rounding effect.

In Georgia, LULUCF sector had a net sink of greenhouse gases during 1990-2015. The sink capacity of the LULUCF sector fluctuates between (-2,525) Gg CO2 eq and (-6,850) Gg CO2 eq. Without consideration of the LULUCF sector, in 2015 greenhouse gas emissions in Georgia totaled 17,589 Gg in CO2 equivalent, and 13,707 Gg CO2 eq when taking this sector into account.

Table 1-5 GHGs Emission Trends by Sectors in 1990-2015 (GG CO2 eq.)

Sector	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
Energy	36,698	27,476	20,580	15,421	11,560	10,210	9,030	7,998	7,094	6,302	5,609	5,564	5,520
IPPU	3,879	3,038	1,705	776	414	447	535	504	502	710	725	439	591
Agriculture	3,925	3,492	3,108	2,766	2,463	2,548	2,636	2,727	2,822	2,920	3,021	3,043	3,065
Waste	1,105	1,073	1,041	1,011	978	1,003	1,026	1,050	1,074	1,099	1,124	1,138	1,153
LULUCF (Net removals)	(6,839)	(6,819)	(6,793)	(6,763)	(6,730)	(6,482)	(6,231)	(5,970)	(5,690)	(5,377)	(5,007)	(4,989)	(4,952)
Total (excluding LULUCF)	**45,607**	**35,079**	**26,434**	**19,974**	**15,415**	**14,208**	**13,227**	**12,279**	**11,492**	**11,031**	**10,479**	**10,184**	**10,329**
Total (including LULUCF)	**38,768**	**28,260**	**19,641**	**13,211**	**8,685**	**7,726**	**6,996**	**6,309**	**5,802**	**5,655**	**5,472**	**5,195**	**5,377**

Sector	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Energy	5,477	5,436	5,396	5,796	6,226	6,689	7,187	7,722	9,758	10,443	9,034	9,665	10,874
IPPU	699	846	957	1,136	1,314	1,383	1,106	1,443	1,794	1,872	1,892	2,035	2,058
Agriculture	3,087	3,109	3,132	3,042	2,956	2,872	2,790	2,712	2,649	2,859	3,186	3,201	3,271
Waste	1,167	1,182	1,199	1,223	1,249	1,275	1,303	1,330	1,362	1,375	1,375	1,377	1,388
LULUCF (Net removals)	(4,899)	(4,834)	(4,758)	(4,719)	(4,629)	(4,455)	(4,145)	(3,612)	(5,073)	(3,811)	(4,737)	(2,498)	(3,882)
Total (excluding LULUCF)	**10,431**	**10,574**	**10,684**	**11,198**	**11,745**	**12,219**	**12,385**	**13,208**	**15,563**	**16,549**	**15,487**	**16,278**	**17,591**
Total (including LULUCF)	**5,532**	**5,740**	**5,926**	**6,479**	**7,116**	**7,764**	**8,240**	**9,595**	**10,490**	**12,738**	**10,750**	**13,780**	**13,707**

In the table 1-6 GHG emissions and removals from LULUCF sector are provided in Gg CO2 equivalent.

Table 1-6 GHG Emissions and Removals from LULUCF sector (Gg CO2 eq.)

Source	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
Emission (GG CO2 eq.)	3,557	3,554	3,558	3,566	3,577	3,595	3,622	3,664	3,729	3,833	3,998	3,961	3,944
Removal (GG CO2)	10,396	10,374	10,351	10,329	10,307	10,077	9,853	9,633	9,419	9,209	9,004	8,950	8,896
Net removals	**(6,839)**	**(6,819)**	**(6,793)**	**(6,763)**	**(6,730)**	**(6,482)**	**(6,231)**	**(5,970)**	**(5,690)**	**(5,377)**	**(5,007)**	**(4,989)**	**(4,952)**

Source	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Emission (GG CO2 eq.)	3,943	3,955	3,978	4,079	4,232	4,469	4,843	5,439	3,687	5,081	4,092	5,982	4,598
Removal (GG CO2)	8,842	8,789	8,736	8,798	8,861	8,924	8,987	9,051	8,760	8,892	8,830	8,480	8,480
Net removals	**(4,899)**	**(4,834)**	**(4,758)**	**(4,719)**	**(4,629)**	**(4,455)**	**(4,145)**	**(3,612)**	**(5,073)**	**(3,811)**	**(4,737)**	**(2,498)**	**(3,882)**

1.5 Indirect Greenhouse Gases and Sulphur Dioxide

Tables below show direct and indirect GHG emissions by sectors and sub-sectors for 1990 and 2015.

Table 1-7 Direct and Indirect GHG Emissions by Sectors and Sub-Sectors in 1990 (Gg)

Greenhouse Gas Sources and Sink Categories	**CO_2 Emissions (Gg)**	**CO_2 Removals (Gg)**	**CH_4 (Gg)**	**N_2O (Gg)**	**NOx (Gg)**	**CO (Gg)**	**NMVOCs (Gg)**	**SOx (Gg)**
Total National Emissions and Removals for 1990	**37,918**	**10,755**	**434**	**10**	**109**	**406**	**61**	**39**
1. Energy	**30,368**	**0**	**295**	**0**	**104**	**354**	**60**	**38**
A. Fuel Combustion (sectoral approach)	30,294		9	0	104	354	60	38
1. Energy Industries	13732		0.41	0.087	36.46	3.43	0.99	9.03
2. Manufacturing Industries and Construction	7,535		0.45	0.07	20.65	6.37	0.98	16.52
3. Transport	3,744		0.99	0.186	35.06	237.63	44.84	1.56
4. Other Sectors	5,283		6.71	0.102	11.37	106.78	13.01	11.09
5. Other	NE		NE	NE	NE	NE	NE	NE
B. Fugitive Emissions from Fuels	73.8		286.29		NE	NE	NE	NE
1. Solid Fuels			32.22		NE	NE	NE	NE
2. Oil and Natural Gas			254.08		NE	NE	NE	NE
2. Industrial Processes	**3,730**	**NA**	**NA**	**3**	**5**	**1**	**2**	**1**
A. Mineral Products	572				NE	NO	0.25	0.53
B. Chemical Industry	C		NO	3	4.99	1.0	NO	0.007
C. Metal Production	C		0.04	NO	0.003	NO	0.002	0.003
D. Non-Energy Products from Fuel and Solvent Use	0		NO	NO	NO	0.006	0.03	NO
E. Electronic Industry	NO		NO	NO	NO	NO	NO	NO
F. Product Uses as Substitutes for ODS								
G. Other Product Manufacture and Use	NO		NO	NO	NO	NO	NO	NO
H. Other (please specify)	NO		NO	NO	NO	NO	2	NO
3. Agriculture			**86.13**	**6.83**	**NE**	**NE**	**NE**	**NA**
A. Enteric Fermentation			77.11					
B. Manure Management			9.02	1.21			NE	
C. Rice Cultivation			NO				NO	
D. Agricultural Soils			NE	5.61			NE	
E. Prescribed Burning of Savannahs			NO	NO	NO	NO	NO	
F. Field Burning of Agricultural Residues			NE	NE	NE	NE	NE	
G. Other			NO	NO	NO	NO	NO	
4. Land-use Change and Forestry	**3,472.53**	**10,395.93**	**3.45**	**0.04**	**0.27**	**49.84**	**NA**	**NA**

Greenhouse Gas Sources and Sink Categories	**CO_2 Emissions (Gg)**	**CO_2 Removals (Gg)**	**CH_4 (Gg)**	**N_2O (Gg)**	**NOx (Gg)**	**CO (Gg)**	**NMVOCs (Gg)**	**SOx (Gg)**
A. Changes in Forest and Other Woody Biomass Stocks	658.83	7,117.3						
B. Forest and Grassland conversion	13.2	NE	3.45	0.04	0.27	49.84		
C. Abandonment of Managed Lands		NE						
D. CO2 Emissions and Removals from Soil	2,800.5	3,278.6						
E. Other	NE	NE	NE	NE	NE	NE		
5. Waste			**49.91**	**0.18**	**NE**	**NE**	**NE**	**NE**
A. Solid Waste Disposal on Land			26.60		NE		NE	
B. Waste-water Handling			23.31	0.18	NE	NE	NE	
C. Waste Incineration					NE	NE	NE	NE
D. Other			NO	NO	NO	NO	NO	NO
6. Other	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
Memo items								
International Bunkers	**608.6**		0.004	0.017	NE	NE	NE	NE
Aviation	608.6		0.004	0.017	NE	NE	NE	NE
Marine	NE		NE	NE	NE	NE	NE	NE
CO2 Emissions from Biomass	**2,149**							

Table 1-8 Anthropogenic Emissions of HFCs, PFCs and SF6 in 1990 (Gg)

Greenhouse Gas Source and Sink Categories	**HFCs (Gg)**				**PFCs (Gg)**			**SF_6 (Gg)**
	HFC-23	**HFC-134**	**HFC-125**	**HFC-143a**	**CF4**	**C2F6**	**Other**	
Total National Emissions and Removals 1990	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
1. Energy								
A. Fuel Combustion (sectoral approach)								
1. Energy Industries								
2. Manufacturing Industries and Construction								
3. Transport								
4. Other Sectors								
5. Other								
B. Fugitive Emissions from Fuels								
1. Solid Fuels								
2. Oil and Natural Gas								

Greenhouse Gas Source and Sink Categories	HFCs (Gg)				PFCs (Gg)			SF_6 (Gg)
	HFC-23	HFC-134	HFC-125	HFC-143a	CF4	C2F6	Other	
2. Industrial Processes	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
A. Mineral Products								
B. Chemical Industry								
C. Metal Production	NO	NO	NO	NO	NO	NO	NO	NO
D. Non-Energy Products from Fuel and Solvent Use								
E. Electronic Industry	NO	NO	NO	NO	NO	NO	NO	NO
F. Product Uses as Substitutes for ODS	NO	NO	NO	NO	NO	NO	NO	NO
G. Other Product Manufacture and Use	NA	NA	NA		NA	NA		NO
H. Other (please specify)								
3. Agriculture								
A. Enteric Fermentation								
B. Manure Management								
C. Rice Cultivation								
D. Agricultural Soils								
E. Prescribed Burning of Savannahs								
F. Field Burning of Agricultural Residues								
G. Other								
4. Land-use Change and Forestry								
A. Changes in Forest and Other Woody Biomass Stocks								
B. Forest and Grassland Conversion								
C. Abandonment of Managed Lands								
D. CO2 Emissions and Removals from Soil								
E. Other								
5. Waste								
A. Solid Waste Disposal on Land								
B. Waste-water Handling								
C. Waste Incineration								
D. Other								
6. Other (please specify)	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
Memo Items								

Greenhouse Gas Source and Sink Categories	HFCs (Gg)				PFCs (Gg)			SF$_6$ (Gg)
	HFC-23	HFC-134	HFC-125	HFC-143a	CF4	C2F6	Other	
International Bunkers								
Aviation								
Marine								
CO2 Emissions from Biomass								

Table 1-9 Direct and Indirect GHG Emissions by Sectors and Sub-Sectors in 2015 (Gg)

Greenhouse Gas Sources and Sink Categories	CO$_2$ Emissions (Gg)	CO$_2$ Removals (Gg)	CH$_4$ (Gg)	N$_2$O (Gg)	NOx (Gg)	CO (Gg)	NMVOCs (Gg)	SOx (Gg)
Total national emissions and removals for 2015	**14,591**	**9,094**	**271**	**6**	**58**	**678**	**45**	**16**
1. Energy	**8,616**	**0**	**103**	**0**	**50**	**267**	**44**	**15**
A. Fuel Combustion (sectoral approach)	8,602		7	0	50	267	44	15
1. Energy Industries	1619		0.03	0.007	3.41	0.45	0.11	0.01
2. Manufacturing Industries and Construction	1,058		0.09	0.01	4.08	1.90	0.25	5.23
3. Transport	4,062		1.89	0.195	39.11	179.14	33.01	1.30
4. Other sectors	1,863		5.13	0.07	3.82	85.28	10.23	8.62
5. Other	NE		NE	NE	NE	NE	NE	NE
B. Fugitive Emissions from Fuels	14		96.04		NE	NE	NE	NE
1. Solid Fuels			5.94		NE	NE	NE	NE
2. Oil and Natural Gas			90.10		NE	NE	NE	NE
2. Industrial Processes	**1,660**	**NA**	**NA**	**0.83**	**5**	**2**	**1**	**1**
A. Mineral Products	759				NE	0.004	0.15	0.49
B. Chemical Industry	C		NO	C	4.73	1.74	1.04	0.01
C. Metal Production	C		0.66	NE	0.01	0.0003	0.01	0.01
D. Non-Energy Products from Fuel and Solvent Use	11		NO	NO	NA	NA	0.02	NA
E. Electronic Industry	NO		NO	NO	NO	NO	NO	NO
F. Product Uses as Substitutes for ODS								
G. Other Product Manufacture and Use	NO		NO	C	NO	NO	NO	NO
H. Other (please specify)	NO		NO	NO	NO	NO	NO	NO
3. Agriculture			**75.73**	**5.42**	**NE**	**NE**	**NE**	**NA**
A. Enteric Fermentation			70.11		-			
B. Manure Management			5.62	1.07			NE	
C. Rice Cultivation			NO				NO	

Greenhouse Gas Sources and Sink Categories	CO_2 Emissions (Gg)	CO_2 Removals (Gg)	CH_4 (Gg)	N_2O (Gg)	NOx (Gg)	CO (Gg)	NMVOCs (Gg)	SOx (Gg)
D. Agricultural Soils			NE	4.36			NE	
E. Prescribed Burning of Savannahs			NO	NO	NO	NO	NO	
F. Field Burning of Agricultural Residues			NE	NE	NE	NE	NE	
G. Other			NO	NO	NO	NO	NO	
4. Land-use Change and Forestry	**4,315**	**9,094**	**28.30**	**0.35**	**2.20**	**409**	**NA**	**NA**
A. Changes in Forest and Other Woody Biomass Stocks	1,095	6,742						
B. Forest and Grassland conversion	3,220	410	28.30	0.35	2.20	409		
C. Abandonment of Managed Lands		NE						
D. CO2 Emissions and Removals from Soil	NE	1,943						
E. Other	NE	NE	NE	NE	NE	NE		
5. Waste			**63.33**	**0.19**	**NE**	**NE**	**NE**	**NE**
A. Solid Waste Disposal on Land			42.57		NE		NE	
B. Waste-water Handling			20.76	0.19	NE	NE	NE	
C. Waste Incineration					NE	NE	NE	NE
D. Other			NO	NO	NO	NO	NO	NO
6. Other	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
Memo items								
International Bunkers	**214.7**		0.002	0.006	NE	NE	NE	NE
Aviation	214.7		0.002	0.006	NE	NE	NE	NE
Marine	NE		NE	NE	NE	NE	NE	NE
CO2 Emissions from Biomass	**1,866**							

Table 1-10 Anthropogenic Emissions of HFCs, PFCs and SF6 in 2015 (Gg)

Greenhouse gas source and sink categories	HFCs (Gg)				PFCs (Gg)			SF6 (Gg)
	HFC-23	HFC-134	HFC-125	HFC-143a	CF4	C2F6	Other	
Total national emissions and removals 2015	**0.009**	**0.060**	**0.013**	0.009	**NE**	**NE**	**NE**	**0.319**
1. Energy								
A. Fuel Combustion (sectoral approach)								
1. Energy Industries								
2. Manufacturing Industries and Construction								
3. Transport								

Greenhouse gas source and sink categories	**HFCs (Gg)**				**PFCs (Gg)**			**SF6 (Gg)**
	HFC-23	**HFC-134**	**HFC-125**	**HFC-143a**	**CF4**	**C2F6**	**Other**	
4. Other Sectors								
5. Other								
B. Fugitive Emissions from Fuels								
1. Solid Fuels								
2. Oil and Natural Gas								
2. Industrial Processes	**0.009**	**0.060**	**0.013**	0.009	**NE**	**NE**	**NE**	**0.319**
A. Mineral Products								
B. Chemical Industry								
C. Metal Production	NO	NO	NO	NO	NO	NO	NO	NO
D. Non-Energy Products from Fuel and Solvent Use								
E. Electronic Industry	NO	NO	NO	NO	NO	NO	NO	NO
F. Product Uses as Substitutes for ODS	0.009	0.060	0.013	0.009	NE	NE	NE	NE
G. Other Product Manufacture and Use	NA	NA	NA		NA	NA		0.319
H. Other (please specify)								
3. Agriculture								
A. Enteric Fermentation								
B. Manure Management								
C. Rice Cultivation								
D. Agricultural Soils								
E. Prescribed Burning of Savannahs								
F. Field Burning of Agricultural Residues								
G. Other								
4. Land-use Change and Forestry								
A. Changes in Forest and Other Woody Biomass Stocks								
B. Forest and Grassland Conversion								
C. Abandonment of Managed Lands								
D. CO2 Emissions and Removals from Soil								
E. Other								
5. Waste								

Greenhouse gas source and sink categories	HFCs (Gg)				PFCs (Gg)			SF6 (Gg)
	HFC-23	HFC-134	HFC-125	HFC-143a	CF4	C2F6	Other	
A. Solid Waste Disposal on Land								
B. Waste-water Handling								
C. Waste Incineration								
D. Other								
6. Other (please specify)	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
Memo Items								
International Bunkers								
Aviation								
Marine								
CO2 Emissions from Biomass								

2 Energy

2.1 Sector Overview

In 2015, greenhouse gas emissions from the energy sector amounted 10,874 Gg CO_2 equivalent, which is about 62% of Georgia's total GHG emission (excluding LULUCF). It is considerably lower compared to the contribution of this sector in 1990 (80%). Compared to 1990, the total GHG emissions of the sector decreased by 70%, while they increased by 94% relative to 2000.

Table 2-1. Energy Sectoral Table for 1990 and 2015

Categories	**1990 Emissions (Gg)**			**2015 Emissions (Gg)**		
	CO_2	**CH_4**	**N_2O**	**CO_2**	**CH_4**	**N_2O**
1 - Energy	30,368.23	294.84	0.44	8,616.92	103.21	0.29
1.A - Fuel Combustion Activities	30,294.35	8.55	0.44	8,602.83	7.17	0.29
1.A.1 - Energy Industries	13,731.86	0.41	0.09	1,619.51	0.03	0.01
1.A.2 - Manufacturing Industries and Construction	7,534.96	0.45	0.07	1,058.14	0.09	0.01
1.A.3 - Transport	3,744.54	0.99	0.19	4,062.32	1.89	0.20
1.A.4 - Other Sectors	5,282.99	6.71	0.10	1,862.87	5.17	0.07
1.A.4.a - Commercial/Institutional	1,076.52	0.45	0.01	409.86	0.12	0.00
1.A.4.b - Residential	3,688.24	6.01	0.09	1,414.94	5.04	0.07
1.A.4.c - Agriculture/Forestry/ Fishing/Fish Farms	518.23	0.24	0.00	38.07	0.01	0.00
1.B - Fugitive Emissions from Fuels	73.88	286.29	0.00	14.09	96.04	0.00
1.B.1 - Solid Fuels	62.20	32.21		11.48	5.94	
1.B.2 - Oil and Natural Gas	11.68	254.07	0.0002	2.62	90.10	0.00004
1.B.2.a - Oil	11.41	7.09	0.00	2.49	1.76	0.00
1.B.2.b - Natural Gas	0.27	246.98	0.00	0.13	88.34	0.00

A significant fall in GHG emissions in the 1990s is due to the breakup of the Soviet Union and fundamental changes in the economy of the country. However, the national economy started increasing after 2000 and the average annual growth of real GDP amounted to 8.4% before 2008. During 2008-2009, economic growth of Georgia has slowed down due to the Russian-Georgian war. Again, from 2010, the real GDP of the country started increasing by 4.9% on average until 2015[15].

In 2010, hydro generation reached its maximum, while the generation from thermal power plants was the lowest in the past decade. From 2011 emissions in the energy sector increased mainly due to the increased thermal power generation and improvement of the economic situation. Table 2.2 shows the CO_2 equivalent of emissions in the energy sector. The Global Warming Potentials used to convert from GHG to CO2 eq are from the second assessment report.

Table 2-2. Greenhouse Gas Emissions from the Energy Sector (Gg, CO_2 eq.)

Source-Category	**1990**	**1994**	**2000**	**2005**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
1A Fuel Combustion	**30,611**	**10,032**	**4,508**	**4,123**	**6,035**	**7,586**	**8,086**	**7,436**	**8,176**	**8,842**
1A1 Energy Industries	13,767	4,088	1,447	1,200	560	1,274	1,379	1,000	1,534	1,622
1A2 Manufacturing Industries and Construction	7,565	2,153	688	303	910	1,652	2,031	1,477	1,026	1,064
1A3 Transport	3,823	1,419	945	1,537	2,601	2,583	2,690	3,380	3,757	4,163
1A4 Other sectors (commercial/Institutional, residential, agriculture/ forestry/ fishing)	5,456	2,373	1,427	1,084	1,964	2,076	1,986	1,579	1,859	1,993
1B Fugitive Emissions from Fuels	**6,087**	**1,527**	**1,102**	**1,273**	**1,686**	**2,173**	**2,357**	**1,600**	**1,488**	**2,032**
1B1. Solid fuels	739	82	3	2	119	157	188	180	133	137
1B2. Oil and natural gas	5,348	1,445	1,099	1,271	1,567	2,016	2,169	1,420	1,355	1,895
Total from Energy Sector	**36,698**	**11,559**	**5,610**	**5,396**	**7,721**	**9,759**	**10,443**	**9,036**	**9,664**	**10,874**

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[15] GEOSTAT – Real Growth of GDP.

As can be seen from the Table, a large share of emissions from the energy sector is due to fuel combustion (81% in 2015) and the remaining 19% is caused by fugitive emissions. Among emission source-categories, the highest growth relative to 2000 was in fugitive emissions from the transformation of solid fuel (3 Gg in 2000, 137 Gg in 2015), which is due to the intensification of coal mining works in recent years. During 2000-2015, GHGs emissions from the industry and transport sectors increased about 1.6 and 4.4 times respectively. In the transport sector, GHG emissions increased due to the growing auto-park and a majority share of second-hand cars in the park. In Georgia, the number of motor vehicles in 2002-2016 period increased from 319,600 to 1,126,470[16]. From 2006, the development of energy transit pipelines (South Caucasus Gas Pipeline, Baku-Tbilisi-Erzurum oil Pipeline) through Georgia required additional gas and diesel for the pipeline operation. Figure 2.1 shows emission trends in 1990-2015 from the energy sector by various source-categories.

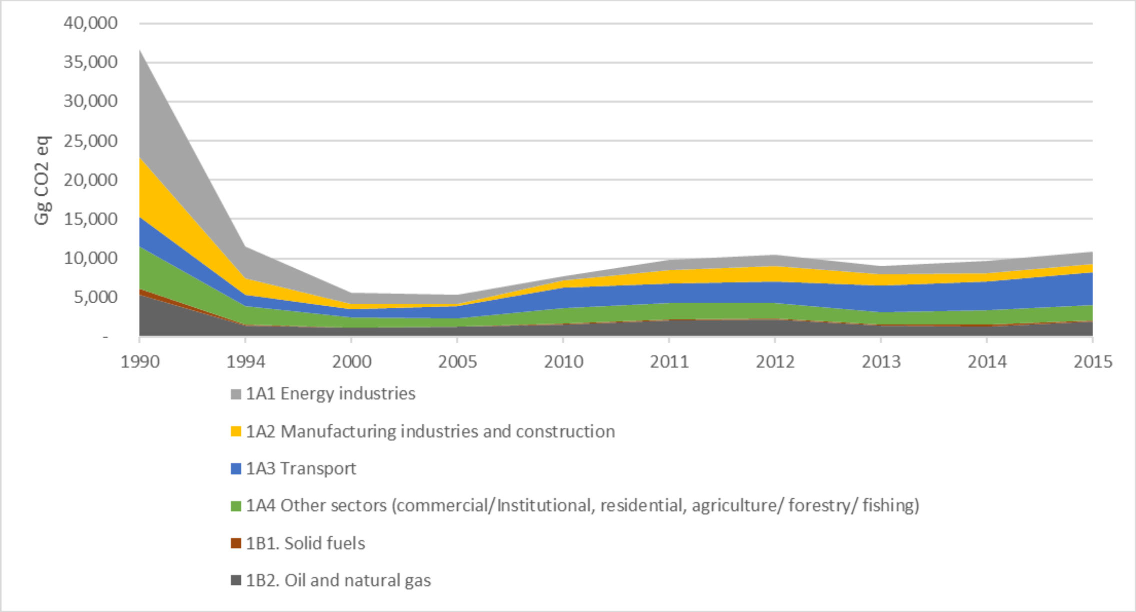

Figure 2-1 Trend of Greenhouse Gas Emissions from The Energy Sector 1990-2015 (Gg co2 eq.)

In 2015, the following source categories had the largest shares, in total GHG emission from the Energy Sector: Transport – 38%, Other Sectors – 18%, Oil and Natural Gas – 17%, Energy Industries – 15%, Manufacturing Industries and Construction – 10%. Results of uncertainty analysis in energy sector is provided in sub-chapter 7.1.

2.2 Fuel Combustion Activities

2.2.1 Description of Source-Categories and Calculated Emissions

Emissions of greenhouse gases from the Fuel Combustion source-category totaled 8,842 Gg in CO_2eq in 2015. In that year, carbon dioxide, methane and nitrous oxide accounted for 97%, 2%, and 1% of emissions from fuel combustion source-category respectively. The transport sector has the highest share: 47% in GHGs emissions from the source. The residential sector has the highest contribution in methane emissions, and transport sector in nitrous oxide emissions. Greenhouse gas emissions from fuel combustion are shown in Table 2.3.

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[16] Ministry of Internal Affairs, 2016

Table 2-3. Greenhouse Gas Emissions from Fuel Combustion (Gg)

Gas	1990	1994	2000	2005	2010	2011	2012	2013	2014	2015
CO_2	**30,368**	**9,888**	**4,289**	**3,977**	**5,862**	**7,432**	**7,803**	**7,190**	**7,939**	**8,617**
CH_4	295	77	60	66	86	108	122	83	78	103
CO_{2eq}	**6,192**	**1,619**	**1,269**	**1,376**	**1,798**	**2,265**	**2,555**	**1,746**	**1,639**	**2,168**
N_2O	0.444	0.169	0.167	0.139	0.200	0.196	0.274	0.322	0.277	0.286
CO_{2eq}	**138**	**52**	**52**	**43**	**62**	**61**	**85**	**100**	**86**	**89**
Total CO_2eq	**36,698**	**11,560**	**5,610**	**5,397**	**7,722**	**9,758**	**10,443**	**9,036**	**9,664**	**10,873**

2.2.1.1 Methodology

2.2.1.2 Method Used

Emissions in the source-category are calculated using the IPCC methodology Tier 1 – sectoral approach. The sectoral approach for assessing emissions from Fuel Combustion Stationary Source-categories is based on the data on actual consumption of fuel combusted in the source category provided in the country’s energy balance and emission factor. Emission Factors come from the default values provided together with associated uncertainty range.

The following equation is used to calculate greenhouse gas emissions from stationary combustion according to the sectoral approach:

$$\textbf{Emissions}_{\textbf{GHG, fuel}} = \textbf{Fuel Consumption}_{\textbf{fuel}} \times \textbf{Emission Factor}_{\textbf{GHG, fuel}}$$

Where:

Emissions $_{\text{GHG, fuel}}$ – Emissions of a given GHG by type of fuel (kg GHG)

Fuel Consumption $_{\text{fuel}}$ – Amount of fuel combusted (TJ)

Emission Factor $_{\text{GHG, fuel}}$ – Default emission factor of a given GHG by type of fuel (kg gas/TJ). For CO2, it includes the carbon oxidation factor, assumed to be 1.

Not all fuel supplied to an economy is burned for heat energy. Some is used as a feedstock for manufacture of products, such as plastics or in a non-energy use (e.g. bitumen for road construction), without oxidation (emissions) of carbon. This is called stored carbon, and is deducted from the carbon emissions calculation. The estimation of the stored carbon, requires data for fuel use by activities using the fuel as raw material.

Recalculations in GHGs emission inventories for 1990, 1994, 2000, 2005, 2010-2013 are mainly due to shifting from IPCC 1996 to IPCC 2006 guidelines.

2.2.2 Emission Factors

The emission factor is a coefficient that relates the Activity Data to the amount of the chemical compound, which is the source of later emissions. Emission Factors for CO_2 from fossil fuel combustion are expressed on a per unit energy basis, since the carbon content of fuels is generally less variable when expressed on a per unit energy basis, than when expressed on a per unit mass basis. Therefore, net calorific values (NCVs) are used to convert fuel consumption data on a per unit mass or volume basis, to data on a per unit energy basis. Country specific NCV-s of different fuels were obtained from the GEOSTAT energy balance (2013-2015).

Table 2-4. Conversion Factors and Carbon Emission Factors for Various Types of Fuel

Fuel type	Unit	Net Calorific Values (TJ/Unit)	Carbon content (kg/GJ)
Crude Oil	1000 t	42.5	20.0
Motor Gasoline	1000 t	44.0	18.9
Jet Kerosene	1000 t	43.2	19.5
Other Kerosene	1000 t	43.2	19.6
Gas/Diesel Oil	1000 t	43.3	20.2
Residual Fuel Oil	1000 t	40.4	21.1
LPG	1000 t	45.0	17.2
Naphtha	1000 t	44.5	20.0
Bitumen	1000 t	38.0	22.0
Lubricants	1000 t	38.0	20.0
Fuel Oil	1000 t	41.9	20.0
Other Oil Products	1000 t	43.3	20.0
Anthracite	1000 t	29.3	26.8
Lignite	1000 t	17.0	27.6
Sub-Bituminous Coal	1000 t	18.9	26.2
Other-Bituminous Coal	1000 t	25.0	25.8
Coking Coal	1000 t	28.2	25.8
Coke Oven/Gas Coke	1000 t	29.3	29.2
Natural Gas (Ng)	1 000 000 m^3	35.0	15.3
Fuel Wood	1000 m^3	7.8	30.5
Petroleum Coke	1000 t	32.5	26.6
Charcoal	1000 t	30.8	26.6
Patent Fuel	1000 t	29.0	26.6
Other Primary Solid Biomass	1000 t	18.0	27.3

Emission Factors for CO_2 are in units of kg CO_2/GJ on a net calorific value basis and reflect the carbon content of the fuel. CO_2 Emission Factors for all Tiers reflect the full carbon content of the fuel less any non-oxidized fraction of carbon retained in the ash, particulates or soot. Since this fraction is usually small, the Tier 1 default Emission Factors neglect this effect by assuming a complete oxidation of the carbon contained in the fuel (carbon oxidation factor equal to 1). Emission Factors for CH_4 and N_2O for different source categories differ due to differences in combustion technologies applied in the different source categories. The default factors presented for Tier 1 apply to technologies without emission controls[17].

2.2.3 Activity Data

Generally, in the energy sector the national energy balance is the basis for the assessment of greenhouse gas emissions in the course of fuel combustion. In energy balance production of fuel, its import, export, changes in stocks, and consumption, is provided in physical units (tons or m^3) or in energy units (terajoules or kilo tons of oil equivalent). For comparison of data in the energy balance, physical units are converted into energy units using fuel specific net calorific values (NCV).

In 2014, the National Statistics Office of Georgia (GEOSTAT) published its first energy balance for 2013, counting from 2000. Quality of the data is improving by years. Meanwhile, there are no official energy balances available for 1990, 1994, 2000, 2005 and 2010-2012, and Activity Data has been taken from various sources.

The following data was provided from different sources:

- Energy balances for 2013-2015 were provided by the National Statistics Office of Georgia (GEOSTAT)[18];

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[17] The Emission Factor Database (EFDB)

[18] GEOSTAT - Energy Statistics

- Energy balances for 1990, 1994, 2000, 2005 were provided by the International Energy Agency (IEA);
- Natural gas balances for 2010-2012, jet kerosene and firewood supply, and consumption data were obtained from the Ministry of Energy of Georgia in 2015;
- Information on the natural gas and crude oil transit were provided by the Georgian Oil and Gas Corporation (GOGC)[19];
- Electricity balances for 2010-2012 years were obtained from the Electricity Market Operator (ESCO)[20];
- Natural gas transmission and distribution losses were provided by the Georgian National Energy and Water Supply Regulatory Commission (GNERC)[21];
- Data for natural gas and diesel consumption in operations of energy transit pipelines for 2010-2015 years were provided by the British Petroleum Georgia[22].

Based on the data, aggregated energy balances were prepared for 2010-2012 (provided in Annex). Data provided by BP-Georgia has not been reflected in the energy balances, as the country has neither the right, nor the obligation to intervene in the operations of SCP and BTC transit. However, the data has been used for GHG emission calculation in the transport sector.

2.3 Comparison of the Results of Sectoral and Reference Approaches

The Reference Approach is a top-down approach, using a country's energy supply data to calculate the emissions of CO_2 from combustion of mainly fossil fuels. The Reference Approach is a straightforward method that can be applied on the basis of relatively easily available energy supply statistics. Improved comparability between the sectoral and reference approaches continues to allow a country to produce a second independent estimate of CO_2 emissions from fuel combustion with limited additional effort and data requirements. The Reference Approach provides an upper bound to CO_2 emissions inferred from the country's supply of fossil fuels by identifying the carbon content, subtracting from it the excluded carbon - carbon stored in non-energy products and products made from fuels used as raw material, adjusting for carbon, which remains unburnt, and multiplying by 44/12. Under the Reference Approach, carbon dioxide emissions are calculated using the formula:

Carbon dioxide emission (Gg CO2) =
∑i {[Apparent Consumption of fuel (Units)
x Calorific value of fuel (TJ/Unit)
x Carbon emission factor (t C/TJ) /1000 - Excluded carbon]
x Fraction of carbon oxidized} x 44/12

Where the lower index *i* refers to the type of fuel, and apparent consumption for each primary fuel is calculated as:

Apparent Consumption = Production + Imports - Exports -International Bunkers - Stock Change

While for secondary fuels, apparent consumption is calculated as:

Apparent Consumption = Imports - Exports -International Bunkers - Stock Change

Usually the value of fraction of carbon oxidized is 1, reflecting complete oxidation.

Excluded carbon is calculated using the formula:

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[19] www.gogc.ge
[20] www.esco.ge
[21] www.gnerc.org
[22] www.bpgeorgia.ge

Excluded Carbon (Gg C) = Non-energy use (10^3t)
x Calorific value of fuel (TJ/10^3t)
x Carbon emission factor (t C/TJ)
x Fraction of excluded carbon x 10^{-3}

The Reference approach is an upper bound, as some of the carbon will be emitted in forms other than CO_2, in part because fuel combustion is not always complete, but also because fuels may leak or evaporate. Consequently, the CO_2 emissions figure obtained from the Reference Approach will include carbon emitted as CH_4, CO, N_2O or NMVOC.

The Reference Approach uses a simple assumption: once carbon is brought into a national economy in fuel, it is either saved in some way or it must be released to the atmosphere. In order to calculate the carbon released, it is not necessary to know exactly how the fuel was used or what intermediate transformations it underwent. In this respect, the methodology may be termed a “top-down” approach compared with the “bottom-up” methods used for other gases. The “bottom-up” methods are a higher-level approach, when the information about fuel consumption and Emission Factors is collected at the level of specific enterprises. The sectoral approach is an intermediate approach between these two approaches, since it uses information about fuel consumption at the level of economic sectors. The difference between carbon dioxide emissions calculated using the Reference approach and sectoral approach, should not be more than 5%, otherwise the reason for the difference should be explained.

Table 2-5 shows carbon dioxide emissions in 2014-2015, calculated using these two approaches for different types of fuel, followed by the explanation of differences.

Table 2-5. Comparison of Carbon Dioxide Emissions Calculated Using the Reference and Sectoral Approaches

Fuel type	Year	2014	2015
Liquid Fuel	Reference approach, Gg	2,890	3,363
	Sectoral approach, Gg	2,880	3,322
	Difference, %	0.3%	1.2%
Solid Fuel	Reference approach, Gg	1,235	1,151
	Sectoral approach, Gg	1,236	1,152
	Difference, %	-0.1%	-0.1%
Gas Fuel	Reference approach, Gg	3,799	4,201
	Sectoral approach, Gg	3,808	4,129
	Difference, %	-0.2%	1.7%
Total	Reference approach, Gg	7,925	8,715
	Sectoral approach, Gg	7,925	8,603
	Difference, %	0.0%	1.3%

Difference in gas fuel is due to natural gas losses at the time of transportation and distribution, which is treated as methane emission, while under the reference approach it is treated as combusted and transformed into carbon dioxide.

2.4 International Bunkers Fuels

2.4.1 Description of Source-Categories and Calculated Emissions

All emissions from fuels used for international aviation and water-borne navigation (bunkers) are to be excluded from national totals, and reported separately as memo items. Emissions from international aviation is defined as emissions from flights that depart in one country and arrive in a different country, including take-offs and landings for these flight stages.

Emissions from international water-borne navigation is sourced from fuels used by vessels of all flags that are engaged in international water-borne navigation. The international navigation may take place at sea, on inland lakes and waterways and in coastal waters. Includes emissions from journeys that depart in one country and arrive in a different country.

The 1990, 1994, 2000, 2005, 2010-2015 inventory provides emissions from the International Aviation Bunkers. Data on jet kerosene consumption was provided by IEA (1990, 1994, 2000, 2005), the Ministry of Energy of Georgia (2010-2012) and GEOSTAT (2013-2015).

Table 2-6. Emissions of fuel consumed by international aviation bunkers

Year	Jet Kerosene Consumption, TJ	CO_2 (Gg)	CH_4 (Gg)	N_2O (Gg)	Gg CO2 eq
1990	8,512	609	0.004	0.017	**614**
1994	2,765	198	0.001	0.006	**368**
2000	648	46	0.0003	0.001	**47**
2005	1,599	114	0.001	0.003	**115**
2010	1,673	127	0.001	0.004	**128**
2011	1,512	108	0.001	0.003	**109**
2012	2,949	211	0.001	0.006	**213**
2013	3,656	261	0.002	0.007	**264**
2014	3,470	248	0.002	0.007	**250**
2015	3,002	215	0.002	0.006	**217**

Data on international marine bunker fuel (diesel and fuel oil) consumption is available for only 1994 year. CO_2, CH_4 and N_2O emissions from the source category are 167 Gg, 0.015 Gg, 0.004 Gg respectively.

2.5 Feedstocks and Non-Energy Use of Fuels

2.5.1 Description of Source-Categories

Not all fuel supplied to an economy is burned for heat energy. Some is used as a feedstock for manufacturing products such as plastics, or in a non-energy use (e.g. bitumen for road construction, natural gas for ammonia, naphtha, ethane, paraffin and candles production), without oxidation (emissions) of carbon. This is called excluded/stored carbon, and is deducted from the carbon emissions calculation. The values of the consumption of fossil fuel products for non-energy purposes are provided in Table 2.7.

Table 2-7. The Consumption of Fossil Fuel for Non-Energy Purposes

Year	Lubricants (Gg)	Bitumen (Gg)	Natural gas mln.m^3
1990	120	260	171
1994	71	46	57
2000	8	9	0
2005	10	68	211
2010	10	93	117
2011	14	60	126
2012	17	102	133
2013	15	79	251
2014	17	82	259
2015	20	89	273

Carbon emissions from the use of fuels listed above as feedstock are reported within the source categories of the Industrial Processes and Product Use (IPPU) chapter. Lubricating oil statistics usually cover not only use of lubricants in engines but also oils and greases for industrial purposes and heat transfer and cutting oils. Bitumen/asphalt is used for road paving and roof covering where the carbon it contains remains stored for long periods of time. Consequently, there are no fuel combustion emissions arising from the deliveries of bitumen within the year of the inventory. Natural gas is mainly used in production of fertilizers.

2.6 Energy Industries

2.6.1 Description of Source-Categories and Calculated Emissions

The energy industry source category comprises emissions from fuels combusted by the fuel extraction or energy-producing industries, including the following sub-categories:

- Main Activity Electricity and Heat Production includes emissions from main activity producers of electricity generation, combined heat and power generation, and heat plants. Main activity producers (formerly known as public utilities) are defined as those undertakings whose primary activity is to supply the public. They may be in public or private ownership.
- Petroleum refining covers all combustion activities supporting the refining of petroleum products including on-site combustion for the generation of electricity and heat for own use.
- Manufacture of Solid Fuels and Other Energy Industries - combustion emissions from fuel use during the manufacture of secondary and tertiary products from solid fuels including production of charcoal. Emissions from own on-site fuel use should be included. Also includes combustion for the generation of electricity and heat for own use in these industries.
- Emissions from fuel combustion in coke ovens within the iron and steel industry should be reported under other energy industries (1A1c) and not within manufacturing industry[23].

Currently, in Georgia, electric energy is produced mainly by hydropower plants (HPP) and gas thermal power plants (TPP). Georgia is a country rich with hydro resources and the largest share of power generation comes from hydropower plants. In 2015, the country has 66 HPPs (2,805 MW) and 4 gas

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[23] IPCC 2006, Table 8.2

TPPs (913 MW)[24]. The electric energy production by hydro and thermal power plants for 2010-2015 years are provided in Table below.

Table 2-8. Electric Energy Production

Year	Hydro Power Plants (GWh)	Gas Thermal Power Plants (GWh)	Total
2010	9,375	683	10,058
2011	7,892	2,212	10,105
2012	7,221	2,477	9,698
2013	8,271	1,788	10,059
2014	8,335	2,036	10,371
2015	8,454	2,379	10,833

As can be seen from the table, domestic power production increased in 2011 compared to 2010 and decreased in 2012 due to the reduction in hydro power generation. The largest share of hydro power production – 93% in total power generation, can be noticed in 2010 due to the high level of precipitation. From 2013 with increasing power consumption, thermal power generation increased. During 2010-2015, the average annual electricity consumption growth rate was 4.2%[25]. In 2013, four new hydro power plants with 46 MW installed capacity (250 GWh annual generation) were completed. In 2015 new Gardabani gas thermal power plant (230 MW installed capacity) was completed.

As for heat production, during the Soviet period, till 1991, centralized heating systems were operated in large cities of Georgia; these systems used natural gas and heavy fuel oil as fuel. Later, these systems gradually became fully useless; hence, greenhouse gas emissions from this subsector dropped to almost zero. Currently, the majority of the population uses firewood and natural gas for heating. Emissions from the consumption of these fuels are reflected in the residential sub-category.

Table 2-9. GHGs Emissions from the Energy Industry Source-Category (Gg)

Gas/Sub-sectors	1990	1994	2000	2005	2010	2011	2012	2013	2014	2015
CO_2	**13,732**	**4,078**	**1,445**	**1,198**	**559**	**1,273**	**1,378**	**999**	**1,531**	**1,619**
CH_4	0.41	0.13	0.03	0.03	0.01	0.02	0.03	0.02	0.02	0.03
$CO_{2eq.}$	**8.59**	**2.69**	**0.67**	**0.53**	**0.29**	**0.50**	**0.53**	**0.36**	**0.50**	**0.55**
N_2O	0.087	0.023	0.004	0.003	0.002	0.003	0.002	0.002	0.008	0.007
$CO_{2eq.}$	**27**	**7**	**1**	**1**	**1**	**1**	**1**	**1**	**2**	**2**
Total in $CO_{2eq.}$	**13,768**	**4,088**	**1,447**	**1,199**	**560**	**1,274**	**1,379**	**1,000**	**1,534**	**1,622**
El. Generation	6,218	2,737	1,447	652	560	1,274	1,379	953	1,130	1,275
Heat Plants	7,551	1,351	-	176	-	-	-	-	-	-
Other Energy Industries	-	-	-	371	-	-	-	47	404	347

2.6.2 Methodology

2.6.2.1 Method Used

Emissions have been calculated using the IPCC Tier 1 Sectoral Approach explained in Paragraph 1.2.2.a.

2.6.2.2 Emission Factor

Country specific net calorific values were used to convert the amount of consumed fuel from physical units into energy units (Table 2-4). The following default Emission Factors are provided in the table below[26].

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[24] GEOSTAT, Energy Balance 2015

[25] Electricity Market Operator (ESCO) – Electricity Balance 2015

[26] IPCC 2006, Volume 2, table 2.2 - default emission factors for stationary combustion in the energy industries

Table 2-10. Default Emission Factors for Stationary Combustion in The Energy Industries (kg/TJ on a Net Calorific basis)

Fuels\GHGs	CO_2	CH_4	N_2O
Natural Gas	56,100	1.0	0.1
Diesel	74,100	3.0	0.6

2.6.2.3 Activity Data

Data was taken from the energy balances (See Annex).

2.7 Manufacturing Industries and Construction

2.7.1 Description of Source-Categories and Calculated Emissions

Manufacturing industries and the construction sub-sector, comprise emissions caused by the burning of fuel from various industries, such as cast iron and steel production, ferroalloys, chemicals, paper, food products, drinks and tobacco production, etc., as well as emissions from construction materials production.

The heavy manufacturing industry in Georgia is one of the most important sectors in terms of value added, exports and employment. After the break-up of the Soviet Union, almost 1/3 of Georgian factories ceased production. But from 1995 the political stabilization and development of new industrial contacts has led to a relative stabilization of main industrial indicators and a positive growth of GDP.

Heavy manufacturing industry in Georgia is one of the most important sectors in terms of value added to exports and employment. Industrial sector accounts for 16.4% of GDP and 7% of the employment[27]. The most important sub-sectors of heavy manufacturing are ferroalloy, steel/iron, fertilizers and cement production.

Four factories function in the production of ferroalloys – Georgian Manganese (the same as Zestaphoni ferroalloy factory), Chiatura Manganese[28], Rusmetal[29] and GTM Group[30]. Zestaphoni ferro-alloy factory is the largest producer of silicon-manganese. Its annual productivity is 185,000 tons.

Steel and iron production take place in three factories - Geosteel[31], Rustavi Metallurgical Plant[32] and Iberia Steel. In this factory the steel is produced in electric ovens by melting scrap metal and slag, while the biGgest share (80-85%) is produced through melting scrap metal (Secondary steel production).

Fertilizers is one of the largest export products of Georgia. 'Rustavi Azoti' is the largest chemical enterprise of mineral fertilizers and industrial chemicals in Trans-Caucasus[33].

The largest company in nonmetallic building materials in Georgia is Heidelberg cement, which owns three plants of cement production– one in Kaspi and two in Rustavi. The company can produce 2mln tons of cement and 1.4mln tons of clinker[34].

Emissions from fuel combustion in coke ovens within the iron and steel industry is reported under 1A1c and not within manufacturing industry. Energy used for transport by industry should be reported under Transport (1A 3).

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[27] National Statistics Office of Georgia www.geostat.ge
[28] Georgian American Alloys – www.gaalloys.com
[29] Rusmetal www.rusmetali.com
[30] Ferro-Alloy Plant www.gtmgroup.ge
[31] Geosteal www.geosteel.com.ge
[32] Rustavi Metallurgical Plant http://www.rmp.ge/en/
[33] www.rustaviazot.ge
[34] Heidelberg cement Georgia www.heidelbergcement.ge

Table 2-11. provides GHGs emissions from the manufacturing industries and construction. GHGs emissions decreased about 7 times from 1990 to 2015 from the source category.

Table 2-11. GHGs Emissions from the Manufacturing Industries and Construction Source–Category (Gg)

Gas/Sub-sectors	1990	1994	2000	2005	2010	2011	2012	2013	2014	2015
CO_2	7,535	2,145	684	302	906	1,644	2,021	1,468	1,020	1,058
CH_4	0.45	0.12	0.06	0.01	0.06	0.12	0.15	0.13	0.09	0.09
$CO_{2eq.}$	9.45	2.44	1.34	0.19	1.30	2.54	3.07	2.75	1.85	1.85
N_2O	0.070	0.017	0.009	0.001	0.009	0.018	0.022	0.019	0.013	0.013
$CO_{2eq.}$	22	5	3	0	3	6	7	6	4	4
Total in $CO_{2eq.}$	**7,566**	**2,153**	**688**	**302**	**910**	**1,652**	**2,031**	**1,477**	**1,026**	**1,064**
Iron and Steel	IE	IE	IE	6	IE	IE	IE	19	40	32
Chemicals	16	22	IE	IE	IE	IE	IE	5	5	5
Pulp, Paper and Print	IE	IE	IE	0.05	IE	IE	IE	3	4	5
Food & Beverages	IE	IE	IE	45	IE	IE	IE	105	86	92
Non-metallic Minerals	IE	IE	IE	182	IE	IE	IE	1,312	855	892
Transport Equipment	IE	IE	IE	7	IE	IE	IE	2	1	1
Machinery	IE	IE	IE	0.1	IE	IE	IE	0.2	0.2	0.8
Mining	IE	IE	IE	IE	IE	IE	IE	0.5	1.5	3.0
Wood and wood products	IE	IE	IE	IE	IE	IE	IE	0.3	0.02	0.4
Construction	371	186	66	25	IE	IE	IE	19	20	24
Textile and Leather	IE	IE	IE	0.8	IE	IE	IE	0.8	1.6	1.9
Non-specified Industry	7,179	1,945	622	37	910	1,652	2,031	10	11	7

As per IPCC 2006 guidelines emissions from fuel combustion in coke ovens within the iron and steel industry should be reported under other energy industries (1A1c) and not within manufacturing industry.

2.7.2 Methodology

2.7.2.1 Method Used

Emissions were calculated using the IPCC Tier 1 sectoral approach.

2.7.2.2 Emission Factor

Country specific net calorific values were used to convert the amount of consumed fuel from physical units into energy units (Table 2-4). The following default Emission Factors are provided in the table below[35].

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[35] IPCC 2006, Volume 2, table 2.3 - default emission factors for stationary combustion in manufacturing industries and construction

Table 2-12. Default Emission Factors for Stationary Combustion in Manufacturing Industries and Construction (kg/TJ on a Net Calorific Basis)

Fuels\GHGs	CO_2	CH_4	N_2O
Natural Gas	56100	1	0.1
Diesel	74100	3	0.6
Anthracite	98300	10	1.5
Other Bituminous Coal	94600	10	1.5
Lignite	101000	10	1.5
Liquefied Petroleum Gases	63100	1	0.1
Kerosene	71900	3	0.6
Residual Fuel Oil	77400	3	0.6
Wood/Wood Waste	112000	30	4
Other Primary Solid Biomass	100000	30	4
Coke Oven Gas	107000	10	1.5
Charcoal	112000	200	4

2.7.2.3 Activity Data

Data was taken from the energy balances (See Annex) provided by GEOSTAT.

2.8 Transport

2.8.1 Description of Source-Categories and Calculated Emissions

Georgia is the transportation hub for the South Caucasus region (Georgia, Armenia, and Azerbaijan) and Central Asia (Kazakhstan, Uzbekistan, Kyrgyzstan, Tajikistan, and Turkmenistan), providing routs to Russia, Turkey and (over the Black Sea) to Europe. Georgia's oil and gas pipelines, the Black Sea ports, developed railway system, and airports with direct air services to more than 20 locations are also playing an increasingly important role in linking East and West.

The transport sector in Georgia, like in the majority of the world's countries, is one of the most significant emitters of greenhouse gases, and therefore major attention is paid to the inventory of emissions from this sector and the implementation of mitigation measures.

In Georgia, the growth of emissions from the transport sector is mainly due to several factors: annual growth of vehicle fleet, large share of second-hand cars in this fleet, and the growth of transit. Since Georgia is a transit country, along with the growth of local vehicles fleet, the number of transit trucks consuming fuel purchased in Georgia is increasing as well. Annual growth of local and transit transport causes the increase of not only carbon dioxide and other greenhouse gases, but also the increase of local pollutants which seriously affect human health. Energy transit pipelines (Baku-Tbilisi-Supsa (WREP), Baku-Tbilisi-Ceyhan (BTC) oil and South Caucasus Gas (SCP) pipelines) go through Georgia as well. Service Company British Petroleum uses natural gas and diesel at the substations to operate the pipelines.

Under the transport sector, Georgia's GHGs Inventory reviews road transport, rail transport, civil aviation, domestic navigation and pipelines.

The trends of greenhouse gases from the transport sector are provided in Tables 2-13 and 2-14. As can be seen from the tables, like other source-categories of fuel combustion, carbon dioxide is a dominant greenhouse gas in this case as well (98% of emissions, 2015).

Table 2-13. GHG Emissions from the Transport Source-Category (Gg)

Gas	1990	1994	2000	2005	2010	2011	2012	2013	2014	2015
CO_2	3,744	1,390	925	1,503	2,550	2,535	2,638	3,282	3,666	4,062
CH_4	0.99	0.36	0.31	0.55	0.69	0.69	0.70	1.47	1.78	1.89
$CO_{2eq.}$	20.71	7.56	6.41	11.57	14.53	14.41	14.70	30.81	37.30	39.67
N_2O	0.186	0.070	0.045	0.073	0.116	0.114	0.120	0.217	0.175	0.195
CO_{2eq}	58	22	14	23	36	35	37	67	54	60
Total in $CO_{2eq.}$	**3,822**	**1,420**	**945**	**1,537**	**2,601**	**2,585**	**2,690**	**3,380**	**3,758**	**4,162**

Greenhouse gases emissions by subcategories in 2010-2015 are provided by subsectors. The dominant subsector is road transport (95% of emissions in 2015). As railway transport is fully electrified effectively in Georgia, it is insignificant in terms of emissions. GHG emissions in civil aviation (during 1990-2010), domestic navigation (during 1990-2011) and other transportation sub-categories (during 2000-2005) are not estimated due to the lack of data.

Table 2-14. GHGs Emissions from Transport Sub-Categories (Gg)

Source/gas	1990	1994	2000	2005	2010	2011	2012	2013	2014	2015
1A3a Civil aviation total in $CO_{2eq.}$	NE	NE	NE	NE	NE	57	2	2	3	2
CO_2	NE	NE	NE	NE	NE	56	2	2	3	2
CH_4	NE	NE	NE	NE	NE	0	0	0	0	0
$CO_{2eq.}$	NE	NE	NE	NE	NE	0	0	0	0	0
N_2O	NE	NE	NE	NE	NE	0.002	0	0	0	0
$CO_{2eq.}$	NE	NE	NE	NE	NE	0.62	0	0	0	0
1A3b Road Transportation total in $CO_{2eq.}$	3,679	1,337	945	1,537	2,411	2,313	2,480	2,948	3,543	3,953
CO_2	3,603	1,310	925	1,503	2,360	2,264	2,428	2,874	3,452	3,853
CH_4	0.98	0.35	0.30	0.55	0.69	0.68	0.69	1.42	1.77	1.88
$CO_{2eq.}$	20.64	7.39	6.36	11.57	14.43	14.32	14.57	29.84	37.17	39.56
N_2O	0.18	0.07	0.05	0.07	0.12	0.11	0.12	0.14	0.17	0.20
$CO_{2eq.}$	54.87	20.15	13.95	22.63	35.96	34.41	37.20	44.64	53.94	60.45
1A3c Railways total in $CO_{2eq.}$	43.33	29.26	0.04	0	0.02	0	0.04	0.04	0.04	0.02
CO_2	43	29	0	0	0	0	0	0	0	0
CH_4	0.001	0.007	0.002	0	0.001	0	0.002	0.002	0.002	0.001
$CO_{2eq.}$	0.021	0.147	0.042	0	0.021	0	0.042	0.042	0.042	0.021
N_2O	0.001	0.001	0	0	0	0	0	0	0	0
$CO_{2eq.}$	0.31	0.31	0	0	0	0	0	0	0	0
1A3d National Navigation total in $CO_{2eq.}$	NE	NE	NE	NE	NE	NE	4.2	4.1	2.2	2.1
CO_2	NE	NE	NE	NE	NE	NE	4.2	4.1	2.2	2.1
CH_4	NE	NE	NE	NE	NE	NE	0	0	0	0
$CO_{2eq.}$	NE	NE	NE	NE	NE	NE	0	0	0	0
N_2O	NE	NE	NE	NE	NE	NE	0	0	0	0
$CO_{2eq.}$	NE	NE	NE	NE	NE	NE	0	0	0	0
1A3e Other Transportation (pipelines, off road) total in CO2eq.	101	53	NE	NE	190	215	204	426	210	205
CO_2	98	52	NE	NE	190	215	204	402	210	205
CH_4	0.002	0.001	NE	NE	0.004	0.004	0.004	0.044	0.004	0.004
$CO_{2eq.}$	0.042	0.021	NE	NE	0.084	0.084	0.084	0.924	0.084	0.084
N_2O	0.008	0.004	NE	NE	0	0.001	0	0.073	0.001	0
$CO_{2eq.}$	2.480	1.240	NE	NE	0	0.31	0	22.63	0.31	0
Total from sector in $CO_{2eq.}$	**3,822**	**1,420**	**945**	**1,537**	**2,601**	**2,585**	**2,690**	**3,380**	**3,758**	**4,162**

2.8.2 Methodology

2.8.2.1 Method Used

In the transport sector, emissions for all subcategories were calculated using the IPCC Tier 1 sectoral approach. For this sector, carbon dioxide emissions were calculated based on the consumed fuel statistics using the Tier 1 (top down) approach, since the carbon dioxide emission factor is dependent on the type of consumed fuel only, and not on the type of transport that has combusted. Methane and nitrous oxide emissions are dependent on the motor vehicle type, catalyzer type and the mode of operation, and for calculating their emissions it is recommended to use higher-tier methods. Such detailed information does not exist in Georgia; therefore, the Tier 1 sectoral approach was used for all greenhouse gases.

2.8.2.2 Emission Factor

Country specific net calorific values were used to convert the amount of consumed fuel from physical units into energy units (Table 2-4). The following default Emission Factors are provided in the table below[36].

Table 2-15. Default Emission Factors for Mobile (kg/TJ on a Net Calorific Basis)

Fuels\GHGs	**CO_2**	**CH_4**	N_2O
Civil Aviation			
Jet Kerosene	71,500	0.5	2
Road Transportation			
Gasoline	69,300	33	3.2
Diesel	74,100	3.9	3.9
Natural Gas	56,100	92	3
LPG	63,100	62	0.2
Railways			
Sub-bituminous Coal	96,100	2	1.5
Other Petroleum Products	NA	5	0.6
Water-borne Navigation			
Diesel	74,100	7	2
Pipelines			
Natural Gas	56,100	1	0.1
Diesel	74,100	3	0.6
Off-road			
Gasoline	69,300	80	2
Diesel	74,100	4.15	28.6

2.8.2.3 Activity Data

Data was taken from the energy balances provided by GEOSTAT. Information on gas and diesel consumption for pipeline operations were provided by British Petroleum Georgia (see Annex 10.2).

2.9 Other Sectors – Commercial, Residential, Agriculture, Forestry, Fishing

2.9.1 Description of Source-Categories and Calculated Emissions

Emissions in this source-category comprise of emissions from the following subsectors:

- Commercial and Public Services;
- Residential;
- Agriculture, Fishing and Forestry.

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[36] IPCC 2006, Volume 2, table 3.2.1, 3.2.2, - Road transport default co2, ch4, n2o emission factors.

Greenhouse gases emissions from this source category are provided in Table 2-16**.** The shares of methane (5.4% in 2015) and nitrous oxide (1.1% in 2015) are high, compared to other source categories; this is due to firewood consumption in the residential sector.

Table 2-16. GHG Emissions from The Commercial/Institutional/Residential/Agriculture/ Fishing/Forestry Source-Categories (Gg)

Gas	1990	1994	2000	2005	2010	2011	2012	2013	2014	2015
CO_2	5,283	2,265	1,228	970	1,833	1,966	1,748	1,424	1,708	1,863
CH_4	6.71	4.25	7.88	4.51	5.19	4.31	9.45	6.13	6.04	5.13
CO_{2eq}.	140.85	89.29	165.54	94.63	108.93	90.53	198.49	128.71	126.90	107.77
N_2O	0.102	0.060	0.107	0.062	0.073	0.062	0.128	0.083	0.081	0.070
CO_{2eq}.	32	19	33	19	23	19	40	26	25	22
Total in CO_{2eq}.	**5,455**	**2,373**	**1,427**	**1,083**	**1,965**	**2,076**	**1,986**	**1,578**	**1,860**	**1,992**

Greenhouse gas emissions by subcategories in 2010-2015 are provided in Table 3-17. The residential sector is a dominant subsector (77% in 2015), while GHGs emissions from commercial and agricultural sub-sectors amounted to 21% and 2% respectively.

Table 2-17. GHG Emissions from Commercial/Institutional/Residential/Agriculture/Fishing/ Forestry Source-Categories, By Sub-Categories (Gg)

Source/Gas	1990	1994	2000	2005	2010	2011	2012	2013	2014	2015
1A4a Commercial total in CO_{2eq}.	1,090	601	181	124	474	464	569	269	467	413
CO_2	1,077	578	177	116	456	446	548	266	463	410
CH_4	0.454	0.853	0.173	0.300	0.657	0.694	0.833	0.124	0.140	0.124
CO_{2eq}.	9.534	17.913	3.633	6.300	13.797	14.574	17.493	2.604	2.940	2.604
N_2O	0.012	0.015	0.003	0.004	0.012	0.010	0.011	0.002	0.002	0.002
CO_{2eq}.	3.720	4.650	0.930	1.240	3.720	3.100	3.410	0.620	0.620	0.620
1A4b Residential total in CO_{2eq}.	3,841	1,305	1,064	680	1,184	1,282	1,343	1,277	1,368	1,541
CO_2	3,688	1,240	871	581	1,078	1,191	1,126	1,126	1,220	1,415
CH_4	6.014	2.607	7.685	3.911	4.181	3.577	8.605	6.000	5.900	5.000
CO_{2eq}.	126.294	54.747	161.385	82.131	87.801	75.117	180.705	126.000	123.900	105.000
N_2O	0.086	0.034	0.103	0.053	0.058	0.050	0.116	0.081	0.079	0.068
CO_{2eq}.	26.660	10.540	31.930	16.430	17.980	15.500	35.960	25.110	24.490	21.080
1A4c Agriculture/ Forestry/ Fishing total in CO_{2eq}.	524	467	182	280	307	330	75	32	25	38
CO_2	518	447	181	273	299	329	74	32	25	38
CH_4	0.239	0.792	0.025	0.295	0.349	0.040	0.014	0.005	0.003	0.008
CO_{2eq}.	5.019	16.632	0.525	6.195	7.329	0.840	0.294	0.105	0.063	0.168
N_2O	0.004	0.011	0.001	0.005	0.003	0.002	0.001	-	-	-
CO_{2eq}.	1.240	3.410	0.310	1.550	0.930	0.620	0.310	-	-	-
Total from sector in CO_{2eq}.	5,455	2,373	1,427	1,083	1,965	2,076	1,986	1,578	1,860	1,992

2.9.2 Methodology

2.9.2.1 Method Used

Emissions were calculated using the IPCC Tier 1 sectoral approach.

2.9.2.2 Emission Factor

Country specific net calorific values were used to convert the amount of consumed fuel from physical units into energy units (Table 2-4). The following default Emission Factors are provided in the table below[37].

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[37] IPCC 2006, Volume 2, table 2.4, 2.5

Table 2-18. Default Emission Factors for commercial/institutional and residential and agriculture/forestry/fishing categories (kg/TJ on a Net Calorific Basis)

Fuels\GHGs	CO_2	CH_4	N_2O
Commercial/Institutional			
Anthracite	98,300	10	1.5
Lignite	101,000	10	1.5
Wood	112,000	300	4
Other primary solid biomass	100,000	300	4
Natural Gas	56,100	5	0.1
LPG	63,100	5	0.1
Residual fuel oil	77,400	10	0.6
Residential			
Lignite	101,000	300	1.5
Wood	112,000	300	4
Other primary solid biomass	100,000	300	4
Natural Gas	56,100	5	0.1
LPG	63,100	5	0.1
Other Kerosene	71,900	10	0.6
Charcoal	112,000	200	1
Agriculture/Forestry/Fishing			
Wood	112,000	300	4
Natural Gas	56,100	5	0.1
Anthracite	98,300	10	1.5
Lignite	101,000	300	1.5
Gasoline	69300	10	0.6
Diesel	74100	10	0.6
LPG	63100	5	0.1

2.9.2.3 Activity Data

Data was taken from the energy balances provided by GEOSTAT (See Annex).

2.10 Fugitive Emissions from Fuels

2.10.1 Description of Source-Categories and Calculated Emissions

Fugitive emissions include all intentional or unintentional release of greenhouse gases (mainly methane) during the extraction, processing and transport of fossil fuels to the point of final use. Fugitive emissions were calculated from the following categories and sub-categories:

Solid fuels (coal mining and handling, underground mines)

- Coal mining;
- Post-mining seam gas emissions;
- Abandoned underground mines.

Oil

- Venting;
- Flaring;
- Oil production and upgrading;
- Oil transport;
- Natural Gas;
- Venting;
- Flaring;
- Production;
- Transmission and storage;
- Distribution.

GHG emissions trend from the fugitive emissions in subsectors are provided in the table below.

Table 2-19. Fugitive Emissions (Gg)

Source	1990	1994	2000	2005	2010	2011	2012	2013	2014	2015
1B1 Solid fuel total in CO_{2eq}.	**739**	**82**	**3**	**2**	**119**	**157**	**188**	**180**	**133**	**136**
CO_2	62	7	0.3	0.2	10	13	16	15	11	11
CH_4	32	4	0.1	0.1	5	7	8	8	6	6
CO_{2eq}.	677	75	3	2	109	144	172	165	122	125
1B2a Oil total in CO_{2eq}.	**160**	**39**	**93**	**57**	**44**	**42**	**37**	**46**	**41**	**39**
CO_2	11	3	7	4	3	3	3	3	3	2
CH_4	7	2	4	3	2	2	2	2	2	2
CO_{2eq}.	149	36	87	53	40	39	35	43	39	37
1B2b Natural Gas total in CO_{2eq}.	**5,187**	**1,406**	**1,005**	**1,215**	**1,524**	**1,974**	**2,132**	**1,375**	**1,313**	**1,855**
CO_2	0.3	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1
CH_4	247	67	48	58	73	94	102	65	63	88
CO_{2eq}.	5,187	1,406	1,005	1,215	1,524	1,974	2,132	1,375	1,313	1,855
Total fugitive emissions CO_2	**74**	**10**	**7**	**4**	**13**	**16**	**19**	**18**	**14**	**14**
Total fugitive emissions CH_4	**286**	**72**	**52**	**60**	**80**	**103**	**111**	**75**	**70**	**96**
Total fugitive emissions in CO_{2eq}.	**6,086**	**1,527**	**1,102**	**1,274**	**1,687**	**2,174**	**2,357**	**1,601**	**1,488**	**2,031**

As can be seen from the table, the dominant subsector is natural gas sector, where high emissions are caused by high losses of natural gas in the process of transportation and distribution. Over the years, emissions from the mining and processing of coal increased as well, which is due to the intensification of mining of this fuel in Georgia. Below all source subcategories are described separately.

2.11 Solid Fuels

Although the mining of coal from underground layers was well developed in Georgia during the Soviet period, later coal mining decreased considerably. From 2009, coal mining started to rise again and, respectively, fugitive emissions from this sub-category increased. Emissions data is provided in the table below.

Table 2-20. Methane Emissions (Gg) from Underground Mines During Coal Mining and Treatment

Source	1990	1994	2000	2005	2010	2011	2012	2013	2014	2015
1B1 Solid fuel total in CO_{2eq}.	**739**	**82**	**3**	**2**	**119**	**157**	**188**	**180**	**133**	**136**
CO_2	62.20	6.90	0.27	0.19	10.04	13.24	15.82	15.16	11.23	11.42
CH_4	32.22	3.58	0.14	0.10	5.20	6.86	8.20	7.85	5.82	5.94
CO_{2eq}.	676.52	75.08	2.98	2.05	109.22	144.00	172.10	164.91	122.12	124.82
1B1ai1 Mining total in CO_{2eq}.	637.83	70.78	2.80	1.93	102.98	135.76	162.26	155.48	115.13	117.68
CO_2	54.62	6.06	0.24	0.17	8.82	11.63	13.89	13.31	9.86	10.08
CH_4	27.77	3.08	0.12	0.08	4.48	5.91	7.07	6.77	5.01	5.12
CO_{2eq}.	583.21	64.72	2.56	1.76	94.16	124.13	148.37	142.17	105.27	107.60
1B1ai2 Post-mining seam gas emissions total in CO_{2eq}.	100.89	11.20	0.45	0.30	16.28	21.48	25.66	24.59	18.21	18.56
CO_2	7.59	0.84	0.03	0.02	1.23	1.62	1.93	1.85	1.37	1.34
CH_4	4.44	0.49	0.02	0.01	0.72	0.95	1.13	1.08	0.80	0.82
CO_{2eq}.	93.30	10.35	0.42	0.28	15.06	19.87	23.73	22.74	16.84	17.22
1B1ai3 Abandoned underground mines total in CO_{2eq}.	0.000040	0.000025	0.000019	0.000015	0.000013	0.000013	0.000013	0.000013	0.000013	0.000013
CH_4	0.000002	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001
CO_{2eq}.	0.000040	0.000025	0.000019	0.000015	0.000013	0.000013	0.000013	0.000013	0.000013	0.000013

Coal deposits in Georgia are mainly located in three regions where coal extraction is underway for 158 years: from 1847 in Tkibuli-Shaori, from Tkvarcheli in 1929 and Akhaltsikhe from 1947[38]. Surface mining of coal is underway only in Tkvarcheli. However, information about the volume, technology and manufacturers is not available, since the entire region is occupied by Russia[39].

There are only 6 abandoned underground mines except Tkvarcheli, two in Tkibuli and four in Akhaltsikhe.

2.12 Methodology

2.12.1 Method Used

In all sub-sectors of solid fuel fugitive emissions were calculated using the IPCC Tier 1 sectoral approach. The Tier 1 approach requires that countries choose from a global average range of Emission Factors and use country-specific Activity Data to calculate total emissions.

The general form of the equation for estimating emissions for Tier 1 approach, based on coal production Activity Data from underground coal mining and post-mining emissions is given by the Equation:

Estimating emissions from underground coal mines for tier 1 and tier 2 without adjustment for methane utilization or flaring

Greenhouse Gas Emissions = Raw Coal Production × Emission Factor × Units Conversion Factor

The fundamental equation for estimating emissions from abandoned underground coal mines is shown in Equation below:

General equation for estimating fugitive emissions from abandoned underground coal mines

CH_4 emissions = Emissions from abandoned mines – CH_4 emissions recovered

2.12.1.1 Emission Factors

Tier 1 Emission Factors for underground mining are shown below.

Tier 1: Global Average Method – Underground Mining – Before Adjustment for Any Methane Utilization or Flaring

CH_4 Emissions = CH_4 Emission Factor × Underground Coal Production × Conversion Factor

Where units are:

Methane Emissions (Gg/year)

CH_4 Emission Factor (m^3/tons)

Underground Coal Production (tons/year)

Emission Factor:

Low CH_4 Emission Factor = 10 m^3/tons

Average CH_4 Emission Factor =18 m^3/tons

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[38] ქვანახშირის მოპოვება საქართველოში და მისი განვითარების პერსპექტივები - მწვანე ალტერნატივა / Coal Production and its Development Perspective – Green Alternative

[39] ღია წესით ქვანახშირის მოპოვება საქართველოში და მასთან დაკავშირებული პრობლემები - მწვანე ალტერნატივა / Surface mining of coal in Georgia and Related Problems – Green Alternative

High CH_4 Emission Factor = 25 m^3/tons

2.12.2 Conversion Factor

This is the density of CH_4 and converts volume of CH_4 to mass of CH_4. The density is taken at 20˚C and 1 atmosphere pressure and has a value of 0.67×10^{-6} Gg/m^3.

Countries using the Tier 1 approach should consider country-specific variables such as the depth of major coal seams to determine the emission factor to be used. As gas content of coal usually increases with depth, the low end of the range should be chosen for average mining depths of <200 m, and for depths of > 400 m the high value is appropriate. For intermediate depths, average values can be used. In Georgia, average mining depths is about 800-1200m, based on the information provided by Georgian Industrial Group (GIG), therefore High CH_4 Emission Factor = 25 m^3/tons was chosen.

For a Tier 1 approach the post-mining emissions factors are shown below together with the estimation method:

TIER 1: GLOBAL AVERAGE METHOD – POST-MINING EMISSIONS – UNDERGROUND MINES

Methane Emissions = CH4 Emission Factor × Underground Coal Production × Conversion Factor

Where units are:

Methane Emissions (Gg/year)

CH_4 Emission Factor (m^3/tons)

Underground Coal Production (tons/year)

Emission Factor:

Low CH_4 Emission Factor = 0.9 m^3/tons

Average CH_4 Emission Factor =2.5 m^3/tons

High CH_4 Emission Factor = 4.0 m^3/tons

Conversion Factor:

This is the density of CH_4 and converts volume of CH_4 to mass of CH_4. The density is taken at 20˚C and 1 atmosphere pressure and has a value of 0.67×10^{-6} Gg/m^3.

Developing emissions estimates from abandoned underground coal mines requires historical records. The two key parameters used to estimate abandoned mine emissions for each mine (or group of mines) are the time (in years) elapsed since the mine was abandoned, relative to the year of the emissions inventory, and Emission Factors that take into account the mine’s gassiness. Tier 1 includes default values and broader time intervals. For a Tier 1 approach, the emissions for a given inventory year can be calculated from Equation

Tier 1 approach for abandoned underground mines

Methane Emissions = Number of Abandoned Coal Mines Remaining Unflooded × Fraction of Gassy Coal Mines × Emission Factor × Conversion Factor

Where units are:

Methane Emissions (Gg/year)

Emission Factor (m^3/year)

Note: The Emission Factor has different units here compared with the definitions for underground, surface and post-mining emissions. This is because of the different method for estimating emissions from abandoned mines compared with underground or surface mining.

This equation is applied for each time interval, and emissions from each time interval are added to calculate the total emissions.

Conversion Factor:

This is the density of CH_4 and converts volume of CH_4 to mass of CH_4. The density is taken at 20˚C and 1 atmosphere pressure and has a value of 0.67×10-6 Gg/m^3.

A Tier 1 approach for determining emissions from abandoned underground mines is described below and is largely based on methods developed by the USEPA (Franklin et al, 2004).

Since in Georgia six underground mines are abandoned during 1976-2000 period default values - percentage of coal mines that are gassy assumed to be 30% selected from the range 8%-100% (IPCC 2006, volume 2, table 4.1.5). As for the Emission Factors, they are obtained from the table 4.1.6 of IPCC 2006, volume 2.

2.12.3 Activity Data

Information about coal mining and its specificities were obtained from the National Statistics Office of Georgia (GEOSTAT).

2.13 Oil and Natural Gas

The sources of fugitive emissions on oil and gas systems include, but are not limited to, equipment leaks, evaporation and flashing losses, venting, flaring, incineration and accidental releases. While some of these emission sources are engineered or intentional and therefore relatively well characterized, the quantity and composition of the emissions is generally subject to significant uncertainty due to the limited use of measurement systems in these cases.

Fugitive emissions are calculated from the following sub-categories:

Oil

- Venting - Emissions from venting of associated gas and waste gas/vapor streams at oil facilities;
- Flaring - Emissions from flaring of natural gas and waste gas/vapor streams at oil facilities;
- Oil production and upgrading - Fugitive emissions from oil production (excluding venting and flaring) occur at the oil wellhead through to the start of the oil transmission system. This includes fugitive emissions related to well servicing, transport of untreated production to treating or extraction facilities, activities at extraction and upgrading facilities, associated gas re-injection systems and produced water disposal systems. Fugitive emissions from upgraders are grouped with those from production rather than those from refining since the upgraders are often integrated with extraction facilities and their relative emission contributions are difficult to establish;
- Oil transport - Fugitive emissions (excluding venting and flaring) related to the transport of marketable crude oil to upgraders and refineries. The transportation systems may comprise pipelines, marine tankers, tank trucks and rail cars. Evaporation losses from storage, filling and unloading activities and fugitive equipment leaks are the primary sources of these emissions.
- Natural Gas;
- Venting - Emissions from venting of natural gas and waste gas/vapor streams at gas facilities;

- Flaring - Emissions from flaring of natural gas and waste gas/vapor streams at gas facilities;
- Production - Fugitive emissions (excluding venting and flaring) from the gas wellhead through to the inlet of gas processing plants, or, where processing is not required, to the tie-in points on gas transmission systems. This includes fugitive emissions related to well servicing, gas gathering, processing and associated waste water and acid gas disposal activities;
- Transmission and storage - Fugitive emissions from systems used to transport processed natural gas to market. Fugitive emissions from natural gas storage systems should also be included in this category;
- Distribution - Fugitive emissions (excluding venting and flaring) from the distribution of natural gas to end users.

Table 2-21. GHG Emissions from Oil and Natural Gas Related Activities (Gg)

Source	1990	1994	2000	2005	2010	2011	2012	2013	2014	2015
1B2 Oil and Natural Gas total in CO_{2eq}.	**5,347**	**1,445**	**1,099**	**1,272**	**1,567**	**2,017**	**2,169**	**1,420**	**1,355**	**1,895**
CO_2	12	3	7	4	3	3	3	3	3	3
CH_4	254	69	52	60	74	96	103	67	64	90
CO_{2eq}.	5,336	1,442	1,092	1,267	1,564	2,013	2,166	1,417	1,352	1,892
1B2ai Oil venting total in CO_{2eq}.	4	1	2	2	1	1	1	1	1	1
CO_2	0.03	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01
CH_4	0.20	0.05	0.12	0.07	0.06	0.05	0.05	0.05	0.05	0.04
CO_{2eq}.	4.16	1.03	2.46	1.50	1.16	1.11	0.99	1.07	0.95	0.90
1B2aii Oil flaring total in CO_{2eq}.	11.08	2.75	6.55	3.99	3.07	2.98	2.63	2.85	2.55	2.38
CO_2	10.93	2.70	6.47	3.94	3.02	2.94	2.59	2.81	2.50	2.36
CH_4	0.007	0.002	0.004	0.002	0.002	0.002	0.002	0.002	0.002	0.001
CO_{2eq}.	0.15	0.04	0.08	0.05	0.04	0.04	0.04	0.04	0.04	0.02
1B2aiii2 Oil production and upgrading total in CO_{2eq}.	145	35	84	51	39	38	34	37	33	31
CO_2	0.45	0.11	0.27	0.16	0.13	0.12	0.11	0.12	0.10	0.10
CH_4	7	2	4	2	2	2	2	2	2	1
CO_{2eq}.	145	35	84	51	39	38	34	37	33	31
1B2aiii3 Oil transport total in CO_{2eq}.	NO	NO	NO	NE	NE	NE	NE	5.06	5.29	5.32
CO_2	NO	NO	NO	NE	NE	NE	NE	0.02	0.02	0.02
CH_4	NO	NO	NO	NE	NE	NE	NE	0.24	0.25	0.25
CO_{2eq}.	NO	NO	NO	NE	NE	NE	NE	5.03	5.27	5.29
1B2bi Natural gas venting total in CO_{2eq}.	45	16	9	10	57	59	60	66	84	84
CO_2	0.03	0.01	0.01	0.01	0.04	0.04	0.04	0.04	0.05	0.05
CH_4	2.14	0.76	0.45	0.50	2.73	2.80	2.84	3.14	4.00	4.00
CO_{2eq}.	45	16	9	10	57	59	60	66	84	84
1B2bii Natural gas flaring total in CO_{2eq}.	0.08	0.00	0.11	0.03	0.01	0.01	0.01	0.01	0.01	0.02
CO_2	0.08	0.00	0.11	0.03	0.01	0.01	0.01	0.01	0.01	0.02
CH_4	0.000050	0.000002	0.000070	0.000020	0.000007	0.000005	0.000005	0.000005	0.000009	0.000010
CO_{2eq}.	0.00105	0.00004	0.00147	0.00042	0.00015	0.00011	0.00010	0.00010	0.00019	0.00021
1B2biii2 Natural gas production total in CO_{2eq}.	15	1	20	5	2	1	1	1	3	3
CO_2	0.006	0.000	0.008	0.002	0.001	0.001	0.001	0.001	0.001	0.001
CH_4	0.72	0.03	0.97	0.22	0.10	0.07	0.07	0.07	0.13	0.14
CO_{2eq}.	15.10	0.66	20.35	4.68	2.08	1.49	1.38	1.39	2.65	2.92
1B2biii4 Natural gas transmission and storage total in	1,476	526	312	344	295	459	485	57	230	360

Source	1990	1994	2000	2005	2010	2011	2012	2013	2014	2015
CO_{2eq}.										
CO_2	0.0005	0.0002	0.0001	0.0001	0.0002	0.0002	0.0002	0.0000	0.0001	0.0001
CH_4	70	25	15	16	14	22	23	3	11	17
CO_{2eq}.	1,476	526	312	344	295	459	485	57	230	360
1B2biii5 Natural gas distribution total in CO_{2eq}.	3,651	863	663	856	1,169	1,455	1,586	1,250	996	1,408
CO_2	0.15	0.04	0.03	0.04	0.05	0.06	0.07	0.05	0.04	0.06
CH_4	174	41	32	41	56	69	76	60	47	67
CO_{2eq}.	3,651	863	663	856	1,169	1,455	1,586	1,250	996	1,408

2.14 Methodology

2.14.1 Method Used

Fugitive emissions from oil and natural gas systems are often difficult to quantify accurately. This is largely due to the diversity of the industry, the large number and variety of potential emission sources, the wide variations in emission-control levels and the limited availability of emission-source data.

In Georgia, oil and natural gas are extracted at a small scale, and this has been considered in the process of the methodology selection. For assessing fugitive emissions in the course of oil extraction, the Tier 1 method was used; Tier 1 comprises the application of appropriate default Emission Factors to a representative activity parameter (usually throughput) for each applicable segment or subcategory of a country’s oil and natural gas industry. Tier 1 approach is done using equations presented below:

Tier 1: ESTIMATING FUGITIVE EMISSIONS FROM AN INDUSTRY SEGMENT

$$E_{\text{gas, industry segment}} = A_{\text{industry segment}} \times EF_{\text{gas, industry segment}}$$

Tier 1: TOTAL FUGITIVE EMISSIONS FROM INDUSTRY SEGMENTS

$$E_{\text{gas}} = \sum E_{\text{gas,industry segment}}$$

Where:

$E_{\text{gas, industry segment}}$ = Annual emissions (Gg)

$EF_{\text{gas, industry segment}}$ = Emission factor (Gg/unit of activity)

$A_{\text{industry segment}}$ = Activity value (units of activity)

Emissions in the course of natural gas transmission and distribution were calculated using the value of losses in the transmission and distribution systems, using the following formula:

CH_4 Emissions (Gg) = Gas Loss (10^6 m^3) X Methane Content in Gas (%)

X Conversion Factor (t CH_4/m^3 CH_4) X 1000

This methodology corresponds to the methodology recommended for the calculation of emissions from natural gas losses under the Clean Development Mechanism (CDM). In the formula, a conversion factor, methane density (ρ), converts methane volume into weight. A value (0.64512 Gg CH4/mln.m3) accepted in the CDM Methodology in standard conditions (at 0°C temperature and 101.3 kPa pressure conditions), ρ= 0.0007168 (t CH_4/m^3 CH_4) was used. In total 90% was taken as the value of methane content in natural gas[40].

2.14.2 Emission Factors

The available Tier 1 default Emission Factors are presented in table below[41]. All of the presented Emission Factors are expressed in units of mass emissions per unit volume of oil or gas throughput. Furthermore, throughput statistics are the most consistently available Activity Data for use in Tier 1 calculations. The Emission Factors apply to systems in developing countries and countries with economies in transition where there are much greater amounts of fugitive emissions per unit of activity (often by an order of magnitude or more). The reasons for the greater emissions in these cases may include less stringent design standards, use of lower quality components, restricted access to natural gas markets, and, in some cases, artificially low energy pricing resulting in reduced energy conservation.

Table 2-22. Emission Factors for Fugitive Emissions (Including Venting and Flaring) From Oil and Gas Operations

Category	Sub-Category	Emission Source	CH_4 Value	CO_2 Value	N_2O Value	Units of Measure
Gas production	All	Fugitives	1.2E-02	9.7E-05	-	Gg per mln. m3 gas production
		Flaring	8.8E-07	1.4E-03	2.5E-08	Gg per mln. m3 gas production
Gas Transmission & Storage	Transmission	Fugitives	0.64512	5.04E-06	-	Gg per mln. m3 of transported gas
		Venting	3.9E-04	5.2E-06	-	Gg per mln. m3 of marketable gas
Gas Distribution	All	All	0.64512	5.73E-04	-	Gg per mln. m3 of distributed gas
Oil Production	Conventional Oil	Fugitives	3.0E-02	2.0E-03	-	Gg per 10^3 m3 conventional oil production
		Venting	8.5E-04	1.1E-04	-	Gg per 10^3 m3 conventional oil production
		Flaring	2.95E-05	4.8E-02	7.6E-07	Gg per 10^3 m3 conventional oil production
Oil Transport	Pipelines	All	5.4E-06	4.9E-07	-	Gg per 10^3 m3 oil transported by pipeline
	Tanker Trucks and Rail Cars	Venting	2.5E-05	2.3E-06	-	Gg per 10^3 m3 oil transported by Tanker Truck

2.14.3 Activity Data

Information about oil and natural gas production, transmission and distribution were obtained from the National Statistics Office of Georgia (GEOSTAT) and Georgian Oil and Gas Corporation (GOGC).

Assessments about natural gas losses were made based on the information obtained from the energy balances provided by GEOSTAT. According to the information, natural gas losses in the transportation system were about 1.1% of the domestic supply in 2015. Gas transmission losses has been assumed to be 2% of the domestic supply in 1990, 1994, 2000, 2005 based on expert judgment.

Natural gas losses are quite high in the gas distribution systems of Georgia. These losses are made up off operational (technological and accidents) and commercial losses. The amount of losses in gas pipelines

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[40] Project 2404 : Leak Reduction in Above Ground Gas Distribution Equipment in the KazTransgaz-Tbilisi Gas Distribution System- Tbilisi, Georgia

[41] From IPCC 2006, Volume 2, table 4.2.5

depends on a number of factors – gas pressure, gas pipeline diameter and length, its technical state, number of gas-control points, etc. It is almost impossible to obtain such data in Georgia.

Under the Decree N26 of November 18, 2010, the Georgian National Energy and Water Regulatory Commission, approved the Rule of Calculation of the Amount of standard losses in the natural gas distribution network. This rule is based on statistical data, expert assessments and gas dynamics postulates. Standard losses were established for natural gas supply licenses according to this rule.

GNERC's annual reports (2012 and 2013 years), state gas distribution losses amounted to about 9% of distributed natural gas in Georgia. This figure has been used for the calculation of gas distribution losses for the 1990, 2000, 2010-2011 years in the GHGs emission inventory.

2.15 Carbon Dioxide Transport and Storage

CO_2 transport and CO_2 storage are not occurring in Georgia.

2.16 Non-CO2 Emissions from Energy Sector

Non-CO_2 emissions, such as CO, NOx, NMVOC and SO_2, were calculated using the Tier 1 approach from fuel combustion. The Tier 1 methodology for non-CO_2 gases estimates emissions by applying Emission Factors to fuel statistics, which are organized by sector. In reality, emissions of these gases depend on the fuel type used, combustion technology, operating conditions, control technology, and on maintenance and age of the equipment. However, since Georgia does not have such a detailed data, the Tier 1 methodology was used, it ignores these refinements. Table 2-23 provides estimates of non-CO_2 emissions from fuel combustion for 1990, 1994, 2000, 2005, and 2010-2015.

Table 2-23. Non-CO_2 Emissions In Energy Sector

Non-CO_2 From Fuel Combustion (Tier 1) Gg	1990	1994	2000	2005	2010	2011	2012	2013	2014	2015
CO	354	157	209	200	246	227	308	257	262	267
NOx	104	37	22	23	32	37	39	40	46	50
NMVOCs	60	25	30	33	41	38	47	41	42	44
SO2	38	13	15	8	13	13	23	17	17	15

In 2015, transport and other sectors contributed about 67% and 32% respectively in CO emissions. While transport sector (78%) was a key contributor in NOx emissions. 76% and 23% shares had transport and other sectors in NMVOC emissions in the same year. Manufacturing industry and other sectors had 35% and 57% shares respectively in SO_2 emission.

3 Industrial Processes and Product Use

3.1 Sector Overview

The Chapter 3 comprises description of methodologies used for estimating GHG emissions as well as information on references to Activity Data and Emission Factors reported under CRF Sector 2 –Industrial Processes for the period 1990 to 2015.

The GHG Emissions from this sector cover emissions from the following categories: Mineral Products (2A), Chemical Industry (2B), Metal Production (2C), Non-Energy Products from Fuels and Solvent Use (2D), Product Uses as Substitutes for ODS (2F) Other Product Manufacture and Use (2G) Other Industries such as paper, drinks and food production (2H) Table 3-1.

Table 3-1. Emissions from the Industrial Processes in Georgia in 1990-2015

Years	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**
Total CO_2 eq. Emissions from Mineral Productions (Gg)	572	357	211	110	45	32	48	42	84
Total CO_2 eq. Emissions from Chemical Productions (Gg)	672	646	440	391	252	321	406	356	307
Total CO2 eq. emissions from Metal Industry Emissions (Gg)	2635	2035	1053	276	116	94	81	106	111
Total CO_2 eq. emissions from Non-Energy Products from Fuel and Solvent Use (Gg)	0	0	0	0	0	0	0	0	0
total CO2 eq. emissions from Product Uses as Substitutes for ODS (Gg)	NO	NO	NO	NO	NO	NO	NO	NO	NO
Total CO2 eq. emissions from Other Product Manufacture and Use (Gg)	0	0	0	0	0	0	0	0	0
Total emissions CO2eq. (Gg)	**3879**	**3038**	**1705**	**776**	**414**	**447**	**535**	**504**	**502**
Years	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
Total CO2 eq. emissions from Mineral Productions (Gg)	138	143	146	161	161	188	226	332	521
Total CO2 eq. emissions from Chemical Productions (Gg)	510	536	221	369	424	466	522	582	577
Total CO2 eq. emissions from Metal Industry Emissions (Gg)	62	46	71	61	111	187	200	214	207
Total CO_2 eq. emissions from Non-Energy Products from Fuel and Solvent Use (Gg)	0	0	0	0	0	0	0	0	0
total CO2 eq. emissions from Product Uses as Substitutes for ODS (Gg)	NO	NO	0	1	3	5	9	9	9
Total CO2 eq. emissions from Other Product Manufacture and Use (Gg)	0	0	0	0	0	0	0	0	0
Total emissions CO2eq. (Gg)	**710**	**725**	**438**	**591**	**699**	**846**	**957**	**1136**	**1314**
Years	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	
Total CO2 eq. emissions from Mineral Productions (Gg)	585	328	413	625	625	639	752	759	
Total CO2 eq. emissions from Chemical Productions (Gg)	548	533	614	666	681	675	670	710	
Total CO2 eq. emissions from Metal Industry Emissions (Gg)	235	224	362	438	473	465	482	438	
Total CO_2 eq. emissions from Non-Energy Products from Fuel and Solvent Use (Gg)	0	0	0	0	0	9	10	11	
Total CO2 eq. emissions from Other Product Manufacture and Use (Gg)	0	0	0	0	0	0	0	0	
total CO2 eq. emissions from Product Uses as Substitutes for ODS (Gg)	14	21	54	64	93	105	121	140	
Total emissions CO2eq. (Gg)	**1383**	**1106**	**1443**	**1794**	**1872**	**1892**	**2035**	**2058**	

Only non-energy industrial activities related emissions are considered in this sector. Emissions due to fuel combustion in manufacturing industries are allocated to IPCC Sub-category 1A2 – Fuel Combustion Activities – Manufacturing Industries and Construction (see Chapter 2.7).

Furthermore, the chapter includes information on emissions of indirect GHGs such as non-methane volatile organic compounds (NMVOCs), carbon monoxide, nitrogen oxides.

3.2 Sub-sector: Mineral Products (2A)

The Sub-sector of the mineral products considers the direct GHG emissions from the Cement Production, Lime Production and Glass Production source-categories. The non-direct GHG emission additionally estimated for the source category of Asphalt Processing. The highest emissions from the sub-sector of mineral products estimated in 2015 about 759 Gg of CO_2 eq. mainly caused by performance improvement in clinker production. The emissions value at the end of estimation period was 25 per cent higher than the value estimated in 1990 (571 Gg of CO_2 eq.). Other picking years of emissions were in 2008 and 2011. The emissions have significantly declined after 1990 for next five years from the sub-sector. Although the production processes of all three processes have been reduced the steep depletion of the GHG emission is mainly related to the sharp decline of clinker production. The recovery of the construction markets for chemical industries has taken more than a decade. The transformation period has characterized with a few crises in economic development translated in to the lowest level of GHG emissions from the sub-sector. The collapse of socialism system has reduced production of construction goods more than twenty times. In 1995 the emissions dropped by 95 per cent comparing to the 1990 level and reached its lowest level for the whole time series period 32 Gg of CO_2 eq. The emissions have declined from 2008 to 2009 due to the economic crisis in the construction market in Georgia. The emissions have increased between 2009 and 2015 by approximately 57 per cent. The largest upturn was recorded in 2009-2011 from 328 Gg to 625 Gg of CO_2 eq. Afterwards, the emissions have steadily increased by 2 per cent. At the end of the period the emissions have increased again by 15 per cent comparing the value calculated for the year of 2013. The emissions trend is illustrated in the Figure 1 beneath.

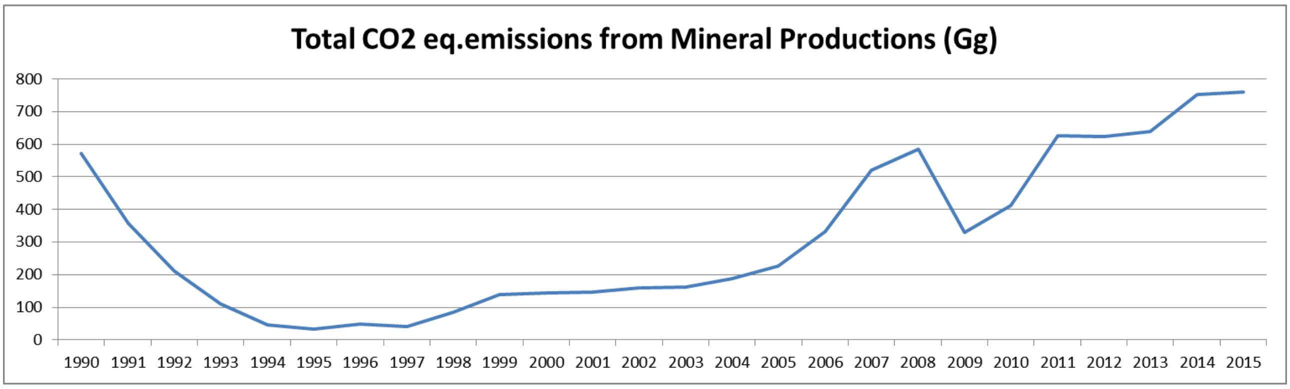

Figure 3-1 The Emissions from The Sub-Category of Mineral Production

3.2.1 Cement Production (2A1)

3.2.1.1 Description of Source-category and Calculated Emissions

The clinker in Georgia is produced by two different methods called dry and wet methods in three factories. The dry method is used in Rustavi Factory, while the wet method is used both in Rustavi and Kaspi factories.

In 2014 the emissions were about C Gg CO_2 the highest value for the whole time series. In 2015 the emissions slightly declined by 1.2 per cent[42] to C Gg CO_2. The emissions estimated for the year of 1990 were about 29 per cent lower than in 2014. Following five years the emissions trend was down warding and it reached the level of C Gg CO_2 (depletion by 95 per cent). During the two decades from the restitution of independence of Georgia the other low production level has been performed due to the economic crisis. In 2009 the emissions have dropped by 48 per cent comparing to the 2008 level and 43 per cent comparing to the 1990 level mainly caused by the economic crisis in the international market. The emissions from C Gg CO_2 (in 2009) have increased up to C (in 2015) by 146 per cent.

The calculated CO_2 emissions for the whole time-series 1990-2015 are given in Annex.

2A1 - Cement Production is a key source-category with regard to CO_2 emissions. It has been a key source without interruption since 1990 (Table 3-2).

The calculated CO_2 emissions from the clinker productions are presented in Table 3-2 beneath.

Table 3-2. CO_2 Emissions from Clinker Production (Gg) in 1990, 1994, 2000, 2005, 2010-2015

	Module	**Industrial Processes**			
	Submodule	**Cement Production**			
	Method	**Tier 2 CO_2 Emissions**			
Step 1					
Year	**A Quantity of Clinker or Cement Produced (t)**	**B Emission Factor (t CO_2/t clinker or cement produced)**	**C CKD Correction Factor**	**D CO_2 Emitted (t)**	**E CO_2 Emitted (Gg)**
				D=(A*B*C)	E=D/10^3
1990	C	0.51025	1.02	C	C
1994	C	0.51025	1.02	C	C
2000	C	0.51025	1.02	C	C
2005	C	0.51025	1.02	C	C
2010	C	0.51025	1.02	C	C
2011	C	0.51025	1.02	C	C
2012	C	0.51025	1.02	C	C
2013	C	0.51025	1.02	C	C
2014	C	0.51025	1.02	C	C
2015	C	0.51025	1.02	C	C

The calculated emissions of Sulfur dioxide from the cement production are shown in the Table 3-3 beneath.

Table 3-3. SO_2 Emissions (Gg) from Cement and Clinker Production in 1990, 1994, 2000, 2005, 2010, 2014-2015

	Module	**Industrial Processes**		
	Submodule	**Cement Production**		
	Sheet	**2 of 2 SO_2 Emissions**		
Step 2				
Year	**A Quantity of Cement Produced (Gg)**	**B Emission Factor (t SO_2 /Gg cement produced)**	**D SO_2 Emitted (t)**	**E SO_2 Emitted (Gg)**
			C=(A*B)	D=C/10^3
1990	1290.0	0.3	387	0.39

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[42] The value was calculated based on the date expressed in thousandths

Module	**Industrial Processes**			
Submodule	**Cement Production**			
Sheet	**2 of 2 SO_2 Emissions**			
Step 2				
Year	**A** **Quantity of Cement Produced (Gg)**	**B** **Emission Factor (t SO_2 /Gg cement produced)**	**D** **SO_2 Emitted (t)**	**E** **SO_2 Emitted (Gg)**
1994	88.7	0.3	27	0.03
2000	347.7	0.3	104	0.10
2005	529.5	0.3	159	0.16
2010	907	0.3	272	0.27
2014	1618.7	0.3	486	0.49
2015	1758.6	0.3	528	0.53

3.2.2 Methodology

3.2.2.1 Method Used

CO_2 emissions from cement production are estimated using the IPCC 2006 Tier 2 approach. In accordance with the Tier 2 method the estimation of CO_2 emissions is able to be calculated from the clinker production:

CO_2 Emissions = $EF_{clinker}$ ● Clinker Production ● CKD Correction Factor

Where:

The Cement Kiln Dust Correction Factor equals to 1.02.

The emission factor calculation is represented beneath:

$EF_{clinker}$ = 0.785 ● 0.65* = 0.51025

** The default value of the CaO content for clinker*

b) Activity Data

In Georgia, three clinker production plans operate (two plans in Rustavi City and One in Kaspi City). During the production of clinker, limestons, which is mainly calcium carbonate ($CaCO_3$), is calcined to produce lime (CaO) and CO_2 as a by-product.

Activity Data – figures of clinker production is obtained from the Factories. All three factories belong to the one company. Accordingly, the production data is confidential. (Table 3-4).

Table 3-4. The Activity Data of Clinker Production

Clinker Production	
Year	**Activity Data (t)**
1990	C
1994	C
2000	C
2005	C
2010	C
2011	C
2012	C
2013	C
2014	C
2015	C

3.2.2.2 Emission Factors

According to the IPCC 2006 emission factor is calculated as follows: EF = CaO fraction × 0.785 (molecular weight ratio of CO_2 / CaO = 44.01 / 56.08). The default value of the CaO content in clinker is equal to 65%. Accordingly, EF = 0.65 × 0.785 = 0.51025 t CO_2 /t clinker. For clinker EF = 0.51 CO_2 ton / ton of produced clinker.[43]

In this sub-sector sulfur dioxide (SO_2) emissions also are calculated, its emission rate according to IPCC 1996 is 0.3 kg of SO_2 / ton of product.

Georgia is going to advance these assumptions by addressing its national circumstances and provide relevant information in its forthcoming submissions in accordance with the study of the source-category under the project Georgia's Integrated Transparency Framework for Implementation of Paris Agreement.

3.2.3 Lime Production (2A2)

3.2.3.1 Description of Source-category and Calculated Emissions

In 2014 the emissions were about 31 Gg CO_2 the lowest value for the last three years. In 2015 the emissions increased by 32.8 per cent[44] to 46 Gg CO_2. The highest emissions from the Lime Production in Georgia were performed in 2011 46 Gg of CO_2 during the whole time series from 1990 to 2015. The emissions estimated for the year of 1990 were about (37 Gg CO_2) 21 per cent lower than in 2011. Following four years the emissions trend was down warding and it reached the level of 1.3 Gg CO_2 (depletion by 63 per cent). During the two decades from the restitution of independence of Georgia the other low production level has been performed due to the economic crisis. In 1997 the emissions dropped by 148 times comparing to the 1996 level mainly caused by the economic crisis in the country. In 2004 the emissions dropped by 55 per cent comparing to the previous year estimation resulted by the economic changes in the country. In 2008 the increase of Lime production has terminated due to the war, accordingly the emissions slightly declined by 14 per cent (17 Gg CO_2) comparing to the 2007 level. The international market crisis has not affected significantly to the Lime Production sector, since the produced goods are mostly used domestically. In 2009 the emissions reached 40 Gg CO_2. The increase of CO_2 emissions is 57 per cent higher than in 2008.

The calculated CO_2 emissions for the whole time-series 1990-2015 are given in Annex.

The calculated carbon dioxide emissions from lime production in Georgia are presented in the Table 3.5 beneath.

Table 3-5. CO_2 Emissions from Lime Production from 1990,1994,2000,2005,2010, 2014-2015

Module	**Industrial Processes**					
Submodule	**Production of Lime**					
Method	**Tier2 of CO_2 Emissions**					
Step 1						
Year	**A** **Quantity of Lime Produced (t)**	**B** **Emission Factor (t CO_2/t Quicklime produced)**	**C** **LKD**	**D** **Water correction factor**	**E** **CO_2 Emitted (t)**	**F** **CO_2 Emitted (Gg)**
					D=(A*B*C)	E=D/10^3
1990	36.6573	0.75	1.02	0.97[45]	36 657.27	36.66

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[43] 2006 IPCC Guidelines for National Greenhouse Gas Inventories. http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html

[44] The value was calculated based on the date expressed in thousandths

[45] In case of factory specific data the water correction factor equals to 0.986

1994	1.3357	0.75	1.02	0.97	1 335.69	1.34
2000	2.3003	0.75	1.02	0.97	2 300.36	2.3
2005	12.1696	0.75	1.02	0.97	12 169.62	12.17
2010	32.2514	0.75	1.02	0.97	32 251.43	32.25
2011	61 700	0.75	1.02	0.97	46 128.30	46,13
2012	39 000	0.75	1.02	0.97	29 314.02	29,31
2013	44 400	0.75	1.02	0.97	33 328.44	33,33
2014	30.8312	0.75	1.02	0.97	30 831.23	30.83
2015	45.8574	0.75	1.02	0.97	45 857.35	45.86

2A2 – Lime Production is a key source-category with regard to CO_2 emissions (see chapter 1.3).

3.2.4 Methodology

3.2.4.1 Method Used

In accordance with the GPG 2000 the CO_2 emissions from the Lime production is calculated by the following equitation.

CO_2 Emissions = Emission Factor (EF) ● Lime Production ● Water Correction Factor

Where:

Emission factor equals to 0.75

Default water correction factor is 0.97;

Factory specific correction factor is 0.986.

3.2.4.2 Activity Data

A major producer of lime in Georgia is JSC "Heidelberg Cement." It owns approximately 72% of the lime production in Georgia. In Georgia lime is also produced by several small enterprises, such as small plants in Kutaisi, Surami, Dzirula, Ozurgeti, and Zugdidi. All of them mainly use limestons as raw material. There is no accurate statistics on data of used raw materials. According to data supplied by the manufacturer[46] to get 1 ton of lime it needs approximately 1.75 tons of raw materials. Production technology is mostly based on the wet method.

3.2.4.3 Emission Factors

In theory, assuming that calcination of the raw material is 100%, the emission factor for lime is equal to 785 kg of CO_2 per a ton of lime. Furthermore, since the wet production technology is used to produce the largest amount of lime in Georgia the default hydrated lime correction factor 0.97 were used in calculations.

Georgia is going to advance these assumptions by addressing its national circumstances and provide relevant information in its forthcoming submissions in accordance with the study of the source-category under the project Georgia's Integrated Transparency Framework for Implementation of Paris Agreement.

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3.2.5 Limestones and Dolomite Use (2A3)

3.2.5.1 Description of Source-category and Calculated Emissions

The source-category of Limestones and Dolomite Use covers emissions related to the limestones use in metal production in accordance with IPCC 2000 GPG. The other emissions from the use of limestones and dolomite are accounted for in IPCC sub-categories 2A1 – Cement Production and 2A7 – Other – Glass Production.

3.2.6 Source-Category: Soda Production (2A4)

This source category does not exist in Georgia.

3.2.6.1 Production of Other Mineral Products: Glass Production (2A5)

Description of Source-category and Calculated Emissions

This subcategory is considering those productions, whose technology is related to carbonate thermal processing. One of it used in the glass production. The CO_2 emissions from the glass production are included in this category.

The emissions from the source-category of Glass Production are significantly low in Georgia. In 2014 the emissions were about C Gg CO_2. In 2015 the emissions increased by 9.7 per cent[47] to C Gg CO_2. The highest emissions from the Glass in Georgia were performed in 1990 C Gg of CO_2 during the whole time series from 1990 to 2015. Following four years the emissions trend was down warding and it reached the level of C Gg CO_2 (depletion by 88 per cent). The lowest level of emission was estimated in 2009 about C Gg CO_2 due to the war. Afterwards the emitted amount of CO_2 has increased steadily and the end of the estimation period it was 73 per cent higher than in the year of 2009.

The calculated CO_2 emissions for the whole time-series 1990-2015 are given in Annex.

The calculated quantities of emitted NMVOCs and CO_2 from glass production of Georgia are presented in Table 3-6, and Table 3-7.

Table 3-6. CO_2 Emissions from Glass Production

Module		Industrial Process			
Submodule		Production and use of different mineral resources			
Sheet		CO_2 *–emission from glass production*			
Year	A Glass production (t)	B EF of Glass Production (t CO_2/t glass)	C Cullet (ratio)	D CO_2 Emission (t)	E CO_2 Emission (Gg)
				D=A.B.(1-C)	E=D/10^3
1990	C	0.21	0.65	C	C
1994	C	0.21	0.65	C	C
2000	C	0.21	0.65	C	C
2005	C	0.21	0.65	C	C
2010	C	0.21	0.7	C	C
2011	C	0.21	0.65	C	C
2012	C	0.21	0.7	C	C

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[47] The value was calculated based on the date expressed in thousandths

Module		Industrial Process			
Submodule		Production and use of different mineral resources			
Sheet		CO_2 *–emission from glass production*			
2013	C	0.21	0.65	C	C
2014	C	0.21	0.65	C	C
2015	C	0.21	0.65	C	C

Table 3-7. NMVOCs Emissions from Glass Production in 2010-2013

Glass production		**Emission factor (t NMVOCs /Gg glass)**	**NMVOCs emissions (t)**	**NMVOCs emissions (Gg)**
Year	Gg		C = (AxB)	$D=C/10^3$
1990	C	4.5	C	C
1994	C	4.5	C	C
2000	C	4.5	C	C
2005	C	4.5	C	C
2010	C	4.5	C	C
2014	C	4.5	C	C
2015	C	4.5	C	C

3.2.7 Methodology

3.2.7.1 Method Used

The IPCC 1996 methodology was used, according to which, only NMVOCs emissions from this sub-sector will be considered. From 2006 the IPCC methodology includes the CO_2 emission as well. For the calculation three levels are used. Based on the Tier 1 approach CO_2 emissions are calculated by the following formula:

$$E_{CO_2} = M \bullet EF \bullet (1\text{-}CR)$$

Where:

E_{CO_2} - Emitted carbon dioxide quantity, Gg;

EF - Emission factor, ton of CO_2 / ton of glass;

CR - Blamed on the initial charge of broken glass, fractional.

Estimation of NMVOCs emission is done by multiplying emission factor (tons of NMVOCs emitted from glass production) by the number of tons of glass produced during the year.

3.2.7.2 Activity Data

In Georgia the glass production is run by JSC “Mina” - Ksani glass factory, located in Mtskheta region, in Ksani. Currently the plant is using 4 recipes of blend for green, antique green, blue and light green glass bottle making. Ksani glass factory began work in 1987 with 3 furnace and 8 production lines and its annual capacity was 40 thousand tons. In 1992-97 due to the ongoing processes in the country the plant's capacity was reduced to a single oven. In 1997, the Turkish industrial holding "Shishejam" has bought the plant’s control package of shares and the plant’s capacity increased up to 18 thousand tons. At the end of 2002 the second furnace was launched with 2 production lines and the plant’s capacity became 48 thousand tons / year. In 2008, the first furnace has stopped working due to the lapse of the operational life. Now the second furnace is operating there and the plant capacity is 35 thousand tons / year.

The Activity Data and the cullet content data has provided by the Ksani Glass Factory for the years of 2003 -2015.

Table 3-8. The Activity Data of Glass Production

Glass Production	
Year	**Activity Data (t)**
2005	C
2010	C
2011	C
2012	C
2013	C
2014	C
2015	C

3.2.7.3 Emission Factors

NMVOCs emission is determined by the weight of melted glass mass. At the plant a similar blend composition is mainly used and the glass is produced with the same technology. The IPCC 1996 Methodology proposes emission coefficient 4.5 kg of NMVOCs / ton of produced glass.

The IPCC 2006 methodology has presented CO_2 emission factor - 0.21 ton of CO_2 / a ton of glass, which is exactly the same as the CO_2 emission coefficient calculated on the basis of chemical composition of glass blend that is used at Ksani plant (a ton of raw materials gives 0.85 ton of glass and the mass loss is about 17.85%, so the emission coefficient is 0.17 / 0.85 = 0.21 ton of CO_2 / a ton of produced glass).

3.2.8 Other Process Uses of Carbonates (2A6)

The ceramic production occurs in Georgia from this source category, which is characterized as carbon free process in accordance to the laboratory analysis provided by the plant.

3.3 Sub-sector: Chemical Industry (2B)

The Sub-sector Chemical Industry considers emissions from the Ammonia Production and Nitric Acid Production source-categories. The highest emissions from the sub-sector of chemical industry estimated in 2015 about 709 Gg of CO_2 eq. mainly caused by performance improvement in both production lines. The emissions value at the end of estimation period was 4.65 per cent higher than the value estimated in 1990 (672 Gg of CO_2 eq.). Other picking years of emissions were in 1996, 2000 and 2007. The emissions have significantly declined after 1990 for next four years from the sub-sector. Although the production processes of both chemicals have been reduced the steep depletion of the GHG emission is mainly related to the sharp cut of ammonia customers. Finding new markets for chemical industries have taken more than a decade. The transformation period has characterized with a few crises in economic development translated in to the lowest level of GHG emissions from the sub-sector. The collapse of socialism system has reduced production of chemical goods more than twice. In 1994 the emissions dropped by 62 per cent comparing to the 1990 level. In 2001 the emissions reached its lowest level for the whole time series period 221 Gg of CO_2 eq. (only 33 per cent of 1990 level). The emissions have declined from 2008 to 2010 due to the economic crisis in the industry market. The emissions have increased between 2010 and 2015 by approximately by 15 per cent. The largest upturn was recorded in 2011 from 613 Gg to 665 Gg of CO_2 eq. Afterwards, the emissions have slightly declined by 1.6 per cent due to the reduction of producing of nitric acid. At the end of the period the emissions have increased again by 6 per cent comparing the value calculated for the year of 2014. The emissions trend is illustrated in the Figure 3-2 beneath.

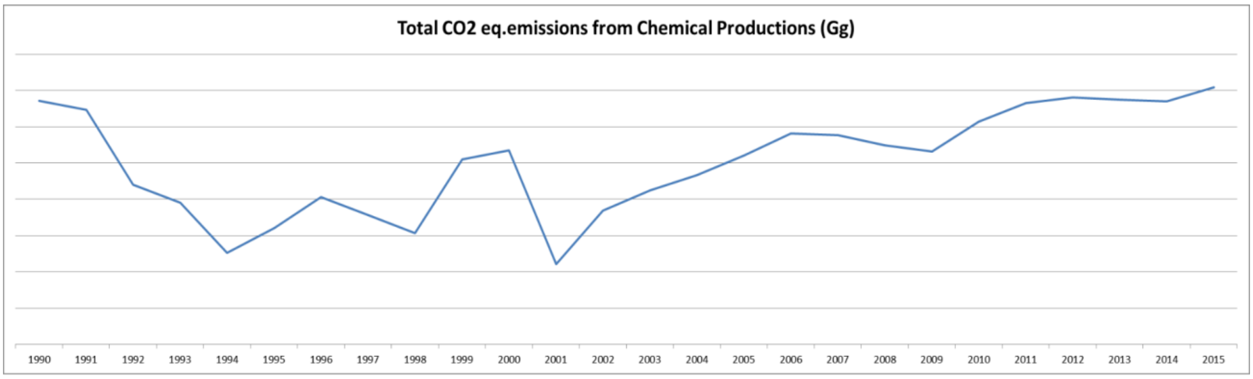

Figure 3-2 The emissions trend for Chemical Industry

3.3.1 Source-Category Ammonia Production (2B1)

3.3.1.1 Description of Source-category and Calculated Emissions

Most of the ammonia in Georgia is produced by the Haber-Bosch process called a synthesis of ammonia: nitrogen and hydrogen enter into a reaction. The required hydrogen is a product of natural gas conversion. Ammonia is obtained at 25-29 MPa pressure and 470-550° C temperature from nitrogen and hydrogen mixture with iron catalyst in place.

The carbon dioxide from the production of ammonia has been used for obtaining the dry ice. By taking into account the fact that the carbon dioxide very soon turns into the atmosphere after applying the dry ice, the intermediate retention of CO_2 in products and production processes will not be considered.

In 2015 the emissions were about C Gg CO_2 the highest value after 1991. In 2014 the emissions slightly declined by 0.87 per cent[48] from C Gg CO_2 to C Gg CO_2. The highest emissions estimated for the year of 1990 about C Gg CO_2. Following four years the emissions trend was down warding and it reached the level of C Gg CO_2 (depletion by 60.38 per cent). During the first decade from the restitution of independence of Georgia two other lowest production levels have been performed due to the economic crisis. In 1998 the emissions have dropped by 56 per cent

comparing to the 1990 level and in 2001 the emission level reduced by 69 per cent comparing to the 1990 emission estimation. The emissions have been declined by 12 per cent[49] after 2007 for two years mainly caused by the economic crisis in the international market. The emissions from C Gg CO_2 (in 2009) have increased up to C (in 2015) by 33 per cent.

The calculated CO_2 emissions for the whole time-series 1990-2015 are given in Annex.

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[48] The value was calculated based on the date expressed in thousandths

[49] The comparision of the emission levels between the years of 2007 and 2009.

Table 3-9. CO_2 Emissions from the Ammonia Production Calculated on The Basis of Products Quantity in 1990, 1994, 2000, 2005, 2010-2015

	Module	**Industrial Processes**			
	Submodule	**AMMONIA PRODUCTION**			
	Method	**TIER 2 - CO_2 EMISSIONS**			
			Step 1		
Year	**A** **Total natural gas requirement (Gj)**	**B** **Carbon content factor of the natural gas (kg C/GJ)**	**C** **carbon oxidation factor of the natural gas (fraction)**	**D** **CO2 recovered for downstream use (kg)**	**E** **CO2 Emitted (Gg)**
					$E=((A*B*C*44/12)-D)/10^6$
1990	C	15.3	1[50]	0	C
1994	C	15.3	1[51]	0	C
2000	C	15.3	0.9916	0	C
2005	C	15.3	0.9956	0	C
2010	C	15.3	0.9837	0	C
2011	C	15.3	0,9842	0	C
2012	C	15.3	0,9970	0	C
2013	C	15.3	0,9903	0	C
2014	C	15.3	0.9774	0	C
2015	C	15.3	0.9866	0	C

In Table 3-10 NMVOCs, CO and SO_2 emissions from ammonia production calculated for 2010-2011 are given.

Table 3-10. NMVOCs, CO and SO_2 emissions from ammonia production in 1990, 1994, 2000, 2005, 2010-2015

	Module	**Industrial Processes**		
	Submodule	**Ammonia production**		
	Sheet	**3 OF 3 TIER 1b - NMVOC, CO, SO_2 EMISSIONS**		
		Step 3		
Year	**A** **Quantity of Ammonia Produced (t)**	**B** **Emission Factor (Kg pollutant/t Ammonia produced)**	**C** **NMVOC Emitted (kg)**	**D** **NMVOC Emitted (Gg)**
			C=(A*B)	D=C/10^6
1990	C	4.7	C	C
1994	C	4.7	C	C
2000	C	4.7	C	C
2005	C	4.7	C	C
2010	C	4.7	C	C
2014	C	4.7	C	C
2015	C	4.7	C	C
			CO Emitted	CO Emitted
1990	C	7.9	C	C

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[50] The default data is used due to the absence of the factory specific data.

[51] The default data is used due to the absence of the factory specific data.

	Module	**Industrial Processes**		
	Submodule	**Ammonia production**		
	Sheet	**3 OF 3 TIER 1b - NMVOC, CO, SO_2 EMISSIONS**		
		Step 3		
Year	**A** **Quantity of Ammonia Produced (t)**	**B** **Emission Factor (Kg pollutant/t Ammonia produced)**	**C** **NMVOC Emitted (kg)**	**D** **NMVOC Emitted (Gg)**
1994	C	7.9	C	C
2000	C	7.9	C	C
2005	C	7.9	C	C
2010	C	7.9	C	C
2014	C	7.9	C	C
2015	C	7.9	C	C
			SO_2 Emitted	SO_2 Emitted
1990	C	0.03	C	C
1994	C	0.03	C	C
2000	C	0.03	C	C
2005	C	0.03	C	C
2010	C	0.03	C	C
2014	C	0.03	C	C
2015	C	0.03	C	C

3.3.2 Methodology

3.3.2.1 Method Used

The Tier 2 of the IPCC 2006 guideline was used for the calculation of the emissions from the Ammonia Production source-category. The approach is based on the factory specific data from ammonia production process.

3.3.2.2 Activity Data

Natural gas consumption data is obtained from Ammonia producing plant in Rustavi "Azoti." The performance of ammonia production factory in 1990-2015 is given in Table 3-11.

Table 3-11. Ammonia Production Data for 1990, 1995, 2000, 2005, 2010-2015

Natural Gas in Ammonia Production	
Year	**Activity Data (m^3)**
1990	C
1994	C
2000	C
2005	C
2010	C
2011	C
2012	C
2013	C
2014	C
2015	C

3.3.2.3 Emission Factors

The carbon content factor of recommended by the IPCC 2006 is 15.3 kg of carbon per Gj of used natural gas. The carbon oxidation factor of natural gas has been provided by the Plant for the years of 1996, 1998-2015. The default value[52] has been taken for other years as recommended by the IPCC 2006. From ammonia production in the atmosphere also are emitted NOx, NMVOCs, CO and SO_2. Their emissions are calculated by using default Emission Factors proposed in the IPCC 1996 methodology. Used emission coefficients of trace admixtures are given in Table 3-12.

Table 3-12. Emission Coefficients of Trace Admixtures Emitted from Ammonia Production[53] (kg of gas / ton of ammonia)

Gases Emitted	NMVOCs	CO	SO_2
EFEF	4.7	7.9	0.03

3.3.3 Source-Category Nitric Acid Production (2B2)

3.3.3.1 Description of Source-category and Calculated Emissions

Nitric acid (HNO_3) is produced as a result of catalytic oxidation of ammonia with an oxygen of air at high temperature. During this process nitrous oxide (N_2O) and nitrogen oxides (NOx-s) are produced as indirect products. The indirect gases absorbed by the vapour condensate.[54] The quantity of emitted gases is proportional to the quantity of used ammonia. Their concentration in exhaust gases depends on a type of plant's technology and a level of emissions control.

In 2014 the emissions were about C Gg CO_2 one of the high values for the last five years. The highest emission from the Nitric Acid Production in Georgia was estimated for the year of 2015 5 per cent[55] larger than previous year (C Gg CO_2) during the whole time series from 1990 to 2015. The emissions estimated for the year of 1990 were about (C Gg CO_2) 43 per cent lower than in 2015. From the year of 1991 following three years the emissions trend was down warding and it reached the level of C Gg CO_2 (depletion by 70 per cent). During the two decades from the restitution of independence of Georgia the other low production level performed in 2001 the emissions dropped by 2.5 times comparing to the 2000 level mainly caused by the economic instability in the country. In 2010 the increase of the emissions from the Nitric Acid production was about 14 per cent comparing to the 2009 level. After this significant effect of emissions enlargement from the factory performance the emissions up-ward trend was continued steadily and comparing to the level of 2010 the emissions in 2015 was 14 per cent higher.

Taking into account the available statistical data and listed above assumptions the calculated nitrogen oxide emissions are given in Table 3-13.

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[52] 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 3, Chapter 3: Chemical Industry Emissions, p.3.15, Table 3.1)

[53] http://www.ipcc-nggip.iges.or.jp/public/gl/invs5b.html (page 2.14, Table 2.4)

[54] Factory technology description paper.

[55] The value was calculated based on the date expressed in thousandths

Table 3-13. Nitrogen Oxides Emissions from Nitric Acid Production in 1990, 1995, 2000, 2005, 2010, 2014-2015

Module	**Industrial Processes**				
Submodule	**Nitric Acid Production**				
Method	**Tier 2 - N_2O AND Tier 1 - NOx EMISSIONS**				
Step 1					
Year	**A** **Quantity of Nitric Acid Produced (t)**	**B** **Emission Factor (kg N_2O/t Nitric Acid produced)**	**C** **N_2O Emitted (Kg)**	**D** **N_2O Emitted (Gg)**	**E** **CO_2 eq. Emitted (Gg)**
			C=(A*B)	D=C/10^6	E=D*296
1990	C	2	C	C	C
1994	C	2	C	C	C
2000	C	2	C	C	C
2005	C	2	C	C	C
2010	C	2	C	C	C
2011	C	2	C	C	C
2012	C	2	C	C	C
2013	C	2	C	C	C
2014	C	2	C	C	C
2015	C	2	C	C	C
			NO_x	NO_x	
1990	C	12	C	C	
1995	C	12	C	C	
2000	C	12	C	C	
2005	C	12	C	C	
2010	C	12	C	C	
2014	C	12	C	C	
2015	C	12	C	C	

2B2 – Nitric Acid Production is a key source-category with regard to CO2 eq. emissions (see chapter 1.3).

3.3.4 Methodology

3.3.4.1 Method Used

The tier 1 methodology is used for calculation of emissions from the source-category of nitric acid production, since the Activity Data covers the amount of nitric acid produced per annum, in accordance with the IPCC 2006 guideline.

3.3.4.2 Activity Data

The source of Nitric acid production data is nitric acid production - Rustavi synthetic fertilizer's plant. The so-called weak nitric acid is produced by catalytic oxidation of ammonia with oxygen from the air, followed by the absorption of oxides generated with water vapor at medium pressure.

3.3.4.3 Emission Factors

According to the IPCC 2006[56] for factories with Non-Selective Catalytic Reduction (NSCR) technology the emission coefficient for nitrous oxide (N_2O) is equal to 2 kg of N_2O / ton of HNO_3. The estimation presented in First BUR considered emission factor of 6.75 kg of N_2O / ton of HNO_3 calculated an average of medium pressure production default Emission Factors. The change of emission factor is caused by the technology line description provided by the factory. The Rustavi synthetic fertilizer's plant uses the NSCR technology for abatement of the nitrogen oxides (NO_x). The N_2O is further removed in this catalyst bed.

3.3.5 Source-Category Adipic Acid Production (2B3)

This source category does not exist in Georgia.

3.3.6 Source-Category Caprolactam, Glyoxal and Glyoxylicacid Production (2B4)

This source category does not exist in Georgia.

3.3.7 Source-Category Carbide Production (2B5)

This source category does not exist in Georgia.

3.3.8 Source-Category Titanium Dioxide Production (2B6)

This source category does not exist in Georgia.

3.3.9 Source-Category Soda Ash Production (2B7)

This source category does not exist in Georgia.

3.3.10 Source-Category Petrochemical and Carbon Black Production (2B8)

This source category does not exist in Georgia.

3.3.11 Source-Category Fluorochemical Production (2B9)

This source category does not exist in Georgia.

3.4 Sub-sector: Metal Production (2C)

The sub-sector of Metal Production covers steel and ferroalloys processing in Georgia. The emissions from the ferroalloys production are about 26 times higher than the emissions from the steel production. The significant difference among the source-categories in produced emissions mostly relates to the technology used in steel production. In Georgia, the steel manufacturing use Electric Arc Furnace characterized as low emitter. In contradiction of this, the steel production was the biGgest contributor of GHG emissions in 90's. Accordingly, since 2000 the emission trend for the Metal Production sub-sector mostly maintained by the ferroalloys production source-category, while the steel production was leading beforehand. The trend is illustrated in the Figure 3-3 beneath.

The highest emissions from the sub-sector of metal production estimated in 1990 about 2635 Gg of CO_2 eq. mainly caused by performance improvement in both production lines. The emissions value at the end of estimation period was 83 per cent lower than the value estimated in 1990. The emissions have significantly declined after 1990 for next four years from the sub-sector. Although the production processes of both types of metal industry have been reduced the steep depletion of the GHG emission is

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[56] http://www.ipcc-nggip.iges.or.jp/public/gl/invs5b.html (page 2.16, Table 2.5 and 2.6)

mainly related to the termination of the sinter and cast-iron productions. The transformation period has characterized with a crisis in economic development translated in to the lowest level of GHG emissions from the sub-sector for the period between 1996 and 2003. The collapse of socialism system has reduced production of steel goods more than nineteen times. In 1996 the emissions dropped by 97 per cent comparing to the 1990 level. In 2000 the emissions reached its lowest level for the whole time series period 46 Gg of CO_2 eq. (only 1.7 per cent of 1990 level). The emissions have increased between 2002 and 2006 by approximately by 72 per cent. The largest upturn was recorded in 2009-2012 from 224 Gg to 473 Gg of CO_2 eq. At the end of the period the emissions have slightly declined by 9 per cent comparing the value calculated for the year of 2014. The emissions trend is illustrated in the Figure 3-3 beneath.

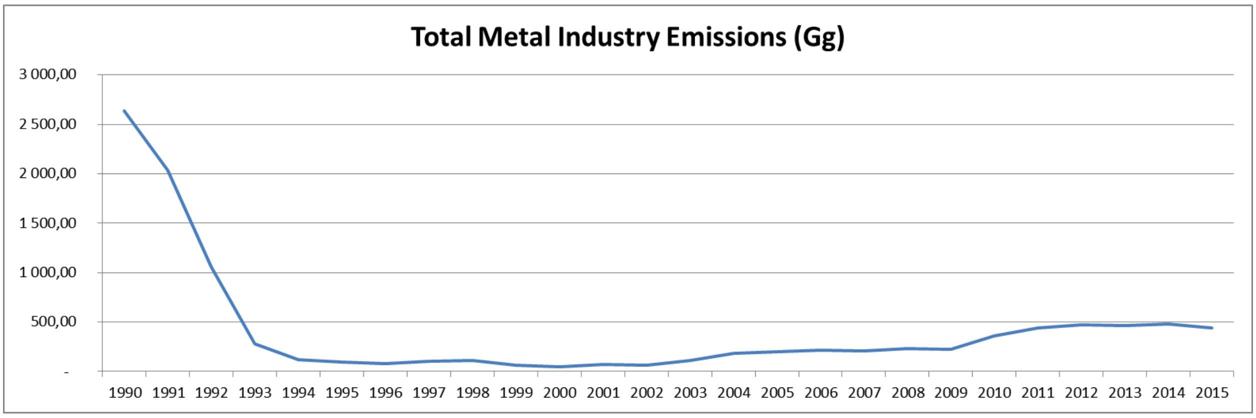

Figure 3-3 The Emissions Trend from the Metal Production In 2010-2013

3.4.1 Source-Category Cast Iron and Steel Production (2C1)

3.4.1.1 Description of Source-category and Calculated Emissions

Currently, the Steel production is performed by two major factories in LTD Georgia Rustavi Steel and Geosteel through the use of Electric Arc Furnace. In the recent past the steel was produced by the only metallurgical factory in Georgia LTD Georgia Rustavi Steel. In 1990 the several technological lines were functioning in the factory, particularly it had a sinter production, pig iron production and steel production via marten kiln lines. In 1993 the pig iron production was terminated. The sinter production was quitted in the following year. The use of marten kilns was terminated in 1999. The factory has produced steel material through the melting the cast iron between 2000 and 2010 which is not characterized with the industrial GHG emissions.

From 2010 the steel production through the EAF was launched by Geosteel and two years later the Rustavi Steel joined it. The last few years of the trend have characterized with the significantly low emission comparing to the emission related to the years of 1990-1992.

In 2015 the emissions were about 33 Gg CO_2 the highest value for the last six years. It has been increased by 86 per cent[57] comparing to the value of 2010 years. The emission has an upwarding trend between 2010 and 2015 period. The highest emissions from the Cast Iron and Steel production in Georgia were estimated in 1990 2492 Gg of CO_2 during the whole time series from 1990 to 2015. Following nine years the emissions trend was down warding and it reached the level of 0 Gg CO_2 in 2000. The emission in 2015 was 75 times lower than it used to be in 1990.

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[57] The value was calculated based on the date expressed in thousandths

The calculated amount of emitted CO_2 and CH_4 in 1990-2015 during production of sinter, pig iron and steel are given in Table 3-14 beneath.

Table3-14. CO_2 Emissions from the Steel Production in 1990, 1994, 200, 2005, 2010, 2014-2015

Module	**Industrial Processes**							
Submodule	**SINTER PRODUCTION**							
Sheet	**TIER 2 - CO2 EMISSIONS**							
Step 1								
Year	**A Amount of Coke Consumed (t)**	**B Coke C content**	**C Natural Gas Consumed (m^3)**	**D C content in Natural gas (kg/GJ)**	**E Limestons (t)**	**F C content in Limestons**	**G CO_2 Emitted (t)**	**H CO_2 Emitted (Gg)**
							G=A*B+D/1000 +E*F	E=D/10^3
1990	C	0.825	C	C	C	0.5	C	C
1994	C	0.825	C	C	C	0.5	C	C

Module	**Industrial Processes**				
Submodule	**SINTER PRODUCTION**				
Sheet	**TIER 1 – CH4 EMISSIONS**				
Step 1					
Year	**A Amount of Sinter Produced (t)**	**B EF (CH_4 kg/t Sinter)**	**C CH_4 Emissions (t)**	**D CH_4 Emissions (Gg)**	**E CO_2 eq. Emissions (Gg)**
			C=A*B/1000	D=C/1000	E=D*21
1990	C	0.07	C	C	C
1994	C	0.07	C	C	C

Module	**Industrial Processes**				
Submodule	**STEEL PRODUCTION**				
Sheet	**TIER 2 - CO_2 EMISSIONS**				
Step 1					
Year	**A Amount of input materials (t)**	**B Amount of Steel Produced (t)**	**C C Content**	**D CO_2 Emitted (t)**	**E CO_2 Emitted (Gg)**
				G=A*B+D/1000+E*F	E=D/10^3
1990	C	C	0.0029	C	C
1994	C	C	0.0029	C	C
2000	C	C	0.0029	C	C
2005	C	C	0.0029	C	C
2010	C	C	0.0029	C	C
2011	C	C	0.0029	C	C
2012	C	C	0.0029	C	C
2013	C	C	0.0029	C	C
2014	C	C	0.0029	C	C
2015	C	C	0.0029	C	C

The emissions of trace admixtures are presented in Table 3-15 beneath.

Table 3-15. Trace admixtures' emissions from the steel production 1990-2015

Steel production		**EF (g gas / t steel)**		**Emissions (g)**	**Emissions (Gg)**
Year	Tons			C = (AxB)	D = C/10^9
1990	C	NOx	40	C	C
		NMVOCs	30	C	C
		CO	1	C	C
		SO_2	45	C	C
1994	C	NOx	40	C	C
		NMVOCs	30	C	C
		CO	1	C	C
		SO_2	45	C	C
2000	C	NOx	40	C	C
		NMVOCs	30	C	C
		CO	1	C	C
		SO_2	45	C	C
2005	C	NOx	40	C	C
		NMVOCs	30	C	C
		CO	1	C	C
		SO_2	45	C	C
2010	C	NOx	40	C	C
		NMVOCs	30	C	C
		CO	1	C	C
		SO_2	45	C	C
2014	C	NOx	40	C	C
		NMVOCs	30	C	C
		CO	1	C	C
		SO_2	45	C	C
2015	C	NOx	40	C	C
		NMVOCs	30	C	C
		CO	1	C	C
		SO_2	45	C	C

2C1 – Metal Production is a key source-category with regard to CO2 emissions (see chapter 1.3).

3.4.1.2 Method Used

The tier 2 method from IPCC 2006 guideline was used for calculation of CO_2 emissions from the sinter and steel production. In Georgia the steel manufacturing process uses sinter production technology, Marten oven and electric arc furnace EAF. Subsequently, the tier 2 approach provides following formula for calculations of emissions:

For sinter production:

E_{CO2} = [Mass of Coke Consumed * C + Quantity of Natural Gas Consumed] * 44/12

For steel production:

E_{CO2} = [Mass of Coke Consumed * C_{PC} + Mass of heavy oil Consumed * C + Mass of Limestons Consumed * C_L + Mass of Dolomite Consumed * C_D + Mass of Carbon Electrodes Consumed * C_{CE} + Mass of Sinter Consumed * C + Quantity of Coke Oven Gas Consumed * C_{COG} - Steel Produced * C_S] * 44/12

The Tier 1 method was used for calculating the emitted CH_4 and indirect gases (NO_x, NMVOC, CO and SO_2) from the steel processing.

E_{CH4} = Sinter Production * EF

3.4.1.3 Activity Data

The Activity Data of sinter production, pig iron production and steel production has been gathered from the factory. The carbon content values have been provided by the factories as well. The data on raw materials, including coke, graphite, Silicomanganese, and natural gas with their carbon content.

The aggregated data of produced steel from 1990 to 2015 are shown beneath in the Table 3-16.

Table 3-16. Amount of Produced Steel in Georgia for 1990, 1994, 2000, 2005, 2010- 2015

Steel Production	
Year	**Activity Data (t)**
1990	C
1994	C
2010	C
2011	C
2012	C*
2013	C*
2014	C*
2015	C*

* *Sum of data from Rustavi Metallurgy Plant and GeoSteel Factory*

The data of produced steel was used for the calculation of indirect emissions in accordance with the Revised IPCC 1996 Guidance.

3.4.1.4 Emission Factors

The Emission Factor for methane emissions is taken from the IPCC 2006 guidelines and equals 0.07kg CH_4 per ton of sinter produced.

From the steel productions some trace admixtures could also spread out in the atmosphere: NOx, NMVOCs, CO and SO_2. The default Emission Factors are given in the same book[58] and correspondingly are: 40, 30, 1 and 45 g of gas/ton of produced steel (source 1996 revised guideline).

3.4.2 Source-Category Ferroalloys Production (2C2)

3.4.2.1 Description of Source-category and Calculated Emissions

The ferroalloy plants produce the enriched alloys that are transmitted to the steel producing plants for manufacturing steel alloy. Ferroalloys production includes the metallurgical reduction process that causes significant emission of CO_2 and minor emission of CH_4. The ferroalloys including Ferro silicomanganese, Ferrosilicon, and Ferromanganese have been produced by several plants in Georgia. The dominant product is silicomanganese with about 82 per cent followed by ferrosilicon with 14 per cent and ferromanganese with 4 per cent.

In 2015 the emissions were about 405 Gg CO_2 eq. the lowest value for the last five years. It has been slightly declined by 11 per cent comparing to the value of 2014 years. The emission has a fluctuating trend between 2011 and 2015 period. The highest emissions from the ferroalloys production in Georgia were estimated in 2012 457 Gg of CO_2 eq. during the whole time series from 1990 to 2015. At the beginning of the period the emission was 65 per cent lower than in 2015. Following six years the emissions trend was down warding and it reached the level of 25 Gg CO2 eq. in 1996 the minimum level of emission for the whole estimating period.

The calculated CO_2 emissions for the whole time-series 1990-2015 are given in Annex.

The emissions calculated based on statistical data provided in this subsector and on the emission, coefficients given in the methodological instructions of the IPCC 2006 guidelines, are presented in the Table 3-17

Table 3-17. CO_2 Emissions (Gg) From Production of The Silicon-Manganese in 1990, 1994, 2000, 2005, 2010-2015

Module		**Industrial Processes**		
Submodule		**Metal Production**		
Sheet		**FERROALLOYS - TIER 1 - CO_2 EMISSIONS**		
Step 4				
Year	A Amount of silicomanganese Produced (t)	B Emission Factor (t CO_2/t Ferroalloy Produced)	C CO_2 Emitted (t)	D CO2 Emitted (Gg)
			C=(A*B)	D=C/10^3
1990	C	1.4	C	C
1994	C	1.4	C	C
2000	C	1.4	C	C
2005	C	1.4	C	C
2010	C	1.4	C	C
2011	C	1.4	C	C

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[58] http://www.ipcc-nggip.iges.or.jp/public/gl/invs5b.html (pages 2.27-2.28, Tables 2-13, 2-14, 2-15 , 2-16)

Module		Industrial Processes		
Submodule		Metal Production		
Sheet		FERROALLOYS - TIER 1 - CO_2 EMISSIONS		
Step 4				
2012	C	1.4	C	C
2013	C	1.4	C	C
2014	C	1.4	C	C
2015	C	1.4	C	C
	Ferrosilicon			
1990	C	4	C	C
1994	C	4	C	C
2000	C	4	C	C
2005	C	4	C	C
2010	C	4	C	C
2011	C	4	C	C
2012	C	4	C	C
2013	C	4	C	C
2014	C	4	C	C
2015	C	4	C	C
	Ferromanganese			
1990	C	1.3	C	C
1994	C	1.3	C	C
2000	C	1.3	C	C
2005	C	1.3	C	C
2010	C	1.3	C	C
2011	C	1.3	C	C
2012	C	1.3	C	C
2013	C	1.3	C	C
2014	C	1.3	C	C
2015	C	1.3	C	C
	Ferrosilicon	CH_4 t/t ferrosilicon	CH_4 Emitted (t)	CH_4 Emitted (Gg)
1990	C	0.001	C	C
1994	C	0.001	C	C
2000	C	0.001	C	C
2005	C	0.001	C	C
2010	C	0.001	C	C
2011	C	0.001	C	C
2012	C	0.001	C	C
2013	C	0.001	C	C

Module		**Industrial Processes**		
Submodule		**Metal Production**		
Sheet		**FERROALLOYS - TIER 1 - CO_2 EMISSIONS**		
Step 4				
2014	C	0.001	C	C
2015	C	0.001	C	C

2C2 – Ferroalloys Production is a key source-category with regard to CO2 emissions (see chapter 1.3).

3.4.3 Methodology

3.4.3.1 Method Used

The Tier I approach of the IPCC 2006 guideline is used that calculates the emissions by multiplication of the quantity of produced ferroalloys and typical Emission Factors for each type of ferroalloys.

E_{CO2} = Mass of Ferroalloys produced * EF

3.4.3.2 Activity Data

The State National Statistics Office is the sources for the ferroalloy production data. Only the silicon manganese production was performed.

3.4.3.3 Emission Factors

The default EFs for the ferrosilicon, ferromanganese, and silicomanganese have been taken from the 2006 guidelines[59]. Accordingly, 4 ton of CO_2/ton of produced ferrosilicon, 1.3 ton of CO_2/ton of produced ferromanganese, 1.4 ton of CO2/ton of produced silicomanganese.

3.4.4 Source-Category: Primary Aluminum Production (2C3)

This source category does not exist in Georgia.

3.4.5 Source-Category: Magnesium Production (2C4)

This source category does not exist in Georgia.

3.4.6 Source-Category: Lead Production (2C5)

This source category does not exist in Georgia.

3.4.7 Source-Category: Zinc Production (2C6)

This source category does not exist in Georgia.

3.4.8 Source-Category: SF_6 Used in Aluminum and Magnesium Foundries (2C7)

This source category does not exist in Georgia.

3.5 Non-Energy Products from Fuel and Solvent Use (2D)

The Activity Data on the usage of Lubricants and wax for non-energy purposes has been gathered since the national statistics office launched the energy balance processing. Accordingly, the emissions have been estimated for the years of 2013, 2014, and 2015. The emissions from the sub-category of non-

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[59] 2006 IPCC Guidelines for National Greenhouse Gas Inventories Vol.3 Chapter 4, Table 4.5 p.4.37

energy products from fuel and solvent use are about 0.55 per cent of the total GHG emissions of the country for 2015. The end of estimation period the emissions level was highest. In 2013 it was 77 per cent (8.76 Gg) of the latest estimation. The biGgest contributor of the upwarding trend was the amount of used lubricants for this period of time.

3.5.1 Lubricant Use (2D1)

3.5.1.1 Description of Source-category and Calculated Emissions

In 2015 the emissions were about 11.07 Gg CO_2 eq. the highest value for the last three years. It has been slightly increased by 15 per cent[60] comparing to the value of 2014 years. The emission has an upwarding trend between 2013 and 2015 period. At the beginning of the period the emission was 24 per cent lower than in 2015.

The emissions calculated based on statistical data provided in this subsector and on the emission, coefficients given in the methodological instructions of the IPCC 2006 guidelines, are presented in the Table 3-18, and NMVOCs emissions in the Table 3-19.

Table 3-18. CO_2 Emissions from Lubricant Use 1990-2015

Module	**Industrial Processes**				
Submodule	**LUBRICANT USE**				
Method	**TIER 1 - CO_2 EMISSIONS**				
Step 1					
Year	A Total Lubricant consumed (TJ)	B Carbon content factor of the lubricant (kg C/GJ)	C ODU factor of the lubricant (fraction)	D Mass ration of CO_2/C	E CO2 Emitted (Gg)
					$E=((A*B*C*44/12)/10^6$
1990	NE	NE	NE	44/12	NE
1995	NE	NE	NE	44/12	NE
2000	NE	NE	NE	44/12	NE
2005	NE	NE	NE	44/12	NE
2010	NE	NE	NE	44/12	NE
2011	NE	NE	NE	44/12	NE
2012	NE	NE	NE	44/12	NE
2013	570.7	20	0.2	44/12	8.37
2014	638.4	20	0.2	44/12	9.36
2015	754.8	20	0.2	44/12	11.07

3.5.1.2 Methodology

Method Used

The Tier I approach of the IPCC 2006 guideline is used that calculates the emissions by multiplication of the quantity of used lubricants and typical emission factor.
E_{CO2} = Energy content of Lubricant used * C content of lubricants * ODU Factor * 44/12

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[60] The value was calculated based on the date expressed in thousandths

Activity Data

The State National Statistics Office is the sources for the Lubricant use data for the non-energy purposes.

Emission Factors

The default carbon content factor (20 kg C/GJ) for lubricants and ODU factor (0.2) have been taken from the 2006 guidelines[61].

3.5.2 Paraffin Wax Use (2D2)

3.5.2.1 Description of Source-category and Calculated Emissions

In 2015 the emissions were about 0.3 Gg CO_2 eq. the average value for the last three years. It has been slightly increased by 17 per cent[62] comparing to the value of 2014 years. The emission has an upwarding trend between 2014 and 2015 period. At the beginning of the period the emission was 23 per cent higher than in 2015.

The emissions calculated based on statistical data provided in this subsector and on the emission, coefficients given in the methodological instructions of the IPCC 2006 guidelines, are presented in the table below.

Table 3-19 CO2 Emissions from Paraffin Wax Use 1990-2015

Module		**Industrial Processes**			
Submodule		**PARAFFIN WAX USE**			
Method		**TIER 1 - CO_2 EMISSIONS**			
			Step 1		
Year	A Total Paraffin Wax consumed (TJ)	B Carbon content factor of the paraffin wax (kg C/GJ)	C ODU factor of the paraffin wax (fraction)	D Mass ration of CO_2/C	E CO2 Emitted (Gg)
					$E=((A*B*C*44/12)/10^6$
1990	NE	NE	NE	44/12	NE
1995	NE	NE	NE	44/12	NE
2000	NE	NE	NE	44/12	NE
2005	NE	NE	NE	44/12	NE
2010	NE	NE	NE	44/12	NE
2011	NE	NE	NE	44/12	NE
2012	NE	NE	NE	44/12	NE
2013	26.9	20	0.2	44/12	0.39
2014	17.1	20	0.2	44/12	0.25
2015	20.6	20	0.2	44/12	0.30

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[61] 2006 IPCC Guidelines for National Greenhouse Gas Inventories Vol.3 Chapter 5, Table 5.2 p.5.9

[62] The value was calculated based on the date expressed in thousandths

3.5.2.2 Methodology

Method Used

The Tier I approach of the IPCC 2006 guideline is used that calculates the emissions by multiplication of the quantity of used paraffin waxes and typical Emission Factors.
E_{CO2} = Energy content of Paraffin wax used * C content of wax * ODU Factor * 44/12

Activity Data

The State National Statistics Office is the sources for the wax use data for the non-energy purposes.

Emission Factors

The default carbon content factor (20 kg C/GJ) for lubricants and ODU factor (0.2) have been taken from the 2006 guidelines.[63]

3.5.3 Asphalt Production and Use (2D3)

3.5.3.1 Description of Source-category and Calculated Emissions

Georgia is mainly producing artificial asphalt. The calculated carbon monoxide emissions from asphalt production are presented in the tables beneath.

Table 3-20 CO Emissions from Asphalt Production in 1990-2015

Asphalt-concrete production		**Emission factor (t CO /Gg asphalt)**	**CO emission (t)**	**CO emission (Gg)**
Year	Gg		C = (AxB)	$D=C/10^3$
1990	NO	0.0095	NO	NO
1994	NO	0.0095	NO	NO
2000	19.7	0.0095	0.18715	0.0002
2005	293.4	0.0095	2.7873	0.002
2010	371,6	0.0095	3.5302	0.004
2014	325,4	0.0095	3.0913	0.003
2015	627,4	0.0095	5.9603	0.006

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[63] 2006 IPCC Guidelines for National Greenhouse Gas Inventories Vol.3 Chapter 5, p.5.12

Table 3-321 NMVOCs Emissions from Asphalt Production in 1990-2015

Asphalt-concrete production		Emission factor (t NMVOCs /Gg asphalt)	NMVOCs emission (t)	NMVOCs emission (Gg)
Year	Gg		C = (AxB)	D=C/10^3
1990	NO	0.0475	NO	NO
1994	NO	0.0475	NO	NO
2000	19.7	0.0475	0.93575	0.0009
2005	293.4	0.0475	13.9365	0.013
2010	371,6	0.0475	17.651	0.018
2014	325,4	0.0475	15.4565	0.015
2015	627,4	0.0475	29.8015	0.030

3.5.3.2 Methodology

Method Used

The methodology used in the IPCC 1996 has been applied according to which in this sub-sector only NMVOCs and CO emissions will be considered because it is believed that the direct effects of the greenhouse gas emissions from asphalt production is negligible. Emission rate is calculated by Emission Factors (gases emitted during production of a ton of asphalt) multiplying by tons of produced asphalt.

Activity Data

This sub-sector considers asphalt producing enterprises (oil refineries are not considered) and its usage. In Georgia asphalt production technology is as follows: after processing of oil products the remaining mass Bitumen and fillers (cement, lime) are stirred in mobile or stationary units in about 30-50 km away from the place where asphalt is used. Asphalt products are also used as binder and hermetic material, for example for foundations, etc. Asphalt surface for roads is condensed, contains compact fillers and bitumen connecting. Liquid asphalt is characterized by a relatively high level of emissions. They are bitumen and asphalt emulsion. The latter is mainly composed of water and a small or zero amounts of solvents. During discussed period in Georgia the main part of asphalt was produced by several large and small enterprises. They produced the so-called hot asphalt mixture almost by the same technology. The data has been provided by Georgian statistics office.

Emission Factors

Emissions from asphalt production are calculated on the national level only for CO and NMVOCs. Emission Factors are taken from the EMER / CORINAIR (SNAP 40610) guidelines[64] whereas the technology of the asphalt production (saturation without emission) and therefore is: for NMVOCs - 0.0475, while for CO - 0.0095 kg / ton of asphalt.

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[64] EMEP/CORINAR (SNAP A0 610), Atmosperic emission inventory guidebook. Second edition 2009. http://eea.europa.eu/publications/Emep CORINARS 5

3.5.3.3 Road Paving with Asphalt

Since the proper data on the area of asphalt paved is not available the emissions cannot be calculated for the source-category.

3.5.4 Solvent Use (2D4)

This source category does not exist in Georgia.

3.5.5 Other Product Use (2D5)

This source category does not exist in Georgia.

3.6 Sub-sector: Electronic Industry (2E)

This source category does not exist in Georgia.

3.7 Sub-sector: Product Uses as Substitutes for Ozone Depleting Substances (2F)

Nowadays, the industrial gases (hydrofluorocarbons -HFCs, perfluorocarbons -PFCs and Sulphur hexafluoride -$SF_{6)}$ are imported only for utilization. Accordingly, the emissions are specified only by their usage. Calculation of halocarbons is important as they are characterized by stability and high global warming potential (GWP).

3.7.1 Refrigeration and Air Conditioning

The emissions from the consumption of HFCs have been estimated based on the halogens imported in Georgia. These compounds and mixtures are HFC-134a, R-404A, R-407C, R-507A, R-410A. The composition analysis of these mixtures reviles that mostly four different compounds of HFCs are accounted for the period of time between 2001 and 2015. The emissions from the HFCs consumption counts from the year of 2001 due to the appearance in imported goods.

In general, the emission from the HFCs consumption has an upwarding trend in Georgia. The highest emissions were in 2015 about 139 Gg CO_2 eq. In 2014 the emissions were 14 per cent[65] to lower than in 2015. The lowest emissions from the HFCs consumption in Georgia were estimated in 2001 0.2 Gg of CO_2 eq. almost 700 times less than at the end of the period.

3.7.1.1 Methodology

Method Used

According to the IPCC 2006 guideline for estimation of actual emissions the Tier 1a/b method were used. The spreadsheet contained in the 2006 Guidelines has been used for the calculations.

In accordance to the national circumstances of Georgia the HFCs have not been produced yet. Subsequently, production is zero. The same condition is in case of export. Accordingly, the emissions from the sub-sector of Consumption of Halocarbons correspond to the imported gases and equipment mostly for the air conditioning and refrigerants.

Activity Data

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[65] The value was calculated based on the date expressed in thousandths

Since the most accurate data of imported goods are collected by the customs service, the data of the HFC gases are collected there. The aggregated values were separated in 4 different compounds HFC-134a, HFC-125, HFC-143a, and HFC-32 by the expert judgment.

Emission Factors

According to the IPCC 2000 GPG, the imported or produced halocarbons and perfluorocarbons are emitted completely and consequently their emission coefficient is equal to 1.

3.7.1.2 Calculated Emissions

The potential emissions from the f-gases in Refrigerators and Air conditioners are represented in the Table 3-22 beneath.

Table 3-22. HFC Potential Emissions in Georgia in 2001-2015

Gases	Quantity of Pollutant (t)	GWP	CO_2 eq. (Gg)
HFC-134a			
2001	0.0840	1300	0.11
2005	3.5280	1300	4.59
2010	20.3120	1300	26.41
2011	23.4924	1300	30.54
2012	43.6724	1300	56.77
2013	50.0565	1300	65.07
2014	52.6032	1300	68.38
2015	59.8697	1300	77.83
HFC-125			
2001	0.0170	2800	0,05
2005	0;8306	2800	2.33
2010	4.5938	2800	12.86
2011	6.1816	2800	17.31
2012	6.8077	2800	19.06
2013	7.6174	2800	21.33
2014	10.9696	2800	30.71
2015	13.4327	2800	37.61
HFC-143a			
2001	0.0156	3800	0.06
2005	0.4550	3800	1.73
2010	3.6605	3800	13.91
2011	3.8259	3800	14.54
2012	3.9509	3800	15.01
2013	4.0103	3800	15.24
2014	4.4569	3800	16.94
2015	4.7304	3800	17.98
HFC-32			
2001	0.0035	650	0.002
2005	0.4099	650	0.27
2010	1.3704	650	0.89
2011	2.7940	650	1.82
2012	3.2982	650	2.14
2013	4.0310	650	2.62
2014	6.9600	650	4.52
2015	9.1770	650	5.97

3.7.2 Foam Blowing Agents (2F2)

The emissions form this source-category is going to be estimated by using the methods delivered under the project Georgia’s Integrated Transparency Framework for Implementation of the Paris Agreement for the period of 2020-2022.

3.7.3 Fire Protection (2F3)

The emissions form this source-category is going to be estimated by using the methods delivered under the project Georgia’s Integrated Transparency Framework for Implementation of the Paris Agreement for the period of 2020-2022.

3.7.4 Aerosols (2F4)

The emissions form this source-category is going to be estimated by using the methods delivered under the project Georgia’s Integrated Transparency Framework for Implementation of the Paris Agreement for the period of 2020-2022.

3.7.5 Solvents (2F5)

The emissions form this source-category is going to be estimated by using the methods delivered under the project Georgia’s Integrated Transparency Framework for Implementation of the Paris Agreement for the period of 2020-2022.

3.7.6 Other Applications

The emissions form this source-category is going to be estimated by using the methods delivered under the project Georgia’s Integrated Transparency Framework for Implementation of the Paris Agreement for the period of 2020-2022.

3.8 Other Product Manufacture and Use (2G)

3.8.1 Electrical Equipment (2G1)

In Georgia during the reporting period operation of only SF_6 equipment was done. At energy facilities SF_6 is used in communication equipment. According to official information provided by the State Electricity specialists, namely, it has started since 1997 in different voltage breakers. Currently existing "Elegas Breakers'' amount on the balance of JSC "GSE" consists of 304 suites, while in them the sum number of SF_6 is 5 771.1 kg. Type of used breakers is hermetic; their operation term is 30-40 years. It should be noted that according to experts' reports in recent years, quality (hermitization) of this type of equipment has significantly improved that the subsequently reduced (50-90%) SF_6 emissions from electric utilities. Statistics of installed SF_6 breakers in JSC "Georgian State Electro system" from 2010-2013 is presented in Table 3-23.

Table 3-23. Installed in State Electricity System Number of Breakers That Contain SF_6 in 2010-2015

Year	2010	2011	2012	2013	2014	2015	Total
Amount	85	31	14	1	15	21	146

Amount of SF_6 released during working processes of electrical equipment is calculated for 1997-2013 in Georgia. The results of calculations are presented in Table 3-24.

Table 3-24. SF_6 Quantities Released from Electrical Equipment in Georgia in 2010-2015

Year	Consumed SF_6, tons	Rate of SF_6 losses	SF_6 emission, Tons	SF_6 emission, Gg	SF_6 emission in Gg CO_2eq.
2010	4.6704	0.002	0.00934	0.00000934	0.22
2011	5.2740	0.002	0.01055	0.00001055	0.25
2012	5.7480	0.002	0.01150	0.00001150	0.27
2013	5.7711	0.002	0.01154	0.00001154	0.28
2014	6.3099	0.002	0.01262	0.00001262	0.30
2015	6.6875	0.002	0.01338	0.00001338	0.32

Calculations showed that from used equipment SF_6 emission is practically insignificant in energy system of Georgia. It reached maximum in 2015 and amounted to 0.00001338 Gg or 0.32 Gg CO_{2eq}.

For calculation of SF_6 emission the Methodology from IPCC-2006 guideline was used as there are given the spreading coefficients according to the regions and to the types of devices (airproof, closed). These data are provided in the Table 3-25.

Table 3-25. The Coefficients of SF_6 Emissions According to the Regions and to the Types of Devices

Region/ Phase	Airproof / leakage per year %	Closed / leakage per year %
Europe	**0.002**	**0.026**

3.8.2 SF6 and PFCs from Other Product Uses (2G2)

3.8.3 N2O from Product Uses (2G3)

3.8.3.1 Sector Review and Calculated Emissions

In general, one of major sources of greenhouse gas emissions is solvents and their associated components. This sector considers nitrous oxide (N_2O) emissions, the main source of its use being anesthesia in the medical field.

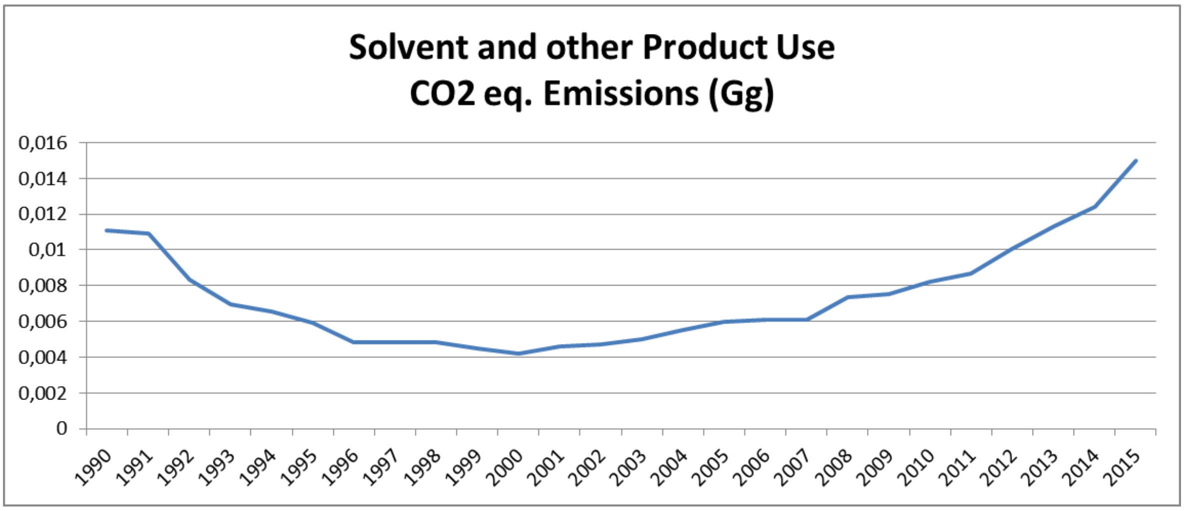

Figure 3-4 The Emissions from the Solvent and Other Product Use

Average annual emissions of N_2O used for anesthesia in medicine during the discussed period amounted to 0.00003 Gg/year, or slightly smaller size.

N_2O emissions in 2010-2013 are estimated in this subsector for anesthesia in medical field. Nitrogen monoxide (N_2O) emissions are released in different ways (agriculture, industry, transport) and one of the fields, which also contribute to the emission of nitric oxide, is medicine.

Nitrogen monoxide-containing substances most actively are used during anesthesia in medical sector. In addition, mostly inhalational anesthetics contain N_2O.

Table 3-26. Emission of N_2O from the Subsector "Solvents and Other Product Use" in 1990, 1994, 2000, 2005, 2010-2015

Year	Number of Medical Operations Conducted	EF (kg N_2O /per surgery)	N_2O Emission (Gg)	CO_2 eq. Emission (Gg)
1990	182072	$0.196*10^{-3}$	3.5686E-05	0.011
1994	108194	$0.196*10^{-3}$	2.1206E-05	0.007
2000	69360	$0.196*10^{-3}$	1.35946E-05	0.004
2005	98688	$0.196*10^{-3}$	1.93428E-05	0.006
2010	134941	$0.196*10^{-3}$	2.64484E-05	0.008
2011	143262	$0.196*10^{-3}$	2,80794E-05	0,009
2012	165679	$0.196*10^{-3}$	3,24731E-05	0,010
2013	186715	$0.196*10^{-3}$	3,65961E-05	0,011
2014	204553	$0.196*10^{-3}$	4.00924E-05	0.012
2015	246457	$0.196*10^{-3}$	4.83056E-05	0.015

3.8.4 Methodology

3.8.4.1 Method Used

Calculations were based on the assumption that N_2O used for anesthesia is emitted in the atmosphere as a whole or emission of N_2O is equal to its use.

It was assumed that consumed N_2O is proportional to a total number of surgical operations in the country. These data and the results of the calculations are presented in Table 3-27.

3.8.4.2 Activity Data

Surgery visits from 1990-2015 in Georgia were used for calculation, which was provided by the Ministry of Health and Social Security, and National Statistics Office of Georgia. The number of medical operations is represented in the Table 3-27.

Table 3-27. Activity Data on Surgeries Carried out in Georgia in 1990-2015

Year	Number of medical operations conducted
1990	182072
1994	108194
2000	69360
2005	98688
2010	134941
2011	143262
2012	165679
2013	186715
2014	204553
2015	246457

3.8.4.3 Emission Factor

Emission factor is 0.196×10^{-3}kg[66].

3.9 Sub-sector: Other Production (2H)

This category includes production of pulp and paper (2H1), also of food and drinks (2D2). Processing of wood[67] is not conducted at present in Georgia. But the paper is produced in Tserovani Plant by using the imported raw materials and their turning into the paper does not cause the greenhouse gas emissions into the atmosphere.

3.9.1 Source-Category - Food and Beverages Industry (2H2)

3.9.1.1 Source–category description and calculated emissions

From the source category “Food and Drinks Production “the direct greenhouse gases are not produced and therefore only indirect gases and NMVOCs were estimated. During the discussed period different enterprises of food industry in Georgia were functioning, among them the meat and fish processing, the corn drying and milling, bakery, confectionary, sugar, wine, spirit, beer, soft drinks, dairy products, coffee roasting and milling were the major. From this subcategory only the non-methane volatile organic compounds emissions (NMVOCs) are calculated.

The emissions calculated on the basis of statistical data provided in this subsector and on the emission, factors offered by the methodological instructions of IPCC 1996, are given in the Table 3-28.

According to the conducted calculations it is obvious that the amount of NMVOCs spread into the atmosphere from foods and drinks production at the territory of Georgia during 1990-2015 is significant and 200 times exceeds the emissions from the asphalt production (see the Table 3-28).

Table 3-28. NMVOCs Emissions from The Food and Drinks Production in 1990, 1994, 2000, 2005, 2010, 2014-2015 in Georgia (Gg)

Production	1990	1994	2000	2005	2010	2014	2015
Food and Drink	11	6	1	1	2	2	2

In this sector the food production is the major contributor in NMVOCs emission, they are approximately 98% from total amount of emitted NMVOCs.

3.9.2 Methodology

3.9.2.1 Method Used

It is recommended to conduct the calculations according to Tier 2 that provides taking into consideration the production technology designed for each separate product. As for Tier 3 approach, it foresees including the modeling into the calculation process. The Tier 2 approach was applied for calculations.

3.9.2.2 Activity Data

The subsector of food and drinks production integrates the complete circle of food production: thermal processing of fats, baking, fermentation, cooking, drying, corn drying and milling processes. Their

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[66] EMEP/CORINAR (EEA-2009); (page 5.18, Table 8.11- coefficients for European countries)

[67] Here is foreseen the paper and cardboard production that was conducted in Zugdidi in past years

conduction is accompanied by emission of different volatile compounds, among which will be discussed only the NMVOCs emissions according to the IPCC Methodological Guidelines. In this sector the emissions from processing of dairy products or oils are not discussed, as their processing technologies do not require heating, and consequently the emissions are not significant. In drinks (beer, wine, alcohol) production are used grapes, fruits and corn, which should be matured before processing. During this process the starch is turned into sugar and the sugar turns into the ethyl spirit with participation of yeast microbes. This process is called fermentation. Sometimes the technological process requires preparing raw materials before the fermentation (for example, for beer production, preparing of malt, for spirit production – distillation of the fermented liquid). The technological process of preparing food products and drinks includes: roasting of raw materials, fermentation and distillation. The fermentation process determines the sugar content of drinks and stipulates the emission of NMVOCs most of all. In Table 3-27 the data on the food production during 1990-2015 in Georgia is provided.

Table 3-29. The Food Products (Tons) And Drinks (Hl) Produced in Georgia in 1990-2015

Product/Food and Drink	1990	1994	2000	2005	2010	2014	2015
Meat and semi-prepared meat food (t)	44235,0	245,6	994,9	2640,1	9987,1	27772,6	28544,0
Fish and fish product (t)	59678,0	187,8	63,0	298,7	1002,0	1970,4	2004,6
Margarine and similar products (t)	NE	NE	NE	NE	NE	NE	NE
Drying and grinding of wheat (t)	951699,0	420420,6	102977,3	195754,1	401482,7	447427,6	428262,3
Bread baking (t)	855572,0	498331,2	111335,3	92937,6	126085,7	164562,0	159408,6
Confectionary (t)	59504,0	465,9	143,6	348,2	6463,8	16338,9	17597,9
Sugar (t)	C	C	C	C	C	C	C
Milling and roasting of coffee (t)	NE	NE	1411,2	758,0	1888,7	1956,5	2166,7
Forage for domestic animals (t)	1079685,0	135550,0	2701,2	602,8	3207,2	16894,2	19139,3
Sparkling wine (hl)	1451,4	171,4	87,7	189,2	114,2	180,7	127,7
White wine (hl)	NE	NE	NE	2 476	2 905	4 499	6 552
Beer (hl)	9477,0	632,1	2344,9	5863,7	8279,0	9965,5	8605,8
Spirit, vodka (hl)	822,0	229,1	521,8	1336,5	1427,4	1421,2	950,1
Brandy (hl)	2165,0	282,0	71,3	226,6	99,9	286,1	322,7

3.9.2.3 Emission Factors

The emission coefficients offered in the IPCC Guidelines are provided in the Table 23 and are calculated under following assumptions:

- For producing of 1-ton beer 0.15 ton of grains is consumed;
- Brandy fermentation is performed during 3 years, but other alcohol drinks do not require fermentation;
- It is considered that the beer includes 4% of alcohol, with the quotation if the mass of 1m^3 is 1 ton;
- The spirit includes 40% of alcohol;
- The density of the ethyl alcohol is 789 kg/m^3.

Table 3-30 Coefficients of NMVOCs Emissions for the Subcategory “Food and Drinks Production “

Food	**EF** **kg NMVOCs/t food production**	**Beverages**	**EF** **Kg NMVOCs/hl drink production**
Meat and meat semi-prepared food	0.3	Sparkling wine	0.080
Fish and fish product	0.3	White wine	0.035
Margarine and similar products	10.0	Beer	0.035
Drying and grinding of wheat	1.3	Spirit, vodka	15.000
Bread baking	10.0	Brandy	3.500
Confectionary	1.0	Alcohol free drinks	0.400
Sugar	10.0		
Milling and roasting of coffee	0.6		
Forage for domestic animals	1.0		

4 Agriculture

Georgia's agricultural sector plays a key role in the country's economy. Georgian farmers are going to fulfill a principal role in providing one of the fundamental needs of society: a safe, secure, and affordable food supply. Agriculture sector plays a significant role in the national economy of Georgia, contributing with 9.3 per cent to its GDP in 2016. In 2016, under the agriculture sector the animal breeding accounted for a relatively large share – 55.7 per cent, plant production– for 38.0 per cent, while the services – for circa 6.3 per cent. More than 50 per cent of active population is employed in this sector.

4.1 Sector Overview

The agriculture sector of Georgia as source of greenhouse gas (GHG) emissions comprises four subcategories: Enteric fermentation; Manure management; Agricultural Soils; and Field Burning of Agricultural Residues. The other IPCC subcategories of rice cultivation, prescribed burning of savannas, and "other" are not specific for Georgia and aren't considered. Manure management refers to all emissions from Animal waste management systems (AWMS), in particular from anaerobic lagoons, liquid systems, solid storage, and drylot, "used for fuel" and "other systems". Emissions from daily spread and animal waste dropped on the soil during grazing on grasslands ("pasture range and paddock") are reported under subcategory "agricultural soils".

The GHG emissions from the agricultural sector are summarized in Tables 4.1-4.3. It clearly shows that methane (CH_4) emissions from enteric fermentation are the largest source of methane within this sector while the largest source of nitrous oxide (N_2O) is "Agriculture soils".

Table 4-1. Methane Emissions from Agriculture Sector in Gg (thousand tons)

Source	1990	1994	2000	2005	2010	2011	2012	2013	2014	2015
Enteric fermentation	77.11	51.83	62.93	64.66	56.42	56.36	59.76	63.62	68.09	70.11
Manure management	9.02	5.20	6.25	6.38	4.44	4.42	5.03	5.24	5.47	5.62
CH_4 total in Gg	**86.1**	**57.0**	**69.2**	**71.0**	**60.9**	**60.8**	**64.8**	**68.9**	**73.6**	**75.7**

Table 4-2. Nitrous Oxide Emissions from Agriculture Sector in Gg

Source	1990	1994	2000	2005	2010	2011	2012	2013	2014	2015
Manure management	1.21	0.80	0.98	1.00	0.86	0.86	0.91	0.97	1.03	1.07
Agricultural soils	5.62	3.28	4.08	4.29	3.77	3.57	3.92	4.65	4.31	4.36
Direct soil emissions	3.53	2.07	2.56	2.70	2.35	2.24	2.45	2.90	2.70	2.73
Synthetic fertilizers	*1.19*	*0.61*	*0.93*	*0.91*	*0.99*	*0.85*	*0.97*	*1.27*	*1.00*	*0.98*
Organic N fertilisers applied to soils	*0.46*	*0.29*	*0.34*	*0.35*	*0.30*	*0.30*	*0.32*	*0.34*	*0.36*	*0.37*
Crop residue decomposition	*0.20*	*0.13*	*0.13*	*0.21*	*0.07*	*0.10*	*0.09*	*0.13*	*0.114*	*0.12*
Pasture range and paddock	*1.68*	*1.04*	*1.15*	*1.23*	*1.00*	*0.99*	*1.07*	*1.16*	*1.23*	*1.26*
Indirect soil emissions	2.08	1.21	1.52	1.59	1.41	1.33	1.47	1.75	1.61	1.62
Atmospheric deposition	*0.34*	*0.20*	*0.24*	*0.25*	*0.23*	*0.21*	*0.24*	*0.27*	*0.26*	*0.26*
Nitrogen leaching & run off	*1.74*	*1.01*	*1.28*	*1.34*	*1.19*	*1.12*	*1.23*	*1.48*	*1.35*	*1.36*
N_2O total in Gg	**6.83**	**4.08**	**5.06**	**5.29**	**4.62**	**4.43**	**4.83**	**5.61**	**5.34**	**5.42**

Changes between current and previous inventories (Table 4–3) are mainly caused due to applying 2006 IPCC Guidelines for National Greenhouse Gas Inventories instead of 1996 Guidelines. Methodologies and most of default values are different in these guidelines. National Statistics Office of Georgia (NSOG) provided reassessed livestock data for previous years (new methodology was used). Besides, N fertilizer data are also specified by NSOG.

Table 4-3. GHG Emissions from Agriculture Sector in Gg CO_2eq

Gas/Source	1990	1994	2000	2005	2010	2011	2012	2013	2014	2015
CH4										
Enteric fermentation	1,619	1,088	1,321	1,358	1,185	1,184	1,255	1,336	1,430	1,472
Previous inventories TNC and FBUR	*1,664*	*967*	*1,288*	*1,254*	*1,227*	*1,214*	*1,278*	*1,351*		
Difference, %	*-3*	*11*	*3*	*8*	*-4*	*-3*	*-2*	*-1*		
Manure management	189	109	131	134	93	93	106	110	115	118
Previous inventories TNC and FBUR	*309*	*207*	*260*	*278*	*100*	*95*	*105*	*118*		
Difference, %	*-63*	*-89*	*-98*	*-107*	*-7*	*-2*	*1*	*-7*		
CH4 total in Gg	1,809	1,198	1,453	1,492	1,278	1,276	1,360	1,446	1,545	1,590
Previous inventories TNC and FBUR	*1,973*	*1,174*	*1,548*	*1,532*	*1,327*	*1,309*	*1,383*	*1,469*		
Difference, %	*-9*	*2*	*-7*	*-3*	*-4*	*-3*	*-2*	*-2*		
N_2O										
Manure management	376	249	304	309	265	265	283	299	321	331
Previous inventories TNC and FBUR	*161*	*71*	*71*	*84*	*127*	*124*	*133*	*152*		
Difference, %	*57*	*71*	*77*	*73*	*52*	*53*	*53*	*49*		
Agricultural soils										
Direct soil emissions	1,096	641	794	837	730	694	761	898	838	848
Previous inventories TNC and FBUR	*905*	*663*	*713*	*986*	*564*	*552*	*589*	*663*		
Difference, %	*17*	*-3*	*10*	*-18*	*23*	*20*	*23*	*26*		
Synthetic fertilizers	370	189	289	281	306	264	301	393	309	304
Previous inventories TNC and FBUR	*331*	*171*	*258*	*419*	*96*	*81*	*93*	*121*		
Difference, %	*11*	*10*	*11*	*-49*	*69*	*69*	*69*	*69*		
Animal waste applied to soils	144	91	107	110	92	92	99	105	112	116
Previous inventories TNC and FBUR	*171*	*90*	*99*	*115*	*118*	*112*	*124*	*136*		
Difference, %	*-19*	*2*	*7*	*-5*	*-28*	*-22*	*-25*	*-30*		
Crop residue decomposition	62	40	41	65	22	31	28	41	35	38
Previous inventories TNC and FBUR	*112*	*96*	*87*	*133*	*19*	*34*	*34*	*40*		
Difference, %	*-81*	*-143*	*-115*	*-105*	*13*	*-10*	*-20*	*3*		
Pasture range and paddock	520	321	357	381	310	308	332	359	381	390
Previous inventories TNC and FBUR	*453*	*267*	*270*	*319*	*332*	*322*	*341*	*366*		
Difference, %	*13*	*17*	*24*	*16*	*-7*	*-5*	*-3*	*-2*		
Indirect emissions	645	374	472	494	438	414	455	542	498	503
Previous inventories, TNC and FBUR	682	375	453	577	381	362	387	437		
Difference, %	*-6*	*0*	*4*	*-17*	*13*	*13*	*15*	*19*		
Atmospheric deposition	105	62	76	78	70	67	73	84	81	82
Previous inventories TNC and FBUR	*121*	*68*	*78*	*93*	*74*	*71*	*74*	*84*		
Difference, %	*-16*	*-10*	*-3*	*-19*	*-5*	*-7*	*-1*	*0*		
Nitrogen leaching & run off	540	313	396	416	368	347	382	458	417	421
Previous inventories TNC and FBUR	*561*	*307*	*375*	*484*	*307*	*291*	*313*	*353*		

Gas/Source	1990	1994	2000	2005	2010	2011	2012	2013	2014	2015
Difference, %	*-4*	*2*	*5*	*-16*	*17*	*16*	*18*	*23*		
N2O total in Gg	2,117	1,265	1,569	1,640	1,433	1,373	1,499	1,740	1,656	1,681
Previous inventories TNC and FBUR	*1,752*	*1,113*	*1,240*	*1,649*	*1,073*	*1,039*	*1,113*	*1,256*		
Difference, %	*17*	*12*	*21*	*-1*	*25*	*24*	*26*	*28*		
Agriculture total, CO2eq	**3,926**	**2,463**	**3,022**	**3,132**	**2,712**	**2,649**	**2,859**	**3,186**	**3,201**	**3,271**
Previous inventories TNC and FBUR	***3,725***	***2,287***	***2,788***	***3,181***	***2,400***	***2,348***	***2,496***	***2,725***		
Difference, %	***5.1***	***7.1***	***7.7***	***-1.6***	***11.5***	***11.4***	***12.7***	***14.5***		

The shares of gases in agriculture sector emissions as well as share of sub-categories emissions in agriculture sector emissions are presented in Table 4.4. According to this table share of methane varies within 45-49 percent. The largest source is enteric fermentation. The share of nitrous oxide varies within 51-55 percent.

Table 4-4. Share of Sub-Categories Emissions in Agriculture Sector Emissions (%)

Source	1990	1994	2000	2005	2010	2011	2012	2013	2014	2015
CH_4										
Enteric fermentation	41	44	44	43	44	45	44	42	45	45
Manure management	5	4	4	4	3	4	4	3	4	4
Total CH_4	46	49	48	48	47	48	48	45	48	49
N_2O										
Manure management	10	10	10	10	10	10	10	9	10	10
Agricultural soils	44	41	42	43	43	42	43	45	42	41
Direct soil emissions	28	26	26	27	27	26	27	28	26	26
Synthetic fertilizers	*9*	*8*	*10*	*9*	*11*	*10*	*11*	*12*	*10*	*9*
Organic N fertilisers applied to soils	*4*	*4*	*4*	*3*	*3*	*3*	*3*	*3*	*4*	*4*
Crop residue decomposition	*2*	*2*	*1*	*2*	*1*	*1*	*1*	*1*	*1*	*1*
Pasture range and paddock	*13*	*13*	*12*	*12*	*11*	*12*	*12*	*11*	*12*	*12*
Indirect emissions	16	15	16	16	16	16	16	17	16	15
Atmospheric deposition	3	3	3	2	3	3	3	3	3	3
Nitrogen leaching & run off	14	13	13	13	14	13	13	14	13	13
Total N_2O in Gg	54	51	52	52	53	52	52	55	52	51
Agriculture total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

4.2 Enteric fermentation

The emissions source category “Enteric Fermentation” consists of the sub-sources: cattle, buffalos, sheep, goats, and swine. Since 2005 data on number of horses is absent. Camels and mules are not specific for Georgia. During 1900-2015 GHG emissions varied mainly according to the livestock population.

Major “Key Source” is enteric fermentation by cattle, which contributes about 90% of the total emissions from enteric fermentation.

Tier 1

Methodology: To estimate methane emissions for source category "enteric fermentation" the IPCC 2006 methodology is used. The amount of methane emitted by a population of animals is calculated by multiplying the emission rate per animal by the number of animals.

$$EM_i = EF_i \bullet Pop_i$$

Where:

EM_i	emissions from animal type i
i	index refers to animal type
EF_i	methane emission factor for animal type i
Pop_i	quantity of animal type i

Activity Data: Quarterly data on livestock population are used. As livestock population significantly decreased by end of each year, application of early data (population by end of year) will lead to the underestimated values. Numbers of animals in 1990-2015 years are given in table 4.5.

Table 4-5. The Number of Animals (thousand heads)

Animal Category	1990	1994	2000	2005	2010	2011	2012	2013	2014	2015
Cattle	1,386	967	1,210	1,226	1,100	1,101	1,159	1,227	1,323	1,365
Buffalos	39	23	25	23	17	17	17	18	12	15
Sheep	1,550	754	547	720	597	577	688	796	866	842
Goats	68	39	81	96	57	54	55	61	54	50
Horses	20	21	35	43	0	0	0	0	0	0
Swine	880	367	443	455	110	105	204	191	170	162
Poultry	21,760	12,290	7,826	7,482	6,522	6,360	6,159	6,761	6,658	8,309

Prevailing native breeds of cattle in Georgia are Georgian Mountain (Highlander) and Red Mingrelian. Georgian Mountain and Red Mingrelian are late maturing and are endowed with small weight, low productivity, and high fattiness of milk. Since the 30-ies of the 20th century several high-productive early maturing breeds have been imported. According to estimations, the characteristics and accordingly the Emission Factors of early maturing breeds slightly (by 3-4%) differ. Therefore, averaged value of Emission Factors has been used and 3 breeds are considered: Early maturing, Georgian Mountain and Red Mingrelian. Cattle distribution by breeds in 2010-2015 is based on expert judgments.

Table 4-6. Cattle Distribution by Breeds

year	Breed			Total
	Early maturing	Georgian Mountain	Red Mingrelian	
1990	277,196	554,393	554,393	1,385,982
1994	193,462	386,924	386,924	967,309
2000	242,096	484,193	484,193	1,210,481
2005	245,184	490,367	490,367	1,225,918
2010	220,012	440,025	440,025	1,100,061
2011	220,236	440,472	440,472	1,101,180
2012	231,769	463,538	463,538	1,158,844
2013	245,450	490,901	490,901	1,227,252

year	Breed			Total
	Early maturing	Georgian Mountain	Red Mingrelian	
2014	264,558	529,116	529,116	1,322,789
2015	272,906	545,812	545,812	1,364,529

Tier 1

Emission Factors: Emission Factors for late maturing cattle were taken according to default values for Asia region, as the characteristics for this type of animals are most of all suitable to Georgian conditions. In particular, cattle mainly are fed in pastures or kept stalled; animals are relatively small in size and have a multi-purpose application. For Early maturing cattle default values of Eastern European region are used [IPCC 2006, Volume 4, p. 10.29, table 10.11]. Emission Factors for other types of animals are taken according to default values for developing countries with temperate climate [IPCC 2006, Volume 4, p. 10.28, table 10.10]. CH_4 Emission Factors for livestock categories are presented in table 4-8.

Emissions: CH4 emissions from enteric fermentation for animal categories are presented in Table 4-8.

Table 4-8. CH_4 Emissions from Enteric Fermentation (tier 1)

Animal category	Population, thousand heads										Emission factor kgCH_4/head	Emission, Gg CH_4									
	1990	1994	2000	2005	2010	2011	2012	2013	2014	2015		1990	1994	2000	2005	2010	2011	2012	2013	2014	2015
Late maturing cattle	1,109	774	968	981	880	881	927	982	1,058	1,092	47	52.1	36.4	45.5	46.1	41.4	41.4	43.6	46.1	49.7	51.3
Early maturing cattle	277	193	242	245	220	220	232	245	265	273	58	16.1	11.2	14.0	14.2	12.8	12.8	13.4	14.2	15.3	15.8
Buffalos	39	23	25	23	17	17	17	18	12	15	55	2.1	1.3	1.4	1.3	0.9	0.9	0.9	1.0	0.7	0.9
Sheep	1,550	754	547	720	597	577	688	796	866	842	5	7.7	3.8	2.7	3.6	3.0	2.9	3.4	4.0	4.3	4.2
Goats	68	39	81	96	57	54	55	61	54	50	5	0.3	0.2	0.4	0.5	0.3	0.3	0.3	0.3	0.3	0.2
Horses	20	21	35	43	0	0	0	0	0	0	18	0.4	0.4	0.6	0.8	0.0	0.0	0.0	0.0	0.0	0.0
Swine	880	367	443	455	110	105	204	191	170	162	1	0.9	0.4	0.4	0.5	0.1	0.1	0.2	0.2	0.2	0.2
Total												**79.6**	**53.6**	**65.1**	**66.9**	**58.4**	**58.4**	**61.9**	**65.9**	**70.5**	**72.6**
Total in Gg CO_2eq												**1,672**	**1,125**	**1,368**	**1,405**	**1,227**	**1,226**	**1,299**	**1,383**	**1,481**	**1,525**

Table 4-9. Share of Animal Category in Methane Emissions from Enteric Fermentation in Percentage (tier 1)

Animal category	1990	1994	2000	2005	2010	2011	2012	2013	2014	2015
Late maturing cattle	65.4	67.9	69.9	68.9	70.8	70.9	70.4	70.1	70.5	70.7
Early maturing cattle	20.2	20.9	21.6	21.3	21.8	21.9	21.7	21.6	21.8	21.8
Buffalos	2.7	2.4	2.1	1.9	1.6	1.6	1.5	1.5	0.9	1.2
Sheep	9.7	7.0	4.2	5.4	5.1	4.9	5.6	6.0	6.1	5.8
Goats	0.4	0.4	0.6	0.7	0.5	0.5	0.4	0.5	0.4	0.3
Horses	0.4	0.7	1.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0
Swine	1.1	0.7	0.7	0.7	0.2	0.2	0.3	0.3	0.2	0.2
Total	100	100	100	100	100	100	100	100	100	100

Tier 2

According to *IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* (farther referred as IPCC GPG), if enteric fermentation is a key source category, for the animal categories that represent a large portion of the country's total emissions the Tier 2 approach should be used. In 2010-2015 methane emissions from cattle constitute about 90% of total methane emissions from "Enteric fermentation" (see Table 4.9). Consequently, for this category tier 2 approach is used.

Methodology: Tier 2 represents more complicated approach, which requires detailed characteristics of cattle (breed, age, weight, milk production, birth and etc.). Emission factor for each selected animal category (type) will be assessed based on these data. Afterwards, emissions are calculated for each group of cattle by multiplying a population of cattle (grouping is made according to breed and age) with corresponding emission factor and summing up calculated emissions.

Activity Data: Methane emissions from enteric fermentation in cattle depends on cattle characteristics. Cattle by age have been classified based on the scientific information from the experts in zoological veterinary. The classification has been performed separately for early maturing and late maturing breeds as their growth characteristics are different. The parameters have been selected based on the following information:

1. Early maturing cattle bring first calf at 3 years of age, cattle 5 years of age are considered to be mature. Late maturing cattle deliver first calf at 4 years of age and are considered mature from 6 years of age. Cattle's average lifetime equals to 15 years;
2. A cow's gestation period lasts 9 months, Lactation period 12 months and dry period 2 months;
3. Ratio female to male equals to 50:50. According to Genetics in cattle, generally similar in all animals, the sex heredity is equal;
4. In Georgia the consumption of calf veal traditionally is high, so that the slaughter percentage is correspondingly higher.

In tables 4-10 - 4-11 cattle distribution by age is presented.

Table 4-10. Late Maturing Cattle Population / Distribution by Age

Cattle category	Age, year	Population, thousand heads									
		Georgian mountain / Red Mingrelian									
		1990	1994	2000	2005	2010	2011	2012	2013	2014	2015
Calf – females	0-1	61.8	43.1	54.0	54.7	49.1	49.1	51.7	54.7	59.0	60.9
Heifer	1-2	47.9	33.4	41.8	42.4	38.0	38.1	40.1	42.4	45.7	47.2
Heifer	2-3	42.7	29.8	37.3	37.8	33.9	34.0	35.7	37.8	40.8	42.1
Heifer	3-4	41.8	29.2	36.5	37.0	33.2	33.2	35.0	37.0	39.9	41.2
Cow	4-5	18.0	12.6	15.8	16.0	14.3	14.3	15.1	16.0	17.2	17.8
Lactating cow	4-5	19.5	13.6	17.1	17.3	15.5	15.5	16.3	17.3	18.6	19.2
Cow	5-6	17.0	11.9	14.9	15.0	13.5	13.5	14.2	15.1	16.2	16.7
Lactating cow	5-6	18.4	12.8	16.1	16.3	14.6	14.6	15.4	16.3	17.5	18.1
Cow	>6	144.8	101.0	126.4	128.1	114.9	115.0	121.0	128.2	138.2	142.5
Lactating cow	>6	71.4	49.8	62.3	63.1	56.6	56.7	59.7	63.2	68.1	70.2
Calf – males	0-1	19.1	13.3	16.7	16.9	15.1	15.2	15.9	16.9	18.2	18.8
Bullock	1-2	16.8	11.7	14.7	14.8	13.3	13.3	14.0	14.9	16.0	16.5

Cattle category	Age, year	Population, thousand heads									
		Georgian mountain / Red Mingrelian									
		1990	1994	2000	2005	2010	2011	2012	2013	2014	2015
Bullock	2-3	13.4	9.4	11.7	11.9	10.7	10.7	11.2	11.9	12.8	13.2
Bullock	3-4	11.1	7.8	9.7	9.9	8.8	8.9	9.3	9.9	10.6	11.0
Bull (castrate)	4-5	4.6	3.2	4.0	4.1	3.6	3.7	3.8	4.1	4.4	4.5
Bull (castrate)	5-6	3.7	2.6	3.2	3.3	2.9	2.9	3.1	3.3	3.5	3.6
Bull (castrate)	>6	2.3	1.6	2.0	2.0	1.8	1.8	1.9	2.0	2.2	2.3
Total		**529.5**	**554.4**	**386.9**	**484.2**	**490.4**	**440.0**	**440.5**	**463.5**	**490.9**	**529.1**

Table 4-11: Early Maturing Cattle Population / Distribution by Age

Cattle category	Age, year	Population, thousand heads									
		Early maturing									
		1990	1994	2000	2005	2010	2011	2012	2013	2014	2015
Calf – females	0-1	37.4	26.1	32.7	33.1	29.7	29.8	31.3	33.2	35.7	36.9
Heifer	1-2	32.7	22.8	28.6	29.0	26.0	26.0	27.4	29.0	31.2	32.2
Heifer	2-3	29.8	20.8	26.0	26.3	23.6	23.6	24.9	26.3	28.4	29.3
Cow	3-4	11.7	8.2	10.2	10.4	9.3	9.3	9.8	10.4	11.2	11.5
Lactating cow	3-4	12.6	8.8	11.0	11.2	10.0	10.0	10.6	11.2	12.1	12.4
Cow	4-5	12.4	8.7	10.8	11.0	9.9	9.9	10.4	11.0	11.8	12.2
Lactating cow	4-5	13.4	9.4	11.7	11.9	10.7	10.7	11.2	11.9	12.8	13.2
Cow	>5	63.2	44.1	55.2	55.9	50.2	50.2	52.8	55.9	60.3	62.2
Lactating cow	>5	31.1	21.7	27.2	27.5	24.7	24.7	26.0	27.6	29.7	30.6
Calf – males	0-1	12.1	8.4	10.5	10.7	9.6	9.6	10.1	10.7	11.5	11.9
Bullock	1-2	8.4	5.9	7.3	7.4	6.7	6.7	7.0	7.4	8.0	8.3
Bullock	2-3	6.3	4.4	5.5	5.6	5.0	5.0	5.3	5.6	6.0	6.2
Bull (castrate)	3-4	3.0	2.1	2.6	2.6	2.4	2.4	2.5	2.6	2.9	2.9
Bull (castrate)	4-5	1.6	1.1	1.4	1.4	1.3	1.3	1.3	1.4	1.5	1.6
Bull (castrate)	>5	1.4	1.0	1.2	1.2	1.1	1.1	1.2	1.2	1.3	1.4
Total		**277.2**	**193.5**	**242.1**	**245.2**	**220.0**	**220.2**	**231.8**	**245.5**	**264.6**	**272.9**

Emission factor: Emission Factors for this category were calculated as described in the IPCC GPG - Tier 2 approach, which uses the following formula:

To estimate CH_4 Emission Factor for enteric fermentation from cattle equation 10.21 from 2006 IPCC is used:

$$EF = [GE \bullet (Y_m / 100) \bullet 365) / 55.65]$$

Where:

EF emission factor, kg CH4/head/year

GE gross energy intake, MJ/head/day

Ym methane conversion factor, per cent of gross energy in feed converted to methane. Default value for Eastern Europe $Y_m = 0.065$ is used (IPCC 2006, Chapter 10, p.10.72, table 10A.2).

The factor 55.65 (MJ/kg CH4) is the energy content of methane

For GE equation 10.16 from 2006 IPCC is used

$$GE = [(NE_m + NE_a + NE_l + NE_{work} + NE_p) / REM) + (NE_g / REG)] / (DE/100)$$

Where:

GE gross energy, MJ/day

NE_m Net energy for maintenance (MJ/day). $NE_m = Cf_i \bullet (weight)0^{.75}$. $Cf_i = 0.322$ for non- lactating cattle and $Cf_i = 0.386$ for lactating cattle (2006 IPCC, p.10.16, table 10.4).

NE_a Net energy for animal activity (MJ/day). $NE_a = C_a \bullet NE_m$. C_a coefficient corresponds to animal feeding conditions. In Georgia cattle usually grazes on pastures and hilly areas hence wasting much of the energy in feeding. According to 2006 IPCC, p.10.17, Table 10.5 in these conditions $C_a = 0.36$.

NE_l Net energy for lactation (MJ/day). NE_l=daily milk amount$\bullet$(1.47+0.40$\bullet$fattiness) 2006 IPCC, p.10.18, equation 10.8). Daily milk means daily milk production. Fattiness is fatt content of milk (%)

NE_{work} Net energy for work, MJ/day. $NE_w = 0.10 \bullet NE_m \bullet$ hours of work per day (2006 IPCC, p.10.11, equation 10.11). It was assumed that bulls are working for 1 hour per day.

NE_p Net energy required for pregnancy (MJ/day). $NE_p = C_{pregnancy} \bullet NE_m$ (p.10.20, Equation 10.13), $C_{pregnancy}$ is pregnancy coefficient. For cattle $C_{pregnancy} = 0.1$ (2006 IPCC, p.10.20, table 10.7).

REM ratio of net energy available in a diet for maintenance to digestible energy consumed $REM = 1.123 - (4.092 \bullet 10^{-3} \bullet DE) + [1.126 \bullet 10^{-5} \bullet (DE)^2] - (25.4/DE)$, (2006 IPCC, p.10.20, Equation 10.14)

DE% digestible energy expressed as a percentage of gross energy. Based on estimates for the former USSR, default value DE =60% (IPCC 2006, Chapter 10, p.10.72, table 10A.1) is used.

NE_g net energy needed for growth, MJ day-1.

$NE_g = 22.02 \bullet [(BW/(C \bullet MW)] \bullet WG^{1.097}$ (2006 IPCC, p.10.17, equation 10.6)

C=0.8 for females and C=1.2 for bulls (2006 IPCC, P.10.17).

BW body mass of mature animal (kg)

WG daily weight gain (kg/day).

REG Ratio of net energy available for growth in a diet to digestible energy consumed.

$REG = 1.164 - (5.160 \bullet 10^{-3} \bullet DE) + [1.308 \bullet 10^{-5} \bullet (DE)^2] - (37.4/DE)$ consumed (IPCC 2006, Chapter 10, p.10.21, Eq. 10.15)

Activity Data: Necessary data for calculations is given in tables 4-12 – 4-14.

Table 4-12. Females Live-Weight Standards

Breed	Live weight by moths, kg														
	Newborn	6	7	8	9	10	12	15	18	24	30	36	48	60	72
Georgian Mountain	13	55	60	70	80	85	100	115	130	135	157	169	180	200	210
Red Mingrelian	15	75	85	95	105	115	130	160	190	200	217	234	250	280	300
Early maturing	32	152	168	187	203	220	250	297	345	397	420	443	487	520	520

Table 4-13. Males Live-Weight Standards

Breed	Live weight by moths, kg														
	Newborn	6	7	8	9	10	12	15	18	24	30	36	48	60	72
Georgian Mountain	13	60	65	75	85	95	110	140	160	190	220	255	290	320	320
Red Mingrelian	15	80	90	100	110	125	160	200	210	310	350	390	460	480	480
Early maturing	32	170	195	225	240	263	310	385	458	543	613	693	773	820	820

Table 4.14: Average Milk Production and Average Fat Content for Cows

Breed	Fat, %	Milk production kg							
		Averaged in herd		1st lactation		2nd lactation		3rd and more lactation	
		Per year	Per day	Per year	Per day	Per year	Per day	Per year	Per day
Georgian Mountain	4.3	1,358	3.7	1,228	3.4	1,302	3.6	1,376	3.8
Red Mingrelian	4.3	1,460	4.0	1,047	2.9	1,269	3.5	1,491	4.1
Early maturing	3.7	2,610	7.1	2,349	6.4	2,597	7.1	2,845	7.8

Emission Factors: The calculated Emission Factors for cattle are given in table 4-15.

Table 4-15. Estimated Methane Emission Factors

Cattle category	Age, year	Emission factor, kgCH$_4$/head	
		Georgian mountain	Red Mingrelian
Calf – females	0-1	13	16
Heifer	1-2	29	40
Heifer	2-3	34	43
Heifer	3-4	34	44
Cow	4-5	37	49
Lactating cow	4-5	52	61
Cow	5-6	38	50
Lactating cow	5-6	53	66
Cow	>6	37	49
Lactating cow	>6	53	65
Calf – males	0-1	13	17

Cattle category	Age, year	Emission factor, kgCH$_4$/head
		Early maturing
Calf – females	0-1	28
Heifer	1-2	70
Heifer	2-3	70
Cow	3-4	74
Lactating cow	3-4	90
Cow	4-5	77
Lactating cow	4-5	94
Cow	>5	74
Lactating cow	>5	94
Calf – males	0-1	30
Bullock	1-2	85

Cattle category	Age, year	Emission factor, kgCH_4/head	
		Georgian mountain	Red Mingrelian
Bullock	1-2	36	53
Bullock	2-3	45	63
Bullock	3-4	49	71
Bull (castrate)	4-5	56	76
Bull (castrate)	5-6	55	75
Bull (castrate)	>6	55	65

Cattle category	Age, year	Emission factor, kgCH_4/head
		Early maturing
Bullock	2-3	101
Bull (castrate)	3-4	112
Bull (castrate)	4-5	114
Bull (castrate)	>5	111

Emissions: The calculation of emissions from the slaughtered cattle (estimating emissions since beginning of considered year up to slaughtering) is based on the following rough assumption: the slaughter took place on the average at the middle of the year and emission factor for the slaughtered cattle is equal to a half of the emission factor for this year. The estimated emissions from cattle are given in tables 4-16 - 4-18.

Table 4-16. Estimated Methane Emissions from Late Maturing Cattle (Georgian mountain)

Cattle category	Age, year	Emissions, GgCH_4									
		Georgian mountain									
		1990	1994	2000	2005	2010	2011	2012	2013	2014	2015
Calf – females	0-1	0.80	0.56	0.70	0.71	0.64	0.64	0.67	0.71	0.77	0.79
Heifer	1-2	1.39	0.97	1.21	1.23	1.10	1.10	1.16	1.23	1.33	1.37
Heifer	2-3	1.45	1.01	1.27	1.29	1.15	1.15	1.22	1.29	1.39	1.43
Heifer	3-4	1.42	0.99	1.24	1.26	1.13	1.13	1.19	1.26	1.36	1.40
Cow	4-5	0.67	0.47	0.58	0.59	0.53	0.53	0.56	0.59	0.64	0.66
Lactating cow	4-5	1.02	0.71	0.89	0.90	0.81	0.81	0.85	0.90	0.97	1.00
Cow	5-6	0.65	0.45	0.56	0.57	0.51	0.51	0.54	0.57	0.62	0.64
Lactating cow	5-6	0.97	0.68	0.85	0.86	0.77	0.77	0.81	0.86	0.93	0.96
Cow	>6	5.36	3.74	4.68	4.74	4.25	4.26	4.48	4.74	5.11	5.27
Lactating cow	>6	3.78	2.64	3.30	3.34	3.00	3.00	3.16	3.35	3.61	3.72
Calf – males	0-1	0.25	0.17	0.22	0.22	0.20	0.20	0.21	0.22	0.24	0.24
Bullock	1-2	0.60	0.42	0.53	0.53	0.48	0.48	0.50	0.53	0.58	0.59
Bullock	2-3	0.60	0.42	0.53	0.54	0.48	0.48	0.51	0.54	0.58	0.60
Bullock	3-4	0.55	0.38	0.48	0.48	0.43	0.43	0.46	0.48	0.52	0.54
Bull (castrate)	4-5	0.26	0.18	0.22	0.23	0.20	0.20	0.22	0.23	0.25	0.25
Bull (castrate)	5-6	0.20	0.14	0.18	0.18	0.16	0.16	0.17	0.18	0.19	0.20
Bull (castrate)	>6	0.13	0.09	0.11	0.11	0.10	0.10	0.11	0.11	0.12	0.12
Total		**20.1**	**14.0**	**17.6**	**17.8**	**16.0**	**16.0**	**16.8**	**17.8**	**19.2**	**19.8**

Table 4-17. Estimated Methane Emissions From Late Maturing Cattle (Red Mingrelian)

Cattle category	Age, year	Emissions, GgCH_4									
		Red Mingrelian									
		1990	1994	2000	2005	2010	2011	2012	2013	2014	2015

Cattle category	**Age, year**	**Emissions, $GgCH_4$**									
		Red Mingrelian									
		1990	**1994**	**2000**	**2005**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Calf – females	0-1	0.99	0.69	0.86	0.87	0.79	0.79	0.83	0.88	0.94	0.97
Heifer	1-2	1.92	1.34	1.67	1.70	1.52	1.52	1.60	1.70	1.83	1.89
Heifer	2-3	1.84	1.28	1.61	1.63	1.46	1.46	1.54	1.63	1.75	1.81
Heifer	3-4	1.84	1.28	1.61	1.63	1.46	1.46	1.54	1.63	1.76	1.81
Cow	4-5	0.88	0.62	0.77	0.78	0.70	0.70	0.74	0.78	0.84	0.87
Lactating cow	4-5	1.19	0.83	1.04	1.05	0.95	0.95	1.00	1.06	1.14	1.17
Cow	5-6	0.85	0.59	0.74	0.75	0.67	0.68	0.71	0.75	0.81	0.84
Lactating cow	5-6	1.21	0.85	1.06	1.07	0.96	0.96	1.01	1.07	1.16	1.19
Cow	>6	7.09	4.95	6.20	6.27	5.63	5.64	5.93	6.28	6.77	6.98
Lactating cow	>6	4.64	3.24	4.05	4.10	3.68	3.68	3.88	4.11	4.43	4.57
Calf – males	0-1	0.32	0.23	0.28	0.29	0.26	0.26	0.27	0.29	0.31	0.32
Bullock	1-2	0.89	0.62	0.78	0.79	0.71	0.71	0.74	0.79	0.85	0.88
Bullock	2-3	0.85	0.59	0.74	0.75	0.67	0.67	0.71	0.75	0.81	0.83
Bullock	3-4	0.79	0.55	0.69	0.70	0.63	0.63	0.66	0.70	0.76	0.78
Bull (castrate)	4-5	0.35	0.24	0.31	0.31	0.28	0.28	0.29	0.31	0.33	0.34
Bull (castrate)	5-6	0.28	0.19	0.24	0.24	0.22	0.22	0.23	0.24	0.26	0.27
Bull (castrate)	>6	0.15	0.10	0.13	0.13	0.12	0.12	0.12	0.13	0.14	0.15
Total		**26.1**	**18.2**	**22.8**	**23.1**	**20.7**	**20.7**	**21.8**	**23.1**	**24.9**	**25.7**

Table 4.18: Estimated Methane Emissions from Early Maturing Cattle

Cattle category	**Age, year**	**Emissions, $GgCH_4$**									
		Early maturing									
		1990	**1994**	**2000**	**2005**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Calf – females	0-1	1.05	0.73	0.92	0.93	0.83	0.83	0.88	0.93	1.00	1.03
Heifer	1-2	2.29	1.60	2.00	2.03	1.82	1.82	1.92	2.03	2.19	2.26
Heifer	2-3	2.08	1.45	1.82	1.84	1.65	1.65	1.74	1.84	1.99	2.05
Cow	3-4	0.87	0.61	0.76	0.77	0.69	0.69	0.72	0.77	0.83	0.85
Lactating cow	3-4	1.14	0.79	0.99	1.01	0.90	0.90	0.95	1.01	1.09	1.12
Cow	4-5	0.96	0.67	0.83	0.84	0.76	0.76	0.80	0.85	0.91	0.94
Lactating cow	4-5	1.26	0.88	1.10	1.12	1.00	1.00	1.06	1.12	1.21	1.24
Cow	>5	4.68	3.26	4.08	4.14	3.71	3.71	3.91	4.14	4.46	4.60
Lactating cow	>5	2.93	2.04	2.56	2.59	2.32	2.33	2.45	2.59	2.79	2.88
Calf – males	0-1	0.36	0.25	0.32	0.32	0.29	0.29	0.30	0.32	0.35	0.36
Bullock	1-2	0.71	0.50	0.62	0.63	0.57	0.57	0.60	0.63	0.68	0.70
Bullock	2-3	0.64	0.45	0.56	0.56	0.51	0.51	0.53	0.57	0.61	0.63
Bull (castrate)	3-4	0.33	0.23	0.29	0.30	0.27	0.27	0.28	0.30	0.32	0.33
Bull (castrate)	4-5	0.18	0.13	0.16	0.16	0.15	0.15	0.15	0.16	0.17	0.18
Bull (castrate)	>5	0.15	0.11	0.13	0.14	0.12	0.12	0.13	0.14	0.15	0.15
Total		**19.5**	**13.6**	**17.0**	**17.2**	**15.5**	**15.5**	**16.3**	**17.2**	**18.6**	**19.2**

Methane emissions from enteric fermentation in cattle estimated by tier 2 approach are presented in summary table 4-19.

Table 4-19. Methane emissions (Gg) from enteric fermentation by cattle (Tier 2)

Breed	**Methane emissions**									
	1990	**1994**	**2000**	**2005**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Early maturing	19.5	13.6	17.0	17.2	15.5	15.5	16.3	17.2	18.6	19.2
Georgian Mountain	20.1	14.0	17.6	17.8	16.0	16.0	16.8	17.8	19.2	19.8
Red Mingrelian	26.1	18.2	22.8	23.1	20.7	20.7	21.8	23.1	24.9	25.7
Total, Gg CH_4	**65.7**	**45.8**	**57.3**	**58.1**	**52.1**	**52.2**	**54.9**	**58.1**	**62.7**	**64.6**
Total, Gg CO_2eq	1,379	**962**	**1,204**	**1,220**	**1,094**	**1,095**	**1,153**	**1,221**	**1,316**	**1,357**

Table 4-20. Methane emissions (Gg) from enteric fermentation in livestock (Tier 2 for cattle, for other livestock Tier 1)

Breed	**Methane emissions**									
	1990	**1994**	**2000**	**2005**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Cattle	65.7	45.8	57.3	58.1	52.1	52.2	54.9	58.1	62.7	64.6
Buffalo	2.1	1.3	1.4	1.3	0.9	0.9	0.9	1.0	0.7	0.9
Sheep	7.7	3.8	2.7	3.6	3.0	2.9	3.4	4.0	4.3	4.2
Goats	0.3	0.2	0.4	0.5	0.3	0.3	0.3	0.3	0.3	0.2
Horses	0.4	0.4	0.6	0.8	0.0	0.0	0.0	0.0	0.0	0.0
Swine	0.9	0.4	0.4	0.5	0.1	0.1	0.2	0.2	0.2	0.2
Total in Gg CH_4	**77.1**	**51.8**	**62.9**	**64.7**	**56.4**	**56.4**	**59.8**	**63.6**	**68.1**	**70.1**
Total in Gg CO_2eq	**1,619**	**1,088**	**1,321**	**1,358**	**1,185**	**1,184**	**1,255**	**1,336**	**1,430**	**1,472**

Methane emissions estimated applying tier 1 and tier 2 approaches are compared. Results are presented in table 4.21. According to this table tier 2 approach leads to insignificantly less emissions than tier 1.

Table 4-21. Comparison of estimated methane emissions per tier 1 and tier 2 approaches

Approach	**Source**	**1990**	**1994**	**2000**	**2005**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Tier 1	Emissions from Cattle in Gg CH_4	68.2	47.6	59.6	60.3	54.1	54.2	57.0	60.4	65.1	67.1
Tier 2		65.7	45.8	57.3	58.1	52.1	52.2	54.9	58.1	62.7	64.6
Difference		-4%	-4%	-4%	-4%	-4%	-4%	-4%	-4%	-4%	-4%
Tier 1	Emissions from Livestock in Gg CH_4	79.6	53.6	65.1	66.9	58.4	58.4	61.9	65.9	70.5	72.6
Tier 2		77.1	51.8	62.9	64.7	56.4	56.4	59.8	63.6	68.1	70.1
Difference		-3%	-3%	-3%	-3%	-3%	-3%	-3%	-3%	-3%	-3%

4.3 Manure Management

During the handling or storage of livestock manure, both CH_4 and N_2O are emitted. The magnitude of the emissions depends upon the quantity of manure handled, the manure properties, and the type of manure management system. Typically, poorly aerated manure management systems generate large quantities of CH_4 but smaller amounts of N_2O, while well-aerated systems generate little CH_4 but more N_2O.

4.3.1 Methane Emissions from Manure Management

Shortly after manure is excreted, it begins to decompose. If little oxygen is present, the decomposition will be mainly anaerobic and thus produces CH_4. The quantity of CH_4 produced depends on the type of waste management system, in particular, the amount of aeration, and the quantity of manure.

Tier 1: Methane emissions from manure management are estimated using the IPCC Tier 1 approach that relies on default Emission Factors.

Activity Data: The animal population data are the same as those used for the Enteric Fermentation emission estimates (Tables 4.6-4.7).

Emission Factors: Emission Factors for late maturing cattle, buffalo and swine were taken according to default values for Asia region [IPCC 2006, Volume 4, p. 10.38-10.39, table 10.14], while for early maturing cattle default values for Eastern European region were used. For other types of animals Emission Factors are taken according to default values for developing countries with Temperate from 15 to 25°C (temperate climate) are used [IPCC 2006, Volume 4: Agriculture, Forestry and Other Land Use, p. 10.40, table 10.15].

CH_4 Emission Factors for livestock categories are presented in Table 4-22.

Emissions: Calculated methane emissions from manure management are presented in table 4-22.

Table 4-22. Methane Emissions from Manure Management (Tier 1)

Animal category	Population, thousand heads										Emission Factor kgCH4/head	Emission, GgCH_4									
	1990	**1994**	**2000**	**2005**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**		**1990**	**1994**	**2000**	**2005**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Late maturing cattle	1,109	774	968	981	880	881	927	982	1,058	1,092	1	1.11	0.77	0.97	0.98	0.88	0.88	0.93	0.98	1.06	1.09
Early maturing cattle	277	193	242	245	220	220	232	245	265	273	13	3.60	2.52	3.15	3.19	2.86	2.86	3.01	3.19	3.44	3.55
Buffalos	39	23	25	23	17	17	17	18	12	15	2	0.08	0.05	0.05	0.05	0.03	0.03	0.03	0.04	0.02	0.03
Sheep	1,550	754	547	720	597	577	688	796	866	842	0.15	0.23	0.11	0.08	0.11	0.09	0.09	0.10	0.12	0.13	0.13
Goats	68	39	81	96	57	54	55	61	54	50	0.17	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01
Horses	20	21	35	43	0	0	0	0	0	0	1.64	0.03	0.04	0.06	0.07	0.00	0.00	0.00	0.00	0.00	0.00
Swine	880	367	443	455	110	105	204	191	170	162	4	3.52	1.47	1.77	1.82	0.44	0.42	0.82	0.76	0.68	0.65
Poultry	21,760	12,290	7,826	7,482	6,522	6,360	6,159	6,761	6,658	8,309	0.02	0.44	0.25	0.16	0.15	0.13	0.13	0.12	0.14	0.13	0.17
Total												**9.0**	**5.2**	**6.2**	**6.4**	**4.4**	**4.4**	**5.0**	**5.2**	**5.5**	**5.6**
Total in GgCO2eq												**185**	**109**	**131**	**134**	**93**	**93**	**106**	**110**	**115**	**118**

Table 4-23. Share (%) of Animal Categories In Methane Emissions From Manure Management

Animal category	1990	1994	2000	2005	2010	2011	2012	2013	2014	2015
Late maturing cattle	12.3	14.9	15.5	15.4	19.8	19.9	18.4	18.7	19.3	19.4
Early maturing cattle	39.9	48.3	50.4	50.0	64.4	64.8	59.9	60.9	62.8	63.2
Buffalos	0.9	0.9	0.8	0.7	0.8	0.8	0.7	0.7	0.4	0.6
Sheep	2.6	2.2	1.3	1.7	2.0	2.0	2.1	2.3	2.4	2.2
Goats	0.1	0.1	0.2	0.3	0.2	0.2	0.2	0.2	0.2	0.2
Horses	0.4	0.7	0.9	1.1	0.0	0.0	0.0	0.0	0.0	0.0
Swine	40.0	28.2	28.4	28.5	9.9	9.5	16.3	14.6	12.4	11.5
Poultry	4.9	4.7	2.5	2.3	2.9	2.9	2.5	2.6	2.4	3.0
Total	100	100	100	100	100	100	100	100	100	100

4.3.2 Nitrous Oxide Emissions from Manure Management

4.3.2.1 Direct N_2O emissions from Manure Management

The production of N_2O during storage and treatment of animal waste occurs during nitrification and denitrification of nitrogen contained in the manure. Nitrification is the oxidation of ammonium (NH_4^+) to nitrate (NO_3^-), and denitrification is the reduction of (NO_3^-) to N_2O or nitrogen (N_2). Generally, as the degree of aeration of the waste increases, so does the amount of N_2O produced.

The Animal Waste Management System (AWMS) is an important regulating factor in N_2O emissions. N_2O emissions from some types of AWMS (Anaerobic lagoons; Liquid systems; Solid storage and drylot; and other systems) are reported under Manure Management, while stable manure that is applied to agricultural soils (e.g., daily spread) and dung and urine deposited by grazing animals on fields (pasture range and paddock) is referred in the methodology for estimating direct emissions from agricultural soils. Manure used for fuel is considered an energy-related emission.

Methodology: IPCC tier 1 method is used. Direct nitrous oxide emissions from manure management are estimated by multiplying the total amount of N excretion (from all livestock 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. IPCC default N_2O Emission Factors, default nitrogen excretion data, and default manure management system data are used.

The methodology is based on the following formulae:

$$N_2O_{D(mm)} = [\textstyle\sum_S [\sum_T (N_T \bullet Nex_{(T)} \bullet M_{(T,S)})] \bullet EF_{3(S)}] \bullet 44/28$$

Where:

N_T Number of head of livestock category T in the country

$Nex_{(T)}$ Annual average N excretion per head of species/category T in the country, kgN/animal/year

$MS_{(T,S)}$ Fraction of total annual nitrogen excretion for each livestock species/category T that is managed in manure management system S in the country, dimensionless

$EF_{3(S)}$ Emission factor for direct N_2O emissions from manure management system S in the country, kgN_2O-N/kg N in manure management system S.

S Manure management system

T Species/category of livestock

44/28 Conversion of N_2O-N emissions to N_2O emissions

Activity Data: Animal population data and distribution by categories are taken from table 4.7.

Emission Factors: The average daily nitrogen excretion rates for domestic animals are taken according to default values for Asia region [IPCC 2006, Chapter 10, p.10.59, Table 10.19], Presented in table 4-24 herd average weight for cattle was estimated based on cattle distribution by age (tables 4-10 - 4-11) and cattle weight by age (Tables 4-12, 4-13). Default values for other animals are used (IPCC 2006, Chapter 10, p.10.82, Table 10.A9). EF_3 are taken from the IPCC 2006 (Chapter 10, p.10.62, Table 10.21).

Table 4-24. Cattle Average Weight

Breed	Average weight, kg	Share in herd	Share In cattle average weight, kg
Georgian Mountain	255	0.4	69.8
Mingrelian Red	322	0.4	99.6
Early maturing	536	0.2	84.9
Cattle average weight, kg/ head			**338**

Table 4-25. Nitrogen Excretion Rate (Nex) for Animal Types

Animal	cattle	Poultry	Sheep	Goats	Swine	Buffalo	Horses	Donkeys
Weight, kg	338	0.9	28	30	28	380	238	130
Nex, kg/head/day/1000kg	0.34	1.1	1.17	1.37	0.42	0.32	0.46	0.46
Nex, kg/head/year	42	0.4	12	15	4.3	44.4	40	21.8

The fraction of nitrogen available for conversion into N_2O is estimated by applying system-specific values to the manure nitrogen handled by each management system. The IPCC default values for Asia region are used [IPCC 2006, Chapter 10, pp. 10.78-10.81, tables 10A-5-10A-8], with corrections based on the national agriculture expert judgment (table 4.26).

Table 4-26. Fraction of Manure Nitrogen in Different Management Systems

Animal	Anaerobic Lagoons	Liquid Systems	Solid Storage	Drylot	Daily Spread	Pasture Range and Paddock	Other systems
Cattle	-	-	-	0.46	0.02	0.50	0.02
Poultry	-	-	-	-	-	0.44	0.56
Sheep	-	-	-	-	-	0.83	0.17
Swine	-	-	-	0.54	-	-	0.46
Others	-	-	-	-	-	0.95	0.05

Only insignificant portion of manure nitrogen transforms into nitrous oxide. N_2O Emission Factors (kg N_2O-N/kg emitted nitrogen) for different manure management systems are given in table 4.26. IPCC Default values are used [IPCC 2006, Chapter 10, p.10.62, table 10.21].

Table 4-27. N_2O Emission Factors from Manure Management Systems (kg N_2O-N/kg emitted nitrogen)

AWMS	Anaerobic Lagoons	Liquid Systems	Solid Storage	Drylot	Daily Spread	Pasture Range and Paddock	Other systems
Emission factor - EF3	0	0.001	0.005	0.02	0.0	0.02	0.005

Emissions: Direct N_2O Emissions from different manure management systems are given in Table 4-27.

Table 4-27. Direct N_2O Emissions (Gg) from Manure Management Systems

	Nex, kg/h/yr	Share, MS	EF_3, N_2O/N	1990	1994	2000	2005	2010	2011	2012	2013	2014	2015
Dry lot													
Cattle	42	0.46	0.02	0.536	0.374	0.468	0.474	0.425	0.425	0.448	0.474	0.511	0.527
Swine	4.3	0.54	0.02	0.041	0.017	0.021	0.021	0.005	0.005	0.009	0.009	0.008	0.007

	Nex, kg/h/yr	Share, MS	EF3, N2O/N	1990	1994	2000	2005	2010	2011	2012	2013	2014	2015
Other systems													
Cattle	42	0.02	0.005	0.006	0.004	0.005	0.005	0.005	0.005	0.005	0.005	0.006	0.006
Buffalos	44.4	0.05	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Sheep	12.0	0.17	0.005	0.016	0.008	0.006	0.007	0.006	0.006	0.007	0.008	0.009	0.009
Goats	15.0	0.05	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Swine	4.3	0.46	0.005	0.009	0.004	0.004	0.004	0.001	0.001	0.002	0.002	0.002	0.002
Poultry	0.4	0.56	0.005	0.022	0.012	0.008	0.008	0.007	0.006	0.006	0.007	0.007	0.008
Total, Gg N_N2O				**0.629**	**0.419**	**0.512**	**0.520**	**0.449**	**0.449**	**0.478**	**0.505**	**0.542**	**0.559**
Total, Gg N_2O				**0.99**	**0.66**	**0.80**	**0.82**	**0.71**	**0.71**	**0.75**	**0.79**	**0.852**	**0.88**
Total, Gg CO_2eq				**307**	**204**	**249**	**253**	**219**	**219**	**233**	**246**	**264**	**273**

Indirect N_2O Emissions from Manure Management

Indirect emissions result from volatile nitrogen losses that occur primarily in the forms of ammonia (NH_3) and nitrogen oxides (NO_x). Nitrogen losses begin at the point of excretion in housings and other animal production areas.

Methodology

Tier 1 method is used. Calculation of N volatilization in forms of NH3 and NOx from manure management systems is based on multiplication of the amount of nitrogen excreted (from all livestock categories) and managed in each manure management system by a fraction of volatilized nitrogen (see Equation 10.26). N losses are then summed over all manure management systems. The Tier 1 method is applied using default nitrogen excretion data, default manure management system data (**see Annex 10A.2, Tables 10A-4 to 10A-**8) and default fractions of N losses from manure management systems due to volatilization **(see Table 10.22).**

According to the IPCC 2006, due to extremely limited measurement data on leaching and runoff losses from various manure management systems, "estimation of N losses from leaching and runoff from manure management should be considered part of a Tier 2 or Tier 3 method".

N losses due to volatilization from manure management are estimated using formula

$$N_{volatalization\text{-}MMs} = [\textstyle\sum_S [\sum_T (N_{(T)} \bullet Nex_{(T)} \bullet MS_{(T,S)})_T \bullet (Frac_{GasMS}/100)_{(T,S)}]$$

Where:

$N_{volatalization\text{-}MMs}$	amount of manure nitrogen that is lost due to volatilisation of NH3 and NOx, kg N yr-1
$N_{(T)}$	number of head of livestock species/category T in the country
$Nex_{(T)}$	annual average N excretion per head of species/category T in the country, kg N animal^{-1} yr^{-1}
$MS_{(T,S)}$	fraction of total annual nitrogen excretion for each livestock species/category T that is managed in manure management system S in the country, dimensionless
$Frac_{GasMS}$	percent of managed manure nitrogen for livestock category T that volatilises as NH_3 and NO_x in the manure management system S, %

$$N_2O_{G(mm)} = (N_{volatalization\text{-}MMs} \bullet EF_4) \bullet 44/28$$

Where:

$N_2O_{G(mm)}$ indirect N_2O emissions due to volatilization of N from Manure Management in the country, kg N_2O/year

EF_4 emission factor for N_2O emissions from atmospheric deposition of nitrogen on soils and water surfaces, kg N_2O-N (kg NH_3-N + NO_x-N volatilised).

Activity Data: Animal population data and distribution by categories are taken from table 4.7.

Emission Factors: $MS_{(T,S)}$ and $Nex_{(T)}$ are presented in tables 4.24 and 4.25. For EF_3 default values are used [IPCC 2006, Chapter 11, p.11.24, Table 11.3]. Fracgasm values are taken from IPCC 2006, Chapter 10, p.10.65, Table 10.22.

Emissions

Indirect N_2O Emissions from different manure management systems are given in Table 4.29.

Table 4-28. Indirect N_2O Emissions from Manure Management

	Nex kg/h/yr	FracGasm %	Share MS	EF_3 N_2O/N	1990	1994	2000	2005	2010	2011	2012	2013	2014	2015
Dry lot														
Cattle	42.0	40	0.46	0.02	0.107	0.075	0.094	0.095	0.085	0.085	0.090	0.095	0.102	0.105
Swine	4.3	25	0.54	0.01	0.010	0.004	0.005	0.005	0.001	0.001	0.002	0.002	0.002	0.002
Others														
Cattle	42.0	40	0.02	0.02	0.005	0.003	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.005
Buffalos	44.4	20	0.05	0.01	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Sheep	12.0	25	0.17	0.01	0.008	0.004	0.003	0.004	0.003	0.003	0.003	0.004	0.004	0.004
Goats	15.0	20	0.05	0.01	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Swine	4.3	25	0.46	0.02	0.009	0.004	0.004	0.004	0.001	0.001	0.002	0.002	0.002	0.002
Poultry	0.4	20	0.56	0.02	0.004	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.002
Total, Gg N					**0.143**	**0.092**	**0.112**	**0.114**	**0.096**	**0.095**	**0.103**	**0.109**	**0.116**	**0.120**
Total, Gg N_2O					**0.23**	**0.15**	**0.18**	**0.18**	**0.15**	**0.15**	**0.16**	**0.17**	**0.183**	**0.19**
Total, Gg CO_2eq					**70**	**45**	**54**	**56**	**47**	**46**	**50**	**53**	**57**	**58**

4.4 Agricultural Soils

Nitrous oxide emissions from agricultural soils consist of direct and indirect sources. Direct source emissions result from nitrogen that has entered the soil from synthetic fertilizer, nitrogen from animal manure, nitrogen from crop residue decomposition and nitrogen deposited by grazing animals on fields (pasture range and paddock). Emissions from indirect sources are emitted off site through volatilization and leaching of synthetic fertilizer and manure nitrogen.

4.4.1 Direct N_2O Emissions from Managed Soil

N_2O direct emissions from soils (kg N/year) are calculated by following formula:

$$N_2O_{Direct}\text{-}N = N_2O\text{-}N_{\ inputs} + N_2O\text{-}N_{OS} + N_2O\text{-}N_{PRP}$$

$$N_2O\text{-}N_{\ inputs} = [(F_{SN} + F_{ON} + F_{CR} + F_{SOM}) \bullet EF_1] + [(F_{SN} + F_{ON} + F_{CR} + F_{SOM})_{RF} \bullet EF_{1FR}$$

$$N_2O\text{–}N_{OS} = [(F_{OS,CG,Temp} \bullet EF_{2CG,Temp}) + (F_{OS,CG,Trop} \bullet EF_{2CG,Trop}) +$$

$$(F_{OS,CG,Temp,NR} \bullet EF_{2CG,Temp,NR}) \bullet EF_{2F,Temp,NR}) + (F_{OS,CG,Trop} \bullet EF_{2CG,Trop}) + (F_{OS,F,Trop} \bullet EF_{2F,Trop})]$$

$$N_2O\text{–}N_{PRP} = [(F_{PRP,CPP} \bullet EF_{3PRP,CPP}) + (F_{PRP,SO} \bullet EF_{3PRP,SO})]$$

Notes:

the subscripts CG, F, Temp, Trop, NR and NP refer to Cropland and Grassland, Forest Land, Temperate, Tropical, Nutrient Rich, and Nutrient Poor respectively

The subscripts CPP and SO refer to Cattle, Poultry and Pigs, and Sheep and other animals, respectively

The subscripts CPP and SO refer to Cattle, Poultry and Pigs, and Sheep and Other animals, respectively

The subscripts CG, F, Temp, Trop, NR and NP refer to Cropland and Grassland, Forest Land, Temperate, Tropical, Nutrient Rich, and Nutrient Poor, respectively

Where:

N_2O_{Direct} –N	annual direct N_2O–N emissions produced from managed soils, kg N_2O–N/year
N_2O–$N_{N\ inputs}$	annual direct N_2O–N emissions from N inputs to managed soils, kg N_2O–N/year
N_2O–N_{OS}	annual direct N_2O–N emissions from managed organic soils, kg N_2O–N/year
N_2O–N_{PRP}	annual direct N_2O–N emissions from urine and dung inputs to grazed soils, kgN_2O–N/year
F_{SN}	annual amount of synthetic fertiliser N applied to soils, kg N/year
F_{ON}	annual amount of animal manure, compost, sewage sludge and other organic N additions applied to soils, kg N/year
F_{CR}	annual amount of N in crop residues (above-ground and below-ground), including N-fixing crops, and from forage/pasture renewal, returned to soils, kg N/year
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 or management, kgN/year
F_{OS}	annual area of managed/drained organic soils, ha
F_{PRP}	annual amount of urine and dung N deposited by grazing animals on pasture, range and paddock, kg N/year
EF_1	emission factor for N_2O emissions from N inputs, kg N_2O–N/(kg N input)
EF_{1FR}	emission factor for N_2O emissions from N inputs to flooded rice, kg N_2O–N/(kg N input)
EF_2	emission factor for N_2O emissions from drained/managed organic soils, kg N_2O –N/ha/year
EF_{3PRP}	emission factor for N_2O emissions from urine and dung N deposited on pasture, range and paddock by grazing animals, kg N_2O–N/(kg N input)

4.4.1.1 Synthetic Nitrogen Fertilizers

Synthetic fertilizers add large quantities of nitrogen to agricultural soils. This added nitrogen undergoes nitrification and denitrification, and releases N_2O. Emission rates associated with fertilizer application will depend on many factors such as the quantity and type of nitrogen fertilizers, crop types, soil types, climate and other environmental conditions.

Methodology: Tier 1 approach is used. N_2O emissions are calculated by multiplying fertilizer consumption by the non-volatilized fraction (available for nitrification and denitrification) and by an emission factor:

$$N_2O_{SN} = F_{SN} \bullet EF_1$$

Where:

F_{SN} annual amount of synthetic fertilizer N applied to soils, kg N/year

EF_1 emission factor for N_2O emissions from N inputs, kg N_2O–N/kg N input

According to the IPCC 2006, for the Tier 1 approach, the amount of applied mineral nitrogen fertilizer is not adjusted for the amounts of NH_3 and NO_x volatilization after application to soil. This is a change from the methodology described in the 1996 IPCC Guidelines.

Activity Data: Data on applied to soil synthetic N fertilizers are provided by the National Statistics Office of Georgia. Data on applied to soil Synthetic N is presented in table 4-29.

Emission factor: The IPCC default emission factor EF_1=0.01 kgN_2O-N/kgN is used (IPCC 2006, Volume 4, Chapter 11, page 11.11, table 11.1).

Emissions: N_2O emissions from synthetic fertilizers applied to soil are presented in table 4-29.

Table 4-29. N_2O Direct Emissions from Synthetic Fertilizer N Applied to Soils

	1990	1994	2000	2005	2010	2011	2012	2013	2014	2015
Synthetic fertilizer N applied to soil, Gg	60.8	31.1	47.5	46.2	50.2	43.3	49.5	64.6	50.8	49.9
EF1, kgN2O-N/KgN2O	0.0125	0.0125	0.0125	0.0125	0.0125	0.0125	0.0125	0.0125	0.0125	0.0125
Amount of N input, Gg N	0.76	0.39	0.59	0.58	0.63	0.54	0.62	0.81	0.64	0.62
GHG emission, Gg N_2O	**1.19**	**0.61**	**0.93**	**0.91**	**0.99**	**0.85**	**0.97**	**1.27**	**1.00**	**0.98**
GHG emission, Gg CO_2	**370**	**189**	**289**	**281**	**306**	**264**	**301**	**393**	**309**	**304**

4.4.1.2 Organic N fertilizers Applied to Soils

Organic N fertilizer includes applied animal manure, sewage sludge, compost and other organic amendments applied to soils. The application of organic N fertilizers to soils can increase the rate of nitrification and denitrification and result in enhanced N_2O emissions from agricultural soils. As a rule, all the manure from manure management systems is applied to agricultural soils. Manure deposited on land by grazing animals is considered separately.

Methodology: Emissions are calculated by multiplying the amount of organic nitrogen applied to agricultural soils by the non-volatilized fraction by an emission factor:

$$N_2O_{AW} = F_{ON} \bullet EF_1$$

$$F_{ON} = F_{AM} + F_{SEW} + F_{COMP} + F_{OOA}$$

Where:

F_{ON} = annual amount of animal manure, compost, sewage sludge and other organic N additions applied to soils, kgN/year

EF_1 = emission factor for N_2O emissions from N inputs, kg N_2O–N/kg N input

F_{AM} = annual amount of animal manure N applied to soils, kg N/year

F_{SEW} = annual amount of total sewage N that is applied to soils, kg N/year

F_{COMP} = annual amount of total compost N applied to soils, kg N/year

F_{OOA} = annual amount of other organic amendments used as fertilizer (e.g., rendering waste, guano, brewery waste, etc.), kg N/year

In Georgia sewage, compost and other organic amendments practically/actually are not used as N fertilizer. Consequently, F_{SEW}, F_{COMP} and F_{OOA} are not considered.

For annual amount of animal manure applied to soils the following formula is used:

$F_{AM} = N_{MMS\ Avb} \bullet [1 - (Frac_{FEED} + Frac_{FUEL} + Frac_{CNST})]$

Where:

F_{AM} = annual amount of animal manure N applied to soils, kg N/year

$N_{MMS\ Avb}$ = amount of managed manure N available for soil application, feed, fuel or construction, kgN/year

$Frac_{FEED}$ = fraction of managed manure used for feed

$Frac_{FUEL}$ = fraction of managed manure used for fuel

$Frac_{CNST}$ = fraction of managed manure used for construction

In Georgia, only insignificant amount of manure is used as fuel, and for feed and construction manure is not used at all.

The estimate of managed manure nitrogen available for application to managed soils, is based on the following equation:

$N_{MMS\_\ Avb} = \sum_{(S)} \{\sum_{(T)} [(N_{(T)} \bullet Nex_{(T)} \bullet MS_{(T,S)}) \bullet (1 - Frac_{LossMS}/100)]\}$

Where:

$N_{(T)}$ = number of head of livestock species/category T in the country

$Nex_{(T)}$= annual average N excretion per animal of species/category T in the country, kgN/animal/year

$MS_{(T,S)}$ = fraction of total annual nitrogen excretion for each livestock species/category T that is managed in manure management system S in the country, dimensionless

$Frac_{LossMS}$ = amount of managed manure nitrogen for livestock category T that is lost in the manure management system S, %

S = manure management system

T = species/category of livestock

According to the IPCC 2006, for the Tier 1 approach, the amount of applied organic nitrogen fertilizers is not adjusted for the amounts of NH_3 and NO_x volatilization after application to soil. This is a change from the methodology described in the 1996 IPCC Guidelines.

Activity Data: The animal population data are the same as those used for the Enteric Fermentation estimates (Tables 4.7-4.8).

Emission factor: The IPCC 2006 default emission factor EF_1=0.01 kgN_2O-N/kgN [IPCC 2006, volume 11, p.11.11, table 11.1] and default values of parameter $Frac_{LossMS}$ are used [IPCC 2006, Chapter 10, p.10.67, Table 10.23]. Nitrogen Excretion rate (Nex) for animal types are presented in table 4.24.

Calculated Emissions: Estimated nitrous oxide emissions from Organic N fertilizers applied to soil are presented in table 4-30.

Table 4-30. Estimated Nitrous Oxide Emissions from Manure Applied to Soil in Years 1990-2015

	Nex kg/h/yr	**FracLossMS**	**Share MS**	**EF_1 N_2O/N**	**1990**	**1994**	**2000**	**2005**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Drylot														
Cattle	42.0	40	0.46	0.0125	0.201	0.140	0.175	0.178	0.159	0.160	0.168	0.178	0.192	0.198
Swine	4.3	30	0.54	0.0125	0.018	0.007	0.009	0.009	0.002	0.002	0.004	0.004	0.003	0.003
Other systems														
Cattle	42	40	0.02	0.0125	0.009	0.006	0.008	0.008	0.007	0.007	0.007	0.008	0.008	0.009
Buffalos	44.4	25	0.05	0.0125	0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Sheep	12	25	0.17	0.0125	0.030	0.014	0.010	0.014	0.011	0.011	0.013	0.015	0.017	0.016
Goats	15	25	0.05	0.0125	0.000	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000
Swine	4.3	30	0.46	0.0125	0.015	0.006	0.008	0.008	0.002	0.002	0.004	0.003	0.003	0.003
Poultry	0.4	60	0.56	0.0125	0.022	0.012	0.008	0.008	0.007	0.006	0.006	0.007	0.007	0.008
Total, Gg N					**0.295**	**0.188**	**0.219**	**0.225**	**0.189**	**0.189**	**0.203**	**0.216**	**0.230**	**0.237**
Total, Gg N_2O					**0.46**	**0.29**	**0.34**	**0.35**	**0.30**	**0.30**	**0.32**	**0.34**	**0.36**	**0.37**
Total, Gg CO_2eq					**92**	**58**	**68**	**70**	**59**	**58**	**63**	**67**	**71**	**74**

4.4.1.3 Emissions from Urine and Dung from Grazing Animals

Emissions from manure dropped on the soil during grazing on grasslands are reported under this subcategory. When manure is excreted on pasture and paddock from grazing animals, nitrogen in the manure undergoes transformations. During these transformation processes, N_2O is produced.

Methodology: From the urine and dung from grazing animals are calculated for each animal category by multiplying the animal population by the appropriate nitrogen excretion rate and by the fraction of manure nitrogen available for conversion to N_2O.

Methodology is based on the following formulas:

$$N_2O\text{–}N_{PRP} = F_{PRP,CPP} \bullet EF_{3PRP,CPP} + F_{PRP,SO} \bullet EF_{3PRP,SO}$$

$$F_{PRP} = \sum_{(T)} [(N_{(T)} \bullet Nex_{(T)}) \bullet MS_{(T,PRP)}]$$

Where:

EF_{3PRP} = emission factor for N_2O emissions from urine and dung N deposited on pasture, range and paddock by grazing animals, kg N_2O–N/(kg N input). The subscripts CPP and SO refer to Cattle, Poultry and Pigs, and Sheep and other animals, respectively.

F_{PRP} = annual amount of urine and dung N deposited on pasture, range and paddock by grazing animals, kgN/year

$N_{(T)}$ = number of head of livestock species/category T in the country

$Nex_{(T)}$ = annual average N excretion per head of species/category T in the country, kg N/animal/year

$MS_{(T,PRP)}$ = fraction of total annual N excretion for each livestock species/category T that is deposited on pasture, range and paddock

T = type of animal category.

Activity Data: The animal population data are the same as those used in the Enteric Fermentation emission estimates (Table 4.7). The average annual nitrogen excretion rates for domestic animals are taken from the table 4.24. Fraction of total annual N excretion for each livestock species/category T that is deposited on pasture, range and paddock is given in table 4.25

Emission Factors: The default value for EF_{3PRP} is 2% of the N deposited by all animal types except 'sheep' and 'other' animals. For these latter species, a default emission factor of 1% of the N deposited is used. [IPCC 2006, Chapter 11, p.11.11, Table 11.1].

Emissions: N_2O emissions from urine and dung N deposited on pastures and paddocks are given in table 4-31.

Table 4-31. N_2O Emissions from Urine and Dung N Deposited on Pastures and Paddocks

	Nex kg/h/yr	Share MS	EF3 N_2O/N	1990	1994	2000	20015	2010	2011	2012	2013	2014	2015	
Cattle	42	0.5	0.02	29.11	20.31	25.42	25.74	23.10	23.12	24.34	25.77	27.78	28.66	Gg N
Gg N_2O-N				0.58	0.41	0.51	0.51	0.46	0.46	0.49	0.52	0.56	0.57	
Buffalo	44.4	0.95	0.02	1.63	0.98	1.05	0.99	0.71	0.72	0.72	0.77	0.50	0.65	Gg N
Gg N_2O-N				0.03	0.02	0.02	0.02	0.01	0.01	0.01	0.02	0.01	0.01	
Swine	4.29	0.54	0.02	2.04	0.85	1.03	1.06	0.26	0.24	0.47	0.44	0.39	0.37	Gg N
Gg N_2O-N				0.04	0.02	0.02	0.02	0.01	0.00	0.01	0.01	0.01	0.01	
Poultry	0.36	0.44	0.02	3.46	1.95	1.24	1.19	1.04	1.01	0.98	1.07	1.06	0.32	Gg N
Gg N_2O-N				0.07	0.04	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	
Sheep	11.96	0.83	0.01	15.38	7.48	5.43	7.14	5.92	5.72	6.83	7.90	8.59	8.35	Gg N
Gg N_2O-N				0.31	0.15	0.11	0.14	0.12	0.11	0.14	0.16	0.17	0.17	
Goats	15	0.95	0.02	0.97	0.56	1.15	1.36	0.81	0.76	0.78	0.87	0.77	0.71	Gg N
Gg N_2O-N				0.02	0.01	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.01	
Horses	39.96	0.95	0.02	0.74	0.81	1.32	1.62	0.00	0.00	0.00	0.00	0.00	0.0	Gg N
Gg N_2O-N				0.01	0.02	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.0	
Gg N				53.33	32.96	36.65	39.10	31.84	31.58	34.12	36.82	39.09	40.07	
Gg N_2O-N /N in total				1.07	0.66	0.73	0.78	0.64	0.63	0.68	0.74	0.78	0.80	
Gg N_2O in total				**1.68**	**1.04**	**1.15**	**1.23**	**1.00**	**0.99**	**1.07**	**1.16**	**1.23**	**1.26**	
Gg CO_2eq				**520**	**321**	**357**	**381**	**310**	**308**	**332**	**359**	**381**	**390**	

4.4.1.4 Decomposition of Crop Residues

After harvesting, part of agricultural crop residues is left in the field and decomposed. They represent nitrogen source. As a result of transformation nitrous oxide is formed.

Methodology: Georgia uses the IPCC 2006 Tier 1 methodology for emission calculation. Annual amount of N in crop residues, F_{CR}, the sum of the above-and below-ground N contents, is given by Equation:

$$N_2O\text{-}N_{N\ inputs} = F_{CR} \bullet EF_1$$

$$F_{CR} = \sum_T \{Crop_{(T)} \bullet (Area_{(T)} - Area\ burnt_{(T)} \bullet C_f) \bullet Frac_{Renew(T)} \bullet$$

$$[R_{AG(T)} \bullet N_{AG(T)} \bullet (1 - Frac_{Remove(T)} + R_{BG(T)} \bullet N_{BG(T)}]\}$$

Where:

F_{CR} = annual amount of nitrogen in crop residues (above and below ground), including N-fixing crops, and from forage/pasture renewal, returned to soils annually, kg N/year

EF_1 = emission factor for N_2O emissions from N inputs, kg N_2O–N /(kg N inputs)

$Crop_{(T)}$ = harvested annual dry matter yield for crop T, kg d.m./ha.

$Crop_{(T)}$ = Yield $Fresh_{(T)} \bullet$ DRY

$Yield\_Fresh_{(T)}$ = harvested fresh yield for crop T, kg fresh weight/ha

DRY = dry matter fraction of harvested crop T, kg d.m./(kg fresh weight)

$Area_{(T)}$ = total annual area harvested of crop T, ha/year

Area $burnt_{(T)}$ = annual area of crop T burnt, ha/year

C_f = combustion factor (dimensionless)

$Frac_{Renew(T)}$ = fraction of total area under crop T that is renewed annually

$R_{AG(T)}$ = ratio of above-ground residues dry matter ($A_{GDM(T)}$) to harvested yield ($Crop_{(T)}$), kgd.m./(kg d.m.)

$R_{AG(T)} = A_{GDM(T)} \bullet 1000 / Crop_{(T)}$;

$A_{GDM(T)} = (Crop_{(T)}/1000) * slope_{(T)} + intercept_{(T)}$

$N_{AG(T)}$ = N content of above-ground residues for crop T, kg N/(kg d.m.)

$Frac_{Remove(T)}$ = fraction of above-ground residues of crop T removed annually for purposes such as feed, bedding and construction, kg N/(kg crop-N).

$R_{BG(T)}$ = ratio of below-ground residues to harvested yield for crop T, kg d.m./kg d.m.

$$R_{BG(T)} = R_{BG\text{-}BIO(T)} \bullet [(A_{GDM(T)} \bullet 1000 + Crop_{(T)}) / Crop_{(T)}]$$

$N_{BG(T)}$ = N content of below-ground residues for crop T, kg N/kg d.m.

T = crop or forage type

Activity Data: Data on agriculture crop production are provided by National Statistics Office of Georgia.

Emission Factors: For emission factor 2006 IPCC default value is used EF_1=0.01 kg(N_2O-N)/(kgN inputs). For annual crops $Frac_{Renew}$ = 1. Data for $Frac_{Remove}$ are not available in Georgia, therefore, $Frac_{Remove(T)}$ = 0. Other input factors used for estimation of N added to soils from crop residues are used according to the IPCC 2006 [IPCC 2006, Chapter 11, Tab. 11.2, Chapter 2, Tab. 2.6].

Table 4-32. Input Factors Used for Estimation of N Added to Soils from Crop Residues

Crop	dry matter fraction of harvested crop DRY	N content of above-ground residues N_{AG}	Ratio of belowground residues to above-ground biomass R_{BG-BIO}	N in below-ground residues N_{BG}	Slope	Intercept	combustion factor CF
	kg d.m./ kg fresh weight	kg N/kg d.m.	kg d.m./kg d.m.	kgN/kg d.m			
Wheat	0.89	0.006	0.24	0.009	1.51	0.52	0.9
Barley	0.89	0.007	0.22	0.014	0.98	0.59	0.9
Maize	0.87	0.006	0.22	0.007	1.03	0.61	0.8
Oats	0.89	0.007	0.25	0.008	0.91	0.89	0.8
Potatoes	0.22	0.019	0.20	0.014	0.10	1.06	0.8
Dry Beans	0.9	0.01	0.19	0.01	1.36	0.68	0.8

Emissions: N_2O emissions from crop residue decomposition are given in table 4.33.

Table 4-33. N_2O Emissions from Crop Residue Decomposition

GHG emission / year	1990	1994	2000	2005	2010	2011	2012	2013	2014	2015
Gg N_2O	0.20	0.13	0.13	0.21	0.07	0.10	0.09	0.13	0.1144	0.12
Gg CO_2	62	40	41	65	22	31	28	41	35	38

Table 4-34. Agriculture Crop Production in Thousand Tons,

Crop	1990	1994	2000	2005	2010	2011	2012	2013	2014	2015
Wheat	257.7	89.3	89.4	190.1	48.4	96.8	80.7	81.0	50.2	133.4
Barley	117.8	32.0	30.1	65.4	23.3	30.3	20.7	35.0	31.5	49.4
Maize	270.2	342.8	295.9	421.3	141.1	269.6	267.0	363.9	347.2	231.4
Oats	11.7	6.3	2.0	2.8	2.0	0.7	1.6	3.4	5.6	5.8
Potatoes	293.8	296.9	302.0	432.2	228.8	273.9	252.0	296.6	216.2	206.2
Dry beans	9.5	10.2	5.1	33.7	5.8	8.9	9.6	10.5	8.7	5.8

Table 4-34. Direct N2O Emissions from Soils

Source		1990	1994	2000	2010	2010	2011	2012	2013	2014	2015
Synthetic N fertilizers	Gg N_2O	1.19	0.61	0.93	0.91	0.99	0.85	0.97	1.27	1.00	0.98
Organic N fertilizers		0.46	0.29	0.34	0.35	0.30	0.30	0.32	0.34	0.36	0.37
Urine and dung deposition		1.68	1.04	1.15	1.23	1.00	0.99	1.07	1.16	1.23	1.26
Crop residues decomposition		0.20	0.13	0.13	0.21	0.07	0.10	0.09	0.13	0.11	0.12
Total	**Gg N_2O**	**3.53**	**2.07**	**2.56**	**2.70**	**2.35**	**2.24**	**2.45**	**2.90**	**2.70**	**2.73**
	Gg CO_2eq	**1,096**	**641**	**794**	**837**	**730**	**694**	**761**	**898**	**838**	**848**

4.4.2 Indirect Nitrous Oxide Emissions from Soils

A fraction of the fertilizer nitrogen (from synthetic and organic N fertilizers and urine and dung deposition from grazing animals) that is applied to agricultural fields will be transported off-site either through volatilization and subsequent re-deposition or leaching, erosion and runoff. The nitrogen that is transported from the agricultural field in this manner will provide additional nitrogen for subsequent nitrification and denitrification to produce N_2O. The nitrogen leaving an agricultural field may not be available for the process of nitrification and denitrification for many years, particularly in the case of nitrogen leaching into groundwater.

4.4.2.1 Volatilization and Re-deposition of Nitrogen

Methodology: IPCC 2006 Tier 1 methodology is used to estimate indirect N_2O emissions due to volatilization and re-deposition of nitrogen from applied to soil N.

The N_2O emissions from atmospheric deposition of N volatilized from managed soil are estimated using Equation:

$$N_2O_{(ATD)}{-}N = [(F_{SN} \bullet Frac_{GASF}) + ((F_{ON} + F_{PRP}) \bullet Frac_{GASM})] \bullet EF4$$

Where:

$N_2O_{(ATD)}$ = annual amount of N_2O–N produced from atmospheric deposition of N volatilised from managed soils, kg N_2O–N/year

F_{SN} = annual amount of synthetic fertiliser N applied to soils, kg N/year

$Frac_{GASF}$ = fraction of synthetic fertiliser N that volatilises as NH_3 and NO_x, kg N volatilised/(kg N applied)

F_{ON} = annual amount of managed animal manure, compost, sewage sludge and other organic N additions applied to soils, kg N/year

F_{PRP} = annual amount of urine and dung N deposited by grazing animals on pasture range and paddock, kgN/year

$Frac_{GASM}$ = fraction of applied organic N fertiliser materials (F_{ON}) and of urine and dung N deposited by grazing animals (F_{PRP}) that volatilises as NH_3 and NO_x, (kg N volatilized)/(kg of N applied or deposited)

$N_2O_{(ATD)} = N_2O_{(ATD)}{-}N \bullet 44/28$

Activity Data: The amount of N fertilizers is sourced from the State Statistics Office of Georgia.

Emission factor: The IPCC 2006 default emission factor is applied to derive the N_2O emission estimate EF_4 =0.01 kg(N_2O-N)/kgN [IPCC 2006, Chapter 11, p. 11.24, table 11.3).

$Frac_{GASF}$ = 0.10 (kg N volatilized)/(kg N applied) and $Frac_{GASM}$ = 0.2 (kg NH3–N + NOx–N)/(kg N applied) [IPCC 2006, Chapter 11, p. 11.24, table 11.3).

Emissions: Estimated GHG emissions are presented in table 4-35.

Table 4-35. Estimated N2O Emissions from Volatilization and Re-Deposition in 1990 – 2015

	1990	1994	2000	2005	2010	2011	2012	2013	2014	2015
F_{SN}	61	31	48	46	50	43	50	65	51	50
$Frac_{GASF}$	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
F_{ON}	24	15	18	18	15	15	16	17	18	19
F_{PRP}	53	33	37	39	32	32	34	37	39	40
$Frac_{GASM}$	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
EF_4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
$N_2O_{(ATD)}$–N	**0.21**	**0.13**	**0.16**	**0.16**	**0.14**	**0.14**	**0.15**	**0.17**	**0.17**	**0.17**
Gg N_2O	**0.34**	**0.20**	**0.24**	**0.25**	**0.23**	**0.21**	**0.24**	**0.27**	**0.26**	**0.26**
Gg CO_2eq	**105**	**62**	**76**	**78**	**70**	**67**	**73**	**84**	**81**	**82**

4.4.2.2 N_2O emissions from Leaching and Runoff

When synthetic fertilizer or manure nitrogen is applied to cropland, a portion of this nitrogen is lost through leaching, runoff and erosion. The quantity of this nitrogen loss depends on a number of factors, such as rates, methods and time of nitrogen application, crop type, soil texture, rainfall, landscape, etc. This portion of lost nitrogen can further undergo transformations, such as nitrification and denitrification, thus producing N_2O emissions off site.

Methodology: The IPCC 2006 Tier 1 methodology estimates N_2O emissions from runoff and leaching of nitrogen is used. The N_2O emissions from leaching and runoff are estimated using Equation:

$$N_2O_{(L)}–N = (F_{SN} + F_{ON} + F_{PRP} + F_{CR} + F_{SOM}) \bullet Frac_{LEACH-(H)} \bullet EF_5$$

Where:

$N_2O_{(L)}–N$ = annual amount of N_2O–N produced from leaching and runoff of N additions to managed soils, kg N_2O–N/year

F_{SN} = annual amount of synthetic fertiliser N applied to soils, kgN/ year

F_{ON} = annual amount of managed animal manure, compost, sewage sludge and other organic N additions applied to soils, kg N/year

F_{PRP} = annual amount of urine and dung N deposited by grazing animals, kg N/year

F_{CR} = amount of N in crop residues (above- and below-ground), including N-fixing crops, and from forage/pasture renewal, returned to soils annually in regions where leaching/runoff occurs, kg N/year

F_{SOM} = annual amount of N mineralised in mineral soils associated with loss of soil C from soil organic matter as a result of changes to land use or management in regions where leaching/runoff occurs, kgN/year. In Georgia N_2O emissions from this source category are occurring only in a very small scale

$Frac_{LEACH-(H)}$ = fraction of all N added to/mineralised in managed soils in regions where leaching/runoff occurs that is lost through leaching and runoff, kg N/(kg of N additions)

EF_5 = emission factor for N_2O emissions from N leaching and runoff, kg N N O–N (kg N leached and runoff)

Activity Data: data on nitrogen applied are the same as used in Direct N_2O emissions from managed soil.

Emission factor: IPCC 2006 default emission factor for N_2O emissions from N leaching and runoff, EF_5 = 0.0075 kg N_2O-N/(kg N leaching and runoff) and Fraction of all N added to soils that is lost through leaching and runoff, kg N/(kg of N additions), $Frac_{LEACH\ -(H)}$ = 0.30 ares used [IPCC 2006, Chapter 11, p.11.24, Table 11.3].

Emissions: N_2O emissions from Leaching and Runoff of Nitrogen for 1990-2015 years are given in table 4.36.

Table 4-36. N_2O Emissions from Leaching and Runoff in 1990-2015 years

	1990	**1994**	**2000**	**2005**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
F_{SN}	61	31	48	46	50	43	50	65	51	50
F_{ON}	24	15	18	18	15	15	16	17	18	19
F_{PRP}	53	33	37	39	32	32	34	37	39	40
F_{CR}	10	6	7	11	4	5	5	7	6	6
$Frac_{LEACH-(H)ASM}$	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
EF_5	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
$N_2O_{(ATD)}$–N	1.11	0.64	0.81	0.85	0.76	0.71	0.78	0.94	0.86	0.86
Gg N_2O	**1.74**	**1.01**	**1.28**	**1.34**	**1.19**	**1.12**	**1.23**	**1.48**	**1.35**	**1.36**
Gg CO_2eq	**540**	**313**	**396**	**416**	**368**	**347**	**382**	**458**	**417**	**421**

5 Land Use, Land-Use Change and Forestry

5.1 Description of Source/Sink Categories and Calculated Emissions and Removals

The greenhouse has inventory (GHGI) for the LULUCF sector covers the following source/sink categories: 1) Forest land (5A); 2) Cropland (5B); 3) Grassland (5C); 4) Wetlands (5D); 5) Settlements (5E) and 6) Other land (5F). In this GHGI, emissions and removals have been estimated for three source/sink categories: forest land, cropland and grassland. The abovementioned categories are the key source-categories in Georgia and also the necessary data are available (e.g. databases) for carrying out the calculations in these categories (as compared with the remaining source/sink categories), that allows obtaining the annual parameters for greenhouse gases emissions and removals to determine the trend of annual changes.

The calculations of emissions and removals in the LULUCF sector have been carried out by using default values of Emission Factors (Tier I approach), which according to the methodological explanations of IPCC guidelines correspond to the climatic conditions of Georgia. In Table 5-1, carbon dioxide emissions and removals for each source/sink category are given and also the total sum values for the years 1990, 1994, 2000, 2005 and 2010-2015 years. Figures 5-1 - 5-4 present the trend of calculated total emissions and removals for the entire LULUCF sector and also specifically for the forest land category, respectively. The methodology of calculations, Activity Data and Emission Factors are described in detail hereafter in the respective chapters.

Table 5-1. Carbon Stock Changes and Net CO_2 Emissions and Removals in the LULUCF Sector

Year	Forest lands		Croplands				Grasslands		Net emission/absorption	
			Perennial crops		Arable lands and hay lands					
	Thousand tC	Gg CO_2	Thousand tC	Gg CO_2	Thousand tC	Gg CO_2	Thousand tC	Gg CO_2	Thousand tC	Gg CO_2
1990	1761.42	-6458.52	735.0	-2695.0	155.5	-570.4	-763.8	2800.5	1888.12	-6923.09
1994	1738.46	-6374.37	659.3	-2417.6	211.3	-774.7	-767.2	2813.0	1841.86	-6753.50
2000	1683.80	-6173.94	432.5	-1586.0	130.9	-480.3	-766.5	2810.8	1480.70	-5429.24
2005	1608.02	-5896.07	317.1	-1162.7	174.5	-639.7	-766.5	2810.8	1333.12	-4888.10
2010	1579.11	-5790.08	252.0	-924.4	326.7	-1198	-766.5	2810.8	1391.31	-5101.48
2011	1657.78	-6078.52	178.5	-654.5	323.6	-1186.7	-766.5	2810.8	1393.38	-5109.06
2012	1590.24	-5830.89	262.5	-962.5	325.2	-1192.2	-766.5	2810.8	1411.44	-5175.29
2013	1574.78	-5774.20	273.0	-1001.0	297.7	-1091.4	-766.5	2810.8	1378.98	-5056.26
2014	1539.91	-5646.32	189.0	-693.3	294.5	-1079.8	-766.5	2810.8	1256.91	-4608.66
2015	1533.03	-5621.10	231.0	-847.0	298.9	-1095.9	-766.5	2810.8	1296.43	-4753.57

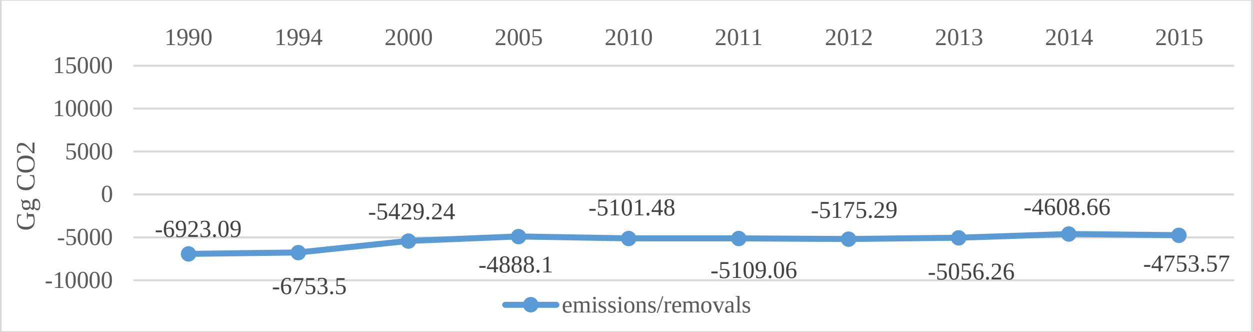

Figure 5-1 Dynamics of net CO2 emissions/removals in the “Land Use, Land-Use Change and Forestry” sector

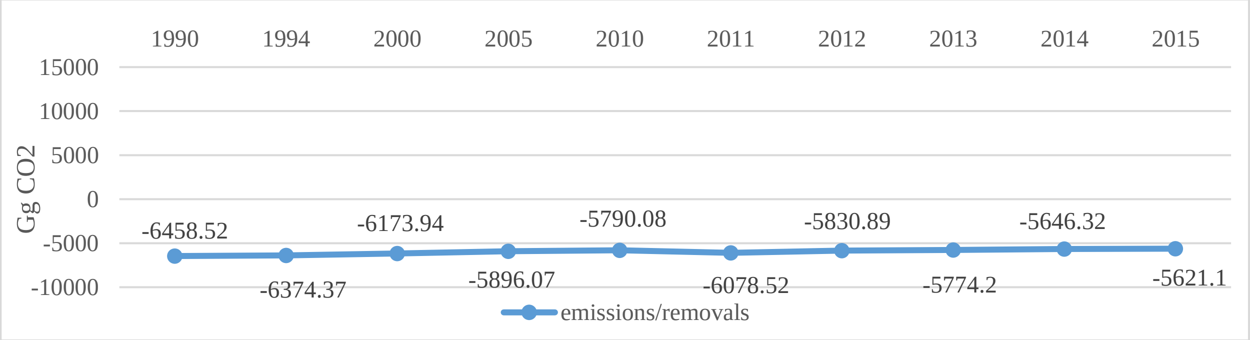

Figure 5-2 Dynamics of net CO2 emissions/removals in the forest land (on territories covered with forest)

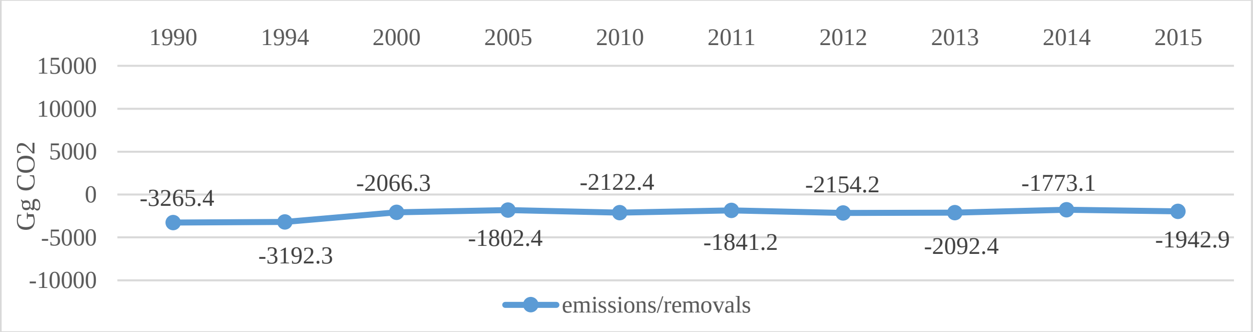

Figure 5-3 Dynamics of net CO2 emissions/removals in the croplands

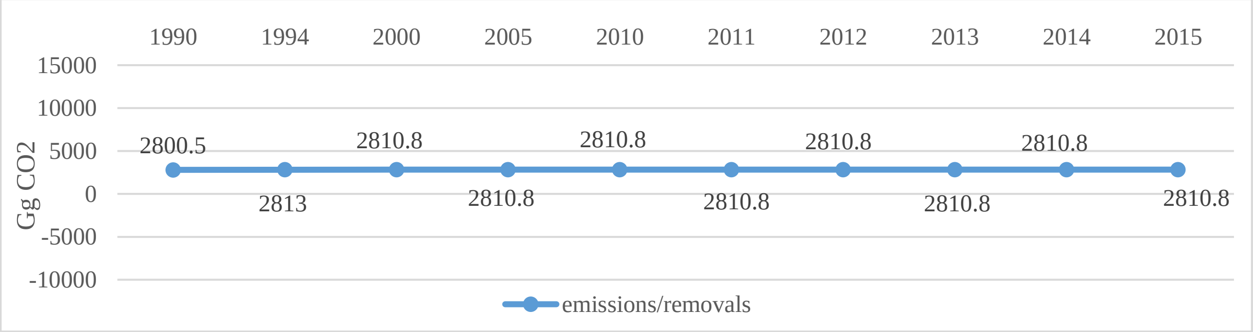

Figure 5-4 Dynamics of net CO2 emissions/removals in the Grasslands

As seen is the given graphs, the sector is accumulator of carbon dioxide, although a trend of declination has been noticed. Namely in 1990 the accumulated volume was about 6923.09 GgCO_2, while in 2015 net emissions decreased by 32 % amounting to 4753.57Gg $CO_{2.}$

5.2 Methodology

5.2.1 Method Used

As we have already mentioned, the greenhouse gas inventory report contains six source/sink categories (land use categories), for which GHG emissions and removals are determined separately, per each change in land use categories, that are calculated by the following formula:

$$\Delta C_{AFOLU} = \Delta C_{FL} + \Delta C_{CL} + \Delta C_{GL} + \Delta C_{WL} + \Delta C_{SL} + \Delta C_{OL}$$

Where:

ΔC_{AFOLU} = carbon stock change
Indices denote the following land-use categories:
FL = Forest land
CL = Cropland
GL = Grassland
WL = Wetlands
SL = Settlements
OL = Other land

The methodology of greenhouse gas inventory is based on the so-called Good Practice Guidance principles that implies carrying out of calculations according to tiers. In particular, there are the following tiers: Tier 1 is feasible even when country-specific Activity Data and emission/removal factors are not available, and works when changes of the carbon pool in biomass on *Forest Land Remaining Forest Land* are relatively small. The method requires the biomass carbon loss to be subtracted from the biomass carbon gain. The annual change in carbon stocks in biomass can be estimated using the gain-loss method; Tier 2 can be used in countries where country-specific Activity Data and emission/removal factors are available or can be gathered at reasonable cost. Tier 3 approach for biomass carbon stock change estimation allows for a variety of methods, including process- based models. Implementation may differ from one country to another, due to differences in inventory methods, forest conditions and Activity Data.

The selection of the tier methodology acceptable for calculations depends on availability of the necessary data. In selection of the appropriate tier for improvement of carrying out of inventory an attention must be paid to those source/sink categories (land use categories) of emissions/removals, where changes in carbon stock are significant in comparison with others, so that this may be considered as a key source category.

5.2.2 Activity Data

According to IPCC requirements existence of annual Activity Data on land use and land-use changes is important and necessary for the inventory in this sector.

Proceeding from these requirements, the Table 2 was compiled based mainly on data from the National Statistics Office and the Ministry of Environmental Protection and Agriculture, where the respective areas of land use categories determined by IPCC guidelines and changes occurred in them for the years 1990, 1994, 2000, 2005 and 2010-2015 are given. In order to obtain some data, in view of unavailability of information in the above-mentioned institutions, the FAOSTAT database has been used.

During the period of carrying out of the inventory (2014-2015), changes in areas of land use categories of Georgia have been mentioned in various directions. It may be said that areas of forest lands and croplands were keeping tendency of reduction, at the same time grasslands in the above-mentioned period increased by 40 thousand ha. It should be noted, that in the forest land of Georgia the areas of economic destination mainly decreased, whereas the areas entering in the protected areas increased (see Table 5-6). In total it may be said that the slight change in the total area of Georgian forest is stipulated by the factor, that in the forests of Georgia clear cutting is not carried out and at the same time conversions of forest lands into other land use categories negligible. It should be noted also that unavailability of new data of land cadaster in the country complicates identification of changes in the land use.

Table 5-2. Distribution of the Territory of Georgia According to Various Land Use Categories (following IPCC classification), (including Abkhazia and South Ossetia), thousand ha

Year	Land use subcategories						Total area of Georgia (Including territorial waters)
	5A. Forest land	5B. Cropland	5C. Grassland	5D. Wetlands	5E. Settlements	5F. Other land	
1990	2902.0	1135.0	1900.0	751.5	88.4	851.5	7 628.4
1994	2901.0	1117.0	1920.0	751.5	88.4	850.5	7 628.4
2000	2893.4	1061.9	1930.0	751.5	88.4	903.2	7 628.4
2005	2892.2	1011.8	1940.0	751.5	88.4	944.5	7 628.4
2010	2890.9	966.8	1940.0	751.5	88.4	990.8	7 628.4
2011	2888.8	926.8	1940.0	751.5	88.4	1032.9	7 628.4
2012	2861.1	926.8	1940.0	751.5	88.4	1060.6	7 628.4
2013	2861.0	931.8	1940.0	751.5	88.4	1055.7	7 628.4
2014	2853.8	911.8	1940.0	751.5	88.4	1082.9	7 628.4
2015	2853.2	911.8	1940.0	751.5	88.4	1083.5	7 628.4

5.3 Forest Land

5.3.1 Description of Source-Categories and Calculated Emissions

In accordance with the IPCC methodology Forest Land category includes all land with woody vegetation consistent with thresholds used to define Forest Land in the national greenhouse gas inventory. It also includes systems with a vegetation structure that currently fall below, but *in situ* could potentially reach the threshold values used by a country to define the Forest Land category.

In the current GHGI, the calculations for the forest land category have been carried out only for those forest areas, where economic activity is permitted. Those areas where officially none cutting is carried out and also those territories of Georgia, which on this stage are not controlled by the country (Abkhazia, South Ossetia) are not included in calculations. The aim of calculations is to elucidate, what a forest is – an absorber or to the contrary an emitter of carbon dioxide, that depends on balance of volume of reduction of biomass, the biomass growth and volume of reforestation, forest yield.

Using the necessary Activity Data for the inventory and Emission Factors, the work sheets have been filled in and emissions and removals have been calculated. According to the obtained results the values of carbon dioxide emissions and removals are given in the Table 5-3.

With regard to CO_2 emissions as a result of forest fires, and emissions of other greenhouse gases obtained by calculations those are given in the Table 5-4.

Table 5-3. Carbon Stock Changes and CO_2 net Emissions from Living Biomass in Commercial Forest Lands in Georgia

Year	commercial forest land, ha	Carbon gains, thousand tons C	Carbon losses thousand tons C	Net carbon stock change, thousand t of C	Carbon dioxide net emissions/removals, Gg CO_2
1990	2156748	1941.09	-179.68	1761.42	-6458.52
1994	2155748	1940.22	-201.75	1738.46	-6374.37
2000	2150017	1892.09	-208.29	1683.80	-6173.94
2005	2148860	1891.02	-283.00	1608.02	-5896.07
2010	2147548	1889.81	-310.70	1579.11	-5790.08
2011	2143529	1886.95	-229.17	1657.78	-6078.52
2012	2115904	1837.51	-247.26	1590.24	-5830.89
2013	2115818	1837.43	-262.65	1574.78	-5774.20
2014	2108586	1829.36	-289.46	1539.91	-5646.32
2015	2107978	1828.82	-295.79	1533.03	-5621.10

Table 5-4. Greenhouse Gas Emissions as a Result of Forest Fires in Commercial Forest land of Georgia

Year	Greenhouse gas emission 10^{-3} Gg			
	CH_4	CO	N_2O	NO_x
1990	3.45	49.84	0.04	0.27
1994	1.01	14.56	0.01	0.08
2000	17.21	248.63	0.21	1.34
2005	5.27	76.05	0.06	0.41
2010	60.12	868.37	0.73	4.68
2011	1.42	20.48	0.02	0.11
2012	55.05	795.19	0.67	4.28
2013	12.81	185.01	0.16	1.00
2014	85.12	1229.45	1.04	6.62
2015	28.30	408.80	0.35	2.20

5.3.2 Methodology

5.3.2.1 Method Used

In accordance with the IPCC methodology, carbon in forest sector is accumulated in or released from the so called “pools”: 1) living biomass (above-ground and below-ground); 2) dead organic matter (dead wood, litter); 3) soils (mineral and organic). Explanation of these pools is provided in Table 5-5.

Based on materials necessary for inventory obtained in advance, and the IPCC guidelines the key category for calculations has been selected, namely, “Forest land remaining forest land”. As we have already noted, this was stipulated by the fact that in Georgia the number of cases of conversion of forest areas into areas of other categories or vice versa is negligible. From the carbon pools a “living biomass” has been selected, because based on conditions in forestry sector of Georgia and proceeding from natural-ecological state the main changes in carbon stocks take place there.

As it was mentioned calculations were made according to the Tier 1, and respectively calculations were made for living biomass. Regarding to dead organic material and soil carbon reservoirs calculations weren’t made. This is in line with forest management system in Georgia, in other terms in most cases clear loGging does not take place in forests of Georgia and accordingly in the mentioned two pools any significant changes do not occur.

Table 5-5. Explanation of Carbon Pools

№	Carbon “reservoirs”		Explanation
1	Living Biomass	Above ground biomass	All living above ground biomass (timber, stumps, branches, bark, leaves, etc.).
		Below ground biomass	All living biomass of live root system
2	Dead Organic Matter	Dead wood	All dead fallen down on the soil not decayed
		Litter	All dead cover (humus) on about 10 centimeters depth
3	Soils	Organic matter of soil	Organic carbon in determined depth of mineral and organic soils (including peats).

The schematic diagram of formulas necessary for calculation of carbon accumulation and release in forest land remaining forest land is given in Fig.5-5. On this stage using the available materials the calculation has been carried out only for the “above-ground and below ground biomass”, i.e. in the pool of living biomass. As it was mentioned, calculations were made for so called living biomass (Tier 1.)

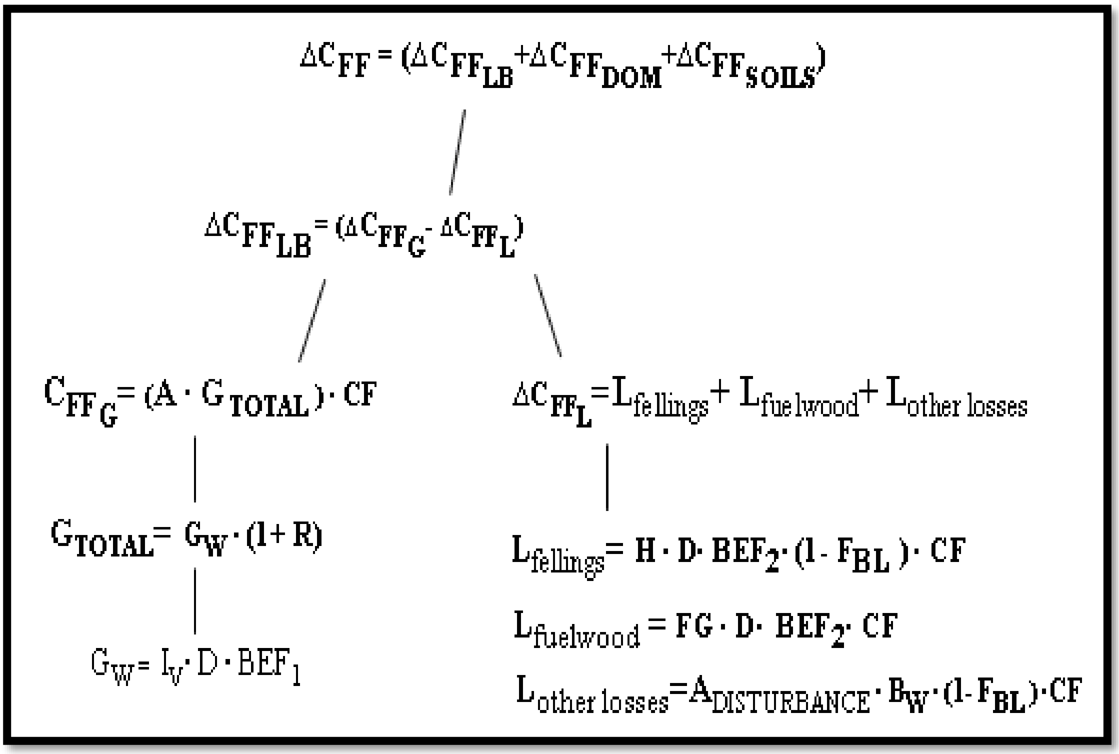

Figure 5-5 The System of Equations For Calculation Of The Amount Of Carbon Accumulation In Biomass

Where:

ΔCFF annual change in carbon stocks from forest land remaining forest land, tons C yr-1;

$\Delta C_{FF_{LB}}$ annual change in carbon stocks in living biomass (includes above- and belowground biomass) in forest land remaining forest land; tons C yr-1;

$\Delta C_{FF_{DOM}}$ annual change in carbon stocks in dead organic matter (includes dead wood and litter) in forest land remaining forest land; tons C yr-1;

$\Delta C_{FF_{SOILS}}$ annual change in carbon stocks in soils in forest land remaining forest land; tons C yr-1;

ΔC_{FF_G}annual increase in carbon stocks due to biomass growth, tons C yr-1;

ΔC_{FF_L}- annual decrease in carbon stocks due to biomass loss, tons C yr-1;

A - Area of forest land remaining forest land, by forest type, ha;

G_{TOTAL}- average annual increment rate in total biomass in units of dry matter, by forest type and climatic zone, tons d.m. ha-yr;

CF-carbon fraction of dry matter (default = 0.5), tons C (tons d.m.)-1;

G_W-average annual aboveground biomass increment, tons d.m. ha-1 yr-1;

I_V- =average annual net increment in volume suitable for industrial processing, m3 ha-1 yr-1;

D-basic wood density, tons d.m. m-3;

BEF_1- biomass expansion factor for conversion of annual net increment (including bark) to aboveground tree biomass increment, dimensionless;

R – root-to-shoot ratio appropriate to increments, dimensionless;

$L_{fellings}$ – annual carbon loss due to commercial fellings, tons C yr-1

$L_{fuelwood}$- annual carbon loss due to fuelwood gathering, tons C yr-1

$L_{other\ losses}$ –annual other losses of carbon, tons C yr-1

H-annually extracted volume, roundwood, m3 yr-1;

BEF_2-biomass expansion factor for converting volumes of extracted roundwood to total aboveground biomass (including bark), dimensionless;

F_{BL}- fraction of biomass left to decay in forest (transferred to dead organic matter);

FG- annual volume of fuelwood gathering, m3 yr-1;

B_W-average biomass stock of forest areas, tons d.m. ha-1;

Besides the natural processes that take place on forest lands and changes in carbon stock due to timber production, emissions of CO_2 and other greenhouse gases into atmosphere resulting from forest fires have also been calculated.

CH_4, N_2O, CO, and NO_X gases are emitted together with release of carbon as a result of forest fires.

The available methodology allows determining quantities of other greenhouse gases (CH_4, N_2O), except carbon dioxide released actually due to forest fires. The calculations are carried out by these formulas.

Methodology facilitates the evaluation of the volume of carbon dioxide, emitted after forest fires, which is entered in summary Indicators. Regarding to estimation of other greenhouse gases (CH_4, N_2O) the following equation[68]is used:

$$L_{FIRE}=A \bullet B \bullet C \bullet D \bullet 10^{-6}$$

Where:

A area burnt, ha;
B-mass of 'available' fuel, kg d.m. ha-1;
C-combustion efficiency (or fraction of the biomass combusted), dimensionless.
D-emission factor, g (kg d.m.)-1;

The mentioned formulas allow calculating of quantities of all greenhouse gases separately, because Emission Factors for different gases differ (see the Table 15).

5.3.2.2 Activity Data

The areas covered by state economic forests in Georgia in 1990, 1994, 2000, 2005, 2010 and 2010-2015 are given in the Table 6. Forest areas in the western and eastern parts of the country are identified separately, because the natural and climatic conditions of Western and Eastern Georgia differ from each other, therefore forest covers also differ. In particular, Western Georgia is characterized by humid subtropical climate; when we go from Black sea in eastern direction in parallel with reduction of precipitation the climate transforms into moderately dry continental climate. It should be noted that in these two parts of the country there are regions with relatively different climate or forest characteristics (e.g. Upper Svaneti).

Unfortunately, it is impossible to carry out inventory of greenhouse gases on forest areas per separate climatic zones, due to unavailability of necessary statistical or taxation data. Therefore, the calculations have been carried out according to units of regional management, namely forest plots, subordinated to the National Forestry Agency, based on inventory data for these plots. From the available data those forest plots became visible, for which climate and forest cover (dominating species, growth parameters) relatively differ from adjacent regions; for these plots' calculations have been carried out separately. For example, separate calculations have been carried out for Upper Svaneti (Mestia) and Borjomi-Bakuriani forests. Forest areas in the protected areas of Georgia and the forests being under the management of Ajara AR also have been treated separately for the GHGI.

The data on average forest yield for forest types located in various climatic zones have been taken separately, based on respective statistical or taxation data (see Table 5-7).

Table 5-6. Forest areas of Georgia, According to Different Climatic Zones in Regions, ha

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[68] Good Practice Guidance for Land Use, Land-Use Change and Forestry, Chapter 3, GREENHOUSE GAS EMISSIONS FROM BIOMASS BURNING, IPCC 2003,http://www.ipcc-nggip.iges.or.jp

Year	**Forest land, ha**										
	West Georgia					**East Georgia**					**Total (6+11)**
	humid continental climate (Upper Svaneti -Mestia)		**humid subtropical climate [1]**		**Total**	**dry continental climate[2]**		**humid continental climate (Borjomi-Bakuriani)**		**Total**	
	coniferous	**deciduous**	**coniferous**	**deciduous**		**coniferous**	**deciduous**	**coniferous**	**deciduous**		
1	2	3	4	5	6	7	8	9	10	11	12
1990	NE	NE	161567	921045	1082612	122098	744853	28813	21966	917730	2000342
1994	NE	NE	161567	921045	1082612	122098	744853	28756	21023	916730	1999342
2000	45603	39544	125856	805325	1016328	121743	743375	26589	20325	912032	1928360
2005	45603	39544	125856	805325	1016328	121743	743375	25432	20325	910875	1927203
2010	45603	39544	125856	805325	1016328	121743	743375	24120	20325	909563	1925891
2011	45603	39544	125856	805325	1016328	119804	741518	23897	20325	905544	1921872
2012	45603	39544	122376	726876	934399	119804	741518	23764	20325	905411	1839810
2013	45603	39544	122376	726876	934399	119804	741518	23678	20325	905325	1839724
2014	45603	39544	122376	726876	934399	119804	741518	23065	20012	904399	1838798
2015	45603	39544	122376	726876	934399	119804	741518	22901	19568	903791	1838190

year	Ajara AR, ha			Abkhazia and South Ossetia, ha	Forest areas that exist on the protected areas			Total area of forest of Georgia, thousand ha (12+16+17+20)
	coniferous	deciduous	Total		unmanaged	managed	Total	
13	14	15	16	17	18	19	20	21
1990	45148	111 258	156406	597910	147312	NO	147312	2901970
1994	45148	111258	156406	597910	147312	NO	147312	2900970
2000	45148	111258	156406	597910	147312	65251	212563	2895239
2005	45148	111258	156406	597910	147312	65251	212563	2894082
2010	45148	111258	156406	597910	147312	65251	212563	2892770
2011	45148	111258	156406	597910	147312	65251	212563	2888751
2012	45148	111258	156406	597910	147312	119688	267000	2861126
2013	45148	111258	156406	597910	147312	119688	267000	2861040
2014	42028	108072	150100	597910	147312	119688	267000	2853808
2015	42028	108072	150100	597910	147312	119688	267000	2853200

1. Racha-Lechkhumi and Lower Svaneti; Imereti; Guria; part of Samegrelo-Upper Svaneti;
2. Inner Kartli; Samtskhe-Javakheti; Mtskheta-Mtianeti; Lower Kartli; Kakheti.

As it seen from Table 5-6 data for Zemo Svaneti region (located in relatively dry climate zone) for 1990 and 1994 years are not available. Thus, calculation for this period was not made.

Table 5-7. Mean Annual Increment of Forest Areas in m^3/ha yr[69]

Species	**West Georgia**		**East Georgia**		**Ajara AR humid subtropical climate**
	humid continental climate	**humid subtropical climate**	**dry continental climate**	**humid continental climate**	
Coniferous	2.3	3.1	2.0	2.9	3.5
Deciduous	1.9	2.5	1.7	2.3	2.9

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[69] existing inventory data

The Table 5-8 provides volumes of timber and firewood produced in Georgia by year. (Source of data: Ministry of Environmental Protection and Agriculture of Georgia, Forestry Agency of Ajara).

Table 5-8 Firewood and Timber Produced (in their number, by illegal logging) in Georgia in 1990, 1994, 2000, 2005 and 2010-2015

Year	**Regions of West Georgia m^3**	**Regions of East Georgia m^3**	**Autonomous Republic of Ajara m^3**	**Protected areas of Georgia m^3**	**Abkhazia and South Ossetia m^3**	**Total m^3**
Roundwood						
1990	140 010			NO	NO	140010
1994	100 500			NO	NO	100500
2000	87 345			NO	NO	87345
2005	77 600			NO	NO	77600
2010	32 145	29 256	9 021	NO	NO	70 422
2011	45 404	21 874	11 361	NO	NO	78 639
2012	44 639	30781	5 705	NO	NO	81 125
2013	49 878	35 280	1 390	NO	NO	86 548
2014	77 099.9	22 812.6	5 125.0	NO	NO	105 037.5
2015	60 538.5	35 385.8	4 726.0	NO	NO	100 650.3
Firewood						
1990	367 965			NO	NO	367965
1994	465 800			NO	NO	465800
2000	490 700			NO	NO	490700
2005	710 015			NO	NO	710015
2010	110 544	586 522	78 478	29 785	NO	775 544
2011	100 214	341 820	88 538	30 881	NO	561 453
2012	98 428	399 917	60 809	35 124	NO	594 278
2013	102 529	447 848	70 635	22 140	NO	643 152
2014	211 389.8	375 787.3	72 856.0	17 180	NO	677 213.1
2015	228 833.6	395895.7	70 784.0	21436	NO	716 949.3

5.3.2.3 Emission Factor

Absolute dry volume weight of timber (D) has been calculated for forest massifs of Western and Eastern Georgia with different climate and also for coniferous and deciduous species separately.

Data about dominating forest species in all three regions have been used for the calculations. The obtained values for volume weight of timber are provided in the Tables 5-9, 5-10 and 5-11.

Table 5-9. Basic Wood Density and Volumes of Reserves of Deciduous and Coniferous Forests in West Georgia (Humid Continental Climate) Volumes of Reserves Are Obtained by Averaging of Data for 2006[70]

Dominant forest species	**Reserves of dominating species (m^3) and share in total reserves (%)**	**Basic wood density timber, t dm/m^3[71]**
Deciduous		
Beech	71 170 (52%)	0.58
Chestnut	30 792 (22%)	0.48
Alder	19 426 (14%)	0.45
Oak	9 009 (6%)	0.66
Hornbeam	6 015 (4%)	0.74
Total	136 412 (100%)	
Basic wood density		**0.55**

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[70] Georgian Statistical Yearbook of Forestry, Ministry of Environment and Natural Resources of Georgia, Forestry Department, Tbilisi, 2006;

[71] Makhviladze S.E. Wood science, Tbilisi 1962 (in Georgian); Боровиков А.М., Уголев Б.Н. Справочник по древесине. “Лесная Промышленность”, Москва, 1989;

Coniferous		
Fir	49 236 (76%)	0.41
Spruce	14 258 (22%)	0.44
Pine	1 253 (2%)	0.48
Total	64 747 (100%)	
	Basic wood density	**0.42**

Table 5-10. Basic Wood Density and Volumes of Reserves of Deciduous and Coniferous Forests in East Georgia (Dry Continental Climate) Volumes of Reserves Are Obtained by Averaging of Data for 2006[72]

Dominant forest species	Reserves of dominating species (m^{3}) and share in total reserves (%)	Basic wood density timber, t dm/m$^{3^{3}}$
Deciduous		
Beech	65 569 (37%)	0.58
Oak	61 085 (34%)	0.66
Hornbeam	39 250 (22%)	0.74
Oriental hornbeam	9 369 (5%)	0.74
Maple	4 025 (2%)	0.65
Total	179 298 (100%)	
Basic wood density		**0.65**
Coniferous		
Spruce	21 365 (61%)	0.48
Pine	10 025 (30%)	0.41
Fir	3 258 (9%)	0.44
Total	34 648 (100%)	
Basic wood density		**0.45**

Table 5-11. Basic Wood Density and Volumes of Reserves of Deciduous and Coniferous Forests in Ajara AR

Dominant forest species	Reserves of dominating species (m^{3}) and share in total reserves (%)	Basic wood density timber, t/m$^{3^{3}}$
Deciduous		
Beech	**24170 (73%)**	**0.58**
Chestnut	**5792 (18%)**	**0.48**
Alder	**1426(4%)**	**0.45**
Hornbeam	**1009(3%)**	**0.74**
Oak	**715(2%)**	**0.66**
Total	**33112(100%)**	
Basic wood density		**0.56**
Coniferous		
Fir	**8386(50%)**	**0.415**
Spruce	**8051(48%)**	**0.44**
Pine	**298(2%)**	**0.48**
Total	**16735(100%)**	
Basic wood density		**0.43**

In calculations of average volume weights given in the Tables the percentage distribution of stocks of dominating species has been taken into consideration. It should be noted that in accordance with IPCC guidelines the values of volume weight of dominating species in the countries of moderate climate in fact coincide with the country specific values of dominating species of Georgia. In particular, IPCC value for deciduous species (species -beech) equals to 0.58 t dm/m^{3}, and for coniferous ones (species -fir tree) - 0.40 t dm/m^{3}.

With regard to the value of volume weight used in calculations of biomass losses, this was obtained taking into account the main species of timber produced in Georgia. Since in Georgia on a national scale volume of timber produced by cutting are not identified by species, therefore expert estimation has

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[72] Georgian Statistical Yearbook of Forestry, Ministry of Environment and Natural Resources of Georgia, Forestry Department, Tbilisi, 2006;

been used for determination of percentage values of the main species, which are used by population as timber and firewood. In particular, the following species are produced in Georgia as timber: beech - 70%, fir-tree - 15%, spruce - 10% and other - 5%, and as firewood: beech - 35%, hornbeam - 30%, oriental hornbeam - 20% and other - 15%. Taking into consideration the above-mentioned percentage values, the average weighted value of volume weight of absolutely dry timber has been calculated (see Table5-12).

Table 5-12. Absolutely Dry Volume of Commercial And Fire Wood Produced in Georgia

Dominant forest species	**Share in total reserves (%)**	**Basic wood density timber, t dm/m^3[73]**
Roundwood		
Beech	70	0.58
Spruce	15	0.48
Fir	10	0.41
Other	5	NO
	100	
Basic wood density		**0.52**
firewood		
Beech	35	0.58
Hornbeam	30	0.74
Oriental hornbeam	20	0.74
Other	15	NO
	100	
Basic wood density		0.57

The majority of parameters indicated in the equations given on the Fig.5-5 have been taken by IPCC methodology from Tables envisaged for countries with moderate climate. In the Table 5- 13 there is a list of some parameters, used in the calculations indicating the respective source.

Table 5-13. Parameters Used in Inventory and Their Values

Factors	**West Georgia**		**East Georgia**		**AR of Ajara**		**Source**
	Deciduous	**Coniferous**	**Deciduous**	**Coniferous**	**Deciduous**	**Coniferous**	
CF- carbon fraction of dry matter, tons C (tons d.m.)	0.48	0.51	0.48	0.51	0.48	0.51	Agriculture, Forestry and Other Land Use (AFOLU), Forest land, Table 4.3
BEF_1- biomass expansion factor for conversion of annual net increment (including bark) to aboveground tree biomass increment, dimensionless;	1.20	1.15	1.20	1.05	1.20	1.15	(IPCC 2003), Table 3A.1.10
R – root-to-shoot ratio appropriate to increments, dimensionless	0.23	0.29	0.23	0.29	0.23	0.29	Agriculture, Forestry and Other Land Use (AFOLU), Forest land, Table 4.4
BEF_2 -biomass expansion factor for converting volumes of extracted roundwood to total aboveground biomass (including bark)	1.35						(IPCC 2003), Table 3A.1.10

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[73] Makhviladze. Timbers, Tbilisi 1962; Боровиков А.М., Уголев Б.Н. Справочникподревесине. “ЛеснаяПромышленность”, Москва, 1989.

According to the data, obtained from the National Forestry Agency and Forestry Agency of Ajaraa, forest fires of various intensity were registered on forest areas during the period of inventory. As a result, on areas enveloped in flames various volumes of biomass have been burnt. The burnt areas are given in the Table 5-14.

Table 5-14. Burnt Areas Registered in Georgia in 1990, 1994, 2000, 2005 and 2010-2015[74]

Year	Burnt areas, ha	
	West Georgia	East Georgia
1990	14.2	
1994	7.0	
2000	85.0	
2005	26.0	
2010	371.1	
2011	7.0	
2012	16.5	182.4
2013	19.3	68.3
2014	183.1	521.9
2015	149.0	39.4

Volumes of greenhouse gases emitted due to fires were calculated, as we have already mentioned, by the IPCC equation 3.2.20[75].

Since substantiated values of factors, necessary for calculations, are not available in Georgia, therefore the calculations for this source-category have been carried out by the Tier 1 approach. The coefficients have been taken from methodological Tables: IPCC Table 3A.1.12; Table 3A.1.16 From these Tables values envisaged for countries of moderate climate have been used, in particular:

C- combustion efficiency =0.45 (IPCC Table 3A.1.12)

As to the Emission Factors, their values are provided in the Table 15.

Table 5-15. Values of Emission Factors for Individual Greenhouse Gases (IPCC Table 3A.1.16)

Gas	(Emission factor, g/kg d.m.)
CH_4	9.00
CO	130.00
N_2O	0.11
NO_X	0.70

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[74] Ministry of Environment Protetion and Agriculture of Georgia, National Forestry Agency.

[75] Good Practice Guidance for Land Use, Land-Use Change and Forestry, Chapter 3, EQUATION 3.2.20. https://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf_files/GPG_LULUCF_FULL.pdf

5.4 Cropland

5.4.1 Description of Source-Categories and Calculated Emissions

In accordance with the IPCC methodology Cropland category includes cropped land, including rice fields, and agroforestry systems where the vegetation structure falls below the thresholds used for the Forest Land category. The perennial crops imply fruit gardens, vineyards and plantations of various kind. In the category of cropland areas, on which annual crop is grown, are also included.

The 1uantity of carbon that is accumulated on croplands depends on the kinds of crops grown on them, the management practices (e.g. fallow lands) and on the climatic conditions. Harvesting of annual crops (cereals, vegetables) takes place every year, therefore, in accordance with IPCC guidelines there is no net accumulation of biomass carbon stocks. In the case of perennial crops (fruit gardens, vineyards etc.) carbon is accumulated annually, that allows accumulating of carbon stock in the long-time period.

With regard to carbon stock changes in soils, those depend on operating practice of cultivable lands, in particular, on ploughing of soil, drainage, use of organic and mineral fertilizers.

Conversion of areas destined for other purposes into the category of cropland may affect the carbon stocks. Conversion of forest lands, grasslands, and wetlands into croplands usually causes losses in carbon stocks. However, there are exceptions - namely, conversion into croplands of such areas, where the vegetable cover is scarce and often the area is totally denuded of biomass supply, causing increasing of carbon stock.

Since the calculations have been carried out following Tier 1 methodology and the data given in the methodology in default form may be used for all countries with moderate climate (all moderately humid or dry climates are included there), therefore the calculations have been conducted on areas of perennial crops in Georgia with the same factor. During the inventory period the areas covered with perennial crops mainly were showing a decreasing tendency, whereas values of emissions obtained as a result of carbon stock changes are given in the Table 5-16.

Table 5-16. Changes in Carbon Stocks in the Biomass of Perennial Crops

Year	Area thousand ha	Reduction of areas compared to previous year, thousand ha	Carbon gains, thousand t C	Carbon losses, thousand t C	Net carbon stock change in cropland, thousand t C	Carbon dioxide net emissions/removals in cropland, $GgCO_2$
1990	350.0	NO	735.0	NO	735.0	-2,70
1994	332.0	18.0	697.2	37.8	659.4	-2,42
2000	269.0	63.0	564.9	132.3	432.6	-1,59
2005	210.0	59.0	441.0	123.9	317.1	-1,16
2010	165.0	45.0	346.5	94.5	252.0	-0,92
2011	125.0	40.0	262.5	84.0	178.5	-0,65
2012	125.0	NO	262.5	NO	262.5	-0,96
2013	130.0	NO	273.0	NO	273.0	-1,00
2014	110.0	20.0	231.0	42.0	189.0	-0,69
2015	110.0	NO	231.0	NO	231.0	-0,85

With regard to emissions and removals in croplands, in particular, in mineral soils, as we have already noted, the factors have been taken from the respective Tables of IPCC guidelines, whereas the results obtained by the calculations are provided in the Table 5-17.

Table 5-17. Carbon Stock Changes and CO_2 emissions/removals in Croplands (in mineral soils)

Land use	Area, thousand ha	Annual change in carbon stocks in mineral soils thousand t C/year	Carbon dioxide net emissions $GgCO_2$/year
1990			
cultivated	701.9	29.2	-107.1
Represents temporary set aside of annually cropland	83.1	130.0	-476.5
Total	785	159.2	-583.6
1994			
cultivated	453.1	18.8	-69.1
Represents temporary set aside of annually cropland	331.9	192.4	-705.6
Total	785	211.2	-774.7
2000			
cultivated	610.8	25.4	-93.2
Represents temporary set aside of annually cropland	182.1	105.6	-387.1
Total	792.9	131	-480.3
2005			
cultivated	539.6	22.4	-82.3
Represents temporary set aside of annually cropland	262.2	152.0	-557.4
Total	801.8	174.4	-639.7
2010			
cultivated	256.7	10.6	-39.2
Represents temporary set aside of annually cropland	545.1	316.0	-1158.8
Total	801.8	326.6	-1198
2011			
cultivated	262.4	10.9	-40.0
Represents temporary set aside of annually cropland	539.4	312.7	-1146.7
Total	801.8	323.6	-1186.7
2012			
cultivated	259.6	10.8	-39.6
Represents temporary set aside of annually cropland	542.2	314.4	-1152.7
Total	801.8	325.2	-1192.3
2013			
cultivated	310.7	12.9	-47.4
Represents temporary set aside of annually cropland	491.1	284.7	-1044.0
Total	801.8	297.6	-1091.4
2014			
cultivated	316.6	13.1	-281.3
Represents temporary set aside of annually cropland	485.2	281.3	-1031.5
Total	801.8	294.4	-1312.8

Land use	Area, thousand ha	Annual change in carbon stocks in mineral soils thousand t C/year	Carbon dioxide net emissions $GgCO_2$/year
2015			
cultivated	308.4	12.8	-47.0
Represents temporary set aside of annually cropland	493.4	286.1	-1048.9
Total	801.8	298.9	-1095.9

Facts of liming of croplands besides 1990, have been registered in Zugdidi Municipality, namely, in the Village Kakhati the private company “Nergeta” has limed kiwi plantations in 2011-2012 and 2014-2015, in total 44 ha. Using the mentioned data, the calculations have been carried out following Tier 1 methodology and the obtained results are given in the Table 5-18.

Table 5-18. CO_2, Emissions, Due to Lime Application

Year	Type of lime applied in the area	Limed area, ha	Amount of limestones applied to the area t limestones/year	Emission factor[76], tC/t limestones	Carbon emissions as a result of liming , T C/year	CO_2 emission 10^{-3} Gg/year
1990	Limestones $CaCO_3$	3000	30000	0.12	3600	13.2
2011	Limestones $CaCO_3$	14	140	0.12	16.8	0.06
2012	Limestones $CaCO_3$	10	100	0.12	12	0.04
2014	Limestones $CaCO_3$	10	100	0.12	12	0.04
2015	Limestones $CaCO_3$	10	100	0.12	12	0.04

5.4.2 Methodology

5.4.2.1 Method

The below given equation is the basis for the calculation of carbon accumulation and release from croplands (which do not change a land use, namely cropland remaining cropland), in accordance with IPCC guidelines (IPCC 2003):

$$\Delta C_{CC}=\Delta C_{CC_{LB}}+\Delta C_{CC_{soils}}$$

Where:

ΔC_{CC} - annual change in carbon stocks in cropland remaining cropland, tons C yr-1

$\Delta C_{CC_{LB}}$ - annual change in carbon stocks in living biomass, tons C yr-1

$\Delta C_{CC_{soils}}$ - annual change in carbon stocks in soils, tons C yr-1

According to the methodology, areas covered with perennial crops are included in the cropland land-use category; calculation of changes in carbon stocks in the above-ground biomass is carried out for these areas. Carbon is accumulated in biomass of perennial crops, such as fruit gardens, tea plantations etc. 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.

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[76] Chapter 3: LUCF Sector Good Practice Guidance, EQUATION 3.3.6. Tier 1.

The amount of changes in carbon stocks in biomass of perennial crops is calculated by the methodology, destined for the forest land, namely, by the equation for estimating changes of carbon stocks, existing in forest biomass from the sub-category “Forest land remaining forest land”. It should be noted here that in accordance with the IPCC guidance, unlike the forestry sector, in perennial crops the calculation is carried out only for the above-ground biomass (for the below-ground biomass calculations are not conducted).

The calculations for perennial crops have been conducted following the Tier 1 methodology, using the default factors provided by the IPCC guidelines (IPCC 2003), fitted for the climatic zones of Georgia.

The year’s decrease of a biomass, caused by annual decrease of areas of crops is subtracted from the year’s growth of a biomass on the areas covered with perennial crops.

As regards to the calculation of CO_2 emissions and removals in soil, it is carried out for mineral and also for organic soils. In addition, losses of carbon from soils as a result of liming have been estimated.

Annual carbon stock changes in soils are calculated using the following formula:

$$\Delta CCCsoils = \Delta CCCmineral - \Delta CCCorganic - \Delta CCClime$$

Mineral soils

The methodology for calculations for mineral soils is based on the determination of changes of carbon stocks existing in soils as a result of changes in of the management of soils in a certain period.

$$\Delta C_{CC_{Mineral}} = [(SOC_0 - SOC_{(0-T)}) \bullet A] / T,$$

$$SOC = SOC_{REF} \bullet F_{LU} \bullet F_{MG} \bullet F_I,$$

Where:

$\Delta C_{CC_{mineral}}$ -annual change in carbon stocks in mineral soils, tons C yr-1

SOC_0 -soil organic carbon stock in the inventory year, tons C ha-1

SOC $_{(0-T)}$ – soil organic carbon stock T years prior to the inventory, tons C ha-1;

T- Inventory time period, yr (default is 20 yr);

A - Land area of each parcel, ha

SOC_{REF}- the reference carbon stock, tons C ha-1;

F_{LU}- stock change factor for land use or land-use change type, dimensionless;

F_{MG}- stock change factor for management regime, dimensionless;

F_I- stock change factor for input of organic matter, dimensionless.

Organic Soils

According to the methodology, dried peat bed where agricultural activities take place is included in the class of organic soils. When organic soils are dried (peat land) and agricultural activities begin, just in this period an oxidation of organic soils is stimulated, that results in releasing of carbon from soil (emissions).

It should be noted that peat lands are mainly located on wetlands of Western Georgia (Kolkheti national park), that are not used as agricultural cultivable lands (in their number croplands). As to agricultural wetlands, where the drainage works began in recent years, they are presented mainly by mineral soils. It should be noted as well that on the mentioned areas the drainage works were fulfilled since the 60-ies of the XX century and the process has been stopped in the 90-ies, due to the deplorable situation that arose in the country in this period, and the areas underwent the secondary flooding. At present the company “Georgian amelioration Ltd” (the state is an owner of 100% of its share), implements rehabilitation and reconstruction of amelioration systems in the entire Georgia. On the basis of IPCC guidelines, in particular, taking into account the 20-year period of conversion (reference index), the estimated values of emissions resulted from drainage works on agricultural cultivable lands, implemented at present are not included in the calculations.

Liming of Croplands

In the calculations are included lime-containing carbonates, e.g. limestones ($CaCO3$), or dolomites ($CaCO3•MgCO3$), that are used in agriculture, that is a source of carbon dispersion.

The humid subtropical soils spread in Western Georgia are characterized by high acidity (pH=3.0-5.5). These soils are distinguished by physical and chemical properties unfavorable for plants, so normal growth of plants, assimilation of nutritional chemicals and substance exchange is limited on them. On the mentioned soils the yield of annual crops as well as citruses and other perennial crops is very low, so increasing of fruitfulness of these soils and improving their productivity liming activities on soils are necessary.

5.4.2.2 Activity Data

In Georgia in 1990, 1994, 2000, 2005 and 2010-2015 the croplands and the areas covered with perennial crops are distributed as presented in Table 5-19.

Table 5-19. Cropland Area

Year	Total, thousand ha	Arable land,[77] thousand ha			Perennial plantations[78], thousand ha
		Total, thousand ha	Represents temporary set aside of annually cropland	Cultivated	
1990	1135.0	785.0	83.1	701.9	350.0
1994	1117.0	785.0	331.9	453.1	332.0
2000	1061.9	792.9	182.1	610.8	269.0
2005	1011.8	801.8	262.2	539.6	210.0
2010	966.8	801.8	545.1	256.7	165.0
2011	926.8	801.8	539.4	262.4	125.0
2012	926.8	801.8	542.2	259.6	125.0
2013	931.8	801.8	491.1	310.7	130.0
2014	911.8	801.8	485.2	316.6	110.0
2015	911.8	801.8	493.4	308.4	110.0

As to liming activities, they begun in Georgia since the 60-ies of the past century and mainly covered acid soils in Western Georgia. The works were carried out annually on the area 10-12 thousand ha. Liming was repeated in Georgia every 6-7 years and it was controlled by the state. At present the facts of liming are rare and they are not accounted perfectly. According to available materials, liming in Georgia has been conducted in 1990 - on an area of 3000 ha and in 1992 - on an area of 500 ha79. After this a liming has been registered in 2011 in Zugdidi municipality; in the village Kakhati the private company “Nergeta” has begun planting of kiwi plantation. During the works the company implemented a liming on its own

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[77] National Statistics Service of Georgia, http://www.geostat.ge/ ;

[78] Statistical data of UN Food and Agriculture Organization, http://www.fao.org/statistics/en/.

[79] Roza Lortkipanidze, Soils of Imereti and agriculture, Tbilisi 1997.

area of various intensity, namely, in 2011 it has limed 14 ha, in 2012 - 10 ha and in 2014-2015 in total (10 ha annually) the company has limed the area to 20 ha.

5.4.2.3 Emission Factor

In order to calculate carbon stock changes in perennial crops according to the IPCC methodology, the data for moderate climatic zone were taken for Georgia. In particular the accumulation rate of carbon in the above-ground biomass is 2.1 t C/ha annually, whereas on 1 ha of perennial crops 63 t of carbon is accumulated at harvest (by the methodology, this value is acceptable for both, warm humid and dry climates). Losses are calculated every year according to data, obtained as a result of decreasing of areas covered with crops (dying or cutting of crops). In this case it is implied that the carbon stock that existed earlier on the released areas has been totally emitted into the atmosphere. Carbon losses (1 ha=63 t C) caused by decreasing of areas are subtracted from carbon increment in perennial crops (1 ha=2.1 t C/year). According to the given years, abrupt changes take place in areas of perennial crops, in particular, the areas covered with perennial crops, as compared with 1990 data, in 2015 have decreased by 240 thousand ha - down to 110 thousand ha.

For calculations in croplands the reference value of carbon stock has been used (for soils), that was obtained on the basis of the research ("Carbon stock in the region of Inner Kartli", Gizo Gogichaishvili) carried out in Georgia. In particular, based on the research carried out in Eastern Georgia, according to the type of soil mainly spread on croplands in Georgia (Cambisols and Calcic Kastanozems) it has been determined that the carbon stock on the area 1 ha is 52 t C (soil depth 0-30 cm.). It should be noted here that by the classification of soils given in the respective Table, attached to the IPCC methodology, and taking into account the types of soils spread in Georgia, the reference carbon stock for Georgia is 38 t C/ha.

For mineral soils the calculations of changes of carbon stock have been made following the Tier 1 methodology, therefore the default stock change factor values have been taken from the Table[80] given in the IPCC methodology. It should be noted that the data for cultivated lands by regions (for western relatively humid and eastern relatively dry zones) are not available, also based on the fact that 70% of arable lands are located in Eastern Georgia, thus values to countries with dry climate were taken. As it was already mentioned the scale of changes of carbon stock in soil depends on a management regime of croplands; according to it appropriate stock change factor values have been chosen. A part of croplands in Georgia are not cultivated (see the Table 5-20) and as a result the regimes of management of arable lands differ from each other, therefore on these two arable lands with different management regimes the calculations were carried out separately.

Table 5-20. Values of Emission Factors used in calculations (1990)

Emission Factors	**SOC(0-T) - soil organic carbon stock T years prior to the inventory, tons C ha-1;**		**SOC0- soil organic carbon stock in the inventory year, tons C ha-1**	
	Cultivated	**Represents temporary set aside of annually cropland**	**Cultivated**	**Represents temporary set aside of annually cropland**
SOC_{REF}- the reference carbon stock, tons C ha	52			
F_{LU} - stock change factor for land use or land-use change type, dimensionless	0.80	0.93	0.80	0.80
F_{MG} - stock change factor for management regime, dimensionless (cultivated)	1	-	1.02	-

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[80] AFOLU, Cropland, Table 5.5. https://www.ipcc- nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_05_Ch5_Cropland.pdf

Emission Factors	SOC(0-T) - soil organic carbon stock T years prior to the inventory, tons C ha-1;		SOC0- soil organic carbon stock in the inventory year, tons C ha-1	
	Cultivated	Represents temporary set aside of annually cropland	Cultivated	Represents temporary set aside of annually cropland
F_{MG} - stock change factor for management regime, dimensionless (Represents temporary set aside of annually cropland)	-	1.1	-	1
F_{I} - stock change factor for input of organic matter, dimensionless	1	1.37	1	1

5.5 Grassland

5.5.1 Description of Source-Categories and Calculated Emissions

In accordance with the IPCC methodology Grassland includes rangelands and pasture land that are not considered Cropland. It also includes systems with woody vegetation and other non-grass vegetation such as herbs and brushes that fall below the threshold values used in the Forest Land category. The category also includes all grassland from wild lands to recreational areas as well as agricultural and silvi-pastural systems, consistent with national definitions.

In this category the calculations have been conducted for the soil pool using the equation that was used for soils of arable land. The calculations have shown that the state of hay lands is stable and thus no emissions take place, whereas the areas of pastures are the source of emission.

The values obtained by calculations on grasslands of Georgia during the inventory period are given in the Table 5-21.

Table 5-21. Hayland and Grassland Areas

Land use	Area, thousand ha	Annual change in carbon stocks in mineral soils thousand t C/year	Carbon dioxide emissions $GgCO_2$/year
1990			
Grassland	1770.0	-865.2	3172.3
Hayland	130.0	101.4	-371.8
Total	1900.0	-763.8	2800.5
1994			
Grassland	1785.0	-872.5	3199.1
Hayland	135.0	105.3	-386.1
Total	1920.0	-767.2	2813
2000			
Grassland	1789.9	-874.9	3208.1
Hayland	140.1	109.3	-400.7
Total	1930.0	-765.6	2807.4
2005			
Grassland	1796.8	-878.3	3220.4
Hayland	143.2	111.7	-409.5
Total	1940.0	-766.6	2810.9

Land use	Area, thousand ha	Annual change in carbon stocks in mineral soils thousand t C/year	Carbon dioxide emissions $GgCO_2$/year
2010			
Grassland	1796.8	-878.3	3220.4
Hayland	143.2	111.7	-409.5
Total	1940.0	-766.6	2810.9
2011			
Grassland	1796.8	-878.3	3220.4
Hayland	143.2	111.7	-409.5
Total	1940.0	-766.6	2810.9
2012			
Grassland	1796.8	-878.3	3220.4
Hayland	143.2	111.7	-409.5
Total	1940.0	-766.6	2810.9
2013			
Grassland	1796.8	-878.3	3220.4
Hayland	143.2	111.7	-409.5
Total	1940.0	-766.6	2810.9
2014			
Grassland	1796.8	-878.3	3220.4
Hayland	143.2	111.7	-409.5
Total	1940.0	-766.6	2810.9
2015			
Grassland	1796.8	-878.3	3220.4
Hayland	143.2	111.7	-409.5
Total	1940.0	-766.6	2810.9

Since there is not available information about areas converted into grasslands from other land-use categories (forest lands, wetlands etc.) for the inventory, therefore due to unavailability of data the calculations in this case were not conducted. It should be noted, however, that in Georgia there are not facts of large-scale conversion of various categories of areas into grasslands and also large-scale misappropriation of areas (for future using as pastures) did not occur.

5.5.2 Methodology

5.5.2.1 Method Used

On grasslands unlike above-ground carbon stocks the below-ground carbon stocks prevail. The carbon stock is accumulated mainly in the root system and organic mass of soil.

The carbon stock existed in grasslands is affected by anthropogenic activity and natural phenomena. Annual accumulation of biomass on grasslands may result to high volumes, but due to rapid losses (grazing, mowing, fires etc.) the grasslands became the source of emission.

The calculations have been carried out following the Tier 1 methodology. In this case the methodology defines that calculations are carried out only on carbon stocks existing in a soil. Taking this into account, the calculation has been carried out similarly, by the equation[81] given for croplands, only the factors have been taken from the Table[82] destined for grasslands.

Despite the fact that in this land-use category, grasslands and hay lands are included together, the regimes of their management radically differ from each other. Thus, calculations of carbon stock changes in soils envisaged for grasslands and hay lands have been carried out separately.

Mineral soils

Below the formula for calculation of changes in carbon stocks in mineral soils is given:

$$\Delta C_{GG_{Mineral}} = [(SOC_0 - SOC_{(0-T)}) \bullet A] / T,$$

$$SOC = SOC_{REF} \bullet F_{LU} \bullet F_{MG} \bullet F_I,$$

Where:

$\Delta C_{GG_{Mineral}}$ = annual change in carbon stocks in mineral soils, tons C yr-1

SOC_0 = soil organic carbon stock in the inventory year, tons C ha-1

$SOC_{(0-T)}$= soil organic carbon stock T years prior to the inventory, tons C ha-1

T = inventory time period, yr (default is 20 yr)

A= land area of each parcel, ha

SOC_{REF} = the reference carbon stock, tons C ha-1;

F_{LU} = stock change factor for land use or land-use change type, dimensionless;

F_{MG} = stock change factor for management regime, dimensionless;

F_I = stock change factor for input of organic matter, dimensionless.

Organic soils

Calculations on grasslands and hay lands existing on organic soils are carried out in the case, when drainage works are made. In Georgia the drainage works on wet grasslands and hay lands are not carried out, therefore the calculations did not conduct.

It should be also noted, that due to unavailability of data for liming of grasslands and hay lands (areas of limed grasslands) the calculations were not conducted in this aspect.

5.5.2.2 Activity Data

The distribution of grasslands and hay lands in Georgia is provided in the Table 5-22. Since the condition of grasslands (as contrasted with hay lands) in the territories of Western and Eastern Georgia drastically differs from each other (the grasslands of Eastern Georgia especially undergo degradation), therefore for the improvement of accuracy of calculations those were carried out separately for Western and Eastern Georgia.

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[81] http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf.html(equi. 3.3.3.)

[82] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_06_Ch6_Grassland.pdf , TABLE 6.2

Table 5-22. Areas of Grasslands and Hay Lands

Years	Total, thousand ha	Hayland, thousand ha	Grassland, thousand ha		
			Total, thousand ha	Temperate warm, humid	Temperate warm, dry
1990	1900.0	130.0	1770.0	548.7	1221.3
1994	1920.0	135.0	1785.0	553.4	1231.6
2000	1930.0	140.1	1789.9	554.8	1235.1
2005	1940.0	143.2	1796.8	557.0	1239.8
2010	1940.0	143.2	1796.8	557.0	1239.8
2011	1940.0	143.2	1796.8	557.0	1239.8
2012	1940.0	143.2	1796.8	557.0	1239.8
2013	1940.0	143.2	1796.8	557.0	1239.8
2014	1940.0	143.2	1796.8	557.0	1239.8
2015	1940.0	143.2	1796.8	557.0	1239.8

5.5.2.3 Emission Factor

Since the calculations for soils have been carried out mainly following the Tier 1 approach, the significant part of Emission Factors has been taken from the following Table from the methodology: Table 6.2[83]. With regard to the value of the reference carbon stock for grasslands, similarly to croplands the data has been taken from researches conducted in Georgia and it equals to 52 t C/ha.

Since in Georgia an essential degradation of grasslands is noted, for Eastern Georgia[84] for the regime of areas management (F_{MG}) a stock change factor corresponding to abrupt degradation has been taken, and for Western Georgia – a factor envisaged for average degradation.

Hay lands as compared with grasslands undergo less degradation and therefore their state is stable. Respectively, other factors (of less degradation) have been taken for them (Table 23).

Table 5-23. Emission Coefficients Used in Calculations (grassland -1990)

Emission Factors	SOC(0-T) - soil organic carbon stock T years prior to the inventory, tons C ha-1;		SOC0- soil organic carbon stock in the inventory year, tons C ha-1	
	West Georgia, temperate warm, humid	East Georgia, temperate warm and dry	West Georgia, temperate warm, humid	East Georgia, temperate warm and dry
SOC_{REF}- the reference carbon stock, tons C ha	52			
F_{LU} - stock change factor for land use or land-use change type	1	1	1	1
F_{MG} - stock change factor for management regime	1	1	0.95	0.7
F_I - stock change factor for input of organic matter	1	1	1	1

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[83] AFOLU, https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_06_Ch6_Grassland.pdf ,GRASSLAND, Table 6.2.

[84] http://www.moe.gov.ge/ka/%E1%83%97%E1%83%94%E1%83%9B%E1%83%94%E1%83%91%E1%83%98/mica

5.6 Wetlands

5.6.1 Description of Source-Categories and Calculated Emissions

In accordance with the IPCC methodology wetlands includes areas of peat extraction and land that is covered or saturated by water for all or part of the year (e.g., peatlands) and that does not fall into the Forest Land, Cropland, Grassland or Settlements categories. It includes reservoirs as a managed sub-division and natural rivers and lakes as unmanaged sub-divisions.

Wetlands, in their number marshes, in Georgia due to specific landscape and climatic conditions are mainly presented in Kolkheti and Javakheti, though it should be noted, that despite of high anthropogenic impact, the fragments and habitats of watery areas are remained in Eastern Georgia. In total, in Georgia wetlands cover 51,500 ha[85]. As to lakes and reservoirs, they occupy in Georgia in total 21,000 ha.

The IPCC methodology distinguish this category to "wetlands remaining the wetlands" and "lands converted to wetlands". Calculations for wetlands basically are done for defining emissions as a result of the development of peat and drying wetlands. Due to the lack of the necessary data calculations were not carried out for this category.

5.7 Settlements

In accordance with the IPCC methodology settlement category includes all developed land, including transportation infrastructure and human settlements of any size, unless they are already included under other categories.

Since the data necessary for calculations were not found in Georgia, that is: areas covered by timber plants (ha) in all settlements (cities, villages and settlements), in all years, as well as the volume of annual accumulation of carbon in the mentioned crops (t C/year), and average age of woody plants in composition of cover (year), the calculations were not conducted. Only limited data on planting up given in the sustainable energy action plans for several self-governed cities are available, which however are not sufficient enough to represent and demonstrate the general picture of Georgia.

5.8 Other Land

In accordance with the IPCC methodology Other Land category includes lands lacking significant amounts of carbon stocks, including bare soil, rock, ice, and all land areas that do not fall into any of the other five categories. It allows the total of identified land areas to match the national area, where data are available.

According to the IPCC methodology, calculations are not done for this category, since it is considered that these are typical unmanaged areas. As for the lands converted into the other land category (forest lands, wetlands etc.) there is lack of the statistical data in Georgia for conversion into other lands, consequently carbon stock change estimation for these land-use conversions category has not been conducted.

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[85] Identification, delineation and classification of wetlands of Georgia, Ilia State University.

6 Waste

6.1 Sector Overview

The treatment of waste has become a serious environmental concern and continues to be an important environmental challenge for Georgia. There is no monitoring system of waste management practices in Georgia so that information on waste generation, composition and disposal is not readily available. Therefore, data on amounts of wastes generated annually, waste types, disposal and utilization are practically absent. Very limited data are scattered among different agencies. These data are not digitized and accessible to different users. Comprehensive waste inventories have not been yet conducted.

Untreated municipal wastewater is a major cause of surface water pollution in Georgia. Water used in households and industry contains a huge amount of toxins that derogate gravely the natural environment, flora and fauna, and the quality of life of population.

The centralized sewage system exists in 45 towns in Georgia. About 80% of the population is connected to sewerage, indicating high network penetration by international standards. The systems are, however, in poor condition. The plants are typically 25-40 years old; some are as yet unfinished, and most are not maintained. Most of the wastewater treatment plants cannot provide sewage treatment with high efficiency. Actually, none of the existing plants is actually providing biological treatment since the technical facilities are out of order.

The estimated GHG emissions from waste sector are given in table 6.1. In the same table, GHG emissions (estimated according to the 1996 IPCC guidelines) from the First Biennial Update Report and Third National Communication of Georgia to the UNFCCC are also presented. Differences are caused mainly due to applied more precise data provided by National Statistic Office of Georgia and Solid Waste Management Company of Georgia.

Table 6-1. GHG emissions from Waste Sector in Thousand Tons

Gas/Source	1990	1994	2000	2005	2010	2011	2012	2013	2014	2015
CH_4 / Solid Waste Disposal Sides	558	663	764	824	881	891	893	894	895	894
Previous inventories (TNC, FBUR)	566	675	767	811	863	874	876	879		
Difference, in %	-1	-2	0	2	2	2	2	2		
CH_4 / Domestic Waste Water Handling	226	219	190	182	183	183	181	181	182	183
Previous inventories (TNC, FBUR)	202	194	186	182	231	233	233	235		
Difference, in %	12	13	2	0	-21	-22	-22	-23		
CH_4 / Industrial Waste Water Handling	139	39	115	133	178	193	193	195	194	206
Previous inventories (TNC, FBUR)	230	1.7	8.4	16.8	34	34	46	44		
Difference, in %	-40	2222	1266	689	422	469	319	342		
N_2O / Domestic Waste Water Handling	57	54	53	54	55	55	55	56	57	58
Previous inventories (TNC, FBUR)	49	54	52	56	64	66	67	67		
Difference, in %	16	1	1	-3	-15	-16	-17	-17		
CO_2eq emissions from Waste sector	980	975	1122	1193	1297	1322	1322	1326	1328	1341
Previous inventories (TNC, FBUR)	1,047	925	1,013	1,065	1,192	1,207	1,222	1,226		
Difference, in %	-6	5	11	12	9	10	8	8		

TNC – Third National Communication

The shares of different source categories in waste sector emissions are presented in table 6.2. Dominant is methane emissions from Solid Waste Disposal Sides.

Table 6-2. Share of Different Sources Categories in GHG Emissions from Waste Sector (%)

Gas/Source	**1990**	**1994**	**2000**	**2005**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
CH_4 / Solid Waste Disposal Sides	57	68	68	69	68	67	68	67	67	67
CH_4 / Domestic Waste Water handling	23	22	17	15	14	14	14	14	14	14
CH_4 / Industrial Waste Water handling	14	4	10	11	14	15	15	15	15	15
N_2O / Domestic Waste Water handling	6	6	5	5	4	4	4	4	4	4
Total CO_2eq	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

6.2 GHG emissions from Solid Waste Disposal Sites (SWDS)

The methane emissions from landfills of Georgia are estimated based on the First order decay (FOD) method. The FOD method assumes that the degradable organic component/degradable organic carbon (DOC) in waste decays slowly throughout a few decades, during which CH_4 and CO_2 are formed.

First Order Decay (FOD) Method

$$CH_{4\ generated,t} = \{ DDOCm_t \bullet [1 - \exp(-k)] + H_{t-1} \bullet [1 - \exp(-k)] \} \bullet 16/12 \bullet F_t$$

$$H_t = DDOCm_t \bullet \exp(-k) + H_{t-1} \bullet \exp(-k), \quad H_o = 0$$

$$DDOCm_t = W_t \bullet DOC_t \bullet DOCF_t \bullet MCF_t$$

$$W_t = Pop_t \bullet GR_t \bullet MSW_{F,t}$$

Where:

$CH_{4\ generated,t}$	generated CH_4 in year t
t	year of inventory
$DDOCm_t$	mass of decomposable DOC deposited in year t (Gg)
$k=\ln(2)/t_{1/2}$	methane generation rate constant
$t_{1/2}$	half life
F_t	fraction by volume of CH_4 in landfill gas
DOC_t	degradable organic carbon in year t
$DOC_{F,t}$	fraction of DOC dissimilated in year t
MCF_t	methane correction factor in year t
W_t	amount of waste deposited in landfills in year t
Pop_t	population whose waste goes to SWDS (habitants)
GR_t	MSW generation rate in year t (kg per capita)
$MSW_{F,t}$	fraction of MSW disposed at SWDS in year t

$$CH_4\ emissions = [\sum_x CH_4\ generated_{x,t} - R_t] \bullet (1 - OX_tT)$$

Where:

CH_4 Emissions	CH_4 emitted in year t, Gg
x	waste category or type/material
R_t	recovered CH_4 in year t, Gg

OX_t oxidation factor in year t, (fraction)

Methane isn't recovered for energy or flaring on landfills of Georgia, R_t =0. Besides, there aren't managed sites covered with methane oxidizing material, consequently Oxidation Factor =0.

Solid waste management company of Georgia has provided data on the amount of waste annually deposited in landfills.

MSW Generation Rate in Year t (kg per capita)

At calculations the following values are used: 2006 IPCC default value for Eastern Europe (1.04 kg/capita/day) for 2000-2015 years, 0.85 kg/capita/day for years before 1990 and linear interpolated values for 1991-1999 years.

Fraction of MSW Disposed to SWDS

The following values are used: 2006 IPCC default value for Eastern Europe MSW_F = 0.9 for 2000-2015 years, 0.93 for years before 1990 and linear interpolated values for 1991-1999 years.

Methane Correction Factor (MCF). MCF accounts for the fact that unmanaged SWDS produce less CH_4 from a given amount of waste than managed SWDS, because a larger fraction of waste decomposes aerobically in the top layers of unmanaged SWDS.

Table 6-3. MCF Default Values for Different Types of Landfills

Landfill type	MCF default values
Managed	1.0
Unmanaged – deep (>5 m)	0.8
Unmanaged – shallow (<5 m)	0.4
Non categorized	0.6

During 2013-2015 years 3 landfills are closed. by 1st January 0f 2016 there were more than 60 landfills in Georgia. In 14 unmanaged landfills waste layer is very shallow (about 0.3 m) and actually methane is not generated. In 12 cities of Georgia with population more than 50,000 habitant landfills are managed. Based on information about unmanaged landfills in towns and settlements two hypothetic unmanaged landfills are considered incorporating all these landfills. In order to calculate the methane emission, the simplifying assumption was made that all the waste from unmanaged landfills with shallow waste layer (<5m) are disposed on hypothetic landfill I and wastes from unmanaged landfills with deep waste layer (>=5m) and are disposed on another hypothetic landfill II.

Solid waste composition: There is very scare information about the composition of solid waste disposed in landfills of Georgia. Since 2014 waste composition is determined for several landfills. Data in table 6.4 are provided by Solid Waste Management Company of Georgia. For other landfills default values for Eastern Europe from the 2006 IPCC are used.

Table 6-4. Solid Waste Composition

Component /Landfill	Tbilisi	Rustavi	Batumi	Kutaisi	Others
Food waste	71	42	41.2	47	30.1
Paper/cardboards	5.6	17	17.4	10	21.8
Textiles	3.2		3.3		4.7
Wood	2.6		0.5		7.5

Component /Landfill	Tbilisi	Rustavi	Batumi	Kutaisi	Others
Rubber/leather					1.4
Other	17.6	41	37.6	43	34.5

Degradable Organic Carbon (DOC) is the portion of organic carbon present in solid waste that is susceptible to biochemical decomposition. For DOC values of specific materials, data from laboratory experiments conducted by Dr. Barlaz[86] are used. Experiments provided data on the amount of CH_4 generated by each type of organic material. DOC for waste components ($DOC^{k}_{100\%}$) is presented in Table 6.6. Data from this table are used in calculations of DOC containing in k component (DOC^{k}_{p}) of waste and DOC in total.

$$DOC^{k}_{p} = DOC^{k}_{100\%} \bullet P/100; \qquad DOC = \sum_k DOC^{k}_{p}$$

Table 6-5. Estimated DOC for Solid Waste Disposed on Landfills

Component /Landfill	Tbilisi	Rustavi	Batumi	Kutaisi	Others
DOC	0.146	0.126	0.145	0.105	0.188

Table 6-6. Details of DOC Estimation (case of other landfills)

Component	Dry-wet Ratio	$DOC^{k}_{100\%}$		Waste composition, %	DOC^{k}_{p}
		dry	wet		
	A	B	C=A*B	D	E=C*D/100
Second Food	0.300	0.458	0.137	30.1	0.0414
Broad Definition for Mixed Paper	0.945	0.425	0.402	21.8	0.0876
Textiles	0.900	0.550	0.495	4.7	0.0233
Wood	0.800	0.492	0.394	7.5	0.0295
Leather	0.800	0.600	0.480	1.4	0.0067
Other				34.0	
$\sum_k DOC^{k}_{p}$				100	**0.1884**

Fraction of Degradable Organic Carbon Dissimilated (DOC_F) is the portion of DOC that is converted to landfill gas. It is good practice to use a value of 0.5 – 0.6 (including lignin C) as the default. According to GPG national values for DOC_F can be used, but they should be based on well-documented research. For the maximum digestibility of lignocellulosic materials, a log-linear relationship of Van Soest[87] and data from Barlaz's experiment were used. DOC_F for mix of materials (municipal solid waste) was calculated by formula:

$$DOC_F = \sum k\,(DOC_k \bullet DOC_{Fk}) \,/\, DOC$$

Table 6-7. Estimated DOC_F for Solid Waste Disposed on Landfills

Component /Landfill	Tbilisi	Rustavi	Batumi	Kutaisi	Others
DOC_F	0.627	0.581	0.573	0.616	0.521

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[86] M.A.Barlaz. 1997. "Biodegradative Analysis of Municipal Solid Waste in Laboratory-Scale Landfills", EPA 600/R-97-071. Solid Waste Management and Greenhouse Gases. A Life-Cycle Assessment of Emissions and Sinks. 2nd EDITION. EPA 530-R-02-006.

[87] http://compost.css.cornell.edu/calc/lignin.html#txt24 http://compost.css.cornell.edu/calc/lignin.html#txt24

Table 6-8. Details of DOC_F Estimation (case of other landfills)

	DOC_i	$DOCF_i$	DOC_i*DOCF_i	DOC_F
Second Food	0.0414	0.7010	0.0290	
Broad Definition for Mixed Paper	0.0876	0.4800	0.0420	
Textiles	0.0233	0.5500	0.0128	
Wood	0.0295	0.3600	0.0106	
Leather	0.0067	0.5500	0.0037	
⍰	0.1884		0.0981	**0.5208**

Fraction of CH_4 in landfill gas (F): To calculate the fraction by volume of CH_4 in landfill gas the Extended Buswell Equation[88] was used.

Table 6-9. Estimated Fraction of CH_4 in landfill gas

Component /Landfill	Tbilisi	Rustavi	Batumi	Kutaisi	Others
Fraction of CH_4 in landfill gas	0.537	0.531	0.532	0.535	0.531

Half-life ($t_{1/2}$): The half-life value is the time taken for the DOCm in waste to decay to half its initial mass. k = ln(2)/t1/2. For located in Western Georgia cities k=0.09 ($t_{1/2}$=7.7) and for cities in Eastern Georgia k=0.06 ($t_{1/2}$=11.55).

The Estimated Methane Emissions

In table 6-11 estimated methane emissions from the SWDSs of Georgia are given.

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[88] Buswell A.M., Hatfield W.D. (ed.) (1937): Anaerobic Fermentations. State of Illinois, Department of Registration and Education, Bulletin No. 32.

Table 6-10. Methane Emissions from SWDSs of Georgia

Year	Tbilisi				Kutaisi	Rustavi		Batumi	Gori	Poti	Zygdidi		Hypothetic		GHG emissions	
	Norio	Gldani	Iagludji	Lilo			New					New	I (MCF=0.4)	II (MCF=0.8)	GgCH$_4$	GgCO$_2$eq
1990		12.8	2.4	0.2	3.4	1.8		3.3	0.3	0.9			1.1	0.5	26.6	558
1994		14.1	4.0	1.0	3.6	1.7		3.6	0.5	0.9			1.4	0.7	31.6	663
2000		15.0	5.8	2.1	3.8	1.2		4.1	0.8	1.0	0.10		1.7	0.9	36.4	764
2005		15.7	6.8	2.5	3.7	0.9		4.3	0.9	1.0	0.54		1.8	1.1	39.2	824
2010		17.4	7.7	1.8	3.5	0.6		4.3	1.0	1.1	0.8		2.1	1.5	42.0	881
2011		17.7	7.9	1.7	3.5	0.6		4.3	1.0	1.1	0.8	0.06	2.1	1.6	42.4	891
2012	1.5	16.7	7.5	1.6	3.4	0.6	0.2	4.3	1.1	1.1	0.7	0.1	2.2	1.6	42.5	893
2013	2.8	15.7	7.0	1.5	3.4	0.5	0.3	4.3	1.1	1.1	0.6	0.2	2.3	1.7	42.6	894
2014	4.1	14.8	6.6	1.5	3.3	0.5	0.5	4.3	1.1	1.1	0.6	0.2	2.3	1.7	42.6	895
2015	5.3	13.9	6.2	1.4	3.3	0.5	0.6	4.3	1.1	1.1	0.5	0.2	2.4	1.8	42.6	894

6.2 Wastewater Handling

The water used in households and industry contains a huge amount of toxins that derogate gravely the environment. Wastewater handling systems transfer wastewater from its source to a disposal site. Wastewater treatment systems are used to biologically stabilize the wastewater before disposal. In the first stage of the wastewater treatment (primary treatment) larger solids from the wastewater are removed. Remaining particulates are then allowed to settle. In next stage treatment consists of a combination of biological processes that promote biodegradation by microorganisms.

Sludge is produced in both stages of treatment. Sludge that is produced in primary treatment consists of solids that are removed from the wastewater. Sludge produced in secondary treatment is a result of biological growth in the biomass, as well as the collection of small particles. This sludge must be treated further before it can be safely disposed of. Methods of sludge treatment include aerobic and anaerobic stabilization (digestion), conditioning, centrifugation, composting, and drying.

When wastewater or sludge is treated anaerobically CH_4 is produced. The methane emissions from aerobic systems are negligible. Wastewater treatment systems generate N_2O through the nitrification and denitrification of sewage nitrogen.

To handle wastewater from municipal sewage and from industrial facilities mainly aerobic methods were used.

6.2.1 Domestic & Commercial Wastewater Treatment

6.2.1.1 Methodological Issues

CH_4 emissions directly depend on the content of the degradable organic material (DC) in the wastewater. The amount of DC in the wastewater is characterized by the BOD (Biochemical Oxygen Demand) or by COD (Chemical Oxygen Demand). The BOD concentration indicates only the amount of carbon that is aerobically biodegradable. The COD measures the total material available for chemical oxidation (both biodegradable and non-biodegradable).

The methane generation depends also on type of the handling systems and temperature**.** Systems that provide anaerobic environments will generally produce CH_4 whereas systems that provide aerobic environments will normally produce little or no methane. With increases in temperature, the rate of CH_4 production increases. CH_4 production typically requires a temperature higher than 15°C.

To estimate total emissions from wastewater, the selected emissions factors are multiplied by the associated organic wastewater production and summed.

The following equation is used

$$CH_4 \text{ Emissions} = [\sum_{i,j} (U_i \bullet T_{i,j} \bullet EF_j] \bullet (TOW - S) - R$$

Where

CH_4 Emissions	CH_4 emissions in inventory year, kg CH_4/yr
TOW	total organics in wastewater in inventory year, kg BOD/yr
S	organic component removed as sludge in inventory year, kg BOD/yr
U_i	fraction of population in income group i in inventory year
$T_{i,j}$	degree of utilisation 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_j	emission factor, kg CH_4 / kg BOD
R	amount of CH_4 recovered in inventory year, kg CH_4/yr

The emission factor for a wastewater treatment and discharge pathway and system is a function of the maximum CH_4 producing potential (Bo) and the methane correction factor (MCF) for the wastewater treatment and discharge system.

$$EF_j = Bo \bullet MCF_j$$

Where

j	each treatment/discharge pathway or system
Bo	maximum CH_4 producing capacity, kg CH_4/kg BOD
MCF_j	methane correction factor (fraction)

(TOW) is a function of human population and BOD generation per person. It is expressed in terms of biochemical oxygen demand (kg BOD/year). The equation for TOW is:

$$TOW = P \bullet BOD \bullet 0.001 \bullet I \bullet 365$$

Where

TOW	total organics in wastewater in inventory year, kg BOD/yr
P	country population in inventory year, (person)
BOD	country-specific per capita BOD in inventory year, g/person/day,

According to the 2006 IPCC it is good practice to treat the three categories of residents: rural population, urban high-income population, and urban low-income population. Data on distribution of urban population by income is unavailable in Georgia. It means that summation by I index applicable only to urban (in total) and rural population.

It is good practice to use a default value of 0.25 kgCH_4/kgCOD or a default value of 0.6 kgCH_4/kgBOD (2006 IPCC, chapter 6, p.6.12). The default for sludge removal is zero (2006 IPCC, chapter 6, p.6.9). The MCF varies between 0.0 for a completely aerobic system to 1.0 for a completely anaerobic system.

Emissions Factors: When country-specific data are not available IPCC 2006 recommends select a BOD default value from a nearby comparable country. Greece default value BOD = 0.057 kg BOD/cap/day (20,805 kgBOD/1000 persons/yr) was used. Methane conversion factor, MCF varies within 10-80%. Calculations were carried out applying parameter MCF=50%. In villages of Georgia commonly latrines small family (3-5 persons) are used, for rural areas MCF=10%. WS varies within 0.1-0.8. T=0.45 for urban and T=1 for rural areas.

Activity Data: Data on urban and rural population whose wastewater is handled are provided by the National Statistic Office of Georgia.

Table 6-11. Urban and Rural Population

Population / Year	1990	1994	2000	2005	2010	2011	2012	2013	2014	2015
Urban	2.523	2.489	2.120	2.032	2.130	2.129	2.119	2.121	2.136	2.152
Rural	2.312	2.136	1.953	1.858	1.655	1.643	1.610	1.600	1.596	1.586
Total, thousand habitants	4.835	4.625	4.073	3.890	3.785	3.773	3.729	3.721	3.731	3,738

GHG Emissions:

CH_4 emissions for domestic and commercial wastewater handling are shown in table 6-12.

Table 6-12. CH_4 Emissions from Domestic & Commercial Wastewater Handling

Source	1990	1994	2000	2005	2010	2011	2012	2013	2014	2015
CH_4 from urban population	7.9	7.8	6.6	6.3	6.6	6.6	6.6	6.6	6.7	6.7
CH_4 from rural population	2.9	2.7	2.4	2.3	2.1	2.1	2.0	2.0	2.0	2.0
Emission in $GgCH_4$	10.8	10.4	9.1	8.7	8.7	8.7	8.6	8.6	8.7	8.7
Emission in $GgCO_2eq$	226	219	190	182	183	183	181	181	182	183

6.2.2 Nitrous Oxide from Human Sewage

Consumption of foodstuffs by humans results in the production of sewage. Main source of nitrogen from human sewage is protein, a complex, high-molecular-mass, organic compound that consists of amino acids joined by peptide bonds.

Sewage nitrogen production can be estimated from FAO per capita protein consumption data and human population counts. FAO Statistics Division provides per person protein consumption data for Georgia for years 1990-1992 (56 g/person/day), 1995-1997 (69 g/person/day), 2000-2002 (72 g/person/day) and 2005-2007 (77 g/person/day). Protein consumption for years 2008-2015 was estimated considering that by 2015 it was rose annually by 1 g/person/day.

The emissions of N_2O from human sewage are calculated by formula:

$$N_2O(S) = Protein \bullet FracNPR \bullet NR_{PEOPLE} \bullet EF_6$$

Where:

$N_2O(s)$	N_2O emissions from human sewage (kg N_2O-N/yr)
Protein	annual per capita protein intake (kg/person/yr)
NR_{PEOPLE}	number of people in country
EF_6	emissions factor [default 0.01 (0,002-0,12) kg N_2O-N/kg sewage-N produced
FracNPR	fraction of nitrogen in protein, default value =0.16 kg N/kg protein

Table 6-13. N_2O Emissions (In Gg) From Humane Sewage

Source	1990	1994	2000	2005	2010	2011	2012	2013	2014	2015
Population	4.835	4.625	4.073	3.890	3.785	3.773	3.729	3.721	3.731	3.738
Protein consumption, g/person/day	65	65	72	77	80	81	82	83	84	85
N_2O emission in Gg	0.18	0.18	0.17	0.17	0.18	0.18	0.18	0.18	0.18	0.19
in CO_2eq	57	54	53	54	55	55	55	56	57	58

6.2.3 Industrial Wastewater

Assessment of CH_4 production potential from industrial wastewater streams is based on the concentration of degradable organic matter in the wastewater, the volume of wastewater and the wastewater treatment system.

Methodology: The method for calculating emissions from industrial wastewater is similar to the Method Used for domestic wastewater, but the development of Emission Factors and Activity Data is more complex because there are many types of wastewater, and many different industries to track. The most accurate estimates of emissions for this source category are based on measured data from point sources. Due to the high costs of measurements and the potentially large number of point sources, comprehensive measurement data are absent in Georgia.

For industrial wastewater streams COD is the appropriate DC indicator. 2006 IPCC provides default COD values different industries by region. Default values of the wastewater produced per unit product by industry in m^3/tons of product are provided also in IPCC GPG.

The equation to estimate CH_4 emissions from industrial wastewater is as follows:

$$CH_4 \text{ Emissions} = \sum_i [(TOW_i - S) \bullet EF_i - R_i]$$

Where:

TOW_i	total organically degradable material in wastewater from industry I in inventory year, kg COD/year
I	industrial sector
S_i	organic component removed as sludge in inventory year, kg COD/year
EF_i	emission factor for industry i, kg CH_4/kg CODr
R_i	amount of CH_4 recovered in inventory year, kg CH_4/year

Emission Factor: Emission factor depends on the maximum CH_4 producing capacity (Bo) in each industry, and on methane correction factor (MCF).

$$EF_j = Bo \bullet MCF_j$$

Where:

EF_j	emission factor for each treatment/discharge pathway or system, kg CH_4/kg COD,
j	each treatment/discharge pathway or system
Bo	maximum CH_4 producing capacity, kg CH_4/kg COD
MCF_j	methane correction factor (fraction)

If no country-specific data are available, it is good practice to use the IPCC COD-default factor for Bo (0.25 kg CH_4/kg COD). MCF=0.3. No organic components are removed and no CH_4 recovered, i.e. S=o and R=0.

The total organic wastewater (TOW_i) for particular industry is calculated by formulae:

$$TOW_i = P_i \bullet W_i \bullet COD_i$$

Where:

TOW_i = total organically degradable material in wastewater for industry i, kg COD/yr

i	industrial sector
P_i	total industrial product for industrial sector i, t/yr
W_i	wastewater generated, m^3/t product
COD_i	chemical oxygen demand (industrial degradable organic component in wastewater), kg COD/m^3

Table 6-14. Wastewater Production and Degradable Organic Component for Different Industries

Industry Type	W, Wastewater Generation, m^3/ton	COD, kg/m^3
Alcohol Refining	24	11
Beer & Malt	6.3	2.9
Dairy Products	7	2.7
Meat & Poultry	13	4.1
Organic chemicals	67	3
Pulp & Paper	162	9
Vegetable, Fruits & Juices	20	5
Wine & Vinegar	23	1.5
Soft drinks	2	2
Canneries	24	3

Activity Data: Production data for different industries provided by National Statistic Office of Georgia are given in table 6-15.

Table 6-15. Different Industries Production Data in Thousand Tons

Source	1990	1994	2000	2005	2010	2011	2012	2013	2014	2015
Alcohol Refining					22.594	23.483	33.682	39.282	27.662	27.067
Beer & Malt	94.600	6.321	23.449	58.637	82.790	78.739	99.034	100.900	119.003	116.445
Dairy Products	265.800	17.821	4.203	6.340	24.745	33.549	40.432	46.441	53.994	52.833
Meat & Poultry	103.800		1.053	678	9.987	15.353	20.537	26.492	27.773	27.176
Organic Chemicals	437.500	124.700	362.400	418.700	560.900	611.099	609.005	614.530	613.421	649.900
Pulp & Paper	26.600		40		16.585	20.151	27.785	21.650	22.479	21.996
Vegetable, Fruits & Juices					3.507	8.943	7.905	6.595	12.492	12.223
Wine & Vinegar	162.830	63.003	16.654	39.060	25.898	30.435	46.228	67.160	110.499	108.124
Soft drinks	144.000	3.628	28.634	124.996	154.052	137.426	191.968	189.551	222.698	217.911
Canneries	694.500	8200	11.200	33.450	4.803	12.370	9.557	9.129	8.933	9.400

Table 6-16. CH_4 Emissions from Industrial Wastewater Handling

Source	1990	1994	2000	2005	2010	2011	2012	2013	2014	2015
Alcohol Refining					0.447	0.465	0.667	0.778	0.548	0.536
Beer & Malt	0.065	0.004	0.016	0.040	0.057	0.054	0.068	0.069	0.082	0.080
Dairy Products	0.188	0.013	0.003	0.004	0.018	0.024	0.029	0.033	0.038	0.037
Meat & Poultry	0.207	0.000	0.002	0.001	0.020	0.031	0.041	0.053	0.056	0.054
Organic chemicals	6.595	1.880	5.463	6.312	8.456	9.212	9.181	9.264	9.247	9.797
Pulp & Paper	1.454	0.000	0.002	0.000	0.907	1.102	1.519	1.184	1.229	1.203
Vegetable, Fruits & Juices					0.026	0.067	0.059	0.049	0.094	0.092
Wine & Vinegar	0.211	0.082	0.022	0.051	0.034	0.039	0.060	0.087	0.143	0.140
Soft drinks	0.043	0.001	0.009	0.037	0.046	0.041	0.058	0.057	0.067	0.065
Canneries	3.750	0.044	0.060	0.181	0.026	0.067	0.052	0.049	0.048	0.051
Emission in Gg CH_4	**12.5**	**2.0**	**5.6**	**6.6**	**10.0**	**11.1**	**11.7**	**11.6**	**11.6**	**12.1**
Emission in Gg CO_2-eq	**263**	**42**	**117**	**139**	**211**	**233**	**246**	**244**	**243**	**253**

7 Uncertainty Assessment

Performance of the uncertainty analysis is stipulated by the Convention Reporting Guidelines and is one of the specific functions performed by the National system (Decision 20 / CP.7).

Uncertainty estimates are an essential element of a complete inventory of greenhouse gas emissions and removals. Uncertainty information is not intended to dispute the validity of the inventory estimates, but to support prioritize efforts to improve the accuracy of inventories and guide decisions on the methodological choice. Performance of this analysis, using correct analytical methods as minimum, is possible for key categories.

There are two methods of uncertainty estimation stipulated by the IPCC 2006: (1) the basic method (Tier 1), which is mandatory and (2) the analytical method (Tier 2).

Tier 2 methodology is based on the Monte-Carlo analysis. The Monte Carlo analysis is quite detailed and requires considerable resources and time.

For uncertainty assessment of the Georgian GHG inventory, the relatively simple approach of Tier 1 was used, which is based on the following formulae (see annex):

- A and B show the IPCC category and greenhouse gas;
- C and D are the inventory estimates in the base year and the current year respectively, for the category and gas specified in Columns A and B, expressed in CO_2 equivalents;
- E and F contain the uncertainties for the Activity Data and Emission Factors respectively, derived from a mixture of empirical data and expert judgement as previously described in this chapter, entered as half the 95 percent confidence interval divided by the mean and expressed as a percentage. The reason for halving the 95 percent confidence interval is that the value entered in Columns E and F corresponds to the familiar plus or minus value when uncertainties are loosely quoted as 'plus or minus *x* percent', so expert judgements of this type can be directly entered in the spreadsheet. If uncertainty is known to be highly asymmetrical;
- enter the larger percentage difference between the mean and the confidence limit;
- G is the combined uncertainty by category derived from the data in Columns E and F using the error propagation equation. The entry in Column G is therefore the square root of the sum of the squares of the entries in Columns E and F;

$$\mathbf{G}_x = \sqrt{\mathbf{E}_\mathbf{x}^2 + \mathbf{F}_\mathbf{x}^2}$$

- H shows the uncertainty in Column G as a percentage of total national emissions in the current year. The entry in each row of Column H is the square of the entry in Column G multiplied by the square of the entry in Column D, divided by the square of total at the foot of Column D. The value at the foot of Column H is an estimate of the percentage uncertainty in total national net emissions in the current year, calculated from the entries above using Equation 3.1. This total is obtained by summing the entries in Column H and taking the square root.

Contribution to Variance by Category in Year 2015:

$$\mathbf{H}_\mathbf{x} = \frac{(\mathbf{G}_\mathbf{x} * \mathbf{D}_\mathbf{x})^2}{(\sum \mathbf{D}_\mathbf{i})^2}$$

Total emissions uncertainty using error propagation equation:

$$\boldsymbol{H_{tot}} = \sqrt{\sum_x \boldsymbol{H_x^2}}$$

Where,

$\boldsymbol{X}$ is an index that indicates the source-category,

$\mathbf{G}_{\boldsymbol{x}}$ is combined uncertainty of x source-category,

$\mathbf{E_x}$ is Activity Data uncertainty of x source-category,

$\mathbf{F_x}$ is uncertainty of gas emission factor from x source-category,

$\mathbf{H_x}$ is percentage of combined uncertainty of 2015 in total emissions

$\mathbf{D_x}$ is emissions of 2015 from x source-category,

$\mathbf{H_{tot}}$ is total uncertainty of emissions

In addition, the formula below **($\mathbf{I_x}$)** was used to estimate the uncertainty of the trend, which shows A type sensitivity.

$\mathrm{I_x}$ = percentage trend if source category x is increased by 1% in both years – percentage trend without increase

$$\frac{0.01 \bullet \mathrm{D_x} + \sum \mathrm{D_i} - (0.01 \bullet \mathrm{C_x} + \sum \mathrm{C_i})}{(0.01 \bullet \mathrm{C_x} + \sum \mathrm{C_i})} \bullet 100 - \frac{\sum \mathrm{D_i} - \sum \mathrm{C_i}}{\sum \mathrm{C_i}} \bullet 100$$

This equation shows the change in emissions between the base year (1990) and the year t (2015) in response to a 1% increase in emissions of source category x emissions in the base year and year t. This shows the sensitivity of the trend in emissions to a systematic uncertainty in the emission estimate – i.e. one that is correlated between the base year and year t. This sensitivity is described as type A sensitivity.

To estimate the uncertainty of the trend, the formula presented below **($\mathbf{J_x}$),** was used, which shows B type sensitivity.

$\mathrm{J_x}$ = percentage trend if source category x is increased by 1% in year t – percentage trend without increase

$$\mathrm{J_x} \frac{\mathrm{D_x}}{\sum \mathrm{C_i}}$$

This equation shows the changes in emissions between the base year (1990) and year t (2015) in response to a 1% increase in the emissions of source category x in year t only. This shows the sensitivity of the trend in emissions to a random uncertainty error in the emissions estimate – i.e. one that is not correlated between the base year and year Y. This sensitivity is described as type B sensitivity.

To estimate the uncertainty in national emissions due to an uncertainty of Emission Factors (column K the following approach, advised by the IPCC methodology, was used:

Assuming that the same emission factor is used in both years, and the actual Emission Factors are fully correlated, the % error introduced equally in both years. Therefore, the formula for the uncertainty introduced on the trend by the emission factor is:

$$\boldsymbol{K_x} = \textbf{Sensitivity A} * \textbf{Uncertainty of Emission Factor} = \mathbf{I_x} * \mathbf{F_x}$$

In case no correlation between Emission Factors is assumed, sensitivity B should be used and the result increased by $\sqrt{2}$, for the reason given below, in the main derivation for column L:

$$\boldsymbol{K_x} = \textbf{Sensitivity B} * \textbf{Uncertainty of Emission Factor} * \sqrt{\mathbf{2}} = \mathbf{J_x} * \mathbf{F_x} * \sqrt{\mathbf{2}}$$

To estimate uncertainty in national emissions due uncertain Activity Data (column L), the following approach, according to the IPCC methodology, was used:

The trend is the difference between emissions in the base year and in the year t. Therefore, the uncertainty of the Activity Data of the base year and t has to be taken into account. The two uncertainties combined, using the error propagation equation and the assumption that the uncertainty is the same in the base year and year t, is:

$$\mathrm{L_x} = \sqrt{(\text{uncertainty (Activity Data, base year)})^2 + (\text{uncertainty (Activity Data, year t)})^2}$$

$$\approx \sqrt{\text{uncertainty (Activity Data, year t)})^2 * 2} = \mathrm{E_x} * \sqrt{2}$$

Since Activity Data in both years are assumed to be independent, column L equals:

$$\mathrm{L_x} = \text{ sensitivity B} * \text{combined uncertainty of Activity Data of both years} = \mathrm{J_x} * \mathrm{E_x} * \sqrt{2}$$

In case correlation between Activity Data is assumed, sensitivity A should be used and the $\sqrt{2}$ factor does not apply

$$\mathrm{L_x} = \mathrm{I_x} * \mathrm{E_x}$$

To estimate the uncertainty trend in national emission (column M), the following approach was used:

Column M combines the uncertainty introduced in the trend by the uncertainty in the Activity Data and the emission factor.

$$M_x = \sqrt{K_x^2 {}_+ L_x^2}$$

The entries Mi in column M are combined to obtain the total uncertainty of the trend, using the error propagation equation, as following:

$$M_{tot} = \sqrt{M_1^2 {}_+ M_2^2 + \cdots + M_n^2}$$

According to the general methodology, uncertainty must be assessed on levels of each emission subcategory and Activity Data, and for each Emission Factors. However, when the sub-categories have no correlation or interdependence between each other (for example if Emission Factors or Activity Data are the same or interdependent for different categories), it is recommended to carry out an uncertainty analysis on the aggregate level were interdependence is negligible. This approach has the advantage that the aggregated categories can be selected allowing them to match key categories analysis and, therefore, serve their purpose. Their purpose is to identify categories (during the uncertainty assessment, as well as analysis of key categories) which require special attention during the inventory.

Most of the countries use the aggregated categories in the uncertainty analysis, and Georgia has selected the same approach in this inventory.

The uncertainty analysis in the inventory is based on the Tier 1 approach and covers all source-categories and all direct greenhouse gases, where 2015 was taken for the uncertainty assessment, and 1990 as base year. The uncertainty estimation for the Activity Data and Emission Factors was based on typical values of the IPCC and on experts' judgment. A detailed description is given in Table 9.1 and calculations of the uncertainty are presented in Table 9.2. The results revealed that the level of emissions' uncertainty (percentage uncertainty in total inventory) is within ±30.85%, and the uncertainty trend – ±13.26%. The highest uncertainty assessments have fugitive emissions from solid fuel, oil and gas extraction and indirect emissions from agriculture, as well as nitrous oxide emissions from manure management. Uncertainty is also relatively high in case of nitrous oxide emissions from Commercial/institutional services, residential, agriculture, fishing, and forestry.

7.1 The Energy Sector

7.1.1 Fuel combustion (1A)

Uncertainty estimates are an essential element of a complete emission inventory. Uncertainty information is not intended to dispute the validity of the inventory estimates, but to help prioritize efforts to improve the accuracy of inventories and guide decisions on methodological choice.

For the fuel combustion source-category (1A) uncertainty was assessed using the Tier 1 approach, which is reviewed in detail in Annex A.

According to the IPCC methodology, overall uncertainty in Activity Data is a combination of both systematic and random errors. Most developed countries prepare balances of fuel supply and deliveries, which provides a check on systematic errors. In these circumstances, overall systematic errors are likely small. Experts believe that uncertainty resulting from the two errors is probably in the range of ±5%. For countries with less well-developed energy data systems, this could be considerably larger, probably about ±10%. Informal activities may increase the uncertainty up to as much as 50% in some sectors for some countries[89]

The uncertainty associated with EFs and NCVs results from two main elements, viz. the accuracy with which the values are measured, and the variability in the source of supply of the fuel and quality of the sampling of available supplies. There are few mechanisms to account for systematic errors in the measurement of these properties. Consequently, the errors could be considered, mainly, random. For traded fuels, the uncertainty is likely to be less than 5%. For non-traded fuels, the uncertainty will be higher and will result, mostly, from variability in the fuel composition[90].

The IPCC typical value of uncertainty for countries with less well-developed energy data systems, where no good practice of energy balances creation exists - is ±10%; in case of countries with well-developed energy data systems the uncertainty is ±5%. A complete official energy balance, according international standards and requirements was developed by the National Statistics Office of Georgia (GEOSTAT) in 2014 (for the 2013 reference period). The energy balance for 1990 was also developed by Official Statistics Office, however it was mostly based on soviet standards and methodologies, and was not fully in line with EU requirements. Therefore, the uncertainty is 7%.

According to the IPCC GHG uncertainty for main activity electricity and heat production, for countries with well-developed statistical systems, when data are based on surveys (or administrative sources), is less than 1%. Therefore, the uncertainty was set at 1%91. Uncertainty for Industrial combustion, for countries with well-developed statistical systems, when data are based on surveys (or administrative sources), is about 2-5%, but when data are based on extrapolation, uncertainty is about 3-10%.

The data on consumption of firewood has high uncertainty. The data is based on survey results on consumption of energy forms, which was conducted by the National Statistics Office of Georgia (GEOSTAT), as well as data from Georgia's Energy Balance. Compared to the 2013 inventory report, more reliable data on consumption of fire wood is available, which has been collected by GEOSTAT since

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[89] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_2_Ch2_Stationary_Combustion.pdf (pg. 2.40)

[90] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_2_Ch2_Stationary_Combustion.pdf (pg. 2.38)

[91] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_2_Ch2_Stationary_Combustion.pdf (table 2.15).

2014 through household surveys and surveys in other sectors (industry, construction etc.). As mentioned above, the standard IPCC value of uncertainty for countries with less well-developed energy data systems, where energy balances creation is not well practiced, is 10%; in case of countries with a well-developed energy data system, the uncertainty is 5%. Due to the fact that fire wood is mainly consumed by the household sector, survey respondents may asses and indicate inaccurate (approximately) volumes of consumed firewood, especially when consumed firewood is not purchased. That's why the 20% uncertainty value was selected.

As for Emission Factors, for all type of fuels the standard IPCC values (5%) were selected.

A more detailed overview of the methods of selection of Activity Data for fuel combustion source category and Emission Factors uncertainty values is provided in Annex A.

As a result of the analysis, the highest uncertainty (±101.98%) is burning of firewood in case of methane and nitrous oxide. Besides burning of firewood, liquid fuel combustion in road transport and gas consumption in various sectors have also a high contribution in the uncertainty of the burning of fuel category.

7.1.2 Fugitive Emissions (1B)

In this sub-category, uncertainty assessments of Activity Data and Emission Factors were based on expert judgments and IPCC default values[92]. Uncertainty values and their determining method are detailed in Annex A.

It is worth to mention that methane emissions from gas transmission and distribution is the category with the highest contribution in total uncertainty, among all categories covered in the National Inventories; respectively, it requires special attention.

7.2 Industrial Processes

7.2.1 Cement Production (2A1)

Uncertainty estimates for cement production result predominantly from uncertainties associated with Activity Data, and to a lesser extent from uncertainty related to the emission factor for clinker.

The Activity Data is sufficiently accurate, their uncertainty is about 5%. For Tier 2, the uncertainty in data on clinker production tonnages, when available, is about 1-2 percent. Collecting data from individual producers (if complete) rather than using national totals will reduce the uncertainty of the estimate because these data will account for variations in conditions at the plant level[93].

As for the emission factor, major source of uncertainty is associated with determining the CaO content of clinker. If clinker data are available, the uncertainty of the emission factor is equal to the uncertainty of the CaO fraction and the assumption that it was all derived from $CaCO_3$ (Table 2.3)[94]. According to the methodology, it is assumed that the content of CaO is standard, associated with 4-8% of uncertainty. Thus, the uncertainty of Emission Factors is about ±5%. Consequently, the combined uncertainty is ±7.07%.

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[92] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/ V2_4_Ch4_Fugitive_Emissions.pdf (table 4.2.4, table 4.2.5)

[93] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_2_Ch2_Mineral_Industry.pdf (pg. 2.16)

[94] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_2_Ch2_Mineral_Industry.pdf (pg. 2.17)

7.2.2 Lime Production (2A2)

Uncertainty estimates for lime production result predominantly from uncertainties associated with Activity Data, and to a lesser extent from uncertainty related to the emission factor.

The stoichiometric ratio is an exact number and, therefore, the uncertainty of the emission factor is the uncertainty of lime composition, in particular of the share of hydraulic lime that has ±15% uncertainty in the emission factor (±2% uncertainty in the other types). Therefore, the total uncertainty is ±15% at most (see Table 2.25, where default uncertainty values for lime production are given)[95].

The uncertainty for the Activity Data is likely to be much higher than for the Emission Factors, based on experience in gathering lime data.

The major data source is National Statistics Office of Georgia (GEOSTAT), one factory have provided production based data. Since lime production is scattered in many small enterprises, there are some risks for full coverage. According the IPCC methodology, this uncertainty could be quite big. In the case of Georgia, based on experts' assessment, the uncertainty of Activity Data from this source is estimated as ±40%.

Consequently, the combined uncertainty (boundaries of emission assessment) is ±42.72% derived from the error propagation equation.

7.2.3 Ammonia Production (2B1)

According to the IPCC methodology[96], 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). This will include uncertainty estimates for fuel use, uncertainty estimates for ammonia production and CO_2 recovered. Where uncertainty values are not available from other sources, a default value of ±5 percent can be used.

Uncertainties for the default values[97] are estimates based on data from EFMA (2000a; p.21) and de Beer, Phylipsen and Bates (2001; p.21). In general, default Emission Factors for gaseous inputs and outputs have higher uncertainties than for solid or liquid inputs and outputs. Mass values for gaseous substances are influenced by temperature and pressure variations and gases are more easily lost through process leaks. It is good practice to obtain uncertainty estimates at the plant level, which should be lower than uncertainty values associated with default values. Default emission factor uncertainties reflect variations between plants across different locations.

According to the new Guidelines (2006 edition), using the Tier 1 approach to determine CO_2 emission parameters, fuel uncertainty needed only for unit weight of the ammonia production, which is about 6-7%, was used to estimate the coefficient. However, such an important parameter as the carbon content in natural gas, which varies according to the specific gas used, is crucial as well.

In Georgia’s energy sector, where this parameter is used, the standard value - 15.3 kg C / GJ was taken. Whereas the carbon content for specific gas is not taken into account with the ammonia coefficient, expert judgment on the overall uncertainty of CO_2 emission in the case of Georgia, set the coefficient at ±7% or more.

Consequently, the combined uncertainty is ±8.6% based on the error propagation equation.

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[95] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_2_Ch2_Mineral_Industry.pdf (pg. 2.25)
[96] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_3_Ch3_Chemical_Industry.pdf (pg. 3.17)
[97] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_3_Ch3_Chemical_Industry.pdf (table 3.1)

7.2.4 Cast Iron and Steel Production (2C1)

According to the 2006 IPCC methodology[98] the default Emission Factors for iron and steel production used in may have an uncertainty of ± 10 percent (see table 4.4).

In terms of uncertainty for Activity Data, the most important type of Activity Data is the amount of steel produced using each method. According guideline, National statistics should be available and likely have an uncertainty of ± 10 percent.

Consequently, the combined uncertainty (boundaries of emissions assessment) is ±14.14% based of error propagation equation.

Time series are agreed, because calculation of emissions for each year was performed with the same methodological approach and Emission Factors.

7.2.5 Ferroalloys Production (2C2)

According IPCC methodology, the most important type of Activity Data is the amount of ferroalloy production by product type and national statistics should be available and likely have an uncertainty less than 5 percent[99]. The Activity Data was collected from the National Statistics Office of Georgia (GEOSTAT), as well as from the MEPA of Georgia. Therefore, the data is rather accurate. Based on expert assessment, their uncertainty value is ±5%.

Applying the Tier I approach, the uncertainty of default Emission Factors are evaluated within ±25% range.

Consequently, the combined uncertainty (boundaries of emissions assessment) is ±25.5% based on the error propagation equation.

7.2.6 Nitric Acid Production (2B2)

According to the 2006 IPCC methodology[100], where Activity Data are obtained from plants, uncertainty estimates can be obtained from producers.

The data is accurate and based on expert judgment, their uncertainty does not exceed ±5%.

The uncertainty of EF of nitrogen oxides emission for this process is high, as the real value is largely determined by parameters of a specific production. 2006 IPCC guidelines for plants with NSCR give standard limits of about ±10% for uncertainty estimation[101].

Consequently, the combined uncertainty (boundaries of emissions assessment) is ±11.18% based on the error propagation equation.

The time series are agreed, since calculating emissions for each year were performed with the same methodological approach and Emission Factors.

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[98] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_4_Ch4_Metal_Industry.pdf (pg. 4.30)

[99] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_4_Ch4_Metal_Industry.pdf (pg. 4.40)

[100] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_3_Ch3_Chemical_Industry.pdf (pg. 2.26)

[101] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_3_Ch3_Chemical_Industry.pdf (table 3.3)

7.3 Agriculture

7.3.1 Enteric Fermentation

The Activity Data was taken from the official statistical publication and is reliable. However, classification and distribution of cattle is not entirely consistent with the IPCC standard on dairy and non-dairy cattle, however, it could be assumed, that the data provided by GEOSTAT about "cows" and "other cattle" are in conformity with the classification of "dairy" and "non-dairy cattle", as cows were intended for exactly dairy purpose in the case of Georgia, and the rest for its meat. Therefore, the uncertainty of Activity Data is moderate and does not exceed of ±20%.

According good practice, In general, uncertainty of Emission Factors is at least 30%, since they were taken from the standard form, without taking into account the specific nature of the country. This uncertainty reaches to ±40% in case of Georgia. As for Activity Data (heads of cattle by species), they should be considered as reliable, since they are based on Official Statistical Data from GEOSTAT.

Due to the mentioned, and based on the error propagation equation, the methane emission uncertainty is about ±44.72%.

7.3.2 Manure Management

7.3.2.1 Methane Emissions from Manure Management

Uncertainty of the data of activity related to number of the animals is assessed at 20%, since it is based on official statistical data. According to the IPCC GPG, ±50% is taken for methane emission-related uncertainty. Consequently, the combined uncertainty is approximately ±54%.

7.3.2.2 Nitrous Oxide Emissions from Manure Management

The uncertainty of Activity Data for nitrous oxide emission calculation in manure management sector was estimated at 50%, as there is no exact information about the management systems. According to the IPCC GPG, uncertainty for Emission Factors was estimated at ±100%. Consequently, the combined uncertainty of nitrous oxide emissions is approximately ±112%.

7.3.2.3 Direct Soil Emissions

The Activity Data was taken from the National Statistics Office of Georgia (GEOSTAT), which is a competent source and is quite accurate. Therefore, ±20% was selected as the indicator of uncertainty.

The uncertainty for the emission coefficient was taken from the IPCC GPG standard range and is equal to 100%. Consequently, the combined uncertainty for this source-category is approximately ±102%.

7.3.2.4 Indirect Soil Emissions

The uncertainty was estimated for the following subcategories: Nitrogen volatilization and redeposition and Nitrogen leaching, erosion and washing down. The uncertainty of Activity Data in both subcategories is quite high and related to the assumption of the percentage leached. In addition, the nitrogen content in fertilizers has uncertainty. Finally, the uncertainty of Activity Data was set at ±100%[102]. Consequently, the combined uncertainty is much higher (app. ±141 %).

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[102] http://www.ipcc-nggip.iges.or.jp/public/gp/english/4_Agriculture.pdf (pg.4.75)

7.4 Land Use Land, Use Change and Forestry (LULUCF) (CRF Sector 5)

7.4.1 Source Category: Forest Land

7.4.1.1 Emission and Removal Factors

FAO (2006) provides uncertainty estimates for forest carbon factors; basic wood density (±10 to ±40%); annual increment in managed forests of industrialized countries (±6 %); growing stock (industrialized countries ±8%, non-industrialized countries 30%); combined natural losses for industrialized countries (15%); wood and fuel wood removals (industrialized countries ±20%).

In Finland, the uncertainty of basic wood density of pine, spruce and birch trees is under 20% in studies of Hakkila (1968, 1979). The variability between forest stands of the same species should be lower or at most the same as for individual trees of the same species. In Finland, the uncertainty of biomass expansion factors for pine, spruce, and birch was approximately ±10% (Lehtonsn et al., 2003).

In eight Amazon tropical forest inventory plots, combined measurement errors led to errors of 10-30% in estimates of basal area change over periods of less than 10 years (Phillips et al., 2002)103.

The overall uncertainty of country-specific basic wood density values should be about 20%

Activity Data

According the IPCC methodology, area data should be obtained using the guidance in Chapter 3 or from FAO (2000). Industrialized countries estimated an uncertainty in forest area estimates of approximately ±3% (FAO, 2000)[104].

In Georgia's case ±5% uncertainty was selected.

Cropland

The sources of uncertainty when using the Tier 1 method include the degree of accuracy in land area estimates (see Chapter 3) and in the default biomass carbon increment and loss rates. Uncertainty is likely to be low (<10%) or estimates of area under different cropping systems since most countries annually estimate cropland area using reliable methods. A published compilation of research on carbon stocks in agroforestry systems was used to derive the default data provided in Table 5.1 (Schroeder, 1994). While defaults were derived from multiple studies, their associated uncertainty ranges were not included in the publication. Therefore, a default uncertainty level of ±75% of the parameter value has been assigned based on expert judgement[105].

Grassland

Area data and estimates of uncertainty should be obtained using the methods in Chapter 3. Tiers 2 and 3 approaches may also use finer resolution Activity Data, such as area estimates for different climatic regions or for grassland management systems within national boundaries. The finer-resolution data will reduce uncertainty levels when associated with carbon accumulation factors defined for those finer-scale land databases. If using aggregate land-use area statistics for Activity Data (e.g., FAO data), the inventory agency may have to apply a default level of uncertainty for the land area estimates (±50%). However, it is good practice for the inventory compiler to derive uncertainties from country-specific Activity Data instead of using a default level. Therefore, in case of Georgia, Activity Data is quite accurate and based on expert assessment its uncertainty value is within ±15%.

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[103] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_04_Ch4_Forest_Land.pdf

[104] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_04_Ch4_Forest_Land.pdf

[105] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_05_Ch5_Cropland.pdf

In terms of uncertainty of Emission Factors, according to the IPCC methodology[106] and based on expert judgment, a default uncertainty value of ±75% was selected.

7.5 Waste

7.5.1 Solid Waste Disposal

The uncertainty attributable to the data can be classified into Activity Data and parameters.

The uncertainty in waste disposal data depends on how the data is obtained. Uncertainty can be reduced when the amounts of waste in the SWDS are weighed. If the estimates are based on waste delivery vehicle capacity or visual estimation, uncertainty will be higher. Estimates based default Activity Data will have the highest uncertainties.

If waste scavenging takes place at the SWDS, it needs to be taken into account with the waste disposal data, otherwise, the uncertainty in waste disposal data will increase. Scavenging will also increase uncertainties in the composition of waste disposed in the SWDS, and hence also the total DOC in the waste.

Uncertainty estimates for Total Municipal Solid Waste (MSW_T) and Fraction of MSW sent to SWDS (MSW_F) and the default model parameters are given in Table 3.5[107]. The estimates are based on expert judgment.

According to the IPCC 2006 methodology, there are two sources of uncertainty in the Methane correction factor (MCF)

- Uncertainty in the value of the MCF for each type of site (managed-anaerobic, managed-semi-aerobic, unmanaged deep and/or high-water table, unmanaged shallow): These MCF values are based on one experimental study and expert judgment and not on measured data.
- Uncertainty in the classification of sites into the different site types: For example, the distinction between deep and shallow sites (5 m depth of waste) is based on expert opinion. Inevitably, few, if any, countries will be able to classify their unmanaged waste disposal sites into deep and shallow based on measured data. It can also be difficult to determine the sites that meet the IPCC criteria for managed sites.
- There are also two sources of uncertainty in DOC values.
- Uncertainty in setting the DOC for different types of waste types/materials (paper, food, etc.): There are few studies of DOC, and different types of paper, food, wood and textiles can have very different DOC values. The water content of the waste also has an influence. DOC for industrial waste is very poorly known.
- Uncertainty in the waste composition affects estimates of total DOC in the SWDS: Waste composition varies widely even within countries (for example, between urban and rural populations, between households on different incomes, and between seasons) as well as between countries.

For **DOC** (Degradable Organic Carbon), **DOCF** (Fraction of Degradable Organic Carbon Dissimilated), **MCF** (Methane Correction Factor) and **F** (Fraction of CH4 in Landfill Gas) parameters, uncertainty values from the 2006 IPCC considering specific conditions were used.

According to the IPCC methodology, the uncertainty range for Total Municipal Solid Waste (MSWT) is Country-specific: ±30% is a typical value for countries which collect waste generation data on regular

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[106] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_06_Ch6_Grassland.pdf

[107] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_3_Ch3_SWDS.pdf (pg. 3.27)

basis. ±10% for countries with high quality data (e.g., weighing at all SWDS and other treatment facilities). For countries with poor quality data: more than a factor of two.

Total uncertainty range of waste composition is between ±10% for countries with high quality data (e.g., regular sampling at representative SWDS). ±30% for countries with country-specific data based on studies including periodic sampling. For countries with poor quality data: more than a factor of two[108].

Finally, for the value of uncertainty for emission factor ±30% was chosen.

7.5.2 Industrial Waste Water handling

The Activity Data for industrial wastewater is the amount of manufactured produce and the volume of wastewater consumed for manufacturing the produce. According to the expert's judgment and the IPCC Guidelines, the uncertainty limits for them are estimated as following[109]:

- For Industrial Production - ±25% (uncertainty limits should be discussed within the recommended limits, according IPCC, as statistical data related this sector is good quality)
- The uncertainty of industrial wastewater volume (Wastewater/unit production) according to the experts' estimation is no less than ±50%;
- For COD (chemical oxygen demand) concentration (COD/unit wastewater) - no less than ±50%;

The combined uncertainty of this source-category, based on uncertainties of Emission Factors and Activity Data, equals to ±58.31%.

7.5.3 Domestic Waste Water handling

The data of domestic and commercial waste water (Domestic Waste Water handling) includes the number of population and the share of anaerobic treated wastewater. The uncertainty of standard limits of all values are based on experts' judgments and the 2006 IPCC methodology[110].

IPCC methodology provides default uncertainty ranges for emission factor and Activity Data of domestic waste water. According guideline, for identifying Emission factor uncertainty, uncertainty range for maximum CH_4 producing capacity (Bo) is ± 30%. Consequently, the final uncertainty of Emission Factors was set at 30%.

According IPCC methodology[111]:

- Uncertainty for the human population is within ±5% limit;
- For BOD per person ± 30%;
- For fraction of population income group, when good quality data on urbanization are available, however, the distinction between urban high income and urban low income may have to be based on expert judgment ± 15%.

The only national value for the emission calculation formula is the number of population, of which the uncertainty is estimated within 5% limits and, consequently, emission uncertainty estimation from this source is based on the standard factor evaluation given in the 2006 IPCC methodology.

Large uncertainties are associated with the IPCC default Emission Factors for N_2O from effluent. Currently insufficient field data exist to improve this factor. Also, the N_2O emission factor for plants is uncertain, because it is based on one field test[112].

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[108] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_3_Ch3_SWDS.pdf (pg. 3.27)
[109] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_6_Ch6_Wastewater.pdf (ph. 6.23)
[110] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_6_Ch6_Wastewater.pdf (pg. 6.16)
[111] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_6_Ch6_Wastewater.pdf (pg. 6.16)

These ranges of Activity Data and emission uncertainty factor are used to calculate the total uncertainty in methane and nitrous oxide emissions, which makes ±58.31% for industrial waste water, ±30.41% for domestic waste water -, and ±70.18% nitrous oxide emissions. The IPCC methodology includes uncertainty ranges based on expert judgment.

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[112] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_6_Ch6_Wastewater.pdf (pg. 6.26)

Table 7-1 Uncertainty Analysis

	A	B	C	D	E	F	G	H	I	J	K	L	M
	2006 IPCC Categories	**Gas**	**Emissions of 1990**	**Emissions of 2015**	**Uncertainty of Activity Data**	**Emission factor / estimation parameter uncertainty**	**Combined uncertainty**	**Contribution to Variance by Category in Year 2015**	**A type sensitivity**	**B type sensitivity**	**Uncertainty in trend in national emissions introduced by emission factor /estimation parameter uncertainty**	**Uncertainty in trend in national emissions introduced by Activity Data uncertainty**	**Uncertainty introduced into the trend in total national emissions**
			Input data	**Input data**	**Input data (Note A)**	**Input data (Note A)**	$\sqrt{E^2+F^2}$	$\frac{(G \bullet D)^2}{(\Sigma D)^2}$	**Note B**	$\left\lvert\frac{D}{\Sigma C}\right\rvert$	**I * F Note C**	**J * E *** $\sqrt{2}$ **Note D**	K^2+L^2
			Gg CO2-eq.	**Gg CO2-eq.**	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**
1A1	Electricity and Heat Production - Liquid Fuels	**CO_2**	8172,17	0,00	1	5	5,10	0,00	-0,07	0,00	0,00	-0,07	0,00
1A1	Electricity and Heat Production - Gaseous fuels	**CO_2**	4604,23	1275,00	1	5	5,10	0,30	-0,01	0,03	0,24	-0,01	0,06
1A1	Heat Production and other Energy Industries - Solid Fuels	**CO_2**	955,46	344,51	1	5	5,10	0,02	0,00	0,01	0,07	0,00	0,00
1A2	Manufacturing Industries and Construction - solid fuels	**CO_2**	3519,07	801,60	5	5	7,07	0,23	-0,01	0,02	0,15	-0,04	0,02
1A2	Manufacturing Industries and Construction – biomass	**CO_2**	0,00	3,80	5	5	7,07	0,00	0,00	0,00	0,00	0,00	0,00
1A2	Manufacturing Industries and Construction - liquid fuels	**CO_2**	2008,10	31,90	5	5	7,07	0,00	-0,02	0,00	0,01	-0,08	0,01
1A2	Manufacturing Industries and Construction - Gaseous Fuels	**CO_2**	2007,79	224,60	5	5	7,07	0,02	-0,01	0,01	0,04	-0,06	0,00
1A3a	Civil aviation	**CO_2**	0,00	2,00	7	5	8,60	0,00	0,00	0,00	0,00	0,00	0,00
1A3b	Road Transportation - Liquid Fuels	**CO_2**	3603,22	3138,42	7	5	8,60	5,11	0,05	0,08	0,59	0,37	0,49
1A3b	Road transportation - Gaseous Fuels	**CO_2**	0,00	714,70	7	5	8,60	0,26	0,02	0,02	0,14	0,13	0,04
1A3c	Other transportation	**CO_2**	141,32	207,16	7	5	8,60	0,02	0,00	0,01	0,04	0,03	0,00
1A4a	Commercial/Institutional - solid fuels	**CO_2**	85,85	3,08	5	5	7,07	0,00	0,00	0,00	0,00	0,00	0,00

	A	B	C	D	E	F	G	H	I	J	K	L	M
	2006 IPCC Categories	**Gas**	**Emissions of 1990**	**Emissions of 2015**	**Uncertainty of Activity Data**	**Emission factor / estimation parameter uncertainty**	**Combined uncertainty**	**Contribution to Variance by Category in Year 2015**	**A type sensitivity**	**B type sensitivity**	**Uncertainty in trend in national emissions introduced by emission factor /estimation parameter uncertainty**	**Uncertainty in trend in national emissions introduced by Activity Data uncertainty**	**Uncertainty introduced into the trend in total national emissions**
			Input data	**Input data**	**Input data (Note A)**	**Input data (Note A)**	$\sqrt{E^2+F^2}$	$\frac{(G \bullet D)^2}{(\Sigma D)^2}$	**Note B**	$\left\lvert\frac{D}{\Sigma C}\right\rvert$	**I * F Note C**	**J * E *** $\sqrt{2}$ **Note D**	K^2+L^2
			Gg CO2-eq.	**Gg CO2-eq.**	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**
1A4a	Commercial/Institutional - liquid fuels	CO_2	762,45	48,05	5	5	7,07	0,00	-0,01	0,00	0,01	-0,03	0,00
1A4a	Commercial/Institutional - Gaseous Fuels	CO_2	228,21	358,73	5	5	7,07	0,05	0,01	0,01	0,07	0,04	0,01
1A4b	Residential - solid fuels	CO_2	73,83	1,47	5	5	7,07	0,00	0,00	0,00	0,00	0,00	0,00
1A4b	Residential - liquid fuels	CO_2	986,76	50,79	5	5	7,07	0,00	-0,01	0,00	0,01	-0,04	0,00
1A4b	Residential - Gaseous Fuels	CO_2	2627,65	1362,67	5	5	7,07	0,65	0,01	0,04	0,26	0,07	0,07
1A4c	Agriculture, Fishing and Forestry - solid fuels	CO_2	56,76	0,99	7	5	8,60	0,00	0,00	0,00	0,00	0,00	0,00
1A4c	Agriculture, Fishing and Forestry - Liquid Fuels	CO_2	390,99	28,75	7	5	8,60	0,00	0,00	0,00	0,01	-0,02	0,00
1A4c	Agriculture, Fishing and Forestry - Gaseous Fuels	CO_2	70,48	8,33	7	5	8,60	0,00	0,00	0,00	0,00	0,00	0,00
1B1	Fugitive Emissions from Solid Fuel Mining and transformation	CO_2	62,20	11,48	5	300	300,04	0,08	0,00	0,00	0,13	0,00	0,02
1B2	Fugitive Emissions from Fuels - Oil and Natural Gas (Flaring, production, distribution)	CO_2	11,68	2,62	5	300	300,04	0,00	0,00	0,00	0,03	0,00	0,00
2A1	Cement Production	CO_2	C	C	5	5	7,07	0,17	0,01	0,02	0,13	0,07	0,02
2A2	Lime Production	CO_2	36,66	45,86	40	15	42,72	0,03	0,00	0,00	0,03	0,04	0,00
2B1	Ammonia Production	CO_2	C	C	5	7	8,60	0,11	0,01	0,01	0,12	0,04	0,02
2C1	Cast Iron and Steel Production	CO_2	C	C	10	25	26,93	0,00	-0,02	0,00	0,00	-0,17	0,03

	A	B	C	D	E	F	G	H	I	J	K	L	M
	2006 IPCC Categories	**Gas**	**Emissions of 1990**	**Emissions of 2015**	**Uncertainty of Activity Data**	**Emission factor / estimation parameter uncertainty**	**Combined uncertainty**	**Contribution to Variance by Category in Year 2015**	**A type sensitivity**	**B type sensitivity**	**Uncertainty in trend in national emissions introduced by emission factor /estimation parameter uncertainty**	**Uncertainty in trend in national emissions introduced by Activity Data uncertainty**	**Uncertainty introduced into the trend in total national emissions**
			Input data	**Input data**	**Input data (Note A)**	**Input data (Note A)**	$\sqrt{E^2+F^2}$	$\frac{(G \bullet D)^2}{(\Sigma D)^2}$	**Note B**	$\left\lvert\frac{D}{\Sigma C}\right\rvert$	**I * F Note C**	**J * E *** $\sqrt{2}$ **Note D**	K^2+L^2
			Gg CO2-eq.	**Gg CO2-eq.**	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**
2C2	Ferroalloys Production	**CO_2**	C	C	5	25	25,50	0,75	0,01	0,01	0,38	0,05	0,15
5A	Forest land	**CO_2**	-6571,90	-5627,70	5	20	20,62	94,31	-0,09	0,15	4,26	-0,47	18,33
5B	Cropland	**CO_2**	-3265,40	-1942,90	15	75	76,49	154,73	-0,02	0,05	5,51	-0,36	30,48
5C	Grassland	**CO_2**	2800,50	2810,90	15	75	76,49	323,86	0,05	0,08	7,97	0,77	64,12
1A1	Stationary fuel combustion (except biomass)	**CH_4**	8,59	0,54	7	100	100,24	0,00	0,00	0,00	0,00	0,00	0,00
1A2	Fuel combustion (biomass)	**CH_4**	9,44	1,84	20	100	101,98	0,00	0,00	0,00	0,01	0,00	0,00
1A3a	Civil aviation	**CH_4**	0,09	0,03	7	50	50,49	0,00	0,00	0,00	0,00	0,00	0,00
1A3b	Road transportation	**CH_4**	20,60	39,60	7	40	40,61	0,02	0,00	0,00	0,06	0,01	0,00
1A3c	Other transportation	**CH_4**	0,07	0,12	7	100	100,24	0,00	0,00	0,00	0,00	0,00	0,00
1A4a	Commercial/Institutional	**CH_4**	9,50	2,60	5	100	100,12	0,00	0,00	0,00	0,01	0,00	0,00
1A4b	Residential	**CH_4**	126,30	105,80	5	100	100,12	0,79	0,00	0,00	0,40	0,01	0,16
1A4c	Agriculture, Fishing and Forestry	**CH_4**	5,03	0,16	7	100	100,24	0,00	0,00	0,00	0,00	0,00	0,00
1B1	Fugitive Emissions from Solid Fuel Mining and transformation	**CH_4**	676,51	124,82	5	300	300,04	9,83	0,00	0,00	1,42	-0,01	2,00
1B2	Fugitive Emissions from oil Extraction	**CH_4**	66,89	93,20	5	300	300,04	5,48	0,00	0,00	1,06	0,01	1,12
1B2	Fugitive Emissions from oil and natural gas production	**CH_4**	142,02	30,68	5	300	300,04	0,59	0,00	0,00	0,35	0,00	0,12
1B2	Fugitive Emissions from oil and natural	**CH_4**	5126,65	1768,22	50	100	111,80	273,84	0,00	0,05	6,69	0,17	44,73

	A	B	C	D	E	F	G	H	I	J	K	L	M
	2006 IPCC Categories	**Gas**	**Emissions of 1990**	**Emissions of 2015**	**Uncertainty of Activity Data**	**Emission factor / estimation parameter uncertainty**	**Combined uncertainty**	**Contribution to Variance by Category in Year 2015**	**A type sensitivity**	**B type sensitivity**	**Uncertainty in trend in national emissions introduced by emission factor /estimation parameter uncertainty**	**Uncertainty in trend in national emissions introduced by Activity Data uncertainty**	**Uncertainty introduced into the trend in total national emissions**
			Input data	**Input data**	**Input data (Note A)**	**Input data (Note A)**	$\sqrt{E^2+F^2}$	$\frac{(G \bullet D)^2}{(\sum D)^2}$	**Note B**	$\left\lvert\frac{D}{\sum C}\right\rvert$	**I * F Note C**	**J * E *** $\sqrt{2}$ **Note D**	K^2+L^2
			Gg CO2-eq.	**Gg CO2-eq.**	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**
	gas Transmission and distribution												
4A	Enteric fermentation	**CH_4**	1557,0	1472,0	20	40	44,72	30,36	0,03	0,04	2,23	0,52	5,23
4B	Manure management	**CH_4**	185,0	118,0	20	50	53,85	0,28	0,00	0,00	0,22	0,03	0,05
6A	Solid Waste Disposal Sides	**CH_4**	558,0	894,0	30	30	42,43	10,08	0,02	0,02	1,01	0,57	1,36
6B1	Industrial Waste Water handling	**CH_4**	124,0	47,0	30	50	58,31	0,05	0,00	0,00	0,09	0,01	0,01
6B2	Domestic Waste Water handling	**CH_4**	226,0	183,0	5	30	30,41	0,22	0,00	0,00	0,21	0,01	0,04
1A1	Stationary fuel combustion (except biomass)	**N_2O**	26,89	2,19	7	100	100,24	0,00	0,00	0,00	0,01	0,00	0,00
1A2	Fuel combustion (biomass)	**N_2O**	21,56	4,02	20	100	101,98	0,00	0,00	0,00	0,02	0,00	0,00
1A3a	Civil aviation	**N_2O**	0,00	0,00	7	100	100,24	0,00	0,00	0,00	0,00	0,00	0,00
1A3b	Road transportation	**N_2O**	54,90	60,50	7	50	50,49	0,07	0,00	0,00	0,11	0,01	0,01
1A3c	Other transportation	**N_2O**	2,55	0,22	7	100	100,24	0,00	0,00	0,00	0,00	0,00	0,00
1A4a	Commercial/Institutional	**N_2O**	3,70	0,70	5	150	150,08	0,00	0,00	0,00	0,00	0,00	0,00
1A4b	Residential	**N_2O**	26,50	21,10	5	150	150,08	0,07	0,00	0,00	0,12	0,00	0,01
1A4c	Agriculture, Fishing and Forestry	**N_2O**	1,33	0,08	7	150	150,16	0,00	0,00	0,00	0,00	0,00	0,00
2B2	Nitric Acid Production	**N_2O**	C	C	5	20	20,62	0,18	0,01	0,01	0,19	0,03	0,04
3	Solvents and other product use	**N_2O**	0,011	0,015	25	1	25,02	0,00	0,00	0,00	0,00	0,00	0,00

	A	B	C	D	E	F	G	H	I	J	K	L	M
	2006 IPCC Categories	**Gas**	**Emissions of 1990**	**Emissions of 2015**	**Uncertainty of Activity Data**	**Emission factor / estimation parameter uncertainty**	**Combined uncertainty**	**Contribution to Variance by Category in Year 2015**	**A type sensitivity**	**B type sensitivity**	**Uncertainty in trend in national emissions introduced by emission factor /estimation parameter uncertainty**	**Uncertainty in trend in national emissions introduced by Activity Data uncertainty**	**Uncertainty introduced into the trend in total national emissions**
			Input data	**Input data**	**Input data (Note A)**	**Input data (Note A)**	$\sqrt{E^2+F^2}$	$\frac{(G \bullet D)^2}{(\Sigma D)^2}$	**Note B**	$\left\lvert\frac{D}{\Sigma C}\right\rvert$	**I * F Note C**	**J * E *** $\sqrt{2}$ **Note D**	$K^2 + L^2$
			Gg CO2-eq.	**Gg CO2-eq.**	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**
4B	Manure management	**N_2O**	286,0	253,0	50	100	111,80	5,61	0,00	0,01	0,96	0,22	0,96
4D1	Direct soil emissions	**N_2O**	1079,0	623,0	20	100	101,98	28,28	0,01	0,02	2,36	0,15	5,57
4D3	Indirect soil emissions	**N_2O**	329,0	185,0	100	100	141,42	4,80	0,00	0,00	0,70	0,21	0,53
6B2	Domestic Waste Water handling	**N_2O**	57,0	58,0	5	70	70,18	0,12	0,00	0,00	0,15	0,01	0,02
2F	Consumption of halocarbons and sulfur hexafluoride (Refrigeration and Air Conditioning Equipment)	**HFC**	0,00	139,39	5	25	25,50	0,09	0,00	0,00	0,13	0,02	0,02
2F	Consumption of halocarbons and sulfur hexafluoride (Emissions from Appliances (electrical equipment)	**SF6**	0,00	0,32	5	100	100,12	0,00	0,00	0,00	0,00	0,00	0,00
	Total emissions:		**37404,44**	**11946,63**		**Percentage uncertainty in total inventory:**		**951,44**					**175,88**
								30,85				**Trend uncertainty:**	**13,26**

Table 7-2 Uncertainty values of Activity Data and Emission Factors

	IPCC source-category	Gas	Uncertainty values in Activity Data and its selection reasons	Uncertainty in Emission Factors and its selection reasons
1A1	Electricity and Heat Production - Liquid Fuels	**CO_2**	According IPCC GHG uncertainty for main activity electricity and heat production, for countries with well-developed statistical systems, when data are based on surveys (or administrative sources), is less than 1%. https://www.ipcc-nGgip.iges.or.jp/public/2006gl/pdf/2_Volume2/ V2_2_Ch2_Stationary_Combustion.pdf (table 2.15). Therefore, the uncertainty was set at 1%.	According to the IPCC Guidelines, selecting a typical value for Emission Factors is within the 95% confidence interval and uncertainty is less than 5%. Therefore, a value of 5% was selected.
1A1	Electricity and Heat Production - Gaseous fuels	**CO_2**	According IPCC GHG uncertainty for main activity electricity and heat production, for countries with well-developed statistical systems, when data are based on surveys (or administrative sources), is less than 1%. https://www.ipcc-nGgip.iges.or.jp/public/2006gl/pdf/2_Volume2/ V2_2_Ch2_Stationary_Combustion.pdf (table 2.15). Therefore, the uncertainty was set at 1%.	According to the IPCC Guidelines, selecting a typical value for Emission Factors is within the 95% confidence interval and uncertainty is less than 5%. Therefore, a value of 5% was selected.
1A1	Heat Production and other Energy Industries - Solid Fuels	**CO_2**	According IPCC GHG uncertainty for main activity electricity and heat production, for countries with well-developed statistical systems, when data are based on surveys (or administrative sources), is less than 1%. https://www.ipcc-nGgip.iges.or.jp/public/2006gl/pdf/2_Volume2/ V2_2_Ch2_Stationary_Combustion.pdf (table 2.15). Therefore, the uncertainty was set at 1%.	According to the IPCC Guidelines, selecting a typical value for Emission Factors is within the 95% confidence interval and uncertainty is less than 5%. Therefore, a value of 5% was selected.
1A2	Manufacturing Industries and Construction - solid fuels	**CO_2**	According IPCC GHG uncertainty for Industrial combustion, for countries with well-developed statistical systems, when data are based on surveys (or administrative sources), is about 2-5%, but when data are based on extrapolation, uncertainty is about 3-10%. A complete official energy balance, according international standards and requirements was developed by the National Statistics Office of Georgia	According to the IPCC Guidelines, selecting a typical value for Emission Factors is within the 95% confidence interval and uncertainty is less than 5%. Therefore, a value of 5% was selected.

	IPCC source-category	Gas	Uncertainty values in Activity Data and its selection reasons	Uncertainty in Emission Factors and its selection reasons
			(GEOSTAT) in 2014 (for the 2013 reference period). The energy balance for 1990 was also developed by Official Statistics Office, however it was mostly based on soviet standards and methodologies, and was not fully in line with EU requirements. Therefore, the uncertainty was set at 5%.	
1A2	Manufacturing Industries and Construction - biomass	**CO_2**	According IPCC GHG uncertainty for Industrial combustion, for countries with well-developed statistical systems, when data are based on surveys (or administrative sources), is about 2-5%, but when data are based on extrapolation, uncertainty is about 3-10%. A complete official energy balance, according international standards and requirements was developed by the National Statistics Office of Georgia (GEOSTAT) in 2014 (for the 2013 reference period). The energy balance for 1990 was also developed by Official Statistics Office, however it was mostly based on soviet standards and methodologies, and was not fully in line with EU requirements. Therefore, the uncertainty was set at 5%.	According to the IPCC Guidelines, selecting a typical value for Emission Factors is within the 95% confidence interval and uncertainty is less than 5%. Therefore, a value of 5% was selected.
1A2	Manufacturing Industries and Construction - liquid fuels	**CO_2**	According IPCC GHG uncertainty for Industrial combustion, for countries with well-developed statistical systems, when data are based on surveys (or administrative sources), is about 2-5%, but when data are based on extrapolation, uncertainty is about 3-10%. A complete official energy balance, according international standards and requirements was developed by the National Statistics Office of Georgia (GEOSTAT) in 2014 (for the 2013 reference period). The energy balance for 1990 was also developed by Official Statistics Office, however it was mostly based on soviet standards and methodologies, and was not fully in line with EU requirements. Therefore, the uncertainty was set at 5%.	According to the IPCC Guidelines, selecting a typical value for Emission Factors is within the 95% confidence interval and uncertainty is less than 5%. Therefore, a value of 5% was selected.

	IPCC source-category	Gas	Uncertainty values in Activity Data and its selection reasons	Uncertainty in Emission Factors and its selection reasons
1A2	Manufacturing Industries and Construction - Gaseous Fuels	**CO_2**	According IPCC GHG uncertainty for Industrial combustion, for countries with well-developed statistical systems, when data are based on surveys (or administrative sources), is about 2-5%, but when data are based on extrapolation, uncertainty is about 3-10%. A complete official energy balance, according international standards and requirements was developed by the National Statistics Office of Georgia (GEOSTAT) in 2014 (for the 2013 reference period). The energy balance for 1990 was also developed by Official Statistics Office, however it was mostly based on soviet standards and methodologies, and was not fully in line with EU requirements. Therefore, the uncertainty was set at 5%.	According to the IPCC Guidelines, selecting a typical value for Emission Factors is within the 95% confidence interval and uncertainty is less than 5%. Therefore, a value of 5% was selected.
1A3a	Civil aviation	**CO_2**	Typical 7% https://www.ipcc-nGgip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_3_Ch3_Mobile_Combustion.pdf (pg. 3.69)	According to the IPCC Guidelines, with complete survey data, the uncertainty may be very low (less than 5 percent). Selecting a typical value for Emission Factors is within the 95% confidence interval and uncertainty is less than 5%. Therefore, a value of 5% was selected.
1A3b	Road Transportation - Liquid Fuels	**CO_2**	Typical 7%. https://www.ipcc-nGgip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_3_Ch3_Mobile_Combustion.pdf (pg. 3.29)	Typical 5%.
1A3b	Road transportation - Gaseous Fuels	**CO_2**	Typical 7%.	Typical 5%.
1A3c	Other transportation	**CO_2**	Typical 7%.	Typical 5%.
1A4a	Commercial/Institutional - solid fuels	**CO_2**	According IPCC GHG uncertainty for commercial, institutional, residential combustion, for countries with well-developed statistical systems, when data are based on surveys (or administrative sources), is about 3-5%, but when data are based on extrapolation, uncertainty is about 5-10%. In Georgia's case uncertainty of 5% was chosen, as comprehensive energy data collection system for official statistics exists since 2014.	According to the IPCC Guidelines, selection of typical valu for Emission Factors is within 95% confidence interval an uncertainty has less than 5%.
1A4a	Commercial/Institutional - liquid fuels	**CO_2**	According IPCC GHG uncertainty for commercial, institutional, residential combustion, for countries with	Typical 5%.

	IPCC source-category	Gas	Uncertainty values in Activity Data and its selection reasons	Uncertainty in Emission Factors and its selection reasons
			well-developed statistical systems, when data are based on surveys (or administrative sources), is about 3-5%, but when data are based on extrapolation, uncertainty is about 5-10%. In Georgia's case uncertainty of 5% was chosen, as comprehensive energy data collection system for official statistics exists since 2014.	
1A4a	Commercial/Institutional - Gaseous Fuels	**CO_2**	According IPCC GHG uncertainty for commercial, institutional, residential combustion, for countries with well-developed statistical systems, when data are based on surveys (or administrative sources), is about 3-5%, but when data are based on extrapolation, uncertainty is about 5-10%. In Georgia's case uncertainty of 5% was chosen, as comprehensive energy data collection system for official statistics exists since 2014.	Typical 5%.
1A4b	Residential - solid fuels	**CO_2**	According IPCC GHG uncertainty for commercial, institutional, residential combustion, for countries with well-developed statistical systems, when data are based on surveys (or administrative sources), is about 3-5%, but when data are based on extrapolation, uncertainty is about 5-10%. In Georgia's case uncertainty of 5% was chosen, as comprehensive energy data collection system for official statistics exists since 2014.	Typical 5%.
1A4b	Residential - liquid fuels	**CO_2**	According IPCC GHG uncertainty for commercial, institutional, residential combustion, for countries with well-developed statistical systems, when data are based on surveys (or administrative sources), is about 3-5%, but when data are based on extrapolation, uncertainty is about 5-10%. In Georgia's case uncertainty of 5% was chosen, as comprehensive energy data collection system for official statistics exists since 2014.	Typical 5%.
1A4b	Residential - Gaseous Fuels	**CO_2**	According IPCC GHG uncertainty for commercial, institutional, residential combustion, for countries with well-developed statistical systems, when data are based on surveys (or administrative sources), is about 3-5%, but when data are based on extrapolation, uncertainty	Typical 5%.

	IPCC source-category	Gas	Uncertainty values in Activity Data and its selection reasons	Uncertainty in Emission Factors and its selection reasons
			is about 5-10%. In Georgia's case uncertainty of 5% was chosen, as comprehensive energy data collection system for official statistics exists since 2014.	
1A4c	Agriculture, Fishing and Forestry - solid fuels	**CO_2**	The IPCC typical value of uncertainty for countries with less well-developed energy data systems, where no good practice of energy balances creation exists - is 10%; in case of countries with well-developed energy data systems the uncertainty is 5%. A complete official energy balance, according international standards and requirements was developed by the National Statistics Office of Georgia (GEOSTAT) in 2014 (for the 2013 reference period). The energy balance for 1990 was also developed by Official Statistics Office, however it was mostly based on soviet standards and methodologies, and was not fully in line with EU requirements. Therefore, the uncertainty is 7%.	Typical 5%.
1A4c	Agriculture, Fishing and Forestry - Liquid Fuels	**CO_2**	Typical 7%.	Typical 5%.
1A4c	Agriculture, Fishing and Forestry - Gaseous Fuels	**CO_2**	Typical 7%.	Typical 5%.
1B1	Fugitive Emissions from Solid Fuel Mining and transformation	**CO_2**	Coal mining data provided by GEOSTAT is reliable and, therefore, the uncertainty value of 5% was chosen. https://www.ipcc-nGgip.iges.or.jp/public/2006gl/pdf/2_Volume2/ V2_4_Ch4_Fugitive_Emissions.pdf (pg. 4.15, 4.16)	According the IPPC methodology, using the typical emission factor for this category has a huge uncertainty value. Therefore, an uncertainty value of 300% was chosen. https://www.ipcc-nGgip.iges.or.jp/public/2006gl/pdf/2_Volume2/ V2_4_Ch4_Fugitive_Emissions.pdf (pg. 4.15, 4.16)
1B2	Fugitive Emissions from Fuels - Oil and Natural Gas (Flaring, production, distribution)	**CO_2**	Data on Oil and Natural Gas was provided by the Oil and Gas Corporation and is reliable. Therefore, an uncertainty value of 5% was chosen	According the IPPC methodology, using the typical emission factor for this category has huge uncertainty value. Due to the complexity of the oil and gas industry, it is difficult to quantify the net uncertainties in the overall inventories, Emission Factors and Activity Data. Therefore, an uncertainty value of 300% was chosen.

	IPCC source-category	Gas	Uncertainty values in Activity Data and its selection reasons	Uncertainty in Emission Factors and its selection reasons
				https://www.ipcc-nGgip.iges.or.jp/public/2006gl/pdf/2_Volume2/ V2_4_Ch4_Fugitive_Emissions.pdf (table 4.2.4, table 4.2.5)
2A1	Cement Production	**CO_2**	Activity Data is quite accurate; therefore, its uncertainty value is within 5%.	Major source for emission factor uncertainty is associated with determining the CaO content of clinker. If clinker data are available, the uncertainty of the emission factor is equal to the uncertainty of the CaO fraction and the assumption that it was all derived from CaCO3 (Table 2.3)113. According methodology, it is assumed that the content of CaO is standard, associated with 4-8% of uncertainty. That's why, the uncertainty of Emission Factors is about 5%.
2A2	Lime Production	**CO_2**	The source of the data on lime production is National Statistics Office of Georgia (GEOSTAT), however, as far as lime production is scattered in many small enterprises, there are some risks for full coverage. According the IPCC methodology, this uncertainty could be quite big. In the case of Georgia, based on experts' assessment, the uncertainty of Activity Data from this source is estimated as 40%.	The stoichiometric ratio is an exact number and, therefore, the uncertainty of the emission factor is the uncertainty of lime composition, in particular of the share of hydraulic lime that has 15% uncertainty in the emission factor (2% uncertainty in the other types). Therefore, the total uncertainty is 15%
2B1	Ammonia Production	**CO_2**	Activity Data was collected from the National Statistics Office of Georgia (GEOSTAT), as well as from the enterprise Rustavi Chemical Fertilizers Plant, which is rather accurate data. Emissions are calculated from the used natural gas volume, as well as from the produced ammonia amount. Based on the expert judgment, their uncertainty is within 5%.	Based on the 2006 IPCC, the only required fuel uncertainty is estimated from determining the parameters of the CO_2 emissions coefficient for manufacturing the unit weight ammonia, which is about 6-7%, when using the Tier 1 approach. In Georgia's case, based on expert assessment, the overall uncertainty of the CO_2 emission coefficient is not less than 7%.

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[113] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_2_Ch2_Mineral_Industry.pdf (pg. 2.17)

	IPCC source-category	Gas	Uncertainty values in Activity Data and its selection reasons	Uncertainty in Emission Factors and its selection reasons
2C1	Cast Iron and Steel Production	**CO_2**	According guideline, the most important type of Activity Data is the amount of steel produced using each method and national statistics should be available and likely have an uncertainty of ± 10 percent. Therefore, uncertainty value of 10% was selected.	According 2006 IPCC methodology[114] the default Emission Factors for iron and steel production used in may have an uncertainty of ± 25 percent (see table 4.4).
2C2	Ferroalloys Production	**CO_2**	According IPCC methodology, the most important type of Activity Data is the amount of ferroalloy production by product type and national statistics should be available and likely have an uncertainty less than 5 percent. The Activity Data was collected from the National Statistics Office of Georgia (GEOSTAT), as well as from the Metallurgy research Institute of Georgia. Therefore, the data is rather accurate. Based on expert assessment, their uncertainty value is 5%.	In case of using the Tier 1 method, the uncertainty of emission standard coefficients is estimated in a 25% range.
5A	Forest land	**CO_2**	According to the IPCC methodology, uncertainties vary between 1-15% in 16 European countries (Laitat et al. 2000). Area data should be obtained using the guidance in Chapter 3 or from FAO (2000). Industrialized countries estimated an uncertainty in forest area estimates of approximately 3%. In Georgia's case 5% uncertainty was selected.	In Finland, the uncertainty of basic wood density of pine, spruce and birch trees is under 20% in studies of Hakkila (1968, 1979). The variability between forest stands of the same species should be lower or at most the same as for individual trees of the same species. In Finland, the uncertainty of biomass expansion factors for pine, spruce, and birch was approximately 10% (Lehtonsn et al., 2003). In eight Amazon tropical forest inventory plots, combined measurement errors led to errors of 10-30% in estimates of basal area change over periods of less than 10 years (Phillips et al., 2002). The overall uncertainty of country-specific basic wood density values should be about 20%
5B	Cropland	**CO_2**	Activity Data is quite accurate. Based on expert assessment, its uncertainty value is within 15%.	The sources of uncertainty when using the Tier 1 method include the degree of accuracy in land area estimates (see Chapter 3) and in the default biomass carbon increment and loss rates. Uncertainty is likely to be low (<10%) or estimates of area under different cropping

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[114] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_4_Ch4_Metal_Industry.pdf (pg. 4.30)

	IPCC source-category	Gas	Uncertainty values in Activity Data and its selection reasons	Uncertainty in Emission Factors and its selection reasons
				systems since most countries annually estimate cropland area using reliable methods. A published compilation of research on carbon stocks in agroforestry systems was used to derive the default data provided in Table 5.1 (Schroeder, 1994). While defaults were derived from multiple studies, their associated uncertainty ranges were not included in the publication. Therefore, a default uncertainty level of +75% of the parameter value has been assigned based on expert judgment.
5C	Grassland	**CO_2**	Activity Data is quite accurate. Based on expert assessment, its uncertainty value is within 15%.	According to the IPCC methodology and based on expert judgment, the default uncertainty value of 75% was selected.
1A1	Stationary fuel combustion (except biomass)	**CH_4**	Typical 7%.	According to the IPCC GPG document, Table 2.12 reads that the uncertainty boundary is in the 50%-150% interval. In Georgia's case the intermediate at 100% was selected. https://www.ipcc-nGgip.iges.or.jp/public/2006gl/pdf/2_Volume2/ V2_2_Ch2_Stationary_Combustion.pdf
1A2	Fuel combustion (biomass)	**CH_4**	In general, the data on consumption of firewood has high uncertainty. The data is based on survey results on consumption of energy forms, which was conducted by the National Statistics Office of Georgia (GEOSTAT), as well as data from Georgia's Energy Balance. Compared to the 2013 inventory report, more reliable data on consumption of fire wood is available, which has been collected by GEOSTAT since 2014 through household surveys and surveys in other sectors (industry, construction etc.). As mentioned above, the standard IPCC value of uncertainty for countries with less well-developed energy data systems, where energy balances creation are not well practiced, is 10%; in case of countries with a well-developed energy data systems, the uncertainty is 5%. Due to the fact that fire wood is mainly consumed by the household sector, survey respondents may asses and indicate inaccurate	According to the IPCC GPG document, Table 2.12 reads that the uncertainty boundary is in the 50%-150% interval. In Georgia's case the intermediate at 100% was selected. https://www.ipcc-nGgip.iges.or.jp/public/2006gl/pdf/2_Volume2/ V2_2_Ch2_Stationary_Combustion.pdf

	IPCC source-category	Gas	Uncertainty values in Activity Data and its selection reasons	Uncertainty in Emission Factors and its selection reasons
			(approximately) volumes of consumed firewood, especially when consumed firewood is not purchased. That's why the 20% uncertainty value was selected.	
1A3a	Civil aviation	**CH_4**	Typical 7% https://www.ipcc-nGgip.iges.or.jp/public/2006gl/pdf/2_Volume2/ V2_3_Ch3_Mobile_Combustion.pdf (pg. 3.69)	According IPCC GHG methodology, the uncertainty of the CH4 emission factor may range between -57 and +100 percent. In Georgia's case, uncertainty value of 50% was selected. https://www.ipcc-nGgip.iges.or.jp/public/2006gl/pdf/2_Volume2/ V2_3_Ch3_Mobile_Combustion.pdf (pg. 3.69)
1A3b	Road transportation	**CH_4**	Typical 7%.	Methane usually contributes less than 1% of the CO2-equivalent emissions from the transportation sector. Experts believe that there is an uncertainty of ±40% in the CH4 estimate. That's why uncertainty value of 40% was selected https://www.ipcc-nGgip.iges.or.jp/public/2006gl/pdf/2_Volume2/ V2_3_Ch3_Mobile_Combustion.pdf (pg. 3.29)
1A3c	Other transportation	**CH_4**	Typical 7%.	Typical 100%.
1A4a	Commercial/Institutional	**CH_4**	According IPCC GHG uncertainty for commercial, institutional, residential combustion, for countries with well-developed statistical systems, when data are based on surveys (or administrative sources), is about 3-5%, but when data are based on extrapolation, uncertainty is about 5-10%. In Georgia's case uncertainty of 5% was chosen, as comprehensive energy data collection system for official statistics exists since 2014.	According to the IPCC GPG document, Table 2.12, the uncertainty boundary is in the 50%-150% interval. In Georgia's case the intermediate 100% was selected. https://www.ipcc-nGgip.iges.or.jp/public/2006gl/pdf/2_Volume2/ V2_2_Ch2_Stationary_Combustion.pdf (pg.2.38)
1A4b	Residential	**CH_4**	According IPCC GHG uncertainty for commercial, institutional, residential combustion, for countries with well-developed statistical systems, when data are based on surveys (or administrative sources), is about 3-5%, but when data are based on extrapolation, uncertainty is about 5-10%. In Georgia's case uncertainty of 5% was chosen, as comprehensive energy data collection system for official statistics exists since 2014.	According to the IPCC GPG document, Table 2.12, the uncertainty boundary is in the 50%-150% interval. In Georgia's case the intermediate 100% was selected. https://www.ipcc-nGgip.iges.or.jp/public/2006gl/pdf/2_Volume2/ V2_2_Ch2_Stationary_Combustion.pdf (pg.2.38)

	IPCC source-category	Gas	Uncertainty values in Activity Data and its selection reasons	Uncertainty in Emission Factors and its selection reasons
1A4c	Agriculture, Fishing and Forestry	**CH_4**	The IPCC GPG document does not provide uncertainty typical values for Agriculture, Fishing and Forestry sectors. That is why uncertainty typical value of 7% was used (The IPCC typical value of uncertainty for countries with less well-developed energy data systems, where no good practice of energy balances creation exists - is 10%; in case of countries with well-developed energy data systems the uncertainty is 5%. A complete official energy balance, according international standards and requirements was developed by the National Statistics Office of Georgia (GEOSTAT) in 2014 (for the 2013 reference period). The energy balance for 1990 was also developed by Official Statistics Office, however it was mostly based on soviet standards and methodologies, and was not fully in line with EU requirements. Therefore, the uncertainty was defined at 7%).	According to the IPCC GPG document, Table 2.12, the uncertainty boundary is in the 50%-150% interval. In Georgia's case the intermediate 100% was selected. https://www.ipcc-nGgip.iges.or.jp/public/2006gl/pdf/2_Volume2/ V2_2_Ch2_Stationary_Combustion.pdf (pg.2.38)
1B1	Fugitive Emissions from Solid Fuel Mining and transformation	**CH_4**	Coal mining data provided by GEOSTAT is reliable and, therefore, the uncertainty value of 5% was chosen. https://www.ipcc-nGgip.iges.or.jp/public/2006gl/pdf/2_Volume2/ V2_4_Ch4_Fugitive_Emissions.pdf (pg. 4.15, 4.16), (table 4.2.4, table 4.2.5)	According the IPPC methodology, using the typical emission factor for this category has a huge uncertainty value. Therefore, an uncertainty value of 300% was chosen. https://www.ipcc-nGgip.iges.or.jp/public/2006gl/pdf/2_Volume2/ V2_4_Ch4_Fugitive_Emissions.pdf (pg. 4.15, 4.16), (table 4.2.4, table 4.2.5)
1B2	Fugitive Emissions from oil Extraction	**CH_4**	Data on Oil extraction is provided by the Oil and Gas Corporation and is reliable. Therefore, the uncertainty value of 5% was chosen	According the IPPC methodology, using the typical emission factor for this category has huge uncertainty value. Due to the complexity of the oil and gas industry, it is difficult to quantify the net uncertainties in the overall inventories, Emission Factors and Activity Data. Therefore, an uncertainty value of 300% was chosen. https://www.ipcc-nGgip.iges.or.jp/public/2006gl/pdf/2_Volume2/ V2_4_Ch4_Fugitive_Emissions.pdf (table 4.2.4, table 4.2.5)

	IPCC source-category	Gas	Uncertainty values in Activity Data and its selection reasons	Uncertainty in Emission Factors and its selection reasons
1B2	Fugitive Emissions from oil and natural gas production	**CH_4**	Data on gas production was provided by the Oil and Gas Corporation and is reliable. Therefore, an uncertainty value of 5% was chosen	According the IPPC methodology, using the typical emission factor for this category has huge uncertainty value. Due to the complexity of the oil and gas industry, it is difficult to quantify the net uncertainties in the overall inventories, Emission Factors and Activity Data. Therefore, an uncertainty value of 300% was chosen. https://www.ipcc-nGgip.iges.or.jp/public/2006gl/pdf/2_Volume2/ V2_4_Ch4_Fugitive_Emissions.pdf (table 4.2.4, table 4.2.5)
1B2	Fugitive Emissions from oil and natural gas Transmission and distribution	**CH_4**	The data was calculated using the analytical method, it is not based on real measurements and, therefore, an uncertainty value of 50% was chosen.	According the IPPC methodology, 100% value of uncertainty was chosen for Emission Factors. https://www.ipcc-nGgip.iges.or.jp/public/2006gl/pdf/2_Volume2/ V2_4_Ch4_Fugitive_Emissions.pdf (pg. 4.49, 4.50)
4A	Enteric fermentation	**CH_4**	The Activity Data was taken from the official statistical publication and is reliable. However, classification and distribution of cattle is not entirely consistent with the IPCC standard on dairy and non-dairy cattle, however, it could be assumed, that the data provided by GEOSTAT about "cows" and "other cattle" are in conformity with the classification of "dairy" and "non-dairy cattle", as cows were intended for exactly dairy purpose in the case of Georgia, and the rest for its meat. Therefore, the uncertainty of Activity Data is moderate and does not exceed of 20%.	According good practice, In general, uncertainty of Emission Factors is at least 30%, since they were taken from the standard form, without taking into account the specific nature of the country. This uncertainty reaches to 40% in case of Georgia. As for Activity Data (heads of cattle by species), they should be considered as reliable, since they are based on Official Statistical Data from GEOSTAT.
4B	Manure management	**CH_4**	The uncertainty of Activity Data related to animal number is estimated at 20%, as it is based on official statistical data.	According to the IPCC GPG, 50% is taken for methane emissions-related uncertainty.
6A	Solid Waste Disposal Sides	**CH_4**	Estimations were calculated based on the IPCC 2006 methodology, Table 3.5; The final uncertainty of the Activity Data was estimated at 30%. https://www.ipccnGgip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_3_Ch3_SWDS.pdf (pg. 3.27)	Estimations were calculated based on the IPCC 2006 methodology, Table 3.5; and similar calculations performed in the SNC. The value of uncertainty for emission factor 30% was chosen.

	IPCC source-category	Gas	Uncertainty values in Activity Data and its selection reasons	Uncertainty in Emission Factors and its selection reasons
6B1	Industrial Waste Water handling	CH_4	Estimations were calculated based on the IPCC 2006 methodology, Table 6.10 and similar calculations performed in the SNC. The final uncertainty of the Activity Data was set at 50%. https://www.ipcc-nGgip.iges.or.jp/public/2006gl/pdf/5_Volume5/ V5_6_Ch6_Wastewater.pdf (pg. 6.23)	Estimations were calculated based on the IPCC 2006 methodology, Table 6.10 and similar calculations performed in the SNC. The final uncertainty in Emission Factors was set at 30%.
6B2	Domestic Waste Water handling	CH_4	Estimations were calculated based on 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Table 6.7; The final uncertainty of the Activity Data was set at 5%. https://www.ipcc-nGgip.iges.or.jp/public/2006gl/pdf/5_Volume5/ V5_6_Ch6_Wastewater.pdf (pg. 6.17)	Estimations were calculated based on the 2006 IPCC Guidelines (Table 6.7) and similar calculations performed in the SNC. The final uncertainty in Emission Factors was set at 30%.
1A1	Stationary fuel combustion (except biomass)	N_2O	Typical 7%.	According to the IPCC GPG document, Table 2.12 reads that the uncertainty boundary is in the 50%-150% interval. In Georgia's case the intermediate at 100% was selected. https://www.ipcc-nGgip.iges.or.jp/public/2006gl/pdf/2_Volume2/ V2_2_Ch2_Stationary_Combustion.pdf
1A2	Fuel combustion (biomass)	N_2O	Data source is survey results on consumption of energy forms, which was conducted by the National Statistics Office of Georgia (GEOSTAT), as well as data from Georgia's Energy Balance. Compared to the 2013 inventory report, more reliable data on consumption of fire wood is available, which has been collected by GEOSTAT since 2014 through household surveys and surveys in other sectors (industry, construction etc.). As mentioned above, the standard IPCC value of uncertainty for countries with less well-developed energy data systems, where energy balances creation are not well practiced, is 10%; in case of countries with a well-developed energy data systems, the uncertainty is 5%. Due to the fact that fire wood is mainly consumed by the household sector, survey respondents may asses and indicate inaccurate (approximately) volumes of consumed firewood, especially when consumed	According to the IPCC GPG document, Table 2.12 reads that the uncertainty boundary is in the 50%-150% interval. In Georgia's case the intermediate at 100% was selected. https://www.ipcc-nGgip.iges.or.jp/public/2006gl/pdf/2_Volume2/ V2_2_Ch2_Stationary_Combustion.pdf

	IPCC source-category	Gas	Uncertainty values in Activity Data and its selection reasons	Uncertainty in Emission Factors and its selection reasons
			firewood is not purchased. That's why the 20% uncertainty value was selected.	
1A3a	Civil aviation	**N_2O**	Typical 7% (http://www.ipcc-nGgip.iges.or.jp/public/gp/english/2_Energy.pdf pg. 2.63)	According IPCC GHG methodology, the uncertainty of the N_2O emission factor may range between -70 and +150 percent. Based on expert assessment, uncertainty value of 150% was selected. https://www.ipcc-nGgip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_3_Ch3_Mobile_Combustion.pdf (pg. 3.69)
1A3b	Road transportation	**N_2O**	Typical 7%.	Typical 50% https://www.ipcc-nGgip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_3_Ch3_Mobile_Combustion.pdf (pg. 3.29). Nitrous oxide usually contributes approximately 3% to the CO2-equivalent emissions from the transportation sector. Expert judgment suGgests that the uncertainty of the N2O estimate may be more than ±50%. The major source of uncertainty is related to the Emission Factors.
1A3c	Other transportation	**N_2O**	Typical 7%	Typical 100%
1A4a	Commercial/Institutional	**N_2O**	According IPCC GHG uncertainty for commercial, institutional, residential combustion, for countries with well-developed statistical systems, when data are based on surveys (or administrative sources), is about 3-5%, but when data are based on extrapolation, uncertainty is about 5-10%. In Georgia's case uncertainty of 5% was chosen, as comprehensive energy data collection system for official statistics exists since 2014.	According to the IPCC GPG document, Table 2.12, uncertainty ranges from one-tenth of the mean value, to ten times the mean value should be applied. In this case, an uncertainty value of 150% was selected. https://www.ipcc-nGgip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_2_Ch2_Stationary_Combustion.pdf (pg.2.38)
1A4b	Residential	**N_2O**	According IPCC GHG uncertainty for commercial, institutional, residential combustion, for countries with well-developed statistical systems, when data are based on surveys (or administrative sources), is about 3-5%, but when data are based on extrapolation, uncertainty is about 5-10%. In Georgia's case uncertainty of 5% was chosen, as comprehensive energy data collection system for official statistics	According to the IPCC GPG document, Table 2.12, uncertainty ranges from one-tenth of the mean value, to ten times the mean value should be applied. In this case, an uncertainty value of 150% was selected. https://www.ipcc-nGgip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_2_Ch2_Stationary_Combustion.pdf (pg.2.38)

	IPCC source-category	Gas	Uncertainty values in Activity Data and its selection reasons	Uncertainty in Emission Factors and its selection reasons
			exists since 2014.	
1A4c	Agriculture, Fishing and Forestry	**N_2O**	The IPCC GPG document does not provide uncertainty typical values for Agriculture, Fishing and Forestry sectors. That is why uncertainty typical value of 7% was used	The IPCC GPG document does not provide uncertainty typical values for Agriculture, Fishing and Forestry sectors (see. Table 2.12 https://www.ipcc-nGgip.iges.or.jp/public/2006gl/pdf/2_Volume2/ V2_2_Ch2_Stationary_Combustion.pdf (pg.2.38), therefore, an uncertainty typical value of 150% for other sectors (Commercial and Public Services, Residential) was used.
2B2	Nitric Acid Production	**N_2O**	The Activity Data is rather accurate. Based on the expert judgment its uncertainty value does not exceed 5%.	A new IPCC manual allows standard boundaries of 20% uncertainty assessment for medium-pressure technology plants
3	Solvents and other product use	**N_2O**	Activity Data was not collected from the National Statistics Office of Georgia (GEOSTAT) and, therefore, 25% of uncertainty was chosen.	IPCC GPG methodology doesn't provide exact data on Emission Factors uncertainty. Consequently, based on expert's assessment and taking into account of Activity Data, 1% of uncertainty value was selected.
4B	Manure management	**N_2O**	The uncertainty of Activity Data for nitrous oxide emissions calculation in the manure management sector was estimated at 50%, as there is no exact information about the management systems.	According to IPCC GPG, the uncertainty for Emission Factors was estimated at 100%
4D1	Direct soil emissions	**N_2O**	The Activity Data was collected from National Statistics Office of Georgia (GEOSTAT), which is a competent source and quite accurate. Therefore, 20% was selected as the indicator of uncertainty.	The uncertainty for Emission Factors were taken from the standard range of the IPCC GPG and are equal to 100%.
4D3	Indirect soil emissions	**N_2O**	According IPCC GPG, the uncertainty of Activity Data is quite high and related to the assumption of the percentage leached. In addition, nitrogen content in fertilizers has also certain level of uncertainty. Therefore, the uncertainty of Activity Data was set at 100%.	According to the IPCC GPG, the uncertainty of Emission Factors is in the same range. A value of 100% was selected due to the absence of better information.
6B2	Domestic Waste Water handling	**N_2O**	The only national value in the formula to calculate emissions is number of populations, of which the uncertainty is estimated within 5%. Consequently, 5% of uncertainty was chosen.	The assessment for this source is based on estimations of standard coefficient (2006 IPCC) and is about 70%.

	IPCC source-category	Gas	Uncertainty values in Activity Data and its selection reasons	Uncertainty in Emission Factors and its selection reasons
2F	Consumption of halocarbons and sulfur hexafluoride (Refrigeration and Air Conditioning Equipment)	**HFC**	Activity Data is relatively accurate. Based on the expert judgment, its uncertainty value is 5%	According to the IPCC GPG, the uncertainty level for standard coefficients of emission is estimated at 25%.
2F	Consumption of halocarbons and sulfur hexafluoride (Emissions from Appliances (electrical equipment)	**SF6**	Activity Data is relatively accurate. Based on the expert judgment, its uncertainty value is 5%	According to the IPCC GPG, tier 1 estimates are set at an uncertainty of 100% or more, representing an estimate of actual emissions. Therefore, the value of 100% was selected.

8 Quality Assurance and Quality Control

8.1 Introduction

As part of its commitments to the UNFCCC, Georgia as a non-annex I country regularly submits its national communications (NCs) and Biennial Update Reports (BUR) to the UNFCCC through GEF funded enabling activities projects implemented by UNDP, outlining local climate change trends and developments. To this end, Georgia has prepared and submitted three NCs and its first BUR.

In July 2017 new agreement between the Government of Georgian (GoG) and the UNDP on implementation of the project on "Development of Georgia's Fourth National Communication and Second Biennial Update Report to the UNFCCC" was signed. The project contemplates the preparation of Georgia's Second Biennial Update Report (SBUR) to UNFCCC and the Fourth National Communication (FNC) by the quarter 1 of 2019 and quarter 4 of 2020 respectively. The essential element of NC's and BUR's is the national inventory of GHG emissions (NIR). The Project cooperates with the LEPL Environmental Information and Education Centre (EIEC) of the Ministry of Environmental Protection and Agriculture of Georgia for assessment of emissions for 2014-15 years. The project also intends recalculation of GHG emissions of previous years using the new methodology and preparation of respective report and chapter of SBUR.

In this light it is crucial to ensure fostering of the relevant quality assurance (QA) system of National GHG Inventories, established within the first BUR project, and implement the appropriate procedures. The aforementioned goal can be reached by participation in the process of qualified organization not directly involved in the inventory compilation/development process in the QA activities.

To fulfill above mentioned QA procedure/activities of the inventory preparation process in October 3, 2018 a service agreement between UNDP Georgia and Ilia State University was signed.

The main goal of this assignment is to further fostering institutional and technical capacity building process specifically for conducting verified GHG inventories in future by assisting the local institutions, both financially and technically, to provide QA procedures for NIR. Objective of this agreement is to implement quality assurance (QA) procedures for the National GHG Inventory being prepared by the EIEC.

Ilia State University (ILIAUNI) is a lead educational and research center with faculty of Natural Sciences and Engineering having a strong background in Earth Sciences, Environmental Studies, good regional coverage and research in sustainable as well as renewable energy technologies, forestry, urban planning, sustainable resources and waste management. The University has strong and successful experience in participation in various projects of UNDP. ILIAUNI has a high-quality academic staff and experts with vast experience in climate change mitigation technologies, environmental and economic assessments. In 2016 ILIANI staff was involved in preparation of QC/QA for the Georgia's GHG Inventory and BUR.

The QC is carried out through a system of routine technical activities that monitor and maintain the quality of the inventory, while it is being prepared. The QC activities are carried out by team of experts involved during the preparation of the GHG NIR and also by the project coordinator during the compilation and preparation of the GHG NIR of Georgia.

8.2 QA Procedures

8.2.1 QA Fundamentals

Quality Assurance (QA), as defined by the IPCC Good Practice Guidance, is a planned system of review procedures conducted by personnel not directly involved in the inventory compilation/development process. Reviews, preferably by independent third parties, are performed upon a finalized inventory following the QC procedures in order to verify that data quality objectives are met, ensure that the inventory represents the best possible estimates of emissions and removals given the current state of scientific knowledge and data availability, and support the effectiveness of the QC programme. Quality assurance procedures regard some verification activities of the inventory as a whole and at sectoral level. Feedbacks for the inventory should derive from communication of data to different institutions and/or at local level and from information publicly available. For instance, the communication of the inventory to the European Community result in a pre-check of the GHG values before the submission to the UNFCCC and relevant inconsistencies may be highlighted. Results and suggestions from expert reviews of the national inventory within the UNFCCC process can provide valuable feedback on areas where the inventories can be improved.

The quality of the inventory may improve through the organization and participation in sector specific workshops. An independent review and if needed public reviews, should be implemented in order to check emission levels and make controls on the transparency and consistency of methodological approaches performed.

8.2.2 QA Activities

As it is stated in 2006 IPCC Guidelines for National Greenhouse Gas Inventories Chapter 6 - Quality Assurance/Quality Control and Verification [1] "Quality assurance comprises activities outside the actual inventory compilation. *Good practice* for QA procedures includes reviews and audits to assess the quality of the inventory, to determine the conformity of the procedures taken and to identify areas where improvements could be made. QA procedures may be taken at different levels (internal/external), and they are used in addition to the general and category-specific QC procedures".

The inventory may be reviewed as a whole or in parts. The objective of QA implementation is to involve reviewers that can conduct an unbiased review of the inventory and who may have a different technical perspective. It is important to use QA reviewers that have not been involved in preparing the inventory. Preferably these reviewers would be independent experts from other agencies or national or international experts or groups not closely connected with the national inventory compilation, e.g., inventory experts of other countries. Where third party reviewers who are independent from the inventory compiler are not available, persons who are at least not involved in the portion being reviewed can also perform QA. It is *good practice* for inventory compilers to conduct a basic expert peer review of all categories before completing the inventory in order to identify potential problems and make corrections where possible. However, this will not always be practical due to timing and resource constraints. *Key categories* should be given priority as well as categories where significant changes in methods or data have been made. Inventory compilers may also choose to perform more extensive peer reviews or audits as QA procedures within the available resources. In smaller countries, where there may not be external expertise in all technical areas, the inventory compiler should consider contacting inventory compilers from other countries as part of an external review. More specific information on QA procedures related to individual categories is provided in the category-specific QA/QC sections in Volumes 2-5 [2].

Below is provided a list of QA activities which are envisaged under the UNDP-ILIAUNI agreement.

List of QA Activities

1. Detailed work plan prepared and submitted to the UNDP;
2. Check compliance of the inventory to the IPCC formats;
3. Check compliance of the units to the IPCC formats;
4. Check project file for completeness;
5. Check that assumptions and criteria for selection of Activity Data and Emission Factors are documented;
6. Check that changes in data or methodology are documented;
7. Check that all emission calculations are included (i.e., emissions are not hard-wired);
8. Check whether emission units, parameters, and conversion factors are inappropriately hardwired;
9. Check if units are properly labelled and correctly carried through from beginning to end of calculation;
10. Check that conversion factors are correct;
11. Check that temporal and spatial adjustment factors are used correctly;
12. Check a representative sample of calculations, by hand or electronically;
13. Check the aggregation of data within a source category;
14. When methods or data have changed, check consistency of time series inputs and calculations;
15. Check for consistency with IPCC inventory guidelines and good practices, particularly if changes occur;
16. Conduct The first expert review after the initial set of emission estimates is completed:
    a. review of initial data;
    b. review of Emission Factors and methodologies;
    c. review of emission estimates;
17. Conduct the second expert review upon completion of the draft Inventory Report;
18. Consolidate the comments received into one document;
19. Determine whether any changes are necessary to the estimates or text, and record the decision;
20. Prepare Report on implemented QA/QC activities and key findings.

8.2.3 QA Procedure Staff Functions

Under the assignment of UNDP-ILIAUNI Agreement two experts are involved in QA procedure.

1. Task Manager (Quality Assurance Expert) - responsible for project results, overall management and preparation of deliverables, stakeholder relations, and
2. Analyst (Assistant) - data analysis and draft writing, interaction with experts and stakeholders.

References

1. IPCC Guidelines for National Greenhouse Gas Inventories (2006). Chapter 6: QA/QC and Verification https://www.ipcc-nGgip.iges.or.jp/public/2006gl/pdf/1_Volume1/V1_6_Ch6_QA_QC.pdf. (Last accessed in 12/2018).

2. IPCC Guidelines for National Greenhouse Gas Inventories. (2006). Volume 2. Energy. https://www.ipcc-nGgip.iges.or.jp/public/2006gl/vol2.html. (Last accessed in 12/2018).

3. IPCC Guidelines for National Greenhouse Gas Inventories (2006). Annex 8A.1: Prefixes, units and abbreviations, standard equivalents. https://www.ipcc-nGgip.iges.or.jp/public/2006gl/pdf/1_Volume1/V1_8x_Ch8_An1_Units_Index.pdf. (Last accessed in 12/2018).

9 Recalculation of GHG Emissions and Possible Improvements for Future Inventories

During this inventory GHG emissions and removals calculated using 2006 IPCC guidelines for 2014 and 2015 and recalculated results for the following years 1990, 1994, 2000, 2005, 2010, 2011, 2012, 2013. For other years GHG emissions and removals were interpolated using Compound Annual Growth Rate. Exception is the IPPU sector where GHG emissions were recalculated for all previous years. Main sources of difference in recalculated results are: updated Activity Data, net calorific values, Emission Factors. For the next inventory GHG emission and removal estimates will be recalculated for all remaining years 1991-1993, 1995-1999, 2001-2004, 2006-2009 in each sector.

Table 9-1 GHG Emissions and Removals by Sectors for 1990-2015 Period (2006 IPCC Methodology)

Sector	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
Energy	36,698	27,476	20,580	15,421	11,560	10,210	9,030	7,998	7,094	6,302	5,609	5,564	5,520
IPPU	3,879	3,038	1,705	776	414	447	535	504	502	710	725	439	591
Agriculture	3,925	3,492	3,108	2,766	2,463	2,548	2,636	2,727	2,822	2,920	3,021	3,043	3,065
Waste	1,105	1,073	1,041	1,011	978	1,003	1,026	1,050	1,074	1,099	1,124	1,138	1,153
LULUCF (Net removals)	(6,850)	(6,828)	(6,799)	(6,765)	(6,726)	(6,493)	(6,252)	(5,997)	(5,720)	(5,407)	(5,033)	(5,014)	(4,976)
Total (excluding LULUCF)	**45,607**	**35,079**	**26,434**	**19,974**	**15,415**	**14,208**	**13,227**	**12,279**	**11,492**	**11,031**	**10,479**	**10,184**	**10,329**
Total (including LULUCF)	**38,757**	**28,251**	**19,635**	**13,210**	**8,688**	**7,715**	**6,975**	**6,282**	**5,771**	**5,624**	**5,446**	**5,170**	**5,353**

Sector	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Energy	5,477	5,436	5,396	5,796	6,226	6,689	7,187	7,722	9,758	10,443	9,034	9,665	10,872
IPPU	699	846	957	1,136	1,314	1,383	1,106	1,443	1,794	1,872	1,892	2,035	2,058
Agriculture	3,087	3,109	3,132	3,042	2,956	2,872	2,790	2,712	2,649	2,859	3,186	3,201	3,271
Waste	1,167	1,182	1,199	1,223	1,249	1,275	1,303	1,330	1,362	1,375	1,375	1,377	1,388
LULUCF (Net removals)	(4,923)	(4,857)	(4,782)	(4,742)	(4,651)	(4,477)	(4,166)	(3,633)	(5,069)	(3,836)	(4,836)	(2,525)	(4,076)
Total (excluding LULUCF)	**10,431**	**10,574**	**10,684**	**11,198**	**11,745**	**12,219**	**12,385**	**13,208**	**15,563**	**16,549**	**15,487**	**16,278**	**17,589**
Total (including LULUCF)	**5,508**	**5,717**	**5,903**	**6,456**	**7,094**	**7,742**	**8,218**	**9,574**	**10,494**	**12,713**	**10,651**	**13,753**	**13,513**

Table 9-2 GHG Emissions and Removals by Sectors for 1990-2015 Period (1996 IPCC and GPG)

Sector	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
Energy	36,587	28,815	19,395	11,246	7,445	4,790	7,585	9,018	5,057	5,183	5,925	5,466	5,006
Industrial processes	5,383	4,084	2,245	1,068	543	520	703	810	744	1,070	1,096	748	1,058
Agriculture	3,985	3,525	3,242	2,703	2,386	2,461	2,954	3,124	2,790	2,991	2,802	3,025	3,214
Waste	1,232	1,011	1,020	1,024	1,020	1,028	1,030	1,033	1,034	1,043	1,041	1,045	1,049
LULUCF (Net removals)			(7,091)	(6,564)	(6,637)	(882)	(1,392)	(4,930)	(4,592)	(6,415)	(6,088)	(6,156)	(5,523)

Sector	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
Total (excluding LULUCF)	47,187	37,436	25,902	16,040	11,394	8,799	12,272	13,985	9,625	10,287	10,864	10,284	10,326
Total (including LULUCF)	47,187	37,435	18,811	9,477	4,757	7,917	10,880	9,055	5,033	3,872	4,776	4,128	4,804

Sector	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Energy	5,449	6,144	5,786	8,301	8,378	7,849	7,216	7,458	9,413	10,083	9,386
Industrial processes	1,220	1,452	1,810	2,138	2,890	2,822	2,749	1,853	3,013	3,379	3,296
Agriculture	3,331	3,120	3,460	3,115	2,651	2,552	2,604	2,403	2,353	2,502	2,732
Waste	1,051	1,052	1,054	1,073	1,083	1,086	1,097	1,226	1,243	1,260	1,265
LULUCF (Net removals)	(6,361)	32,893	(4,893)	(5,173)	(4,098)	(4,190)	(4,441)	(3,869)	(4,208)	(4,073)	(4,124)
Total (excluding LULUCF)	11,051	11,767	12,110	14,628	15,002	14,309	13,667	**12,939**	**16,022**	**17,224**	**16,679**
Total (including LULUCF)	4,690	44,661	7,217	9,454	10,904	10,119	9,225	**9,070**	**11,814**	**13,151**	**12,555**

More specific information on differences in results in IPPU sector are provided below.

Mineral Industry (2A)

Cement Production (2A1)

Table 9-3 Category-Specific Documentation of Recalculations (Cement Production)

Cement Production/CO2	**Emissions (Gg)**												
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Previous Data	C	C	C	C	C	C	C	C	C	C	C	C	C
Latest Data	C	C	C	C	C	C	C	C	C	C	C	C	C
Difference in per cent	C	C	C	C	C	C	C	C	C	C	C	C	C
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Previous Data	C	C	C	C	C	C	C	C	C	C	C		
Latest Data	C	C	C	C	C	C	C	C	C	C	C		
Difference in per cent	C	C	C	C	C	C	C	C	C	C	C		
Documentation Reason for Recalculation: There are two major reasons triggering the recalculations for the source-category of Cement Production. The factory has provided the factory specific clinker production Activity Data from 2008. The delivered data includes the information on wet and dry processing technologies separately for seven years. In accordance to the 2006 IPCC guidelines the factory specific data has a preference position than the national statistics information, since it allows using the second-tier method for the GHG emissions estimation. Moreover, in 1990 the emissions have been estimated with the combination of cement and clinker productions. Subsequently, the sum up of tier 1 and tier 2 methods has a risk of double counting. In order to reduce the risk, the overlap method was used to reconstruct the clinker production data for the period of 1990 - 2007.													

Lime Production (2A2)

Table 9-4 Category-Specific Documentation of Recalculations (Lime Production)

Lime Production/CO2	**Emissions (Gg)**												
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Previous Data	42	16	9	4	2	4	13	0	3	0	3	11	22
Latest Data	37	14	8	4	1	3	11	0	2	0	2	10	20
Difference in per cent	-12%	-13%	-13%	-13%	-13%	-13%	-13%	-13%	-13%	-13%	-13%	-13%	-13%
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Previous Data	23	11	14	19	22	14	45	37	721	830	891		
Latest Data	20	9	12	16	20	34	40	32	46	29	33		
Difference in per cent	-13%	-13%	-13%	-13%	-12%	140%	-13%	-12%	-94%	-96%	-96%		

Documentation Reason for Recalculation:

The reason of having the recalculation for the lime production relates to the designation of lime type that has been produced in Georgia by one of the plants operating in Georgia. The plant specific data on water content in lime produced has been taken for the calculation of GHG emissions. Subsequently, the lime produced from that factory has been deducted for the data delivered by the national statistics office. The total GHG emissions for this source-category consist of data from national statistics office and one factory producing lime.

In upcoming years, in order to increase accuracy of emissions estimation the collection of factory specific data for all three operating plants would be helpful step.

Glass Production (2A3)

Table 9-5 Category-Specific Documentation of Recalculations (Glass Production)

Glass Production/CO_2	Emissions (Gg)												
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Previous Data	C	C	C	C	C	C	C	C	C	C	C	C	C
Latest Data	C	C	C	C	C	C	C	C	C	C	C	C	C
Difference in per cent	C	C	C	C	C	C	C	C	C	C	C	C	C
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Previous Data	C	C	C	C	C	C	C	C	C	C	C		
Latest Data	C	C	C	C	C	C	C	C	C	C	C		
Difference in per cent	C	C	C	C	C	C	C	C	C	C	C		

Documentation Reason for Recalculation:
The Activity Data by the type of raw material used has been provided by single factory for the years of 2003 - 2015. Accordingly, the emission estimation method has been improved. In order to be kept the improved method results for the whole time series the overlap method has been used for the glass emission for the years of 1990 - 2003. The data of wine and beer production in Georgia has been used for keeping the trend since the bottles are delivered by this factory for these beverages.

Chemical Industry (2B)

Ammonia Production (2B1)

Table 9-6 Category-Specific Documentation of Recalculations (Ammonia Production)

Ammonia Production/CO_2	**Emissions (Gg)**												
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002

Ammonia Production/CO$_2$	**Emissions (Gg)**												
Previous Data	C	C	C	C	C	C	C	C	C	C	C	C	C
Latest Data	C	C	C	C	C	C	C	C	C	C	C	C	C
Difference in per cent	C	C	C	C	C	C	C	C	C	C	C	C	C
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Previous Data	C	C	C	C	C	C	C	C	C	C	C		
Latest Data	C	C	C	C	C	C	C	C	C	C	C		
Difference in per cent	C	C	C	C	C	C	C	C	C	C	C		

Documentation Reason for Recalculation:
The Activity Data including the calorific value of natural gas used and the plant-specific reduction factor has been provided by single factory for the years of 1990 - 2015. Accordingly, the emission estimation method has been improved.

Nitric Acid Production (2B2)

Table 9-7 Category-Specific Documentation of Recalculations (Nitric Acid Production)

Nitric Acid Production/N$_2$O	**Emissions (Gg)**												
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Previous Data	C	C	C	C	C	C	C	C	C	C	C	C	C
Latest Data	C	C	C	C	C	C	C	C	C	C	C	C	C
Difference in per cent	C	C	C	C	C	C	C	C	C	C	C	C	C
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Previous Data	C	C	C	C	C	C	C	C	C	C	C		
Latest Data	C	C	C	C	C	C	C	C	C	C	C		
Difference in per cent	C	C	C	C	C	C	C	C	C	C	C		

Documentation Reason for Recalculation:
The Activity Data with the technological description has been provided by single factory for the years of 1990 - 2015. Since the production has been performed by use of non-selective catalysis the emission factor has been changed based on the IPCC 2006 guidelines from the average coefficient to appropriate value for the NSC.

Metal Industry (2C)

Steel Production (2C1)

Table 9-8 Category-Specific Documentation of Recalculations (Steel Production)

Steel Production/CO2 eq.	**Emissions (Gg)**												
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Previous Data	C	C	C	C	C	C	C	C	C	C	C	C	C
Latest Data	C	C	C	C	C	C	C	C	C	C	C	C	C
Difference in per cent	C	C	C	C	C	C	C	C	C	C	C	C	C
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Previous Data	C	C	C	C	C	C	C	C	C	C	C		
Latest Data	C	C	C	C	C	C	C	C	C	C	C		
Difference in per cent	C	C	C	C	C	C	C	C	C	C	C		

Documentation Reason for Recalculation:
The Activity Data such as sinter and steel production, metallurgical coke, limestons, graphite, ferrosilicon, Silicomanganum, pig iron, rust quantities and their carbon contents has been provided by two plants for the years of 1990 - 2015. Accordingly, the emission estimation method has been improved. Furthermore, the IPCC 2006 guideline provides the methodology to estimate CH4 emissions from the steel production. Comparing to the previous inventories the methane emissions has been estimated and added to the report based on the gathered Activity Data.

Ferroalloys Production (2C2)

Table 9-9 Category-Specific Documentation of Recalculations (Ferroalloys Production)

Ferroalloys Production/CO2 eq.	**Emissions (Gg)**												
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Previous Data	C	C	C	C	C	C	C	C	C	C	C	C	C
Latest Data	C	C	C	C	C	C	C	C	C	C	C	C	C
Difference in per cent	C	C	C	C	C	C	C	C	C	C	C	C	C
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Previous Data	C	C	C	C	C	C	C	C	C	C	C		
Latest Data	C	C	C	C	C	C	C	C	C	C	C		
Difference in per cent	C	C	C	C	C	C	C	C	C	C	C		

Documentation Reason for Recalculation:
The Activity Data by the type of ferroalloys produced in Georgia has been gathered from four different plants for the years of 2015. The aggregated data of production of ferroalloys in the country has been provided by the statistics office of Georgia for the whole time-series period from 1990 to 2015. The plant specific data has been used to identify the production average ratio among the types of ferroalloys. In accordance to the assumptions Ferro silicomanganese annual production is about 82.57 per cent in total ferroalloys, Ferromanganese and Ferrosilicon ratios are 3,88 and 13,55 per cents accordingly. These ratios have been used for the recalculation of the emissions from the Ferroalloys production source-category for the whole time-series period.

10 Annexes

10.1 Energy Balances

Energy Balance (fossil fuel) – 1990

Georgia 1990 (TJ)	Other Bit. Coal	Lignite	Coke Oven Coke	Fuel wood	Natural Gas	Crude Oil	Liquefied Petroleum Gases	Motor Gasoline	Kerosene type Jet Fuel	Kerosene	Road diesel	Fuel oil-low sulphur (< 1%)	Lubricants	Bitumen
Production	-	16,252.00	20,575.62	19,560.00	2,063.70	7,905.00	441.00	17,512.00	4,061.74	-	28,511.14	36,279.20	-	5,928.00
Imports	13,650.00	2,125.00	3,634.44	380.00	188,611.20	90,695.00	2,745.00	30,668.00	5,012.36	2,981.49	21,794.99	111,221.20	5,168.00	3,952.00
Exports	-	9,129.00	-	-	-	-	-	6,468.00	820.99	43.21	23,138.22	11,271.60	-	-
International Marine Bunkers	-	-	-	-	-	-	-	-	-	-	-	-	-	-
International Aviation Bunkers	-	-	-	-	-	-	-	-	8,512.37	-	-	-	-	-
Stock Changes	-	(442.00)	(351.72)	(750.00)	-	2,720.00	(45.00)	(2,376.00)	259.26	172.84	(1,603.21)	4,646.00	(608.00)	-
Domestic Supply	**13,650.00**	**8,806.00**	**23,858.34**	**19,190.00**	**190,674.90**	**101,320.00**	**3,141.00**	**39,336.00**	-	**3,111.12**	**25,564.70**	**140,874.80**	**4,560.00**	**9,880.00**
Statistical Differences	-	-	-	-	(0.00)	-	-	-	-	-	-	-	-	-
Transformation Sector - Input	10,100.00	-	-	-	82,071.90	-	-	-	-	-	736.61	104,878.40	-	-
Thermal Electricity Plants					23,149.80						433.30	62,902.80		
Heat Plants	10,100.00				58,922.10						303.31	41,975.60		
Petroleum Refineries														
Transformation Sector - Production	-	-	-	-	-	101,320.00	-	-	-	-	-	-	-	-
Thermal Electricity Plants														
Heat Plants														
Petroleum Refineries						101,320.00								
Energy Sector	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Coal Mines														
Own Use in Thermal Electricity Plants														
Transmission Losses					3,813.50									
Distribution Losses					9,431.06									
Final Consumption	**3,550.00**	**8,806.00**	**23,858.34**	**19,190.00**	**95,358.45**	-	**3,141.00**	**39,336.00**	-	**3,111.12**	**24,828.09**	**35,996.40**	**4,560.00**	**9,880.00**
Industry Sector	**2,500.00**	**7,225.00**	**23,858.34**	-	**35,789.55**	-	-	**88.00**	-	**561.73**	**519.96**	**24,846.00**	-	-
Iron and steel														
Chemical (including petrochemical)					281.10									
Non-ferrous metals														
Non-metallic minerals														
Transport equipment														
Machinery														
Mining and quarrying														
Food, beverages and tobacco														
Paper, pulp and printing														
Wood and wood products														
Construction	600.00				2,093.40			88.00		129.63	129.99	2,222.00		
Textiles and leather														
Not elsewhere specified (Industry)	1,900.00	7,225.00	23,858.34		33,415.05					432.10	389.97	22,624.00		
Transport Sector	**450.00**	-	-	-	**1,405.80**	-	**135.00**	**26,752.00**	-	**259.26**	**22,401.61**	**1,090.80**	-	-
Road							135.00	26,752.00			22,401.61	1,090.80		
Rail	450.00													
Domestic aviation														
Domestic navigation														
Pipeline transport					1,405.80									
Not elsewhere specified (Transport)										259.26				
Other Sectors	**600.00**	**1,581.00**	-	**19,190.00**	**52,163.10**	-	**3,006.00**	**12,496.00**	-	**2,290.13**	**1,906.52**	**10,059.60**	-	-
Commercial and public services		850.00		1,091.00	4,068.00		261.00			345.68	996.59	8,362.80		
Residential		731.00		14,339.00	46,838.70		2,520.00	9,504.00		1,771.61	563.29			
Agriculture/forestry	600.00				1,256.40		225.00	2,992.00		172.84	346.64	1,696.80		
Fishing														
Not elsewhere specified (Other)				3,760.00										
Non-Energy Use					6,000.00								4,560.00	9,880.00

Energy Balance (fossil fuel) – 1994

Georgia 1994 (TJ)	Other Bit. Coal	Lignite	Coke Oven Coke	Fuel wood	Natural Gas	Crude Oil	Liquefied Petroleum Gases	Motor Gasoline	Kerosene type Jet Fuel	Kerosene	Road diesel	Fuel oil-low sulphur (<1%)	Lubricants	Bitumen
Production		3,128.00		12,149.00	90.00	1,955.00	45.00	1,144.00	475.31		2,036.51	2,383.60		152.00
Imports	3,050.00		1,758.6		67,835.70	5,950.00	1,485.00	11,616.00	2,462.97	3,845.69	14,602.21	43,793.60	2,698.00	1,596.00
Exports								748.00	172.84	43.21	736.61	1,494.80		
International Marine Bunkers											389.97	1,777.60		
International Aviation Bunkers									2,765.44					
Stock Changes								44.00		86.42	43.33			
Domestic Supply	**3,050.00**	**3,128.00**	**1,758.60**	**12,149.00**	**67,925.70**	**7,905.00**	**1,530.00**	**12,056.00**	**-**	**3,888.90**	**15,555.47**	**42,904.80**	**2,698.00**	**1,748.00**
Statistical Differences	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Transformation Sector - Input	-	-	-	-	26,021.70	-	-	-	-	-	563.29	33,289.60	-	-
MA Thermal Electricity Plants					24,586.20						389.97	17,089.20		
MA Heat Plants					1,435.50						173.32	16,200.40		
Petroleum Refineries														
Transformation Sector - Production	-	-	-	-	-	7,905.00	-	-	-	-	-	-	-	-
MA Thermal Electricity Plants														
MA Heat Plants														
Petroleum Refineries						7,905.00								
Energy Sector	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Coal Mines														
Own Use in Thermal Electricity Plants														
Transmission Losses					1,358.51									
Distribution Losses					2,230.69									
Final Consumption	**3,050.00**	**3,128.00**	**1,758.60**	**12,149.00**	**38,314.80**	**-**	**1,530.00**	**12,056.00**	**-**	**3,888.90**	**14,992.18**	**9,615.20**	**2,698.00**	**1,748.00**
Industry Sector	**2,150.00**	**204.00**	**1,758.60**	**1,128.00**	**22,227.10**	**-**	**-**	**352.00**	**-**	**259.26**	**1,343.23**	**4,444.00**	**-**	**-**
Iron and steel														
Chemical (including petrochemical)					393.10									
Non-ferrous metals														
Non-metallic minerals														
Transport equipment														
Machinery														
Mining and quarrying														
Food, beverages and tobacco														
Paper, pulp and printing														
Wood and wood products														
Construction	300.00				897.30			44.00		86.42	303.31	969.60		
Textiles and leather														
Not elsewhere specified (Industry)	1,850.00	204.00	1,758.60	1,128.00	20,936.70			308.00		172.84	1,039.92	3,474.40		
Transport Sector	**300.00**	**-**	**-**	**-**	**747.90**	**-**	**45.00**	**9,548.00**	**-**	**129.63**	**8,709.33**	**1,252.40**	**-**	**-**
Road							45.00	9,548.00			8,709.33			
Rail	300.00											1,252.40		
Domestic aviation														
Domestic navigation														
Pipeline transport					747.90									
Not elsewhere specified (Transport)										129.63				
Other Sectors	**600.00**	**2,924.00**	**-**	**11,021.00**	**13,339.80**	**-**	**1,485.00**	**2,156.00**	**-**	**3,500.01**	**4,939.62**	**3,918.80**	**-**	**-**
Commercial and public services		1,139.00		2,633.00	3,589.20		45.00			172.84	1,039.92	2,181.60		
Residential		1,785.00		6,507.00	8,853.30		900.00	1,804.00		2,981.49	2,253.16			
Agriculture/forestry	600.00			1,881.00	897.30		540.00	352.00		345.68	1,646.54	1,737.20		
Not elsewhere specified (Other)														
Non-Energy Use					2,000.00								2,698.00	1,748.00

Energy Balance (fossil fuel) – 2000

Georgia 2000 (TJ)	Other Bit. Coal	Lignite	Coke Oven Coke	Fuel wood	Natural Gas	Crude Oil	Liquefied Petroleum Gases	Motor Gasoline	Kerosene type Jet Fuel	Kerosene	Road diesel	Fuel oil- low sulphur (< 1%)	Lubricants	Bitumen
Production		124.10		27,014.00	2,782.50	4,675.00					216.65	404.00		
Imports	300.00				37,560.60		2,385.00	11,968.00	648.15	3,283.96	7,236.11	4,080.40	304.00	342.00
Exports		17.00				3,187.50								
International Marine Bunkers														
International Aviation Bunkers									648.15					
Stock Changes		153.00				(595.00)	45.00					161.60		
Domestic Supply	**300.00**	**260.10**	-	**27,014.00**	**40,343.10**	**892.50**	**2,430.00**	**11,968.00**	-	**3,283.96**	**7,452.76**	**4,646.00**	**304.00**	**342.00**
Statistical Differences	-	(62.90)	-	-	0.39	-	-	-	-	-	-	-	-	-
Transformation Sector - Input	-	-	-	-	20,500.20	-	-	-	-	-	259.98	3,555.20	-	-
MA Thermal Electricity Plants					20,500.20						259.98	3,555.20		
MA Heat Plants														
Petroleum Refineries														
Transformation Sector - Production	-	-	-	-	-	892.50	-	-	-	-	-	-	-	-
MA Thermal Electricity Plants														
MA Heat Plants														
Petroleum Refineries						892.50								
Energy Sector	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Coal Mines														
Own Use in Thermal Electricity Plants														
Transmission Losses					806.86									
Distribution Losses					1,713.24									
Final Consumption	**300.00**	**323.00**	-	**27,014.00**	**17,322.40**	-	**2,430.00**	**11,968.00**	-	**3,283.96**	**7,192.78**	**1,090.80**	**304.00**	**342.00**
Industry Sector	**300.00**	-	-	**1,501.00**	**8,254.80**	-	-	**1,584.00**	-	-	**953.26**	**161.60**	-	-
Iron and steel														
Chemical (including petrochemical)														
Non-ferrous metals														
Non-metallic minerals														
Transport equipment														
Machinery														
Mining and quarrying														
Food, beverages and tobacco														
Paper, pulp and printing														
Wood and wood products														
Construction								264.00			606.62	40.40		
Textiles and leather														
Not elsewhere specified (Industry)	300.00			1,501.00	8,254.80			1,320.00			346.64	121.20		
Transport Sector	-	-	-	-	-	-	-	**8,668.00**	-	-	**4,376.33**	**404.00**	-	-
Road								8,668.00			4,376.33			
Rail												404.00		
Domestic aviation														
Domestic navigation														
Pipeline transport														
Not elsewhere specified (Transport)														
Other Sectors	-	**323.00**	-	**25,513.00**	**9,067.60**	-	**2,430.00**	**1,716.00**	-	**3,283.96**	**1,863.19**	**525.20**	-	-
Commercial and public services				500.00	687.60		90.00	1,232.00		345.68	86.66	202.00		
Residential		323.00		25,013.00	8,380.00		2,340.00			2,851.86	43.33	161.60		
Agriculture/forestry								484.00		86.42	1,733.20	161.60		
Fishing														
Not elsewhere specified (Other)														
Non-Energy Use													304.00	342.00

Energy Balance (fossil fuel) – 2005

Georgia 2005 (TJ)	Other Bit. Coal	Lignite	Coke Oven Coke	Fuel wood	Natural Gas	Crude Oil	Liquefied Petroleum Gases	Motor Gasoline	Kerosene type Jet Fuel	Kerosene	Road diesel	Fuel oil- low sulphur (<1%)	Lubricants	Bitumen
Production		85.00		14,612.00	640.80	2,847.50						161.60		304.00
Imports	325.00				43,785.90	722.50	1,755.00	14,696.00	1,598.77	1,123.46	10,919.16	484.80	380.00	2,280.00
Exports						2,720.00	630.00							
International Marine Bunkers														
International Aviation Bunkers									1,598.77					
Stock Changes														
Domestic Supply	**325.00**	**85.00**	-	**14,612.00**	**44,426.70**	**850.00**	**1,125.00**	**14,696.00**	-	**1,123.46**	**10,919.16**	**646.40**	**380.00**	**2,584.00**
Statistical Differences	-	-	-	-	0.38	-	-	-	-	-	-	-	-	-
Transformation Sector - Input	-	-	-	-	11,592.90	850.00	-	-	-	-	2,383.15	-	-	-
MA Thermal Electricity Plants					8,460.00						2,383.15			
MA Heat Plants					3,132.90									
Petroleum Refineries						850.00								
Transformation Sector - Production	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MA Thermal Electricity Plants														
MA Heat Plants														
Petroleum Refineries														
Energy Sector	-	-	-	-	6,609.00	-	-	-	-	-	-	-	-	-
Coal Mines														
Energy industry own Use					6,609.00									
Transmission Losses					888.53									
Distribution Losses					2,210.39									
Final Consumption	**325.00**	**85.00**	-	**14,612.00**	**23,125.50**	-	**1,125.00**	**14,696.00**	-	**1,123.46**	**8,536.01**	**646.40**	**380.00**	**2,584.00**
Industry Sector	**325.00**	-	-	-	**3,833.10**	-	-	-	-	-	**86.66**	**646.40**	-	-
Iron and steel					98.10									
Chemical (including petrochemical)														
Non-ferrous metals														
Non-metallic minerals					3,073.50							121.20		
Transport equipment					128.70									
Machinery					1.80									
Mining and quarrying														
Food, beverages and tobacco					464.40							242.40		
Paper, pulp and printing					0.90									
Wood and wood products														
Construction					52.20							282.80		
Textiles and leather					13.50									
Not elsewhere specified (Industry)	325.00										86.66			
Transport Sector	-	-	-	-	**451.80**	-	-	**14,696.00**	-	-	**6,196.19**	-	-	-
Road					451.80			14,696.00			6,196.19			
Rail														
Domestic aviation														
Domestic navigation														
Pipeline transport														
Not elsewhere specified (Transport)														
Other Sectors	-	**85.00**	-	**14,612.00**	**11,455.20**	-	**1,125.00**	-	-	**1,123.46**	**2,253.16**	-	-	-
Commercial and public services				963.00	1,959.30						86.66			
Residential		85.00		12,770.00	7,385.40		1,125.00			1,123.46	86.66			
Agriculture/forestry				879.00	2,110.50						2,079.84			
Not elsewhere specified (Other)														
Non-Energy Use					7,385.40								380.00	2,584.00

Energy Balance (fossil fuel) – 2010

Georgia 2010 (TJ)	Other Bit. Coal	Lignite	Coke Oven Coke	Fuel wood	Natural Gas	Crude Oil	Liquefied Petroleum Gases	Motor Gasoline	Kerosene type Jet Fuel	Kerosene	Road diesel	Fuel oil-low sulphur (<1%)	Lubricants	Bitumen	Non-specified Petroleum Prods.
Production		4,550.90		15,629.25	283.50	2,186.20									
Imports	1,683.35		2,835.35		243,815.87	217.93	786.26	19,197.61	1,673.09	2,778.27	18,117.44	180.80	555.87	3,541.74	90.40
Exports		252.51			202,849.50	2,468.51		21.64				151.60	11.39		
International Marine Bunkers															
International Aviation Bunkers									1,673.09						
Stock Changes						64.18							(158.46)		(90.56)
Domestic Supply	**1,683.35**	**4,298.39**	**2,835.35**	**15,629.25**	**41,249.87**	**(0.20)**	**786.26**	**19,175.96**	**-**	**2,778.27**	**18,117.44**	**29.20**	**386.02**	**3,541.74**	**(0.16)**
Statistical Differences	-	3.23	-	-	279.65	(0.20)	0.11	0.32	-	(0.13)	17.63	0.11	-	0.15	(0.16)
Transformation Sector - Input	-	-	-	-	6,930.58	-	-	-	-	-	2,300.39	-	-	-	-
MA Thermal Electricity Plants					6,930.58						2,300.39				
MA Heat Plants															
Petroleum Refineries															
Transformation Sector - Production	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MA Thermal Electricity Plants															
MA Heat Plants															
Petroleum Refineries															
Energy Sector	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Coal Mines															
Own Use in Thermal Electricity Plants															
Transmission Losses					762.46										
Distribution Losses					3,020.11										
Final Consumption	**1,683.35**	**4,295.16**	**2,835.35**	**15,629.25**	**30,257.06**	-	**786.15**	**19,175.64**	-	**2,778.40**	**15,799.42**	**29.09**	**386.02**	**3,541.59**	-
Industry Sector	**1,683.35**	**1,030.88**	**2,835.35**	-	**5,692.39**	-	-	**262.24**	-	-	-	**19.39**	-	-	-
Iron and steel															
Chemical (including petrochemical)															
Non-ferrous metals															
Non-metallic minerals															
Transport equipment															
Machinery															
Mining and quarrying															
Food, beverages and tobacco															
Paper, pulp and printing															
Wood and wood products															
Construction															
Textiles and leather															
Not elsewhere specified (Industry)	1,683.35	1,030.88	2,835.35		5,692.39			262.24				19.39			
Transport Sector	-	-	-	-	**268.10**	-	-	**18,389.36**	-	-	**14,684.10**	-	-	-	-
Road					268.10			18,346.68			14,493.02				
Rail								42.68			191.09				
Domestic aviation															
Domestic navigation															
Pipeline transport															
Not elsewhere specified (Transport)															
Other Sectors	-	**3,264.28**	-	**15,629.25**	**20,218.75**	-	**786.15**	**524.04**	-	**2,778.40**	**1,115.31**	**9.70**	-	-	-
Commercial and public services				1,349.63	3,841.88										
Residential				13,582.92	14,437.52		786.15			2,778.40	257.38				
Agriculture/forestry		1,091.40			1,575.70			524.04			857.93				
Not elsewhere specified (Other)		2,172.88		696.70	363.65							9.70			
Non-Energy Use					4,077.83								386.02	3,541.59	

Energy Balance (fossil fuel) – 2011

Georgia 2011 (TJ)	Other Bit Coal	Lignite	Coke Oven Coke	Fuel wood	Natural Gas	Crude Oil	Liquefied Petroleum Gases	Motor Gasoline	Kerosene type Jet Fuel	Kerosene	Road diesel	Fuel oil-low sulphur (<1%)	Lubricants	Bitumen	Non-specified Petroleum Prods.
Production		5,999.30		13,716.53	203.00	2,122.66									
Imports	2,026.46	1.08	3,778.72		249,461.48	109.67	844.59	17,691.67	2,462.97	2,464.78	18,536.43	252.68	547.25	2,276.83	12.80
Exports		121.55			184,698.50	2,076.67					1.28		26.94	4.06	
International Marine Bunkers															
International Aviation Bunkers									1,512.35						
Stock Changes						(155.55)			(172.84)						(12.80)
Domestic Supply	**2,026.46**	**5,878.83**	**3,778.72**	**13,716.53**	**64,965.98**	**0.10**	**844.59**	**17,691.67**	**777.78**	**2,464.78**	**18,535.16**	**252.68**	**520.31**	**2,272.78**	-
Statistical Differences	-	0.06	-	-	167.65	0.10	(0.06)	-	-	0.08	(0.12)	-	-	-	-
Transformation Sector - Input	-	-	-	-	22,008.34	-	-	-	-	-	511.29	-	-	-	-
MA Thermal Electricity Plants					22,008.34						511.29				
MA Heat Plants															
Petroleum Refineries															
Transformation Sector - Production	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MA Thermal Electricity Plants															
MA Heat Plants															
Petroleum Refineries															
Energy Sector	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Coal Mines															
Own Use in Thermal Electricity Plants															
Transmission Losses					1,185.17										
Distribution Losses					3,759.52										
Final Consumption	**2,026.46**	**5,878.77**	**3,778.72**	**13,716.53**	**37,845.29**	-	**844.65**	**17,691.67**	**777.78**	**2,464.70**	**18,023.98**	**252.68**	**520.31**	**2,272.78**	-
Industry Sector	**2,026.46**	**5,141.82**	**3,778.72**	-	**8,118.85**	-	-	-	-	-	**766.94**	**252.68**	-	-	-
Iron and steel															
Chemical (including petrochemical)															
Non-ferrous metals															
Non-metallic minerals															
Transport equipment															
Machinery															
Mining and quarrying															
Food, beverages and tobacco															
Paper, pulp and printing															
Wood and wood products															
Construction															
Textiles and leather															
Not elsewhere specified (Industry)	2,026.46	5,141.82	3,778.72		8,118.85						766.94	252.68			
Transport Sector	-	-	-	-	**484.05**	-	-	**17,691.67**	**777.78**	-	**13,635.08**	-	-	-	-
Road					484.05			17,691.67			13,635.08				
Rail															
Domestic aviation									777.78						
Domestic navigation															
Pipeline transport															
Not elsewhere specified (Transport)															
Other Sectors	-	**736.95**	-	**13,716.53**	**24,820.73**	-	**844.65**	-	-	**2,464.70**	**3,621.95**	-	-	-	-
Commercial and public services				1,480.99	6,336.48		80.55								
Residential				11,538.77	16,941.45		562.95			1,971.67	852.30				
Agriculture/forestry					1,341.55		201.15			493.03	2,769.65				
Not elsewhere specified (Other)		736.95		696.77	201.25										
Non-Energy Use					4,421.66								520.31	2,272.78	

Energy Balance (fossil fuel) – 2012

Georgia 2012 (TJ)	Other Bit. Coal	Lignite	Coke Oven Coke	Fuel wood	Natural Gas	Crude Oil	Liquefied Petroleum Gases	Motor Gasoline	Kerosene type Jet Fuel	Kerosene	Road diesel	Fuel oil-low sulphur (<1%)	Lubricants	Bitumen	Non-specified Petroleum Prods.
Production		7,170.60		30,942.60	189.00	1,874.25									
Imports	1,892.42		3,828.19		253,134.14		808.12	16,884.77	2,201.12	2,201.26	19,906.72	138.80	676.82	3,878.06	12.67
Exports		72.68			182,000.00	1,586.99					6.11	47.31	32.93		
International Marine Bunkers															
International Aviation Bunkers									2,949.08						
Stock Changes						(287.30)			772.59						
Domestic Supply	**1,892.42**	**7,097.93**	**3,828.19**	**30,942.60**	**71,323.14**	**(0.04)**	**808.12**	**16,884.77**	**24.63**	**2,201.26**	**19,900.62**	**91.49**	**643.88**	**3,878.06**	**12.67**
Statistical Differences	-	(0.00)	-	-	(0.00)	(0.04)	-	-	0.00	(2.45)	-	-	-	-	-
Transformation Sector - Input	-	-	-	-	24,555.00	-	-	-	-	-	-	-	-	-	-
MA Thermal Electricity Plants					24,555.00										
MA Heat Plants															
Petroleum Refineries															
Transformation Sector - Production	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MA Thermal Electricity Plants															
MA Heat Plants															
Petroleum Refineries															
Energy Sector	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Coal Mines															
Own Use in Thermal Electricity Plants															
Transmission Losses					1,253.43										
Distribution Losses					4,096.32										
Final Consumption	**1,892.42**	**7,097.93**	**3,828.19**	**30,942.60**	**41,418.39**	-	**808.12**	**16,884.77**	**24.63**	**2,203.71**	**19,900.62**	**91.49**	**643.88**	**3,878.06**	**12.67**
Industry Sector	**1,892.42**	**7,076.51**	**3,828.19**	-	**8,945.86**	-	-	**376.00**	-	**21.61**	**2,482.72**	**52.00**	-	-	-
Iron and steel															
Chemical (including petrochemical)															
Non-ferrous metals															
Non-metallic minerals															
Transport equipment															
Machinery															
Mining and quarrying															
Food, beverages and tobacco															
Paper, pulp and printing															
Wood and wood products															
Construction															
Textiles and leather															
Not elsewhere specified (Industry)	1,892.42	7,076.51	3,828.19		8,945.86			376.00		21.61	2,482.72	52.00			
Transport Sector	-	-	-	-	**862.05**	-	**101.35**	**16,472.46**	**24.63**	-	**17,068.16**	-	-	-	-
Road					862.05		101.35	16,472.46			16,623.43				
Rail											388.60				
Domestic aviation									24.63						
Domestic navigation											56.13				
Pipeline transport															
Not elsewhere specified (Transport)															
Other Sectors	-	**21.41**	-	**30,942.60**	**26,964.13**	-	**706.77**	**36.31**	-	**2,182.11**	**349.74**	**39.49**	-	-	-
Commercial and public services		5.98		2,613.00	9,687.35		14.51					39.49			
Residential		15.44		28,314.78	17,133.28		692.26			1,663.59					
Agriculture/forestry				14.82	143.50			36.31		518.52	349.74				
Not elsewhere specified (Other)															
Non-Energy Use					4,646.35								643.88	3,878.06	12.67

Energy Balance (fossil fuel) – 2013

Georgia 2013 (TJ)	Anthracite	Other Bit. Coal	Lignite	Coke Oven Coke	Fuel wood	Pellets, briquettes, other solid fuels	Other vegetal materials and residual	Natural Gas	Crude Oil	Liquefied Petroleum Gases	Motor Gasoline	Kerosene type Jet Fuel	Kerosene	Road diesel	Heating and other gas oil	Fuel oil-low sulphur (<1%)	Lubricants	Bitumen	Paraffin Waxes	Non-specified Petroleum Prods.
Production	-	-	7,032.86	-	19,835.69	293.98	14.33	182.57	2,034.18	-	-	-	-	-	-	-	-	-	-	-
Imports	231.93	1,760.00	-	4,545.66	-	-	-	64,371.09	-	761.40	16,554.65	3,806.80	17.28	20,606.98	165.63	207.66	657.86	2,965.79	135.74	17.78
Exports	-	-	73.43	-	-	2.23	-	-	2,422.29	-	74.85	-	-	13.35	-	197.68	87.17	38.00	108.79	-
International Marine Bunkers	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
International Aviation Bunkers												3,656.11								
Stock Changes	-	-	9.40	(287.97)	1.16	-	-	-	388.11	(15.43)	366.17	(120.07)	-	(620.25)	-	51.92	-	77.35	-	-
Domestic Supply	**231.93**	**1,760.00**	**6,968.83**	**4,257.69**	**19,836.85**	**291.75**	**14.33**	**64,553.66**	**-**	**745.97**	**16,845.97**	**30.61**	**17.28**	**19,973.39**	**165.63**	**61.89**	**570.68**	**3,005.13**	**26.94**	**17.78**
Statistical Differences	-	-	-	-	-	0.00	(0.00)	-	-	-	-	0.00	-	-	-	-	-	-	-	-
Transformation Sector - Input	-	-	-	-	-	-	-	16,981.53	-	-	-	-	-	-	-	-	-	-	-	-
MA Thermal Electricity Plants								16,981.53												
MA Heat Plants																				
Petroleum Refineries																				
Transformation Sector - Production	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MA Thermal Electricity Plants																				
MA Heat Plants																				
Petroleum Refineries																				
Energy Sector	-	-	24.12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Coal Mines			24.12																	
Own Use in Thermal Electricity Plants																				
Transmission Losses								141.37												
Distribution Losses								3,106.05												
Final Consumption	**231.93**	**1,760.00**	**6,944.71**	**4,257.69**	**19,836.85**	**291.75**	**14.33**	**44,324.71**	**-**	**745.97**	**16,845.97**	**30.61**	**17.28**	**19,973.39**	**165.63**	**61.89**	**570.68**	**3,005.13**	**26.94**	**17.78**
Industry Sector	218.98	1,760.00	6,923.76	4,257.69	8.76	-	-	2,914.32	-	-	375.14	-	8.64	2,493.17	12.93	35.18	-	-	-	-
Iron and steel	-	25.00	13.57	403.80	-	-	-	255.80	-	-	-	-	-	-	7.63	-				
Chemical (including petrochemical)	-	-	-	-	-	-	-	87.61	-	-	-	-	-	-	-	-				
Non-ferrous metals	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-				
Non-metallic minerals	-	1,735.00	6,835.37	3,853.88	-	-	-	800.76	-	-	-	-	4.32	-	-	-				
Transport equipment	-	-	-	-	-	-	-	26.36	-	-	-	-	-	-	-	-				
Machinery	-	-	-	-	-	-	-	4.73	-	-	-	-	-	-	-	-				
Mining and quarrying	-	-	-	-	-	-	-	9.30	-	-	4.78	-	-	508.69	-	-				
Food, beverages and tobacco	217.33	-	74.82	-	8.76	-	-	1,361.58	-	-	-	-	-	-	-	-				
Paper, pulp and printing	-	-	-	-	-	-	-	53.49	-	-	-	-	-	-	-	-				
Wood and wood products	-	-	-	-	-	-	-	5.27	-	-	-	-	-	-	-	-				
Construction	-	-	-	-	-	-	-	275.65	-	-	370.36	-	4.32	1,984.48	5.30	35.18				
Textiles and leather	-	-	-	-	-	-	-	14.71	-	-	-	-	-	-	-	-				
Not elsewhere specified (Industry)	1.64	-	-	-	-	-	-	19.04	-	-	-	-	-	-	-	-				
Transport Sector	-	-	-	-	-	-	-	8,785.26	-	93.56	16,434.61	30.61	-	17,127.35	-	-	-	-	-	-
Road	-	-	-	-	-	-	-	8,785.26	-	93.56	16,434.61	-	-	16,681.55	-	-				
Rail														390.77						
Domestic aviation												30.61								
Domestic navigation														55.03						
Pipeline transport																				
Not elsewhere specified (Transport)																				
Other Sectors	12.96	-	20.95	-	19,828.08	291.75	14.33	23,827.01	-	652.42	36.22	-	8.64	352.87	152.70	26.71	-	-	-	-
Commercial and public services	12.96	-	5.85	-	322.25	11.31	-	4,460.85	-	13.40	-	-	-	-	152.70	26.71				
Residential	-	-	15.10	-	19,504.05	280.44	14.33	19,307.38	-	639.02	-	-	8.64	-	-	-				
Agriculture/forestry	-	-	-	-	1.79	-	-	58.79	-	-	36.22	-	-	352.87	-	-				
Fishing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-				
Not elsewhere specified (Other)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-				
Non-Energy Use								8,798.12									570.68	3,005.13	26.94	17.78

Energy Balance (fossil fuel) – 2014

Georgia 2014 (TJ)	Anthracite	Other Bit. Coal	Lignite	Coke Oven Coke	Patent fuel	Fuel wood	Pellets, briquettes, other solid fuels	Other vegetal materials and residual	Natural Gas	Crude Oil	Liquefied Petroleum Gases	Motor Gasoline	Kerosene type Jet Fuel	Kerosene	Road diesel	Heating and other gas oil	Fuel oil-low sulphur (< 1%)	Lubricants	Bitumen	Paraffin Waxes	Non-specified Petroleum Prods.
Production	-	-	5,088.34	-	-	19,303.20	159.67	7.31	359.44	1,811.82	-	-	-	-	-	-	-	-	-	-	-
Imports	114.99	3,058.13	-	3,836.78	34.73	-	-	-	76,421.70	430.74	815.44	16,453.65	3,379.13	4.38	22,656.27	292.29	581.67	690.32	3,280.03	79.39	7.26
Exports	-	-	43.69	-	-	-	-	-	-	2,178.17	-	41.81	-	-	5.84	-	516.19	45.70	-	62.24	-
International Marine Bunkers	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
International Aviation Bunkers													3,469.72								
Stock Changes	(14.66)	-	(1.70)	106.90	-	-	-	-	-	(63.75)	1.25	370.01	124.97	-	(413.23)	(25.57)	-	(6.20)	(174.95)	-	-
Domestic Supply	**100.34**	**3,058.13**	**5,042.95**	**3,943.68**	**34.73**	**19,303.20**	**159.67**	**7.31**	**76,781.14**	**0.64**	**816.69**	**16,781.84**	**34.38**	**4.38**	**22,237.20**	**266.72**	**65.48**	**638.43**	**3,105.08**	**17.15**	**7.26**
Statistical Differences	-	-	-	-	-	(0.00)	-	-	-	0.64	-	-	-	0.00	-	-	0.00	-	-	-	-
Transformation Sector - Input	-	-	-	-	-	-	-	-	20,110.29	-	-	-	-	-	-	-	-	-	-	-	-
MA Thermal Electricity Plants									20,110.29												
MA Heat Plants																					
Petroleum Refineries																					
Transformation Sector - Production	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MA Thermal Electricity Plants																					
MA Heat Plants																					
Petroleum Refineries																					
Energy Sector	-	-	20.79	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Coal Mines			20.79																		
Own Use in Thermal Electricity Plants																					
Transmission Losses									595.00												
Distribution Losses									2573.67												
Final Consumption	**100.34**	**3,058.13**	**5,022.16**	**3,943.68**	**34.73**	**19,303.20**	**159.67**	**7.31**	**53,502.18**	**-**	**816.69**	**16,781.84**	**34.38**	**4.38**	**22,237.20**	**266.72**	**65.48**	**638.43**	**3,105.08**	**17.15**	**7.26**
Industry Sector	76.80	3,058.13	4,999.80	3,943.68	34.73	13.24	-	0.23	3,346.67	-	0.81	-	-	0.06	-	14.00	22.85	-	-	-	-
Iron and steel	-	212.57	-	3,717.47	13.52	-	-	-	320.27	-	0.10	-	-	-	-	13.87	-				
Chemical (including petrochemical)	-	-	-	-	-	-	-	-	89.01	-	-	-	-	0.06	-	-	-				
Non-ferrous metals	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-				
Non-metallic minerals	-	2,845.56	4,999.80	226.21	-	0.12	-	-	1,003.62	-	0.23	-	-	-	-	-	12.61				
Transport equipment	-	-	-	-	-	-	-	-	15.33	-	-	-	-	-	-	-	-				
Machinery	-	-	-	-	-	-	-	-	3.96	-	-	-	-	-	-	-	-				
Mining and quarrying	-	-	-	-	-	-	-	-	25.94	-	0.05	-	-	-	-	0.02	-				
Food, beverages and tobacco	70.94	-	-	-	21.21	12.30	-	0.23	1,379.53	-	0.09	-	-	-	-	0.02	0.15				
Paper, pulp and printing	-	-	-	-	-	0.06	-	-	79.98	-	-	-	-	-	-	-	-				
Wood and wood products	-	-	-	-	-	-	-	-	0.59	-	-	-	-	-	-	0.10	-				
Construction	-	-	-	-	-	0.67	-	-	344.49	-	0.33	-	-	-	-	-	8.94				
Textiles and leather	-	-	-	-	-	-	-	-	28.07	-	-	-	-	-	-	-	-				
Not elsewhere specified (Industry)	5.86	-	-	-	-	0.09	-	-	55.88	-	-	-	-	-	-	-	1.24				
Transport Sector	-	-	-	-	-	-	-	-	12,250.00	-	94.50	16,746.64	34.38	-	22,032.08	-	17.39	-	-	-	-
Road	-	-	-	-	-	-	-	-	12,250.00	-	94.50	16,746.64	-	-	21,570.99	-	-				
Rail	-	-	-	-	-	-	-	-	-	-	-	-	-	-	431.45	-	17.39				
Domestic aviation													34.38								
Domestic navigation															29.64						
Pipeline transport																					
Not elsewhere specified (Transport)																					
Other Sectors	23.54	-	22.36	-	-	19,289.97	159.67	7.08	28,847.01	-	721.38	35.20	-	4.31	205.12	252.71	25.14	-	-	-	-
Commercial and public services	23.54	-	6.80	-	-	313.52	11.31	-	7,795.79	-	13.50	-	-	-	-	252.71	25.14				
Residential	-	-	15.56	-	-	18,975.68	148.36	7.08	20,916.00	-	707.28	-	-	4.31	-	-	-				
Agriculture/forestry	-	-	-	-	-	0.77	-	-	135.22	-	0.60	35.20	-	-	205.12	-	-				
Fishing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-				
Not elsewhere specified (Other)																					
Non-Energy Use									9,058.50									638.43	3,105.08	17.15	7.26

Energy Balance (fossil fuel) - 2015

Georgia 2015 (TJ)	Anthracite	Other Bit. Coal	Lignite	Coke Oven Coke	Charcoal	Fuel wood	Pellets, briquettes, other solid fuels	Other vegetal materials and residual	Natural Gas	Crude Oil	Liquefied Petroleum Gases	Motor Gasoline	Kerosene type Jet Fuel	Kerosene	Road diesel	Heating and other gas oil	Fuel oil-low sulphur (<1%)	Lubricants	Bitumen	Paraffin Waxes	Non-specified Petroleum Prods.
Production			5,199.79	-	5.86	16,571.49	118.89	7.80	397.39	1,708.50	-	-	-	-	194.99	-	205.31	-	-	-	83.60
Imports	221.40	2,551.36	-	3593.64	5.17	-	-	-	87,528.00	5,665.30	673.30	19,411.12	2,792.60	1.19	25,270.06	610.95	4,466.54	769.44	3,321.47	20.98	543.88
Exports	-	-	29.58	-	3.21	26.60	-	-	3,500.39	6,490.90	-	26.95	-	-	36.04	-	4,571.29	25.04	-	0.40	-
International Marine Bunkers	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
International Aviation Bunkers	-	-	-	-	-	-	-	-	-	-	-	-	3,002.48	-	-	-	-	-	-	-	-
Stock Changes	(128.44)	408.86	(23.02)	(412.99)	(4.65)	-	-	-	-	(266.65)	153.02	(777.58)	238.43	-	161.70	-	(49.04)	10.43	56.66	-	(235.58)
Domestic Supply	**92.96**	**2,960.22**	**5,147.19**	**3,180.65**	**3.17**	**16,544.89**	**118.89**	**7.80**	**84,425.01**	**616.25**	**826.32**	**18,606.58**	**28.55**	**1.19**	**25,590.70**	**610.95**	**51.52**	**754.83**	**3,378.13**	**20.58**	**391.90**
Statistical Differences		(0.00)	0.00	0.00	(0.00)	(0.00)	(0.00)	-	(0.00)	(0.00)	0.00	0.00	(0.00)	-	(0.00)	0.00	(0.00)	0.00	0.00	(0.00)	(0.00)
Transformation Sector - Input	-	-	-	-	-	-	-	-	22,727.16	616.25	-	-	-	-	-	-	-	-	-	-	-
MA Thermal Electricity Plants	-	-	-	-	-	-	-	-	22,727.16	-	-	-	-	-	-	-	-	-	-	-	-
MA Heat Plants	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Petroleum Refineries	-	-	-	-	-	-	-	-	-	616.25	-	-	-	-	-	-	-	-	-	-	-
Transformation Sector - Production	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MA Thermal Electricity Plants	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MA Heat Plants	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Petroleum Refineries	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Energy Sector	-	-	19.36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Coal Mines	-	-	19.36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Own Use in Thermal Electricity Plants	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Transmission Losses									931.17												
Distribution Losses	-	-	-	-	-	-	-	-	3,637.15	-	-	-	-	-	-	-	-	-	-	-	-
Final Consumption	**92.96**	**2,960.22**	**5,127.83**	**3,180.65**	**3.17**	**16,544.89**	**118.89**	**7.80**	**57,129.52**	**-**	**826.32**	**18,606.58**	**28.55**	**1.19**	**25,590.70**	**610.95**	**51.52**	**754.83**	**3,378.13**	**20.58**	**391.90**
Industry Sector	68.38	2,960.22	5,096.87	3,180.65	-	30.98	3.50	-	4,018.00	-	11.17	-	-	-	-	11.11	11.72	-	-	-	391.90
Iron and steel	-	0.47	-	3180.65	-	1.70	-	-	547.18	-	0.90	-	-	-	-	9.80	-	-	-	-	-
Chemical (including petrochemical)	-	-	-	-	-	-	-	-	104.59	-	-	-	-	-	-	-	-	-	-	-	-
Non-ferrous metals	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Non-metallic minerals	-	2,943.75	5,094.05	-	-	-	2.34	-	1,237.12	-	9.65	-	-	-	-	0.50	10.19	-	-	-	391.90
Transport equipment	-	-	-	-	-	-	-	-	11.14	-	0.00	-	-	-	-	-	-	-	-	-	-
Machinery	-	-	-	-	-	-	-	-	14.01	-	-	-	-	-	-	-	-	-	-	-	-
Mining and quarrying	-	-	2.92	-	-	-	-	-	48.06	-	-	-	-	-	-	-	-	-	-	-	-
Food, beverages and tobacco	68.38	16.00	-	-	-	28.91	1.16	-	1,446.19	-	0.31	-	-	-	-	0.63	0.05	-	-	-	-
Paper, pulp and printing	-	-	-	-	-	-	-	-	93.46	-	-	-	-	-	-	-	-	-	-	-	-
Wood and wood products	-	-	-	-	-	-	-	-	7.41	-	-	-	-	-	-	-	-	-	-	-	-
Construction	-	-	-	-	-	-	-	-	421.08	-	0.32	-	-	-	-	0.19	1.48	-	-	-	-
Textiles and leather	-	-	-	-	-	-	-	-	34.53	-	-	-	-	-	-	-	-	-	-	-	-
Not elsewhere specified (Industry)	-	-	-	-	-	0.37	-	-	53.24	-	-	-	-	-	-	-	-	-	-	-	-
Transport Sector	-	-	-	-	-	-	-	-	12,739.78	-	11.48	18,602.27	28.55	-	25,206.80	-	18.85	-	-	-	-
Road	-	-	-	-	-	-	-	-	12,739.78	-	11.48	18,602.27	-	-	24,946.68	-	-	-	-	-	-
Rail	-	-	-	-	-	-	-	-	-	-	-	-	-	-	231.78	-	18.85	-	-	-	-
Domestic aviation	-	-	-	-	-	-	-	-	-	-	-	-	28.55	-	-	-	-	-	-	-	-
Domestic navigation	-	-	-	-	-	-	-	-	-	-	-	-	-	-	28.34	-	-	-	-	-	-
Pipeline transport	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Not elsewhere specified (Transport)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Other Sectors	24.58	-	30.86	-	3.17	16,513.81	115.39	7.80	30,833.02	-	803.67	4.31	-	1.19	383.90	599.84	20.95	-	-	-	-
Commercial and public services	22.86	-	8.16	-	-	274.76	10.07	0.60	6,394.50	-	-	-	-	-	-	599.84	20.95	-	-	-	-
Residential	-	-	14.60	-	3.17	16,238.79	105.32	7.20	24,290.00	-	803.59	-	-	1.19	-	-	-	-	-	-	-
Agriculture/forestry	1.72	-	8.10	-	-	0.37	-	-	148.52	-	0.08	4.31	-	-	383.90	-	-	-	-	-	-
Fishing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Not elsewhere specified (Other)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Non-Energy Use	-	-	-	-	-	-	-	-	9,538.73	-	-	-	-	-	-	-	-	754.83	3,378.13	20.58	-

10.2 Other Energy Data

Natural Gas and Diesel Consumed for Functioning BTC, SCP, WREP Transit Pipelines in Georgia		
Year	**Natural Gas (TJ)**	**Diesel (TJ)**
2010	2,997	294
2011	3,460	280
2012	3,258	282
2013	3,031	286
2014	3,330	307
2015	3,287	279

Source: BP Georgia

10.3 Background tables in IPPU sector

Table 10-1. IPPU Sectoral Table 2015 (Gg)

Categories	**CO_2**	**CH_4**	**N_2O**	**HFCs**	**PFCs**	**SF_6**	**Other halogenated gases with CO_2 equivalent conversion factors**	**Other halogenated gases with CO_2 Equivalent conversion factors**	**NOx**	**CO**	**NMVOCs**	**SO_2**
2 INDUSTRIAL PROCESSES AND PRODUCT USE	1 659.93	0.66	257.69	139.38	-	0.32	-	-	4.99	1.91	2.28	0.54
2A Mineral Industry	759.37069							NO	NO	NO	0.25	0.53

Categories	**CO_2**	**CH_4**	**N_2O**	**HFCs**	**PFCs**	**SF_6**	**Other halogenated gases with CO_2 equivalent conversion factors**	**Other halogenated gases with CO_2 Equivalent conversion factors**	**NOx**	**CO**	**NMVOCs**	**SO_2**
2A1 Cement Production	C							NO	NO	NO	NO	0.53
2A2 Lime Production	45.857348							NO	NO	NO	NO	NO
2A3 Glass Production	C							NO	NO	NO	0.25	NO
2A4 Other Process Uses of Carbonates	NO							NO	NO	NO	NO	NO
2A5 Other (please specify)								NO	NO	NO	NO	NO
2B Chemical Industry	C	NO	C					NO	4.99	1.9	NO	0.007
2B1 Ammonia Production	C	NO	NO					NO	NO	1.9	NO	0.007
2B2 Nitric Acid Production	NO	NO	C					NO	4.99	NO	NO	NO
2B3 Adipic Acid Production	NO	NO	NO					NO	NO	NO	NO	NO
2B4 Caprolactam, Glyoxal and Glyoxylic Acid Production	NO	NO	NO					NO	NO	NO	NO	NO
2B5 Carbide Production	NO	NO	NO					NO	NO	NO	NO	NO
2B6 Titanium Dioxide Production	NO	NO	NO					NO	NO	NO	NO	NO
2B7 Soda Ash Production	NO	NO	NO					NO	NO	NO	NO	NO
2B8 Petrochemical and Carbon Black Production	NO	NO	NO					NO	NO	NO	NO	NO
2B9 Fluorochemical Production	NO	NO	NO					NO	NO	NO	NO	NO
2B10 Other (please specify)	NO	NO	NO					NO	NO	NO	NO	NO
2C Metal Industry	C	0.66	NO	NO	NO	NO	NO	NO	0.00	NO	0.00	0.00

Categories	**CO_2**	**CH_4**	**N_2O**	**HFCs**	**PFCs**	**SF_6**	**Other halogenated gases with CO_2 equivalent conversion factors**	**Other halogenated gases with CO_2 Equivalent conversion factors**	**NOx**	**CO**	**NMVOCs**	**SO_2**
2C1 Iron and Steel Production	C	NO	NO	NO	NO	NO	NO	NO	0.003	NO	0.002	0.003
2C2 Ferroalloys Production	C	0.65738192	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2C3 Aluminum Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2C4 Magnesium Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2C5 Lead Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2C6 Zinc Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2C7 Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2D Non-Energy Products from Fuels and	11.3725333	NO	NO	NO	NO	NO	NO	NO	NO	0.006	0.03	NO
2D1 Lubricant Use	11.0704	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2D2 Paraffin Wax Use	0.30213333	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2D3 Solvent Use	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.006	0.03	NO
2D4 Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2E Electronics Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2E1 Integrated Circuit or Semiconductor	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2E2 TFT Flat Panel Display	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Categories	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Other halogenated gases with CO_2 equivalent conversion factors	Other halogenated gases with CO_2 Equivalent conversion factors	NOx	CO	NMVOCs	SO_2
2E3 Photovoltaics	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2E4 Heat Transfer Fluid	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2E5 Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2F Product Uses as Substitutes for Ozone Depleting Substances	NE	NE	NE	139.382869	NE	NE	NE	NE	NE	NE	NE	NE
2F1 Refrigeration and Air Conditioning	NE	NE	NE	139.382869	NE	NE	NE	NE	NE	NE	NE	NE
2F2 Foam Blowing Agents	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2F3 Fire Protection	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2F4 Aerosols	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2F5 Solvents	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2F6 Other Applications	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2G Other Product Manufacture and Use	NO	NO	0.014975	NO	NO	0.31966298	NO	NO	NO	NO	NO	NO
2G1 Electrical Equipment	NO	NO	NO	NO	NO	0.31966298	NO	NO	NO	NO	NO	NO
2G2 SF_6 and PFCs from Other Product Uses	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Categories	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Other halogenated gases with CO_2 equivalent conversion factors	Other halogenated gases with CO_2 Equivalent conversion factors	NOx	CO	NMVOCs	SO_2
2G3 N_2O from Product Uses	NO	NO	0.014975	NO	NO	NO	NO	NO	NO	NO	NO	NO
2G4 Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2H Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	2	NO
2H1 Pulp and Paper Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2H2 Food and Beverages Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	2	NO
2H3 Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table 10-2. IPPU Background Table: 2A Mineral Industry, 2B (2B1-2B8, 2B10) Chemical Industry - CO_2, CH_4 and N_2O

Categories	Activity Data			Emissions						
	Production/Consumption			CO_2 (Gg)			CH_4 (Gg)		N_2O (Gg)	
	Description	Quantity	Unit	Emissions	Information item Captured and Storage	(memo) Other Reductions	Emissions	Information item Reduction	Emissions	Information item Reduction
2A Mineral Industry				759.37	NO	NO	NO	NO	NO	NO
2A1 Cement Production	Clinker Produced (t)	C	Tons	C	NO	NO	NO	NO		
2A2 Lime Production	Lime Produced	37 259.64	Tons	45.86	NO	NO	NO	NO		
2A3 Glass Production	Container Glass (t)	C	Tons	C	NO	NO	NO	NO		
2A4 Other Process Uses of Carbonates	NO	NO	NO	NO	NO	NO	NO	NO		
2A5 Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B Chemical Industry				C	NO	NO	NO	NO	C	NO
2B1 Ammonia Production	Natural Gas Consumption (Milion m^3)	C	Million m^3	C	NO	NO	NO	NO	C	NO
2B2 Nitric Acid Production	HNO_3 Produced (t)	C	Tons	NO	NO	NO	NO	NO	NO	NO
2B3 Adipic Acid Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B4 Caprolactam, Glyoxal and Glyoxylic Acid Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Categories	Activity Data			Emissions						
	Production/Consumption			CO_2 (Gg)			CH_4 (Gg)		N_2O (Gg)	
	Description	Quantity	Unit	Emissions	Information item Captured and Storage	(memo) Other Reductions	Emissions	Information item Reduction	Emissions	Information item Reduction
2B5 Carbide Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B6 Titanium Dioxide Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B7 Soda Ash Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B8 Petrochemical and Carbon Black Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B9 Fluorochemical Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B10 Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table 10-3. IPPU Background Table: 2B (2B9 - 2B10) Chemical Industry HFCs, PFCs, SF6 and other halogenated gases

Categories	HFC-23	HFC-32	HFC-41	HFC-125	HFC-134	HFC-134a	HFC-143	HFC-143a	HFC-152	HFC-152a	HFC-161	HFC-227ea	HFC-236cb	HFC-236ea	HFC-236fa	HFC-245ca	HFC-245fa	HFC-365mfc	HFC-43-10mee	Other HFCs (2)	Total HFCs	CF4	C2F6	C 3F8	C4F10	c-C4F8	C5F12	C6F14	Other PFCs	Total PFCs	SF6	Other halogenated gases
CO2 equivalent conversion factors	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO		NO	NO	NO	NO	NO	NO	NO	NO		NO	NO
Emissions in original mass unit (tons)																																
2B9 Fluorochemical Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO		NO	NO	NO	NO	NO	NO	NO	NO		NO	NO
2B9a By-product Emissions	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
(information) Reduced amount	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B9b Fugitive Emissions	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO		NO	NO	NO	NO	NO	NO	NO	NO		NO	NO
(information) Reduced amount	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO		NO	NO	NO	NO	NO	NO	NO	NO		NO	NO
2B10 Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO		NO	NO	NO	NO	NO	NO	NO	NO		NO	NO
Emissions in CO_2 equivalent unit (Gg-CO_2)																																
2B9 Fluorochemical Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B9a By-product Emissions	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B9b Fugitive Emissions	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B10 Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table 10-4. IPPU Background Table: 2C Metal Industry CO_2, CH_4 and N_2O

Categories	Activity Data			Emissions						
	Production/Consumption			CO_2 (Gg)			CH_4 (Gg)		N_2O (Gg)	
	Description	Quantity	Unit	Emissions	Information item Captured and Storage	(memo) Other Reductions	Emissions	Information item Reduction	Emissions	Information item Reduction
2C Metal Industry				437.81	NO	NO	NO	NO	NO	NO
2C1 Iron and Steel Production	Steel Produced (t)	C	Tons	C	NO	NO	NO	NO	NO	NO
2C2 Ferroalloys Production	Ferroalloys Produced (t)	C	Tons	C	NO	NO	NO	NO	NO	NO
2C3 Aluminum Production	NO	NO	NO	NO	NO	NO	NO	NO		
2C4 Magnesium Production	NO	NO	NO	NO	NO	NO				
2C5 Lead Production	NO	NO	NO	NO	NO	NO				
2C6 Zinc Production	NO	NO	NO	NO	NO	NO				
2C7 Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table 10-5. IPPU Background Table: 2C (2C3, 2C4, 2C7) Metal Industry HFCs, PFCs, SF_6 and other halogenated gases

Categories	**HFC-134a**	**Other HFCs (2)**	**Total HFCs**	**CF_4**	**C_2F_6**	**C_3F_8**	**C_4F_{10}**	**c-C_4F_8**	**C_5F_{12}**	**C_6F_{14}**	**Other PFCs (2)**	**Total PFCs**	**SF_6**	**Other halogenated gases**
CO2 equivalent conversion factors	NO	NO		NO	NO	NO	NO	NO	NO	NO	NO		NO	NO
Emissions in original mass unit (tons)														
2C3 Aluminum Production				NO	NO	NO	NO	NO	NO	NO	NO			
(information) Reduced amount				NO	NO	NO	NO	NO	NO	NO	NO			
2C4 Magnesium Production	NO	NO		NO	NO	NO	NO	NO	NO	NO	NO		NO	NO
(information) Reduced amount	NO	NO		NO	NO	NO	NO	NO	NO	NO	NO		NO	NO
2C7 Other Metals (please specify)	NO	NO		NO	NO	NO	NO	NO	NO	NO	NO		NO	NO
(information) Reduced amount	NO	NO		NO	NO	NO	NO	NO	NO	NO	NO		NO	NO
Emissions in CO2 equivalent unit (Gg-CO2)														
2C3 Aluminum Production				NO	NO	NO	NO	NO	NO	NO	NO	NO		
2C4 Magnesium Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2C7 Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table 10-6. IPPU Background Table: 2D Non-Energy Products from Fuels and Solvent Use CO_2, CH_4 and N_2O

Categories	Activity Data			Emissions		
	Production/Consumption			CO_2	CH_4	N_2O
	Description	Quantitiy	Unit	(Gg)	(Gg)	(Gg)
2D Non-Energy Products from Fuels and Solvent Use				11.37	NO	4.83056E-05
2D1 Lubricant Use	Lubricant consumption	754.8	TJ	11.07		
2D2 Paraffin Wax Use	Wax consumption	20.6	TJ	0.30	NO	NO
2D3 Solvent Use						
2D4 Other				NO	NO	4.83056E-05

Table 10-7. IPPU Background Table: 2E Electronics Industry HFCs, PFCs, SF6 NF3 and other halogenated gases

Categories	**CO_2**	**N_2O (2)**	**HFC-23**	**HFC-32**	**Other HFCs (3)**	**Total HFCs**	**CF_4**	**C_2F_6**	**C_3F_8**	**c-C_4F_8**	**Other PFCs (3)**	**Total PFCs**	**SF_6**	**NF_3**	**Other halogenated gases**
CO_2 equivalent conversion factors	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Emissions in original mass unit (tons)															
2E Electronics Industry	NO	NO	NO	NO	NO		NO	NO	NO	NO	NO		NO	NO	NO
2E1 Integrated Circuit or Semiconductor	NO	NO	NO	NO	NO		NO	NO	NO	NO	NO		NO	NO	NO
2E2 TFT Flat Panel Display			NO	NO	NO		NO	NO	NO	NO	NO		NO	NO	NO
2E3 Photovoltaics			NO	NO	NO		NO	NO	NO	NO	NO		NO	NO	NO
2E4 Heat Transfer Fluid															NO
2E5 Other (please specify)		NO	NO	NO	NO		NO	NO	NO	NO	NO	NO	NO	NO	NO
Emissions in CO_2 equivalent unit (Gg-CO_2)															
2E Electronics Industry			NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2E1 Integrated Circuit or Semiconductor			NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2E2 TFT Flat Panel Display			NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2E3 Photovoltaics			NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2E4 Heat Transfer Fluid															NO
2E5 Other (please specify)			NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table 10-8. IPPU Background Table: 2F Product Uses as Substitutes for Ozone Depleting Substances HFCs, PFCs and other halogenated gases

Categories	**CO_2**	**HFC-23**	**HFC-32**	**HFC-125**	**HFC-134a**	**HFC-143a**	**HFC-152a**	**HFC-227ea**	**HFC-236fa**	**HFC-245fa**	**HFC-365mfc**	**HFC-43-10mee**	**Other HFCs**	**Total HFCs**	**CF_4**	**C_2F_6**	**C_3F_8**	**C_4F_{10}**	**Other PFCs**	**Total PFCs**	**Other halogenated gases**
CO_2 equivalent conversion factors	NA	NE	650	2800	1300	3800	NE	NE	NE	NE	NE	NE	NE		NE	NE	NE	NE	NE		NE
Emissions in original mass unit (tons)																					
2F Product Uses as Substitutes for Ozone Depleting Substances	NE	NE	9.18	13.43	59.87	17.98	NE	NE	NE	NE	NE	NE	NE		NE	NE	NE	NE	NE		NE
2F1 Refrigeration and Air Conditioning	NE	NE	9.18	13.43	59.87	17.98	NE	NE	NE	NE	NE	NE	NE		NE	NE	NE	NE	NE		NE
2F2 Foam Blowing Agents	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE		NE	NE	NE	NE	NE		NE
2F3 Fire Protection	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE		NE	NE	NE	NE	NE		NE
2F4 Aerosols		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE		NE	NE	NE	NE	NE		NE
2F5 Solvents		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE		NE	NE	NE	NE	NE		NE
2F6 Other Applications		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE		NE	NE	NE	NE	NE		NE
Emissions in CO_2 equivalent unit (Gg-CO_2)																					
2F Product Uses as Substitutes for Ozone Depleting Substances		NE	5.97	37.61	77.83	17.98	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2F1 Refrigeration and Air Conditioning		NE	5.97	37.61	77.83	17.98	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2F2 Foam Blowing Agents		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2F3 Fire Protection		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2F4 Aerosols		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2F5 Solvents		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2F6 Other Applications		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE

Table 10-9. IPPU Background Table: Greenhouse gases without CO_2 equivalent conversion factors

Categories	**HFC-32**	**HFC-125**	**HFC-134a**	**HFC-143a**
Emissions in original mass unit (tons)				
Total	9.18	13.43	59.87	17.98
2B Chemical Industry	NO	NO	NO	NO
2B9 Fluorochemical Production	NO	NO	NO	NO
2B9a By-product Emissions	NO	NO	NO	NO
2B9b Fugitive Emissions	NO	NO	NO	NO
2B10 Other (please specify)	NO	NO	NO	NO
2C Metal Industry	NO	NO	NO	NO
2C4 Magnesium Production	NO	NO	NO	NO
2C7 Other (please specify)	NO	NO	NO	NO
2E Electronics Industry	NO	NO	NO	NO
2E1 Integrated Circuit or Semiconductor	NO	NO	NO	NO
2E2 TFT Flat Panel Display	NO	NO	NO	NO
2E3 Photovoltaics	NO	NO	NO	NO
2E4 Heat Transfer Fluid	NO	NO	NO	NO
2E5 Other (please specify)	NO	NO	NO	NO
2F Product Uses as Substitutes for Ozone Depleting Substances	9.18	13.43	59.87	17.98
2F1 Refrigeration and Air Conditioning	9.18	13.43	59.87	17.98
2F1a Refrigeration and Stationary Air Conditioning	NE	NE	NE	NE
2F1b Mobile Air Conditioning	NE	NE	NE	NE
2F2 Foam Blowing Agents	NE	NE	NE	NE
2F3 Fire Protection	NE	NE	NE	NE
2F4 Aerosols	NE	NE	NE	NE
2F5 Solvents	NE	NE	NE	NE
2F6 Other Applications (please specify)	NE	NE	NE	NE
2G. Other Product Uses	NO	NO	NO	NO
2G1 Electrical Equipment	NO	NO	NO	NO
2G1a Manufacture of Electrical Equipment	NO	NO	NO	NO
2G1b Use of Electrical Equipment	NO	NO	NO	NO
2G1c Disposal of Electrical Equipment	NO	NO	NO	NO
2G2 SF_6 and PFCs from Other Product Uses	NO	NO	NO	NO
2G2a Military Applications (AWACS)	NO	NO	NO	NO
2G2b Accelerators	NO	NO	NO	NO
2G2c Other (please specify)	NO	NO	NO	NO
2G4 Other (please specify)	NO	NO	NO	NO