REPUBLIC OF ARMENIA
MINISTRY OF ENVIRONMENT

National Greenhouse Gas Inventory Document of Armenia 1990-2022

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LIST OF ABBREVIATIONS AND ACRONYMS USED

AR5	IPCC Fifth Assessment Report
BOD	Biochemical oxygen demand
BUR	Biennial Update Report
CH_4	Methane
CKD	Cement kiln dust
CNG	Compressed natural gas
CO	Carbon monoxide
$CO_{2\ eq}$	Carbon dioxide equivalent
CRTs	Common Reporting Tables
DEF	Default EF
DOM	Dead Organic Matter
EEA	European Environment Agency
EEC	Eurasian Economic Commission
EF	EF
EMEP	European Monitoring and Evaluation Programme
ETF	Enhanced Transparency Framework
GHG	Greenhouse gas
GWh	Gigawatt-hour
GWP	Global warming potential
ha	Hectares
HFCs	Hydrofluorocarbons
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Processes and Products Use
kt	Kilotons
LPG	Liquid Petroleum Gas
LT-LEDS	Long-term Low GHG Emissions Development Strategy
LULUCF	Land Use, Land-Use Change, and Forestry
MCF	Methane correction factor
MoEnv	RA Ministry of Environment
MoTAI	Ministry of Territorial Administration and Infrastructure
MPGs	Modalities, Procedures and Guidelines
N_2O	Nitrous oxide
NCV	Net calorific value
NID	National Inventory Document
NIIP	National GHG Inventory Improvement Plan
NMVOCs	Non-methane volatile organic compounds
NOx	Nitrogen oxides
ODS	Ozone-depleting substances
ODU	Oxidized During Use
OECD	Organization for Economic Co-operation and Development

PSRC	Public Services Regulatory Commission
QA/QC	Quality Assurance and Quality Control
RA	Republic of Armenia
RA SC	RA Statistics Committee
RAC	Reactive Atmospheric Compounds
SF_6	Sulfur hexafluoride
SNCO	State Non-Commercial Organization
SO_2	Sulfur dioxide
SRC	State Revenue Committee
TACCC	Transparency, accuracy, completeness, consistency and comparability
TASR	Technical Analysis Summary Report
TOW	Total Organics in Wastewater
TPES	Total primary energy supply
TPP	Thermal power plant
UNFCCC	United Nations Framework Convention on Climate Change

EXECUTIVE SUMMARY

ES.1 Background information on greenhouse gas inventories and climate change

The Republic of Armenia is a Party to both the United Nations Framework Convention on Climate Change (UNFCCC) and the Paris Agreement (PA). Under these international agreements, Armenia has reporting commitments on submissions of biennial transparency reports and greenhouse gas emission inventories.

This report aims at fulfilling the reporting commitments related greenhouse gas emission inventories under the agreements referred to above

This National Inventory Document (NID) was prepared in line with the following:

- Modalities, procedures and guidelines (MPGs) for the transparency framework for action and support referred to in Article 13 of the Paris Agreement agreed by the Conference of Parties serving as the meeting of the Parties to the Paris Agreement (Decision 18/CMA.1)
- Guidance for operationalizing the modalities, procedures and guidelines for the enhanced transparency framework referred to in Article 13 of the Paris Agreement (Decision 5/CMA.3)
- Common Reporting Tables (CRTs) for the electronic reporting of the information in the national inventory reports of anthropogenic emissions by sources and removals by sinks of greenhouse gases (Annex I, Decision 5/CMA.3)
- 2006 IPCC Guidelines for National Greenhouse Gas Inventories
- *2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands*

This report presents emissions and removals for each of the greenhouse gases (GHG) as carbon dioxide equivalents ($CO_{2\ eq.}$) using the 100-year global warming potentials (GWPs) from the IPCC Fifth Assessment Report (AR5). The greenhouse gas inventory provides information on the trends in national greenhouse gas emissions and removals since 1990.

Throughout this report, emission and sink estimates are grouped into five reporting sectors (corresponding to five respective chapters): Energy, Industrial Processes and Products Use (IPPU), Agriculture, Land Use, Land-Use Change, and Forestry (LULUCF), and Waste.

The Ministry of Environment is the state authorized body responsible for the development and implementation of the state policies aimed at addressing climate change issues and for implementing the country's commitments under the UNFCCC and the Paris Agreement.

In 2024, the Government of the Republic of Armenia adopted Resolution No. 54-N "On approving the procedure for the development of greenhouse gas emission inventory", thereby establishing the National Greenhouse Gas Emissions Monitoring and Reporting System. The national inventory arrangements are based on laws and regulations of the Republic of Armenia related to atmospheric air protection and climate change-related actions.

According to this Resolution, the Ministry of Environment of the Republic of Armenia is the state authorized body for greenhouse gas emissions inventory, and State Hydrometeorological Service of the Ministry of Environment of the Republic of Armenia is designated as the Implementing body.

ES.2 Summary of trends related to national emissions and removals

In 2022, Armenia's greenhouse gas emissions totaled 13,314.1 kilotons of carbon dioxide equivalent (kt $CO_{2\ eq.}$), excluding the LULUCF sector.[1] The total emissions in 2022 were approximately 50% (13,442 kt) below the 1990 emissions level.

Net emissions (including sinks) were 12,932.2 kt $CO_{2eq.}$ in 2022. Overall, net emissions decreased by 50.3 % from 1990 levels.

A summary of the Armenia's national emissions and removals for the entire time period (1990 to 2022) is presented in Table ES.2-1.

[1] Within the scope of this National Inventory Document, the total volume of GHG emissions/removals from the "Agriculture" and "Land Use, Land-Use Change and Forestry" (LULUCF) sectors differs from the data presented in the CRT due to the inclusion of emissions from the field burning of agricultural residues under the "Agriculture" sector, whereas in the CRT tables these emissions are included under the "Land Use, Land-Use Change and Forestry" (LULUCF) sector — in accordance with the classification used in the ETF reporting tools. Therefore, the total emissions from the Agriculture sector do not match those presented in the CRT, differing by the emissions from the field burning of agricultural residues.

Table ES.2-1. Armenia's greenhouse gas emissions and removals (kt $CO_{2\ eq.}$)

Sector	1990	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	Percentage change since 1990
Energy	23,360.92	4,653.94	5,748.18	6,398.59	7,415.44	7,298.27	7,784.54	7,401.82	7,677.11	7,842.65	8,603.70	8,850.55	-62.1
Industrial processes and product use[2]	631.16	152.33	397.39	609.86	815.79	821.86	956.74	1,114.16	1,179.26	1,347.05	1,477.71	1,609.00	155
Agriculture	2,210.14	1,600.89	1,906.16	1,816.16	2,506.56	2,611.90	2,280.86	2,142.76	2,260.89	2,084.64	2,102.02	1,989.89	-10.0
Waste	553.87	657.53	717.63	735.22	778.41	784.09	789.38	791.24	780.55	810.75	864.07	864.63	56.1
Total (excluding LULUCF)	**26,756.09**	**7,064.69**	**8,769.36**	**9,559.83**	**11,516.20**	**11,516.13**	**11,811.52**	**11,449.98**	**11,897.81**	**12,085.09**	**13,047.50**	**13,314.08**	**-50.2**
LULUCF	-742.33	-488.01	-539.95	-542.46	-452.14	-495.28	-430.65	-448.73	-345.28	-390.33	-383.69	-381.87	-48.6
Net emissions	**26,013.8**	**6,576.7**	**8,229.4**	**9,017.4**	**11,064.1**	**11,020.8**	**11,380.9**	**11,001.2**	**11,552.5**	**11,694.8**	**12,663.8**	**12,932.2**	**-50.3**

[2] including F gases

Overall, Armenia's gross GHG emissions in 2022 have decreased by over 50% compared to 1990, mainly due to decreased emissions from the Energy sector, which is the most significant source of greenhouse gas emissions in Armenia and, therefore, the key driver behind the trend. Energy related emissions vary significantly in Armenia depending on the economic trends, energy supply structure and volume of electricity export, climate conditions.

Compared to 1990, GHG emissions from the Energy sector have decreased by 62.1%, due to structural changes in the economy, i.e. decreased share of energy intensive industries and increased share of the service sector, widespread use of environmentally friendly fuel - natural gas for energy generation (which replaced mazut) and in transport, the recommissioning of the Armenian Nuclear Power Plant, and an unprecedented increase in renewable energy sources.

The increase in Energy Sector emissions since 2000 (except for 2009-2010) of about 90% was due to:

- economic growth, leading to the growth in traffic volume, which resulted in road transport emissions' growth - during 2000-2022 road transport emissions have increased by about 236%.
- improved household living conditions resulted in the wide use of natural gas for space heating. It became possible because of the unprecedented level of natural gas deliverability reached in the country. During 2005-2022, emissions attributable to energy used by households increased over fivefold.
- production of electricity by natural gas-fired thermal power plants for export to Iran under the gas-for- electricity swap agreement.

In 2022, emission sources in the Industrial Processes and Product Use (IPPU) sector accounted for 12.1% of total gross greenhouse gas emissions in a carbon dioxide (CO_2) equivalent. The GHG emissions from this sector have increased 2.5-fold since 1990, as there were no HFC emissions in 1990, and by 36.4% since 2019, driven predominantly by the growth of emissions from HFCs and cement production.

The use of HFCs as substitutes for ODS is the largest source of emissions in this sector, contributing 67.8% of IPPU emissions in 2022 and driving growth since 2002, when Armenia started importing products and equipment containing HFCs.

Agricultural emissions decreased by nearly 10% over the period 1990 to 2022. Methane emissions from enteric fermentation are the largest source of emissions in the Agriculture sector, consistently maintaining an absolute dominance in the sector's emissions, and, therefore, the key driver behind the emissions trend in the Agriculture sector.

The LULUCF sector has been a sink during the whole time series from 1990 to 2022. The main factor behind this trend was the *Forest Land* category.

Variations in carbon dioxide removals in the *Forest Land* and are driven primarily by changes in the annual volumes of fuelwood harvested.

For the entire period of 1990-2022, total emissions from the Waste sectors increased by 56.1 % (310.8 kt $CO_{2\ eq.}$) due to economic development and improved standards of living.

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

The greenhouse gas emissions and removals are divided into the following reporting categories according to the UNFCCC reporting guidelines on annual inventories: Energy (CRT 1), Industrial Processes and Product Use (CRT 2), Agriculture (CRT 3), Land Use, Land-use change and Forestry (LULUCF) (CRT 4), and Waste (CRT 5).

Between 2020 and 2022, the increase in total greenhouse gas emissions was driven largely by an increase in CO_2 emissions from fossil fuel combustion in power industries and across most end-use sectors – residential, transportation, industrial emissions.

The composition of Armenia's greenhouse gas emissions in 2022 is presented in Figure ES.3-1.

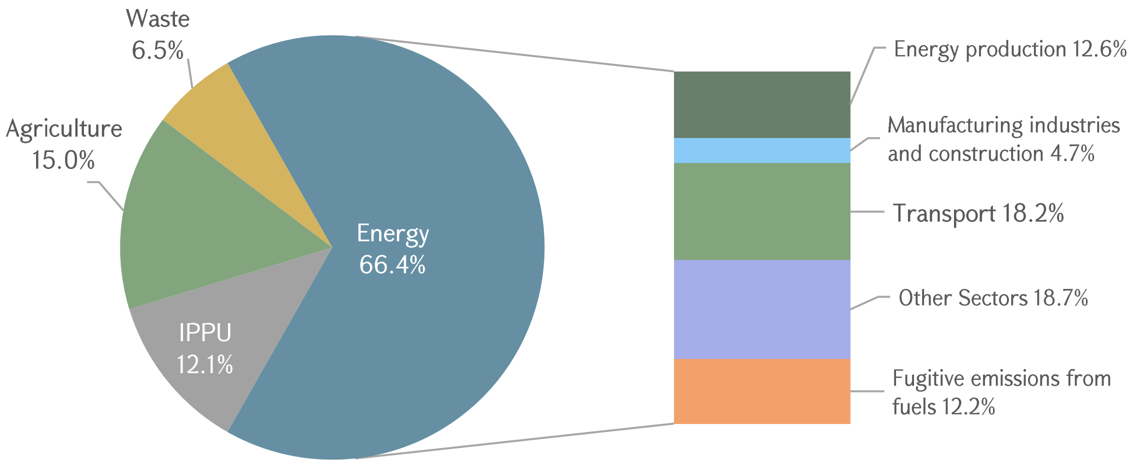


Figure ES.3-1. Armenia's greenhouse gas emissions composition in 2022 (LULUCF sector excluded)

Energy-related activities were the primary sources of Armenia's greenhouse gas emissions, accounting for 66.4% of total gross greenhouse gas emissions in a carbon dioxide (CO_2) equivalent in 2022. This included 97.8, 46.0, and 5.4 percent of the country's CO_2, methane (CH_4), and nitrous oxide (N_2O) emissions, respectively. Energy-related CO_2 emissions alone constituted 54.7 % of total net Armenia's greenhouse gas emissions from all sources on a CO_2-equivalent basis, while the non-CO_2 emissions from energy-related activities accounted for a significantly lower share of total net national emissions (13.7% in total).

Emissions from fossil fuel combustion represented largest portion of (81.6%) of energy-related emissions, with CO_2 being the primary gas emitted (79.9%).

In Armenia fossil fuel combustion accounted for 97.8% of CO_2 emissions in 2022.

Agriculture is the second most significant source of greenhouse gas emissions in Armenia. In 2022, agricultural emissions accounted for 15% (1,989.89 kt $CO_{2\ eq.}$) of total gross emissions. The largest source of emissions in the Agriculture sector is methane emissions from enteric fermentation (1,221.53 kt $CO_{2eq.}$), accounting for 61.4% of the total emissions from the Agriculture sector in 2022. The vast majority of these emissions – 85.3% (1,042.54 kt $CO_{2\ eq.}$) originated from enteric fermentation of cattle.

N_2O emissions in 2022 amounted to 715.94 kt $CO_{2\ eq.}$, which accounts for 36.0% of emissions from the agriculture and 5.5% of the country's total net emissions. Direct N_2O emissions from managed soils predominate in the overall N_2O emissions from the agriculture sector with the share of 72.1% in 2022.

The IPPU Sector emissions amounted to 1,609 kt $CO_{2\ eq.}$ in 2022, or 12.1% of Armenia's gross emissions.

CO_2 emissions from the IPPU sector in 2022 amounted to 513.81 kt, which accounts for 31.9% of emissions from the "Industrial Processes and Product Use" sector and 4.0% of the country's net emissions. The largest source of CO_2 emissions in 2022 was cement production – 471.59 kt CO_2, which accounts for 91.8% of CO_2 emissions from the IPPU sector. Compared to 1990, the emission reduction from cement production for 2022 is 25.2%.

The share of CO_2 emissions from other categories are significantly lower.

HFC emissions in 2022 amounted to 1091.04 kt $CO_{2\ eq.}$, which accounts for 67.8% of emissions from the "Industrial Processes and Product Use" sector and 8.4% of the country's net emissions. HFCs emissions from refrigeration and air conditioning predominate in the overall HFCs emissions with the share of 94.2% in 2022. The share of emissions from the other applications is much smaller.

SF_6 emissions from the use of electrical equipment are incomparably small: 4.15 kt $CO_{2\ eq.}$, making 0.3% of sectoral emissions.

From 2020 to 2022, total emissions from IPPU increased by 19.4% driven by the growth of the emissions from cement production and HFCs emissions. The impact of variations in emissions from the other categories is negligible.

Waste management and treatment activities are sources of CH_4 and N_2O emissions. Overall, emission sources accounted for in the Waste sector generated 864.63 kt $CO_{2\ eq.}$, or 6.5% of Armenia's gross GHG emissions in 2022. In 2022, landfills were the largest source of waste emissions, accounting for 67.3% of waste-related emissions and 4.4% of the country's total net emissions.

Additionally, wastewater treatment generated emissions of 225.55 kt $CO_{2\ eq.}$ and accounted for 26.1 % of waste emissions, while emissions resulting from waste incineration and open burning accounted for the remaining 6.6% of the sector's emissions in 2022.

ES.4 Key category analysis

The aim of the key category analysis is to identify those categories that have a significant impact on emissions level and their trends. The results of this analysis support methodological decision-making by identifying priority areas for possible improvements that may significantly affect the quality of the inventory.

The Approach 1 from the 2006 IPCC Guidelines (Vol. 1, Ch. 4) was used for identifying the key categories. The analysis was performed for absolute values of emissions and removals (level assessment) based on 2022 inventory, as well as for the trends based on 2000 and 2022 inventories. Since in 1990 the structure and management principles of Armenia's economy were absolutely different as compared to the present time, using 1990 as a base year for trend analysis would identify those categories that underwent the most structural changes following the breakup of the Soviet Union and would not be informative for assessing current trends and processes of emission changes. Hence, 2000 was used as a base year for trend assessment.

The key categories listed in Table ES.4-1 were analyzed based on the suggested level of aggregation in the 2006 IPCC Guidelines (Vol. 1, Table 4.1) with some differences, which are described in detail in Chapter 2.

Table ES.4-1 Summary of 2022 key categories analysis using Approach 1, including LULUCF

Code	GHG source and sink key categories	GHG	Criteria used for identification	Tier level
1.A.1	Energy Industries - Gaseous Fuels	CO_2	Level, Trend	T3
1.B.2.b	Fugitive emissions from Natural Gas transportation and distribution	CH_4	Level, Trend	T2
1.A.4.b	Residential- Gaseous Fuels	CO_2	Level, Trend	T2
1.A.3.b	Road Transportation - Liquid Fuels	CO_2	Level, Trend	T1
3.A.1.a	Enteric Fermentation - Cattle	CH_4	Level, Trend	T2
2.F.1	Refrigeration and Air Conditioning	HFCs	Level, Trend	T2a
1.A.3.b	Road Transportation - Gaseous Fuels	CO_2	Level, Trend	T2
5.A	Solid Waste Disposal	CH_4	Level, Trend	T2
1.A.2	Manufacturing Industries and Construction - Gaseous Fuels	CO_2	Level, Trend	T2
3.D.1	Direct N_2O Emissions from managed soils	N_2O	Level, Trend	T1
1.A.4.a	Commercial/institutional - Gaseous Fuels	CO_2	Level, Trend	T2
2.A.1	Cement production	CO_2	Level, Trend	T3
3.B.1.a	Forest land Remaining Forest land	CO_2	Level, Trend	T2
3.A.4	Enteric Fermentation - Other	CH_4	Level, Trend	T2, T1
1.A.4.C	Agriculture/Forestry/Fishing/Fish Farms - Gaseous Fuels	CO_2	Level, Trend	T2
5.D	Wastewater Treatment and Discharge	CH_4	Level, Trend	T1
3.D.2	Indirect N2O Emissions from managed soils	N_2O	Level	T1
1.A.4	Other Sectors - Liquid Fuels	CO_2	Level	T1
5.D	Wastewater Treatment and Discharge	N_2O	Level	T1
1.A.2	Manufacturing Industries and Construction - Liquid Fuels	CO_2	Trend	T1
2.F.2	Foam Blowing Agents		Trend	T1
1.A.4	Other Sectors - Solid Fuels	CO_2	Trend	T1

ES.5 Improvements to Armenia's 1990-2022 GHG Inventory

The main improvements introduced to 1990–2022 National GHG Inventory are presented below per IPCC sectors, according to the principles of transparency, accuracy, completeness, consistency and comparability (TACCC). These improvements are based on the National GHG Inventory Improvement Plan, which incorporates the recommendations from the team of technical experts who conducted the technical analysis of Armenia's Third Biennial Update Report, as presented in the Technical Analysis Summary Report (TASR), along with additional recommendations of the GHG Inventory experts.

Energy

- A new sub-category, (1A4ci*) Stationary,* was considered.
- To ensure the consistency of time series and to calculate GHG emissions from the (1A4ci) *Stationary* subcategory, the time series in the (1A4a) *Commercial/Institutional* and (1A4c) *Agriculture/Forestry/Fishing/Fish Farms* subcategories of the (1A4) *Other Sectors* category have been recalculated.
- The methodology for estimating country-specific emission factors for fugitive emissions from the natural gas transmission (including storage) and distribution systems of Armenia has been updated to reflect recent changes in the country's gas supply systems.

- GHG emissions from the Energy sector have been assessed for the years 1991–1994 and 1996–1999, based on data from scientific and technical literature, as well as accompanying research data.

IPPU

- A new sub-category (2C1) *Iron and Steel Production* was considered.
- CO_2 emissions from (2D2) *Paraffin Wax Use* have been recalculated for the entire time period due to the adjustment of activity data.
- Emissions of NMVOCs from (2D3) *Solvent Use* have been recalculated for the entire period due to the change in the emission factor.
- The time series of NMVOC emissions from (2D4) *Bitumen/Asphalt Production and Use* has been recalculated for the entire period due to the adjustment for the bitumen content in the asphalt mixture.
- The time series of NMVOC emissions from (2H2) *Food and Beverages* has been recalculated for the entire period due to the change in the methodology applied - EMEP/EEA Manual Tier 2 methodology was applied.
- The time series of HFC emissions from RAC applications has been recalculated for the entire period – emissions were calculated for each sub-application using the appropriate factors provided in the 2006 IPCC Guidelines.
- Emissions from closed pressure electrical equipment from 1999 to 2022 have been recalculated based on adjusted activity data from utilities.

Agriculture

- For calculation of emissions from animal husbandry, animal stocks for cattle (both dairy cows and other cattle) and sheep have been divided into sub-division used for purposes of Armenia's emissions reporting.
- Time series has been recalculated, and consistent time series for 1990-2022 has been developed due to the adjustment of data required for assessing emissions from enteric fermentation.
- Time series on methane and nitrous oxide emissions from manure management has been recalculated for the 1990-2022 period with adjusted activity data.
- Based on the data from the "External Trade of the Republic of Armenia (according to the 8- and 10-digit classification of the Commodity Nomenclature of External Economic Activity)" of the RA SC, the time series of direct and indirect nitrous oxide emissions from managed soils has been recalculated for the entire period.

  Due to data gaps with respect to years 1990-1995, emissions for 1990-1995 were estimated by linear interpolation, assuming a constant annual decrease in emissions throughout the period of 1990-1995.

LULUCF

- The recalculation has been performed for the entire time series for *Cropland Remaining Cropland* subcategory have been done due to the adjusted activity data.

- The recalculation of the time series for *Land converted to settlements* subcategory has been performed for the years 2011-2022 due to the updated data on land-use conversion to Settlements and corrections to it. Data on land-use conversion to Settlements are not available before 2011.
- The recalculation of the time series for the years 2011-2022 has been performed due to the updated data on land-use conversion to *Other land* and corrections to it. Data on land-use conversion are not available before 2011.
- The recalculation of the time series for the entire period for *Harvested Wood Products* category has been performed due to the adjusted activity data.

Waste

- 2020-2022 emissions from 5.A. *Solid Waste Disposal* category have been calculated using waste composition data, while for 1990-2019 emissions were calculated using bulk waste.
- The methodology for calculating total waste has been updated with the new approach, considering the total population of Armenia (both urban and rural), whereas in the previous submissions only urban population has been considered.

  Therefore, methane emissions for 1990-2019 need to be recalculated. This will require additional data collection for previous years, identification of any data gaps and consideration of various splicing techniques from the 2006 IPCC Guidelines to identify the most suitable for recalculating this category. This improvement is planned for the next inventory cycle.
- Emissions from (5.C.1.) *Waste incineration* category have been assessed.
- The recalculation has been performed for the entire time series of methane emissions from *(5D1.) Domestic Wastewater* category, using the new data published by the RA Statistics Committee, while in the previous inventories the values of the population's access to the sewerage system were based on expert judgment.
- The time series for nitrogen oxide emissions from *(5D1.) Domestic Wastewater* category has been recalculated using updated data for Armenia published by the UN FAO on the amount of protein consumed per person per day.
- The recalculation has been performed for the entire time series for (5.D2) *Industrial wastewater treatment and discharge* category (methane emissions), using the updated data from RA SC publications, as well as data from the RA SC databases.

1. NATIONAL CIRCUMSTANCES AND INSTITUTIONAL ARRANGEMENTS

Background information on GHG inventories and climate change

The Framework Convention on Climate Change was adopted in 1992 and the Republic of Armenia has ratified the UNFCCC and the Kyoto Protocol in 1993.

In 2015, the international community adopted the Paris Agreement, which aims to prevent dangerous climate-change impacts by limiting global warming to considerably less than 2 °C – and to 1.5°C if possible.

Although as a country Armenia is responsible for a very small contribution to global anthropogenic greenhouse gas emissions, the country is committed to supporting global efforts for enhanced climate action and ratified the Paris Agreement in 2017.

Thus, the Republic of Armenia is party to both the 1992 UNFCCC and the 2015 Paris Agreement. In 2021, Armenia's Nationally Determined Contributions (NDC) for ten-year implementation period (2021-2030) were approved, setting a new unconditional mitigation target to be achieved by 2030, through mainstreaming and integrating climate change considerations into national and sectoral development policies. On December 2023 the RA Government approved the Long-term Low Greenhouse Gas Emissions Development Strategy of the Republic of Armenia (until 2050) (LT-LEDS). Currently, the NDC 3.0 is under development to represent a progression from the last NDC and reflect the highest possible ambition in a nationally appropriate way.

The effectiveness of the Paris Agreement on reducing global greenhouse gas emissions depends on reliability of the emissions data used for controlling compliance. Hence, national reporting and the subsequent international review of emissions inventories play a key role.

This National Inventory Document (NID) of Armenia includes data of the anthropogenic emissions by sources and removals by sinks of the following greenhouse gases (GHGs) not controlled by the Montreal Protocol, namely - carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs) and sulfur hexafluoride (SF_6).

The inventory also includes estimates of precursors -carbon monoxide (CO), nitrogen oxides (NOx), non-methane volatile organic compounds (NMVOCs) and sulfur dioxide (SO_2).

National Inventory Arrangements

The RA Ministry of Environment is the state authorized body responsible for the development and implementation of the state policies aimed at addressing climate change issues and for implementing the country's commitments under the UNFCCC and the Paris Agreement.

In 2015, a Climate Change Policy Division, and in June 2020 - a separate department was established under the Ministry of Environment with the main functions of coordinating the fulfilment of the country's commitments under the UNFCCC and Paris Agreement.

In 2024, the Government of the Republic of Armenia adopted Resolution No. 54-N "On Approving the Procedure for Developing Greenhouse Gas Emission Inventory", thereby establishing the national greenhouse gas emissions monitoring and reporting system. The national inventory arrangements are based on laws and regulations of the Republic of Armenia related to the Atmospheric air protection and climate change-related actions.

The national inventory arrangements are designed and operated to ensure transparency, consistency, comparability, completeness, accuracy and timeliness of greenhouse gas emission inventories.

According to this regulation, the Ministry of Environment of the Republic of Armenia is the state Authorized body for greenhouse gas emissions inventory and State Hydrometeorological Service of the Ministry of Environment of the Republic of Armenia is designated as the Implementing body. The State Hydrometeorological Service is in charge of the compilation of the national greenhouse gas emissions inventory and its quality management according to the UNFCCC inventory reporting guidelines and the Paris Agreement.

National climate change policies and actions are coordinated by the Inter-Agency Coordinating Council on implementation of UNFCCC requirements and provisions, established in 2012. The role and the status of the Council was further revised and expanded, as approved by the Prime Minister's Decree in July 2021, to ensure the fulfilment of the obligations under the UNFCCC and the Paris Agreement.

The Council has the authority to coordinate reporting on climate change and ensure coherent policies for achievement of Armenia's commitments under UNFCCC and Paris Agreement and to evaluate the progress and outcomes towards fulfillment of the obligations undertaken by the Republic of Armenia and provisions deriving from the Convention and the Paris Agreement.

The Council is chaired by the RA Deputy Prime Minister and is composed of representatives of ministries, state agencies, including the Statistics Committee and independent bodies (the Public Services Regulatory Commission and the National Academy of Sciences). Technical cooperation is ensured through the Council working group, comprised of professionals nominated by respective Ministries and agencies.

Inventory preparation process

According to the Resolution "On Approving the Procedure for Conducting Greenhouse Gas Emission Inventory", the Implementing body, i.e., Hydrometeorology and Monitoring Center State Non-Commercial Organization (SNCO) of the RA Ministry of Environment is responsible for developing a draft National GHG inventory report and its submission to the Authorized body - the RA Ministry of Environment.

The data required for the GHG emissions inventory are provided to the authorized body by the respective agencies and institutions designated as data providers according to the Resolution "On Approving the Procedure for Conducting Greenhouse Gas Emission Inventory".

The Implementing entity is in charge of developing the national GHG inventory throughout all stages of the process – from the preparation of the inventory to the development of a draft report on the national greenhouse gas inventory and its submission to the authorized body, ensuring the quality of national inventories.

The draft National Greenhouse Gas Emissions Inventory report is approved by the Inter-Agency Coordinating Council for the Implementation of the Requirements and Provisions of the United Nations Framework Convention on Climate Change and the Paris Agreement following by the submission of the National Greenhouse Gas Emissions Inventory Report to the UNFCCC Secretariat by the Authorized Body.

Prior to starting the inventory development process, the National Greenhouse Gas Inventory Improvement Plan (NIIP) is reviewed. The purpose of the NIIP is to guide the Transparency, Accuracy, Completeness, Comparability and Consistency (TACCC) process for future inventories by identifying and prioritizing actions to improve the national GHG system. This process precedes the inventory development process as it serves as the basis for the formulation of data collection requirements.

Inventory development consists of preparatory and main stages, which are finalized by the management stage.

At the *preparatory* stage the following activities are carried out:

- Definition of the methods for calculation based on the analysis of the GHG inventory improvement plan - review of the calculation methods carried out by the relevant sectoral experts and consideration of the possible changes therein (where necessary). In each case, method selection depends on whether the considered category is a key or not and on the availability of the data for applying higher Tier approach;
- Identification of GHG categories;
- Clarification and approval of forms for providing information.

During the *main* stage the following activities are carried out:

- Data collection;
- Quality Assurance and Quality Control (QA/QC) of activity data in accordance with the 2006 IPCC Guidelines;
- Selection of emission factors – update of country-specific emission factors and development (if required) of country-specific emission factors;
- Estimation of GHG emissions/removals;
- Implementation of general quality control procedures in accordance with the approved quality control and quality assurance plan and application of specific quality control procedures in accordance with the approved quality control and quality assurance plan for both key categories and for categories in which methodological changes have occurred, in accordance with the 2006 IPCC Guidelines;
- Preparation of report sections (texts), and
- Approval by the relevant experts (QA/QC):
  - In each case, the relevant expert responsible for QC also has responsibility for issuing expert level approvals
  - Approvals for written texts and calculation results, prior to any further use of such texts and results.
- Compilation of the draft report of the National GHG Inventory in accordance with the relevant Decisions of the Conference of the Parties to the UNFCCC and the Paris Agreement;
- Evaluation of the draft inventory by an independent third party not involved in its preparation, prior to submission to the authorized body.

The *management* stage includes:

- Internal review of the draft (national trend tables and NID) by the implementing entity - Hydrometeorology and Monitoring Center SNCO, followed by approval, as appropriate;
- Management of electronic database of GHG Inventory;
- Electronic archiving and storage of the national inventory and the information that formed the basis for its development
- Handover of the National GHG Inventory draft report to the authorized body – the RA Ministry of Environment.
- During the international analysis respond to requests for clarification from the team of technical experts regarding information in the national inventory

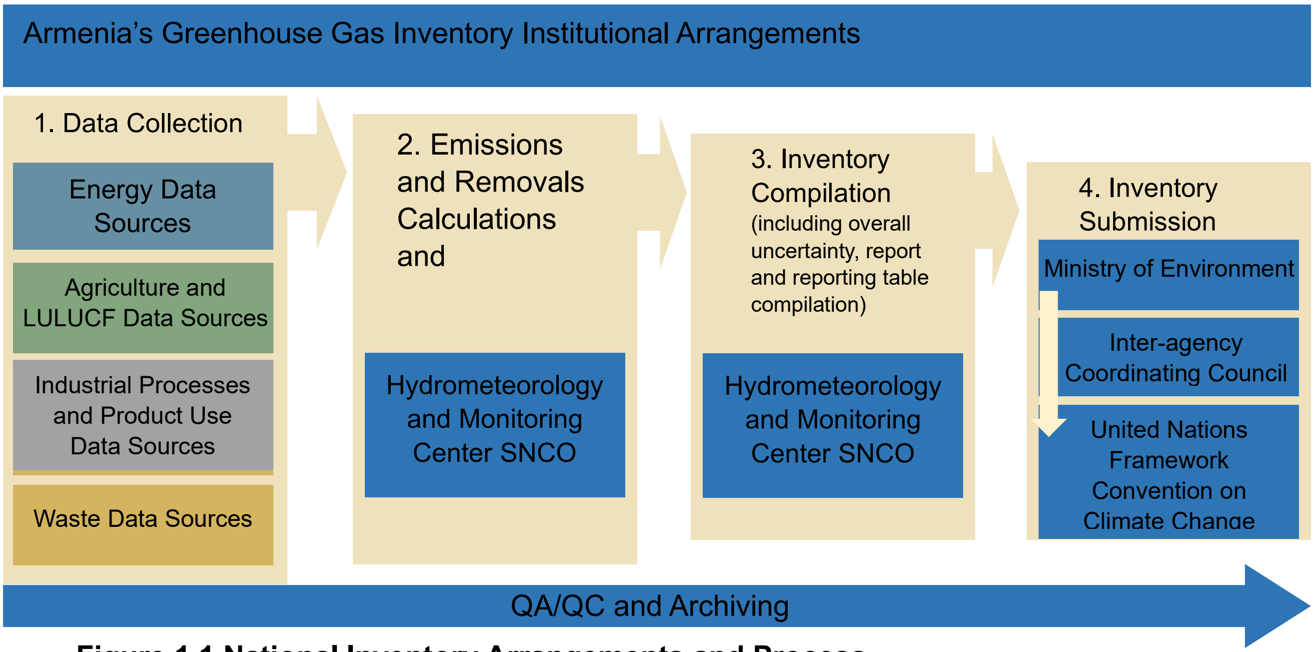


Figure 1.1 National Inventory Arrangements and Process

Archiving

The archiving system is an essential component of the inventory development process. It plays a key role in sustaining the National Inventory System of Armenia, while simultaneously supporting the transparency of national inventories and facilitating the development of subsequent inventories.

Until now, the information used to create the inventory has been archived in a single location (in both electronic and hard copy formats) to ensure that future inventory staff have access to all relevant files when needed, including for responding to reviewer questions, such as those concerning methodologies.

All emission factors and activity data at detailed level are stored, as well as relevant documentation on how these factors and data were acquired, calculated and consolidated to develop the inventory.

The archived data also includes stored internal documentation on QA/QC procedures, external and internal reviews, as well as planned inventory improvements.

All electronic data used for the inventory were stored on the Climate Change Programme Unit server and automatically duplicated in a Google drive cloud storage.

According to the Resolution "On Approving the Procedure for Conducting Greenhouse Gas Emission Inventory", all information related to greenhouse gas emissions inventory will be recorded in an electronic database of greenhouse gas emissions inventory, which will contain all the important data, models and documentation needed in inventory development.

The data storage/archive consists of the following key components:

- IPCC 2006 software package database (mbd file) used for data collection;
- Data and calculation spreadsheets (mainly Excel files) and other electronic files for each category, used by experts to develop inventory estimates, including activity data, disaggregated emission factors and documentation of how these factors and data were generated and aggregated to prepare the inventory;

- Internal documentation on QA/QC procedures;
- Identification of Key category and Uncertainty assessment;
- Internal and external review comments and responses;
- Latest drafts and final electronic versions of the inventory documents (National Inventory Document), in Armenian and in English languages.

Processes for official consideration and approval of inventory

The following steps constitute the process of official consideration and precede the formal approval of the report:

- Implementation of QA procedures by conducting a basic expert peer review;
- Review of the draft NID by the Implementing entity (relevant sectoral experts) for any changes or clarifications, if necessary;
- Internal review of the draft NID by the Inter-Agency Coordinating Council working group, which is comprised of representatives of various state agencies, ministries, as well as climate change experts and consultants, and conducts technical analysis of the draft NID (national trend tables) as contribution to the QC procedure;
- Review of the draft report by data providers - stakeholder state agencies and entities.
- The review outcomes are submitted to the Implementing entity (relevant sectoral experts) for any revisions or clarifications (if necessary and after appropriate consultations).
- Submission of the revised draft National GHG Inventory Report to the Ministry of Environment.
- Handover to the Inter-Agency Coordinating Council, leading to approval by the Council, followed by the final step of
- Submission to the UNFCCC secretariat by the Ministry of Environment

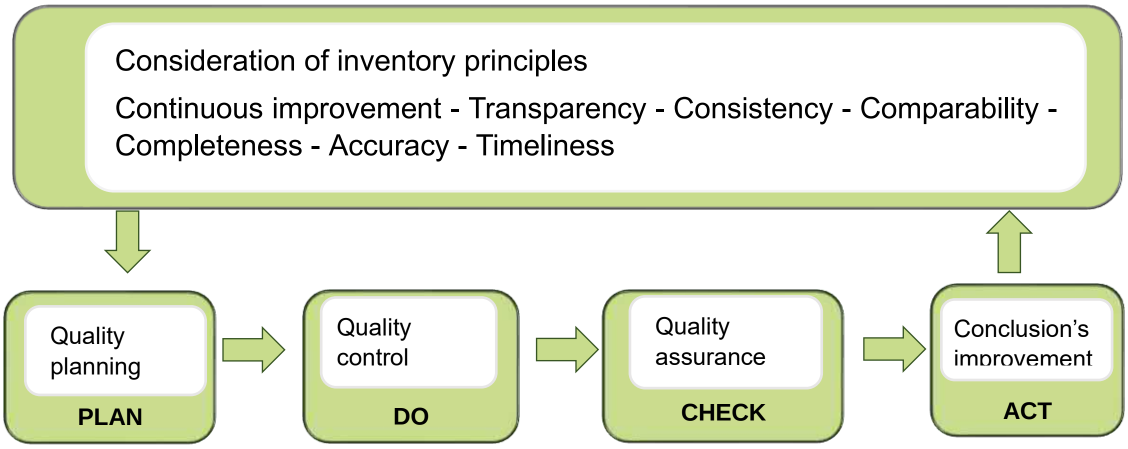
General description of the QA/QC plan and implementation

The ultimate goal of the QA/QC process is to ensure quality, transparency and credibility of inventory and to contribute to the improvement of inventory across all sectors.

The quality of GHG emissions source categories is assured through application of the Armenia's Inventory QA/QC plan outlined in Annex 7 and are carried out within the framework of the Armenia Quality Management Plan for Greenhouse Gas Inventory, approved *by* the Ministry of Environment.

Two types of checks were performed using this plan: (1) general (Tier 1) procedures consistent with Volume 1, Chapter 6 of the 2006 IPCC Guidelines that focus on procedures and checks to be used when gathering, maintaining, handling, documenting, checking, and archiving the data, supporting documents, and files; and (2) source category-specific (Tier 2) procedures that focus on checks and comparisons of the emission factors, activity data, and methodologies used for estimating emissions from the relevant emissions sources. These procedures include: checks to ensure that activity data and emission estimates are consistent with historical trends; that consistent, complete and data sources are used and documented; that interpolation or extrapolation techniques are consistent across sources; and that common units, and conversion factors are used where applicable.

Consistent with the 2006 IPCC Guidelines, additional category-specific QC procedures were performed for more significant emission categories or sources where significant methodological and data updates have taken place. Any significant findings and errors identified are documented and corrected.



2. ARMENIA'S GREENHOUSE GAS EMISSIONS EMISSION INVENTORY

Brief description of methodologies and data sources used

Greenhouse gas emissions and removals from various source and sink categories were estimated using methodologies consistent with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 2006) and 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetland. In general, this report uses published official statistics for activity data, emission factors and other key parameters as inputs to the methods applied, as well as the unpublished data required for emissions/ removals estimate, provided by various entities in response to requests from the Ministry of the Environment.

The IPCC Inventory Software version 2.930.8992 was used for data entry, emissions estimate, results analysis and conclusions.

The vast majority of GHG emissions in Armenia originates from the Energy sector. That is why the Energy Balances of Armenia, officially published by the RA SC, are the key source of data for estimating GHG emissions from the Energy sector.

The GHG Inventory Working Group cooperates with the experts compiling the Energy Balance to ensure data accuracy, reliability and comparability.

The main source of data for the assessing emissions from other sectors is the RA Statistical Committee. Data are also provided by the Ministry of Territorial Administration and Infrastructure of the RA, the RA Ministry of Economy, the RA Ministry of Environment, the RA Public Services Regulatory Commission (PSRC), the RA State Revenue Committee, the State Cadastre of Real Estate, and private industrial/manufacturing enterprises.

The methodologies used for the Armenia's greenhouse gas inventory are consistent with the 2006 IPCC Guidelines. Methods and emission factors by category are presented in Table 2.1.

Descriptions of the methodologies used by sector are detailed in Chapters 4 to 8.

Table 2.1 Summary report for methods and emission factors used in Armenia's inventory in 2022 (CS - country-specific, D- default, PS- plant-specific)

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2		CH_4		N_2O		HFCs		SF_6	
	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor
1. Energy	T1,T2,T3	PS,CS,D	T1,T2	D,CS	T1	D				
1.A. Fuel combustion	T1,T2,T3	PS,CS,D	T1	D	T1	D				
1.A.1. Energy industries	T3	PS	T1	D	T1	D				
1.A.2. Manufacturing industries and construction	T1,T2	D,CS	T1	D	T1	D				
1.A.3. Transport	T1,T2	D,CS	T1	D	T1	D				
1.A.4. Other sectors	T1,T2	D,CS	T1	D	T1	D				
1.A.5. Other	NO	NO	NO	NO	NO	NO				
1.B. Fugitive emissions from fuels	T1	D	T2	CS	NA	NA				
1.B.1. Solid fuels	NO	NO	NO	NO	NO	NO				
1.B.2. Oil and natural gas and other emissions from energy production	T1	D	T2	CS	NA	NA				
1.C. CO_2 transport and storage	NO	NO								
2. Industrial processes	T1,T3	D, PS	NA	NA	NA	NA	T1,T2	D	T1	D
2.A. Mineral industry	T1,T3	D, PS	NA	NA	NA	NA				
2.B. Chemical industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.C. Metal industry	T1	D	NA	NA	NA	NA	NA	NA	NA	NA
2.D. Non-energy products from fuels and solvent use	T1	D	NA	NA	NA	NA				
2.E. Electronic Industry					NO	NO	NO	NO	NO	NO
2.F. Product uses as ODS substitutes							T1,T2	D		
2.G. Other product manufacture and use	NA	NA	NA	NA	NA	NA			T1	D
2.H. Other	NO	NO	NO	NO	NO	NO			NO	NO
3. Agriculture	T1	D	T1,T2	D,CS	T1,T2	D,CS				
3.A. Enteric fermentation			T1,T2	D,CS						
3.B. Manure management			T1,T2	D,CS	T1,T2	D,CS				
3.C. Rice cultivation			NO	NO						
3.D. Agricultural soils			NA	NA	T1	D				

3.E. Prescribed burning of savannahs			NO	NO	NO	NO				
3.F. Field burning of agricultural residues			T1	D	T1	D				
3.G. Liming	NO	NO								
3.H. Urea application	T1	D								
3.I. Other carbon-containing fertilizers	NO	NO								
3.J. Other	NO	NO	NO	NO	NO	NO				
4. Land use, land-use change and forestry	T1,T2	D,CS	T1	D	T1	D				
4.A. Forest land	T2	CS	NA	NA	NA	NA				
4.B. Cropland	T1	D	NA	NA	NA	NA				
4.C. Grassland	T1	D	NA	NA	NA	NA				
4.D. Wetlands	T1	D	T1	D	T1	D				
4.E. Settlements	T1	D	NA	NA	NA	NA				
4.F. Other land	T1	D	NA	NA	NA	NA				
4.G. Harvested wood products	T1	D								
4.H. Other	NO	NO	NO	NO	NO	NO				
5. Waste	T1	D	T1,T2	D	T1	D				
5.A. Solid waste disposal			T2	D						
5.B. Biological treatment of solid waste			NO	NO	NO	NO				
5.C. Incineration and open burning of waste	T1, T2	D	T1	D	T1	D				
5.D. Waste water treatment and discharge			T1	D	T1	D				
5.E. Other	NO	NO	NO	NO	NO	NO				
6. Other (as specified in summary 1)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Description of key categories

According to the 2006 IPCC Guidelines (Chapter 4, Volume 1), *"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".*

Thus, identifying key categories in national inventories allows efforts to be focused on improving the overall quality of the inventory.

The methodology for assessing key categories is described in 2006 IPCC Guidelines for National Greenhouse Gas Inventories (Chapter 4, Volume 1). The Approach 1 was used for selecting the key categories for Armenia's GHG inventory. The analysis has been performed for absolute values of emissions and removals (level assessment) based on 2022 inventory, as well as for the trends based on 2000 and 2022 inventories. Since in 1990 the structure and management principles of Armenia's economy were absolutely different as compared to the present time, using 1990 as a base year for trend analysis would identify those categories that underwent the most structural changes following the breakup of the Soviet Union and would not be informative for assessing current trends and processes of emission changes. Hence, the year 2000 has been used as a base year for trend assessment.

The 2006 IPPC Guidelines suggests an aggregation level of analysis for Approach 1 (Table 4.1, page 4.8, Volume 1, Chapter 4), however inventory compilers modified this list to reflect particular national circumstances and to consider more detailed disaggregation level.

The key categories identified are presented in Table 1.4, whereas calculations, which are the basis for level and trend assessments, are given in Annexes 2.1 and 2.2, respectively. The key category analysis has been performed with and without LULUCF.

Table 2.2 presents summary of key categories analysis for 2022, Approach 1, where the main sources are classified according to absolute values. This table is not fully consistent with the CRT tables. The aggregation level of subcategories used in the analysis is based on the suggested aggregation level in the 2006 IPCC Guidelines (Vol. 1, Table 4.1) with following disaggregation:

- Category *1.A.3.b Road transportation* is subdivided to main fuel types,
- Category *3.A Enteric fermentation* is subdivided to *3.A.1. Cattle* and *3.A.4 Other*
- Category *1.A.4 Other sectors* is subdivided to the 3rd CRT category level.

Table 2.2 Summary of 2022 key categories analysis, Approach 1

Code	GHG source and sink key categories	GHG	Criteria used for identification	Tier level
1.A.1	Energy Industries - Gaseous Fuels	CO_2	Level, Trend	T3
1.B.2.b	Fugitive emissions from Natural Gas transportation and distribution	CH_4	Level, Trend	T2
1.A.4.b	Residential- Gaseous Fuels	CO_2	Level, Trend	T2
1.A.3.b	Road Transportation - Liquid Fuels	CO_2	Level, Trend	T1
3.A.1.a	Enteric Fermentation - Cattle	CH_4	Level, Trend	T2
2.F.1	Refrigeration and Air Conditioning	HFCs	Level, Trend	T2a
1.A.3.b	Road Transportation - Gaseous Fuels	CO_2	Level, Trend	T2
5.A	Solid Waste Disposal	CH_4	Level, Trend	T2
1.A.2	Manufacturing Industries and Construction - Gaseous Fuels	CO_2	Level, Trend	T2
3.D.1	Direct N_2O Emissions from managed soils	N_2O	Level, Trend	T1

1.A.4.a	Commercial/institutional - Gaseous Fuels	CO_2	Level, Trend	T2
2.A.1	Cement production	CO_2	Level, Trend	T3
3.B.1.a	Forest land Remaining Forest land	CO_2	Level, Trend	T2
3.A.4.	Enteric Fermentation – Other	CH_4	Level, Trend	T2, T1
1.A.4.C	Agriculture/Forestry/Fishing/Fish Farms - Gaseous Fuels	CO_2	Level, Trend	T2
5.D	Wastewater Treatment and Discharge	CH_4	Level, Trend	T1
3.D.2	Indirect N2O Emissions from managed soils	N_2O	Level	T1
1.A.4	Other Sectors - Liquid Fuels	CO_2	Level	T1
5.D	Wastewater Treatment and Discharge	N_2O	Level	T1
1.A.2	Manufacturing Industries and Construction - Liquid Fuels	CO_2	Trend	T1
2.F.2	Foam Blowing Agents	HFCs	Trend	T1
1.A.4	Other Sectors - Solid Fuels	CO_2	Trend	T1

There are 22 key categories in Armenia's GHG inventory - 16 of which have been identified with both level and trend assessments, 3 - with only level assessment and 3 more - with trend assessment.

In 2022, emissions from the key categories amounted to 12,276.4 kt $CO_{2\ eq.}$, which accounted for 95.1% of the country's net emissions.

Out of the 22 key categories, 13 were assessed using higher tier (Tier 2 and Tier 3) methodologies, including emissions from the top 8 categories identified through key source level and trend assessments, except for emissions from liquid fuel combustion in *Road Transportation* (1.A.3.b).

Overall, emissions assessed using higher-tier methodologies for these 13 key sources accounted for 84.1% of the net national emissions in 2022.

However, there are still several key categories that have significant shares in the level and trend uncertainty of inventory, which makes them a priority for next inventory cycles. These are *Direct and Indirect N_2O Emissions from Managed Soils* (3.C.4 and 3.C.5), N_2O emissions from W*astewater Treatment and Disch*arge (4.D), and CO_2 emissions from *Liquid fuel use in Road Transportation* (1.A.3.b).

General uncertainty assessment

Uncertainty assessment is an essential element of a complete and transparent emissions inventory. Uncertainty assessment is not intended to bring into question the inventory estimations - on the contrary, along with key category analysis, it helps to improve the accuracy of inventory and prioritize Inventory improvements.

There are two methods of uncertainty estimation stipulated by the 2006 IPCC Guidelines. For uncertainty assessment of the Armenia's GHG inventory the *Approach 1: The propagation of error* was used. The methodology is described in detail in 2006 IPCC Guidelines (Vol. 1, Ch. 3, Section 3.2.3.1)

The uncertainty analysis of Armenia's inventory covers all source categories and all direct greenhouse gases. These analyses reflect the quantitative uncertainty in the emission (and removal) estimates associated with uncertainties in their input parameters (e.g., activity data and EFs) and serve to evaluate the relative contribution of individual input parameter uncertainties to the overall Inventory, its trends, and each source and sink category.

In some cases, the sub-categories have been aggregated to eliminate the interrelation and ensure that data is available at appropriate level for both years 2022 and 2000. The categories are disaggregated in a way that aligns with those used in key category analysis, thus serving to identify categories that will require special attention in the next inventory process to improve accuracy and reduce uncertainty.

The uncertainty has been assessed based on the level in 2022 GHG inventory data, as well as trend, where the base year was selected to be 2000. 2000 has been chosen as a base year instead of 1990 because difference between inventory estimates of 2000 and 2022 better represents the current and possible future trends of Armenia's inventory, than the difference between 1990 and 2022. The difference between 1990 and 2022 shows downward trend due to the breakdown of Soviet Union and consequent restructuring of inventory, whereas the difference between 2000 and 2022 shows an upward trend, which is more characteristic of the current and possible future development of Armenia's emissions and removals.

The uncertainty estimation for the activity data and country specific emission factors is based on expert's analysis of data sources, whereas uncertainty levels of default emission factors are based on suggested values from 2006 IPCC Guidelines. When 2006 IPCC Guidelines give uncertainty assessment for components of activity data and emission factors, they have been combined using error propagation equations. A detailed description of selected emission factors and activity data is given in sectoral chapters.

The uncertainty assessment calculations are presented in Annex 2.3.

The calculations revealed that the level of emissions uncertainty is within 10.3%, and the uncertainty of trend is 17%.

The highest contribution to variance by category in 2022 has *Direct N_2O Emissions from managed soils* (3.C.4), CH_4 and N_2O emissions for the use of natural gas in *Road Transportation* (1.A.3.b), N_2O emissions from *Wastewater Treatment and Discharge* (5.D) and CH_4 emissions from *Solid Waste Disposal* (5.A).

The highest contributors in the uncertainty of trend have CH_4 and N_2O emissions for the use of natural gas in *Road Transportation* (1.A.3.b), CH_4 emissions from *Solid Waste Disposal* (5.A), *Direct N_2O Emissions from managed soils* (3.C.4) and HFC emissions from *Refrigeration and Air conditioning* (2.F.1).

As it can be seen, in all cases the highest uncertainties are related to non-CO_2 emissions. For CO_2 emissions, the categories with highest uncertainty contribution both in level and trend are the liquid fuel use in *Road Transportation* (1.A.3.b) and *Forest Land Remaining Forest Land* (4.A.1). Consequently, the main efforts for reducing uncertainty should be directed towards these categories in future inventory processes.

Metrics

According to recent decisions adopted under the Paris Agreement and the UNFCCC, Parties are required to use 100-year GWP values from the IPCC Fifth Assessment Report (AR5) for calculating $CO_{2\ equivalents}$ in their national reporting.

This report reflects $CO_{2\ equivalent}$ greenhouse gas emission totals using 100-year AR5 GWP values.

Table 2.3 Global warming potential used in the inventory, values for a 100-year time-horizon

Trade or common name	Global warming potential
Carbon dioxide	1
Methane	28
Nitrous oxide	265
HFC-32	677
HFC-125	3,170
HFC-134a	1,300
HFC-143a	4,800
HFC-152a	138
HFC-227ea	3,350
HFC-245fa	858
HFC-365mfc	804
Sulphur hexafluoride	23,500

3. TRENDS IN GREENHOUSE GAS EMISSIONS AND REMOVALS

Overview of greenhouse gas emissions and removals trend by gas

In 2022, Armenia's greenhouse gas emissions totaled 13,314.1 kilotons of carbon dioxide equivalent (kt $CO_{2\ eq.}$), excluding the LULUCF sector.[3]

In 2022, total emissions were approximately 50% (13,442 kt) below the 1990 emissions level. Net emissions (including removals) amounted to 12,932.2 kt $CO_{2\ eq.}$, Overall, net emissions have decreased by 50.3% compared to 1990 levels.

Between 2020 and 2022, the increase in total greenhouse gas emissions was driven largely by an increase in CO_2 emissions from fossil fuel combustion in power industries and across most end-use sectors – residential, transportation, industrial emissions.

Figure 3-1 illustrates the overall trend in total emissions and sinks since 1990.

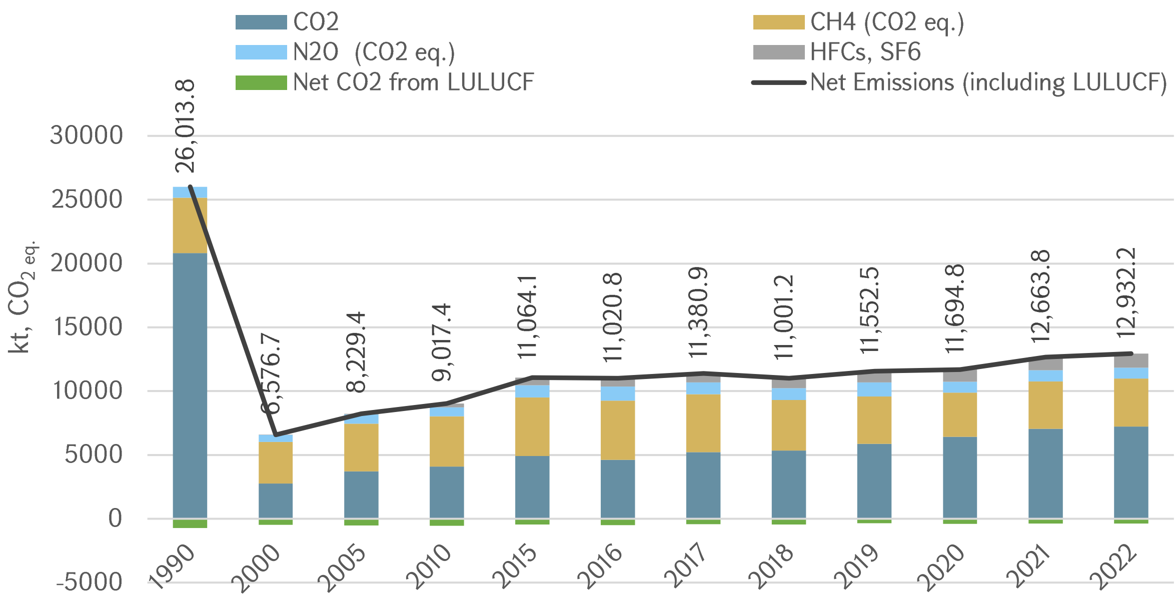


Figure 3.1 The overall trend in total emissions and removals since 1990, kt $CO_{2\ eq}$

Figure 3.1 illustrates the relative contribution of each gas to Armenia's total gross greenhouse gas emissions in 2022, in CO_2 equivalents.

[3] Within the scope of this National Inventory Document, the total volume of GHG emissions/removals from the "Agriculture" and "Land Use, Land-Use Change and Forestry" (LULUCF) sectors differs from the data presented in the CRT due to the inclusion of emissions from the field burning of agricultural residues under the "Agriculture" sector, whereas in the CRT tables these emissions are included under the "Land Use, Land-Use Change and Forestry" (LULUCF) sector - in accordance with the classification used in the ETF reporting tools. Therefore, the total emissions from the Agriculture sector do not match those presented in the CRT, differing by the emissions from the field burning of agricultural residues.

The primary greenhouse gas emitted in Armenia is CO_2, which accounts for 55.9 % of total net greenhouse gas emissions. The largest source of CO_2 and of overall greenhouse gas emissions is fossil fuel combustion - primarily from power generation, residential sector and transportation.

Methane (CH_4) emissions account for 29.1 % of total net emissions. The major sources of methane include natural gas system, enteric fermentation associated with domestic livestock, and decomposition of waste in landfills.

Nitrous oxide (N_2O) emissions account for 6.5 % of total net emissions. Agricultural soil management is the major sources of N_2O emissions, with smaller emissions coming from wastewater treatment and manure management.

Emissions of substitutes for ozone-depleting substances (ODS) were the source of hydrofluorocarbon (HFC) emissions, accounting for 8.4% of total net emissions. Electrical equipment was the source of sulfur hexafluoride (SF_6) emissions, the share of which is negligible.

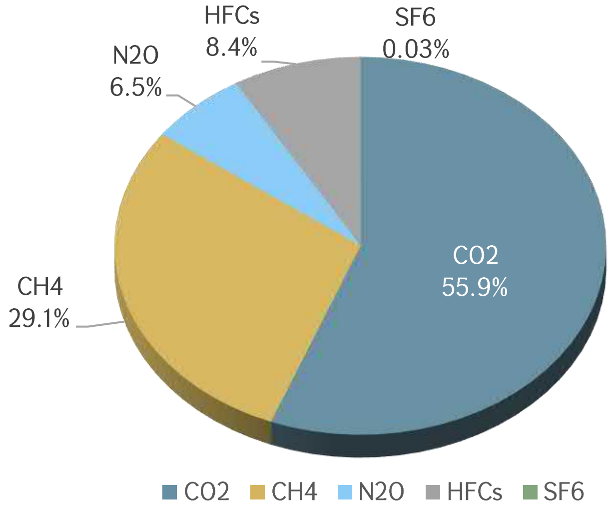


Figure 3.2 2022 Armenia's net greenhouse gas emissions by gas (Percentages based on kt $CO_{2\ eq.}$)

From 1990 to 2022, total CO_2 emissions with LULUCF decreased by 65.27% (13,592.32 kt $CO_{2\ eq.}$), total emissions of methane (CH_4) decreased by 13.2% (573 kt $CO_{2\ eq.}$), and total emissions of nitrous oxide (N_2O) decreased by 1.2% (10.6 kt $CO_{2\ eq.}$).

Since 2000, when Armenia started importing products and equipment containing HFCs, emissions of fluorinated gases HFCs have steadily increased, accounting for 8.4% of total emissions in 2022, while the share of SF_6 is negligible (4.15 kt $CO_{2\ eq.}$). Despite being emitted in smaller quantities relative to the other greenhouse gases, emissions of HFCs, are significant because many of them have extremely high global warming potentials (GWPs).

Emissions and removals by IPCC Sector

Overall, Armenia's total GHG emissions in 2022 have decreased by over 50% compared to 1990, mainly due to decreased emissions from the Energy sector. These resulted from the structural changes in economy, i.e., decreased share of energy intensive industries and increased share of the service sector, wide use of eco-friendly fuel – natural gas for energy production (which replaced mazut) and in transport, recommissioning of Armenia's Nuclear Power Plant and strongest growth of the renewable energy.

Energy sector is the most significant source of greenhouse gas emissions in Armenia and, therefore, the key driver behind the trend. Energy related emissions vary much in Armenia, mainly according to economic trend, energy supply structure and volume of electricity export, climate conditions.

Figure 3.3 and **Table 3.1** illustrate that for the entire time period of 1990 to 2022, total emissions from the Energy sector decreased by 62.1% (14,510 kt $CO_{2\ eq.}$), Agriculture sector decreased by nearly 10% (220.2 kt $CO_{2\ eq.}$) and Waste sectors increased by 56.1 % (310.8 kt $CO_{2\ eq.}$). Emissions from Industrial Processes and Product Use grew by 155% (977.8 kt $CO_{2\ eq.}$). Over the same period, removals from the LULUCF sector decreased by 48.6% (360.5 kt $CO_{2\ eq.}$).

Table 3.1 is not fully consistent with the CRT tables - emissions from burning of agricultural residues are included in Agriculture sector in this table, whereas they are included in LULUCF in CRTs.

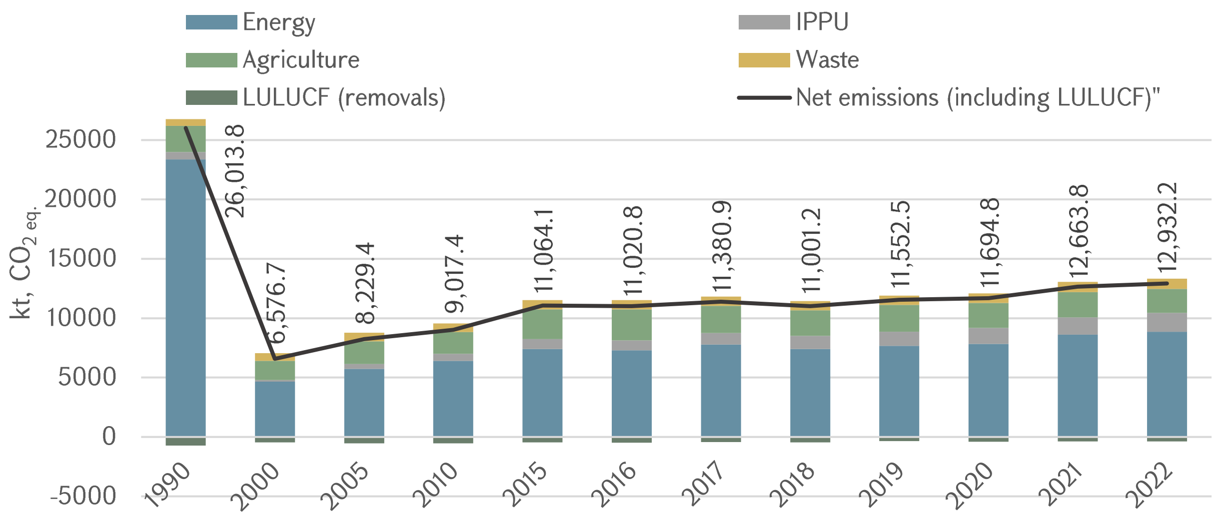


Figure 3.3 Greenhouse Gas Emissions and Sinks by IPCC Sector, kt $CO_{2\ eq.}$

Table 3.1 Recent Trends in Armenia's Greenhouse Gas Emissions and Sinks by IPCC Sector (kt $CO_{2\ eq.}$)

Sector	1990	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	Percentage change since 1990
Energy	23,360.92	4,653.94	5,748.18	6,398.59	7,415.44	7,298.27	7,784.54	7,401.82	7,677.11	7,842.65	8,603.70	8,850.55	-62.1
Industrial processes and product use[4]	631.16	152.33	397.39	609.86	815.79	821.86	956.74	1,114.16	1,179.26	1,347.05	1,477.71	1,609.00	155
Agriculture	2,210.14	1,600.89	1,906.16	1,816.16	2,506.56	2,611.90	2,280.86	2,142.76	2,260.89	2,084.64	2,102.02	1,989.89	-10.0
Waste	553.87	657.53	717.63	735.22	778.41	784.09	789.38	791.24	780.55	810.75	864.07	864.63	56.1
Total (excluding LULUCF)	**26,756.09**	**7,064.69**	**8,769.36**	**9,559.83**	**11,516.20**	**11,516.13**	**11,811.52**	**11,449.98**	**11,897.81**	**12,085.09**	**13,047.50**	**13,314.08**	**-50.2**
LULUCF	-742.33	-488.01	-539.95	-542.46	-452.14	-495.28	-430.65	-448.73	-345.28	-390.33	-383.69	-381.87	-48.6
Net emissions	**26,013.8**	**6,576.7**	**8,229.4**	**9,017.4**	**11,064.1**	**11,020.8**	**11,380.9**	**11,001.2**	**11,552.5**	**11,694.8**	**12,663.8**	**12,932.2**	**-50.3**

[4] including F gases

Figure 3.4 illustrates the relative contribution of each sector to Armenia's total gross greenhouse gas emissions in 2022, in CO_2 equivalents.

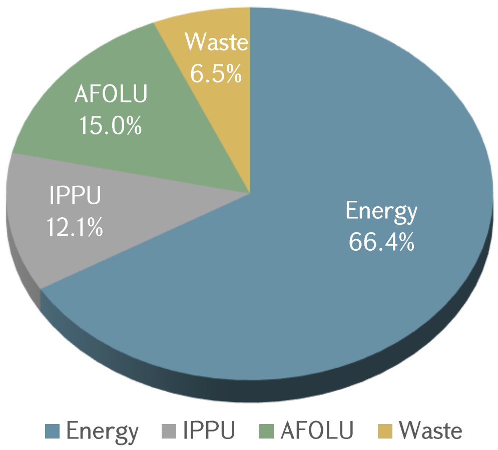


Figure 3.4 2022 Gross Total Armenia's Greenhouse Gas Emissions by Sector (Percentages based on kt $CO_{2\ eq.}$) (LULUCF sector excluded)

Energy

The energy sector is the most significant source of greenhouse gas emissions in Armenia. Emissions from energy-related activities come from two categories: 1) emissions associated with fossil fuel combustion and 2) fugitive emissions from natural gas. Energy-related activities, primarily fossil fuel combustion, accounted for the vast majority of Armenia's CO_2 emissions from 1990 through 2022. Fossil fuel combustion is the largest source of energy-related emissions, with CO_2 being the primary gas emitted.

In 2022, 75.5% of the primary energy used in Armenia was produced through the combustion of fossil fuels. The remaining 24.5% came from other energy sources such as nuclear, hydropower, biomass, wind and solar energy.

Energy-related activities were the primary sources of Armenia's greenhouse gas emissions, accounting for 66.4 % of total gross greenhouse gas emissions in a carbon dioxide (CO_2) equivalent in 2022. This included 97.8, 46.0, and 5.4 percent of the country's CO_2, methane (CH_4), and nitrous oxide (N_2O) emissions, respectively. Energy-related CO_2 emissions alone constituted 54.7 % of total net Armenia's greenhouse gas emissions from all sources on a CO_2-equivalent basis, while the non-CO_2 emissions from energy-related activities represented a much smaller portion of total net national emissions (13.7 % in total).

The increase of Energy Sector emissions since 2000 (except for 2009-2010) amounts to nearly 90% due to:

- Economic growth, leading to the growth in traffic volume, which resulted in road transport emissions' growth - during 2000-2022 road transport emissions have increased by about 236%.
- Improved living conditions resulted in the wide use of natural gas for space heating in households, which became possible because of the unprecedented level of natural gas deliverability reached in the country. During 2005-2022, emissions attributable to energy used by households increased over fivefold.

- Increased generation of electricity by natural gas fired thermal power plants for export to Iran under the gas for electricity swap agreement.

Industrial Processes and Product Use

Emission sources in the Industrial Processes and Product Use (IPPU) accounted for 12.1% of total gross greenhouse gas emissions in a carbon dioxide (CO_2) equivalent in 2022. The GHG emissions from this sector in 2022 have increased 2.5-fold since 1990, as there were no HFC emissions in 1990, and by 36.4% since 2019, driven predominantly by the growth of emissions from HFCs and cement production.

The use of HFCs as substitutes for ozone depleting substances (ODS) is the largest source of emissions in this sector, comprising 67.8% of IPPU emissions in 2022 and driving growth since 2002, when Armenia started importing products and equipment containing HFCs.

The largest source of CO_2 emissions in IPPU sector is cement production, which accounts for 91.8% of CO_2 emissions from the IPPU sector in 2022. Compared to 1990, the emission reduction from cement production for 2022 is 25.2%.

From 2020 to 2022, total emissions from IPPU increased by 19.4% driven by the growth of emissions from cement production and HFCs emissions. The impact of variations in emissions from other categories is negligible.

HFCs emissions from refrigeration and air conditioning predominate in the overall HFCs emissions, with a share of 94.2% in 2022. Share of emissions from the other applications is much smaller.

SF_6 emissions from the use of electrical equipment are negligible, totaling 4.15 kt $CO_{2\ eq.}$, which accounts for 0.3% of sectoral emissions

Agriculture

Methane (CH_4) and nitrous oxide (N_2O) are the main greenhouse gases emitted as a result of agricultural activities, whereas CO_2 is emitted in relatively small quantities.

Methane emissions from enteric fermentation are the largest source of emissions in the Agriculture sector, consistently maintaining an absolute dominance in the sector's emissions, and, therefore, are the key driver behind the emissions trend in the Agriculture sector.

Agricultural emissions decreased by nearly 10% over the period 1990 to 2022. The key driver behind the decreasing trend since 1990 was the overall change in the economy of agriculture, which has resulted in a decrease in the number of animals which consequently led to a continuous reduction in methane emissions from enteric fermentation emissions until the year 2000. In the following years, due to economic recovery of the country and favorable social and economic conditions, an increase in the number of agricultural animals, particularly cattle, was recorded, which consequently led to a rise in methane emissions from enteric fermentation.

In 2018, Cattle Breeding Development Programme was launched in Armenia, which contributed to a significant increase in high-productivity cattle breeds headcount in recent years. In parallel, a decline in the number of local cattle breeds is observed.

Methane emissions from enteric fermentation were the largest contributors to agriculture-related emissions making 61.3% in 2022, with predominant share (85.3%) attributable to cattle.

Compared to 1990, methane emissions from enteric fermentation decreased by 14%, primarily driven by reductions in emissions from the "Other Cattle," sheep, and swine categories, due to declining livestock populations. In contrast, emissions from the Dairy Cows category increased by 13.83%.

Agricultural soils are the largest source of agriculture-related emissions of N_2O, accounting for 77.6 % of N_2O emissions and 4.9 % of total net emissions in Armenia in 2022.

Manure management is the source of CH_4 and N_2O emissions and accounted for 5.8% of Agriculture sector emissions in 2022. Emissions from manure management decreased by 24.7% between 1990 and 2022, driven by changes in the animals' population.

Land Use, Land-Use Change, and Forestry

Net LULUCF sector removals amounted to -381.88 kt $CO_{2\ eq.}$ in 2022.

The LULUCF sector has been a sink during the whole time series from 1990 to 2022. The main factor behind this trend was Forest Land.
The predominating greenhouse gas in this sector is carbon dioxide (CO_2) - the LULUCF sector is a considerable net sink for this greenhouse gas.

Variations in carbon dioxide removals in the Forest land are driven primarily by changes in the annual volumes of fuelwood harvested.

Waste

Waste management and treatment activities are sources of CH_4 and N_2O emissions. Overall, emission sources accounted for in the Waste sector generated 864.63 kt $CO_{2\ eq.}$, or 6.7% of Armenia's net GHG emissions in 2022. In 2022, landfills were the largest source of waste emissions, accounting for 67.3% of waste-related emissions. Landfills are also the largest source of anthropogenic CH_4 emissions, generating 581.8 $CO_{2\ eq.}$ and accounting for 15.4% of total Armenia's CH_4 emissions in 2022.

Additionally, wastewater treatment generated emissions of 225.55 kt $CO_{2\ eq.}$ and accounted for 26.1% of waste emissions, 4.1% of Armenia's CH_4 emissions, and 8.3% of Armenia's N_2O emissions in 2022.

For the entire period of 1990 -2022, total emissions from the Waste sectors increased by 56.1% (310.8 kt $CO_{2\ eq.}$) due to economic development and higher standards of living.

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4. ENERGY (CRT SECTOR 1)

Overview of greenhouse-gas emissions in CRT Sector 1

Energy-related activities were the primary sources of Armenia's greenhouse gas emissions, accounting for 66.4% of total gross greenhouse gas emissions in a carbon dioxide (CO_2) equivalent in 2022. This included 97.8, 46.0, and 5.4 percent of the country's CO_2, methane (CH_4), and nitrous oxide (N_2O) emissions, respectively. Energy-related CO_2 emissions alone constituted 54.7% of total net Armenia's greenhouse gas emissions from all sources on a CO_2-equivalent basis, while the non-CO_2 emissions from energy-related activities represented a much smaller portion of total net national emissions (13.7% together).

Emissions from fossil fuel combustion contribute the vast majority (81.6%) of energy-related emissions, with CO_2 being the primary gas emitted (79.9%) (see **Figure 4.4** and **Figure 4.5**). Due to the significant share of these emissions over time, fossil fuel combustion-related CO_2 emissions are considered in more detail than other energy-related emissions in this report. Fossil fuel combustion also emits CH_4 and N_2O.

Energy-related activities other than fuel combustion - transmission, storage, and distribution of fossil fuels, also emit greenhouse gases. In Armenia these emissions consist of fugitive CH_4 emissions from natural gas systems.

Overview of GHG emissions in CRT Sector 1 (kt $CO_{2eq.}$) is presented in **Figure 4.1**.

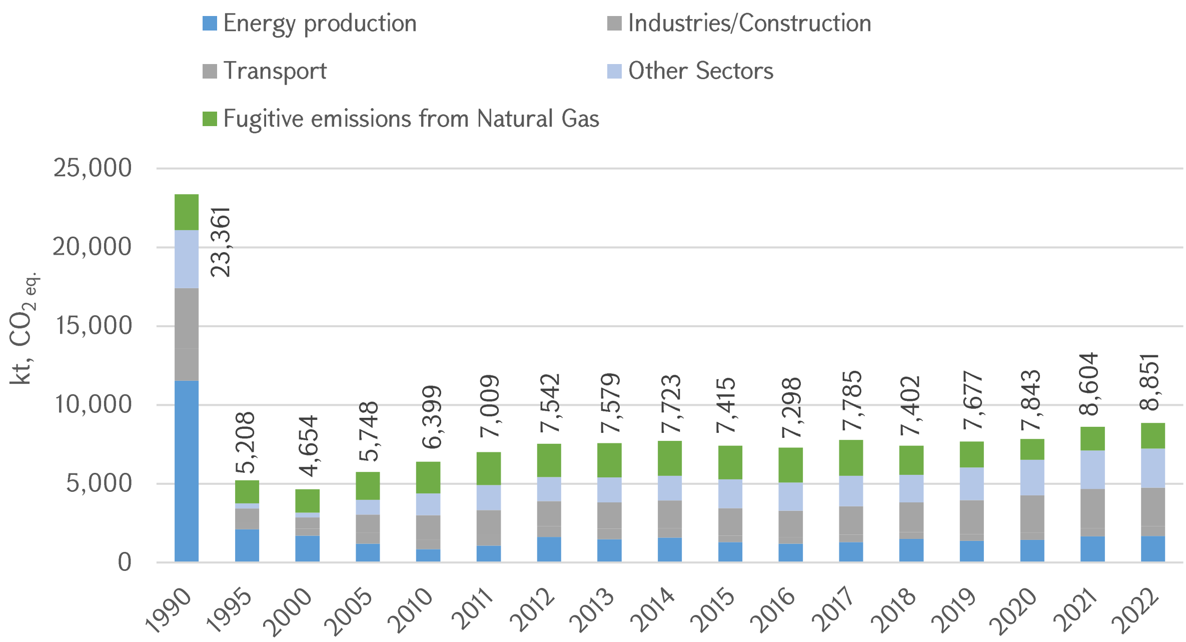


Figure 4.1 Overview of greenhouse gas emissions in CRT Sector 1, (kt $CO_{2\ eq.}$)

About 75.8% of Armenia's total primary energy supply (TPES) comes from fossil fuels, mainly natural gas. The rest comes from other energy sources, such as nuclear, hydro, biomass, wind and solar. Electricity exports amounted to -3.1% from TPES (**Figure 4.2**).

Natural gas is the main fuel consumed in the country. In particular, natural gas has accounted for the largest share of domestic energy demand, making up 56.3% of Armenia's final energy consumption in 2022. It has been consumed both in the electricity generation sector and widely across all end-use sectors of final consumption, including transport, industry, commercial, and residential sectors.

As of 2022, natural gas accounted for about 60.6% of the TPES, 78.5% of fossil fuel consumption (including jet fuel) according to the 2022 Energy Balance (**Annex 3.1.2, EnRef-2**), and more than 77.7% of CO_2 emissions from fossil fuel combustion (excluding international bunkers). This can be explained by the high level of gasification in the country, which stands at 96.33%, and the fact that 1 kWh of useful thermal energy produced from natural gas remains significantly cheaper (about 2.5 times) than 1 kWh of electricity.

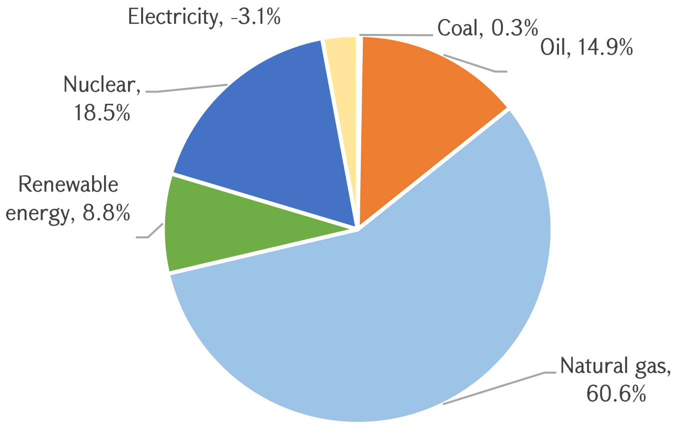


Figure 4.2 Total Primary Energy Supply, 2022

Armenia lacks its own industrial-grade fossil fuel and energy resources; all fuel is imported from Russia and Iran. In 2022, about 87.5% of natural gas was imported from Russia. In these conditions, in terms of energy security, large-scale use of renewable energy sources and the implementation of energy saving measures become a priority and is consistent with the country's commitment to address climate change challenges.

The main power generation capacities in Armenia are nuclear power plant, large hydro power plants and thermal power plants operating on natural gas (including small combined heat and power plants), as well as at small renewable energy plants [small hydro, wind and solar PV plants (including autonomous PVs)], which provided 31.0%, 12.3%, 42.2% and 14.5%, of total electricity generation in 2022, respectively.

Although, as of 2022, renewable energy was mainly represented by hydro power plants (both small and large), however, in recent years, solar energy has developed rapidly. Thus, in 2019, production was 36.6 GWh, in 2022 it was 523.5 GWh, and in 2023 it reached 772.2 GWh. The share of non-fossil energy in total production in 2023 was 58.0% (including solar - 8.76%). This highlights the shift towards solar energy growth over the past few years.

Figure 4.3 presents the greenhouse gas sources of the Energy sector in 2022.

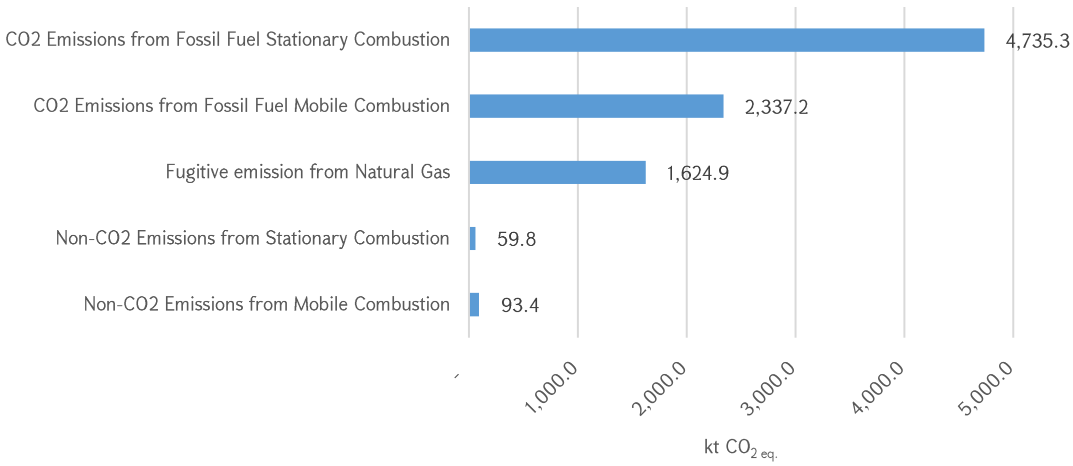


Figure 4.3 Greenhouse gas sources in the Energy sector, 2022, kt $CO_{2\ eq.}$

Greenhouse gas emissions from the Energy sector by categories in 2022 are presented in **Figure 4.4**

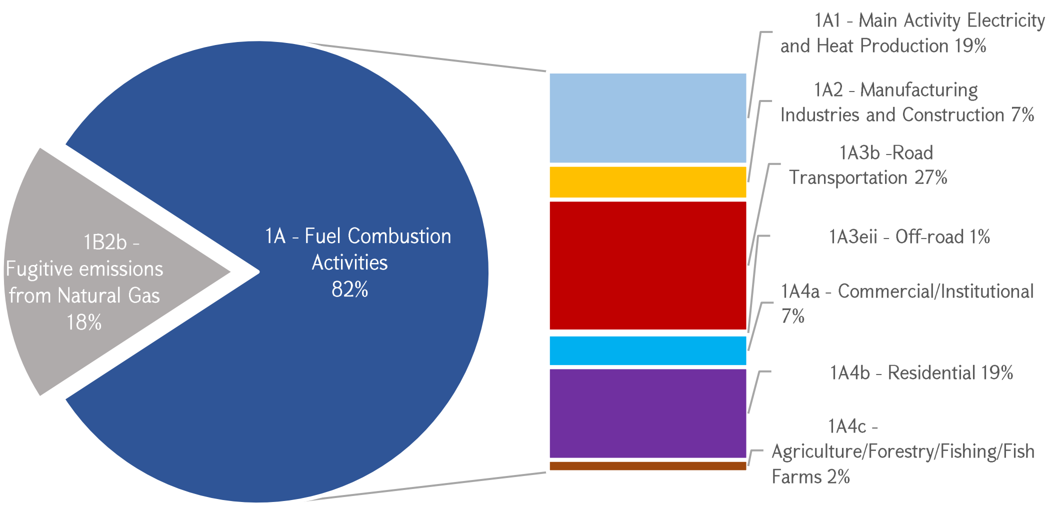


Figure 4.4 Greenhouse gas emissions in Energy sector by sources in 2022, (%, $CO_{2\ eq.}$)

The majority of emissions from Energy sector come from *Road Transportation* (1A3b), *Main Activity Electricity and Heat Public Production* (1A1a), *Residentia*l (1A4b) sector, and *Fugitive emissions from Natural Gas* (1B2b). As of 2022, Road Transport had the largest share in total emissions of Energy sector - 26.9%, followed by Electricity Generation - 19.0%, Residential sector - 18.9%, and Fugitive Natural Gas emissions - 18.4%.

Following them were emissions from *Manufacturing Industries and Construction* (1A2) and the *Commercial/ Institutional* (1A4a) subcategories, which accounted for 7.1 and 6.7%, respectively, while emissions from the *Agriculture/Forestry/Fishing/Fish Farms* (1A4c) subcategory, comprising *Off-road Vehicles* and *Other Machinery* (1A4cii) and *Stationary* (1A4ci) combustion of natural gas in greenhouses made up 2.5%.

Figure 4.5 shows greenhouse gas emissions in Energy sector in 2022 by gases.

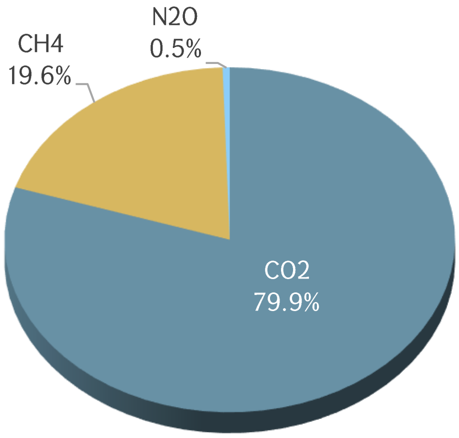


Figure 4.5 Greenhouse gas emissions by gases in Energy sector in 2022, $CO_{2\ eq.}$

Energy is mainly responsible for carbon dioxide emissions, while it also contributes to methane emissions, nitrous oxide and other air pollutants such as carbon monoxide (CO), Non-methane Volatile Organic Compounds (NMVOCs), sulfur dioxide (SO_2) and nitrogen oxides (NOx).

In 2022, 79.9% of the emissions from the Energy Sector were CO_2, 19.6% - CH_4 and 0.5% - N_2O (**Figure 4.5**.).

Methodologies for GHG emissions assessment

Emission estimates from Energy Sector were based on the sectoral approach applying Tier 1, Tier 2 and Tier 3 methods - country-specific approaches were used wherever possible to produce more accurate emissionś estimates than Tier 1 approach:

- *The Tier 3 method* was used for estimating CO_2 emissions from electricity generation at thermal power plants considering disaggregated power plant level data.
- *The Tier 2 method* was used for estimating emissions of CO_2 from both stationary (excluding thermal power plants) and mobile combustion of natural gas based on the activity data from national energy statistics and country-specific emission factors, derived from national fuel characteristics.
- *The Tier 2 method* was also used for estimating emissions of CH_4 from fugitive emissions of natural gas.
- *The Tier 1 method* was used for the CO_2 emission estimates from liquid and solid fuel combustion and for emissions of CH_4 and N_2O from fuel combustion.

In summary, based on the analysis of Key Sources, it can be noted that for all categories within the Energy sector that were included in the Key Sources for 2022 - except for those fuel combustion categories whose emissions result from the burning of liquid fuels - a high-tier methodology using country-specific emission factors was applied.

In addition to assessments based on Sectoral Approach the emissions of CO_2 from fuel combustion were also assessed by Reference Approach and the results were compared for checking purposes (**Annex 3.1.7**).

The methods applied for assessment of greenhouse gases emissions in Energy Sector are summarized in **Table 4.1**. Other emissions were estimated with the Tier 1 method using default emission factor values from the 2006 IPCC Guidelines and the country's activity data

Table 4.1 Summary on methods applied for assessment of greenhouse gas emissions from Energy Sector

Subcategory	GHG	Key Source	Method	Activity Data	Emission Factor
1A FUEL COMBUSTION ACTIVITIES					
1A1a Main Activity Electricity and Heat Production (gaseous fuel)	CO_2	Level, Trend	T3	CS	CS
1A2 Manufacturing Industries and Construction (gaseous fuel)	CO_2	Level, Trend	T2	CS	CS
1A2 Manufacturing Industries and Construction (liquid fuel)	CO_2	Trend	T1	CS	D
1A3b Road transportation (gaseous fuel)	CO_2	Level, Trend	T2	CS	CS
1A3b Road transportation (liquid fuel)	CO_2	Level, Trend	T1	CS	D
1A4a Commercial/Institutional (gaseous fuel)	CO_2	Level, Trend	T2	CS	CS
1A4b Residential (gaseous fuels)	CO_2	Level, Trend	T2	CS	CS
1A4 Other Sectors (liquid fuels)	CO_2	Level, Trend	T1	CS	D
1A4c Agriculture/Forestry/Fishing/Fish Farms	CO_2	Level, Trend	T2	CS	CS
1B FUGITIVE EMISSIONS FROM FUELS					
1B2b Fugitive Emissions of Natural Gas	CH_4	Level, Trend	T2	CS	CS

The emissions of other air pollutants, e.g. CO, NOx, SO_2 and NMVOC form energy sector were also estimated using the methodologies and emission factors from “Air Pollutant Emission Inventory Guidebook” (EMEP/EEA, 2019) and the same activity data used for the assessment of the three main greenhouse gases.

The emissions data with respect to these pollutants are presented in **Table 4.27**.

Energy Sector greenhouse gas source categories

As of 2022, the Energy Sector of Armenia includes the following source categories:

1A *Fuel Combustion Activities*

1A1 Energy Industries

1A1a Electricity and Heat Public Production

1A1ai Electricity Generation

1A1aii Combined Heat and Power Generation

There are no enterprises in the country with the main activity of heat production for commercial delivery. To avoid double counting the existing boiler houses providing heat supply for own use in various areas are considered in the respective categories.

1A2 Manufacturing Industries and Construction

1A2a Iron and Steel

1A2b Non-Ferrous Metals

1A2c Chemicals

1A2d Pulp, Paper and Print

1A2e Food Processing, Beverages and Tobacco

1A2f Non-Metallic Minerals

1A2g Transport Equipment

1A2h Machinery

1A2i Mining (excluding fuels) and Quarrying

1A2j Wood and Wood Products

1A2k Construction

1A2l Textile and Leather

1A2m Non-specified Industry

1A3 Transport

1A3a Civil Aviation

1A3ai International Aviation (International Bunkers)

1A3b Road Transportation

1A3e Other Transportation

1A3eii Off-road

1A4 Other Sectors

1A4a Commercial/Institutional

1A4b Residential

1A4c Agriculture/Forestry/Fishing/Fish Farms

1A4ci Stationary

1A4cii Off-road Vehicles and Other Machinery

1B Fugitive Emissions from Fuels

1B2biii4 Natural Gas Transmission and Storage

1B2biii5 Natural Gas Distribution

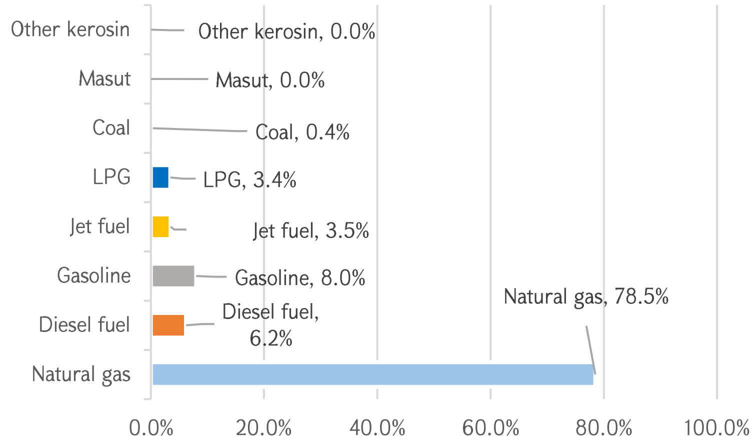
All other sources indicated in 2006 IPCC Guidelines for Energy Sector do not exist in Armenia and are not considered in this Inventory.

Overview of Activity data in Energy Sector

Fossil fuel resources

Armenia has no domestic resources of fossil fuel and highly depends on fossil fuel imports.

Figure 4.6 provides fossil fuel consumption structure in 2022.



In terms of fossil fuel consumption structure by fuel types, natural gas accounted for 78.5% in 2022. In general, fossil fuel consumption structure has remained almost unchanged in recent years.

Figure 4.6 Fossil fuel consumption structure by type of fuel in 2022

Energy Balance of 2022 shows also consumption of fossil fuels for non-energy use, which amounts to 2,974.6 TJ, or 2.42% of the total volume available for final consumption.

Natural gas

Natural gas is widely used in the different sectors of economy and transportation. With natural gas access level of 96.33 % (considering potential gas consumers) Armenia is one of the leaders in the world.

Gazprom Armenia CJSC is a monopoly in charge of the operation and management of the gas supply system in the Republic of Armenia including import, transmission (operation of underground storage), distribution and sale of natural gas.

Natural gas balances (**Annex 3.1.1, EnRef-1**) provided by Gazprom Armenia CJSC are the main activity data sources for assessing greenhouse gas emissions from natural gas combustion.

Some activity data from gas balances required for the emissions estimates are provided in **Table 4.2**.

Table 4.2 Extract from natural gas balances for 2011-2022, (mln m^3)

Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Imports	2,069.1	2,455.5	2,361.1	2,450.9	2,371.8	2,236.5	2,378.7	2,463.4	2,545.4	2,595.4	2,793.8	2,971.4
Gas turnover in GUSF (extracted + injected -)	+46.4	-49.3	+24.3	-27.7	-33.0	+1.9	-23.5	20.8	18.6	-7.5	8.2	-28.2
Own needs, (mln m^3)	7.8	13.5	7.01	9.2	8.1	7.3	9.1	6.7	4.9	7.3	7.5	8.4
Own needs, %	0.38	0.55	0.30	0.38	0.34	0.33	0.38	0.27	0.19	0.28	0.27	0.28
Losses, (mln m^3)	134.05	139	141.63	144.7	138.8	142.6	148.2	123.9	114.2	96.6	107.9	117.7
Losses, %	6.5	5.7	6.0	5.9	5.9	6.4	6.2	5.0	4.5	3.7	3.9	4.0
Consumption, including	1,973.6	2,253.7	2,236.7	2,269.3	2,191.9	2,088.5	2,197.9	2,353.6	2,444.8	2,484.2	2,686.6	2,817.2
Energy Generation	549.3	825.5	759.0	799.5	654.4	603.7	637.5	767.9	691.7	734.1	832.2	864.9
Road Transportation	362.4	418	455.0	481.7	484.6	467.3	477.5	552.7	577.2	472.8	505.3	504.8
Manufacturing Industries/ Construction	326.2	317.7	301.4	278.2	207.7	191.2	200.3	200.9	194.1	209.4	239.6	296.7
Commercial/ Institutional	157.2	127.9	149.6	159.5	261.3	201.1	199.8	212.7	239.5	263.9	255.9	251.1
Residential	550.8	542.0	538.9	515.4	526.6	581.0	621.5	554.1	668.7	724.6	766.3	812.1
Agriculture/Forestry /Fishing/Fish Farms	27.7	22.6	32.8	35.0	57.3	44,1	61.3	65.3	73.5	79.4	87.2	87.6

Table 4.2 shows that in 2022 (compared to 2019), the import of natural gas (million m^3) increased by 16.7%, while consumption grew by 15.2%. An increase in gas consumption was observed in 2022 across all categories (except for the Transport subcategory over the last three years) compared to 2019, driven by economic growth, improved population welfare, and weather conditions (cold winter), meanwhile in 2022 residential sector had the highest gas consumption for 2011-2022 period caused by the cold winter and due to increased heating comfort level in apartments.

Namely, consumption in *Energy Generation* increased by 25.0%, in *Residential* – by 21.4%, in *Manufacturing Industries and Construction* – by 52.9% categories, while a decline was recorded in the *Transport* category – by 12.5%.

At the same time net calorific value (NCV) of imported/supplied natural gas mixture /(kcal/m^3) in 2022 decreased by 0.9% compared to 2019 and carbon content (kg C/m^3) of imported/supplied natural gas mixture decreased by 0.5%, meanwhile Methane content (mol, %) increased by 1.8%.

Figure 4.7 provides CO_2 country-specific emission factors (kg CO_2 /TJ), in comparison to default factor and country specific CH_4 fugitive emission factors (kg CH_4 /m^3) for natural gas mixture for 2011-2022.

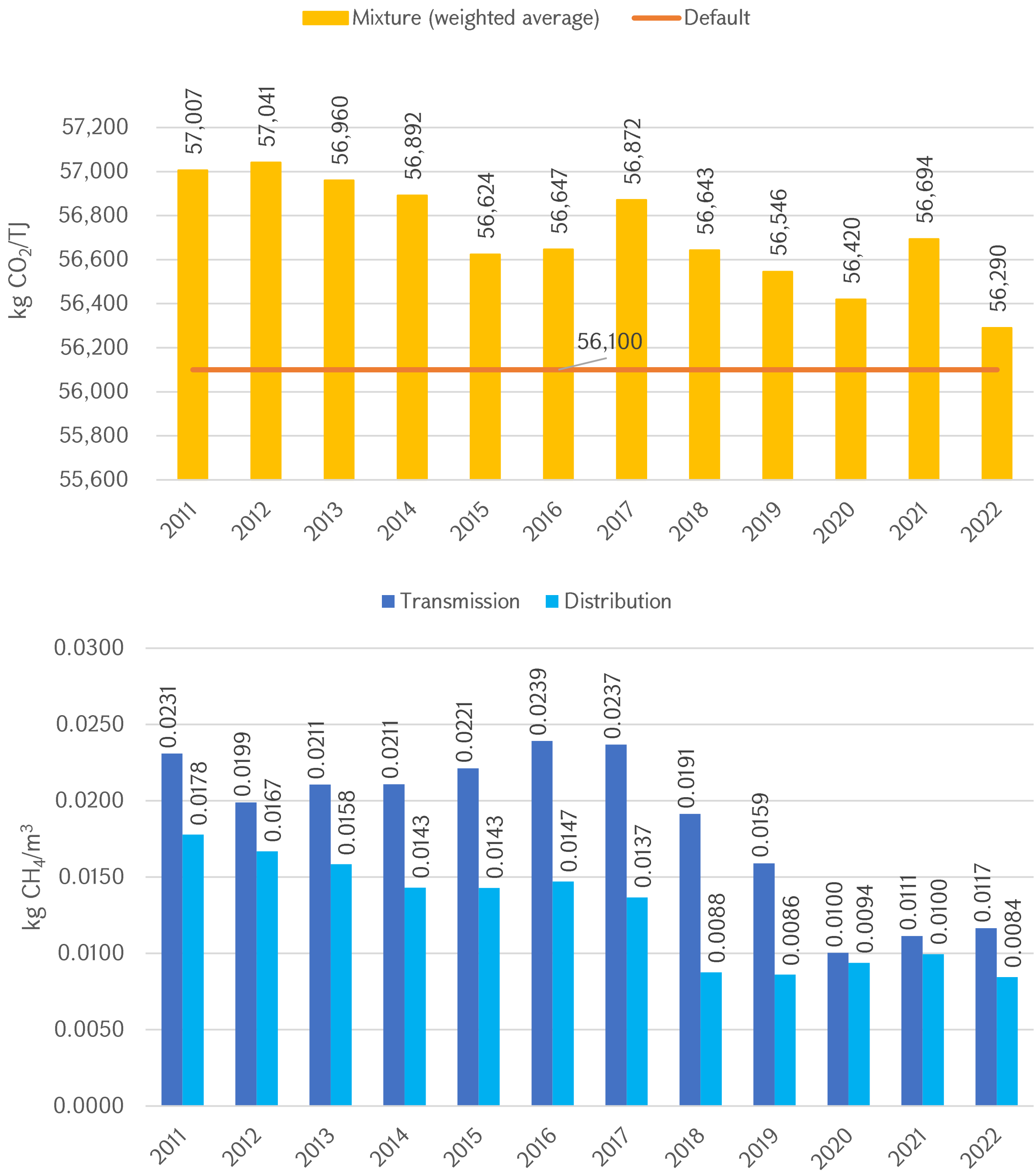


Figure 4.7 CO_2 country-specific emission factors for natural gas mixture (kg CO_2 /TJ) and country-specific CH_4 fugitive emission factors (kg CH_4 /m^3), 2011-2022

The variations in the annual volumes of natural gas imports are mainly due to the changes in the volumes of exported electricity produced by natural gas fired thermal power plants - the largest annual consumption of natural gas is attributable to electricity generation, and variances in the mentioned period reach 50% (relatively stable growth is observed over the last three years).

Oil products

The oil market in Armenia is not regulated. There are several private companies operating in diesel, gasoline and Liquid Petroleum Gas (LPG) import. The RA State Commission for

Protection of Economic Competition is mandated to ensure fair economic competition and protection of consumer rights.

As Armenia does not have domestic fossil fuel resources, refining and large storage facilities for liquid fuel, it can be assumed that the entire volume of imported oil products is fully consumed during the same year.

The quantities of oil products by fuel types imported in Armenia in 2011-2022 are summarized in **Table 4.3**. As can be seen from **Table 4.3,** the quantities of imported/consumed oil products are relatively steady for 2011-2018 period. However, in 2019-2022, an increase in the volume of imported petroleum products is observed: the overall increase in 2022 compared to 2018 is 79.6%, in particular: gasoline - 62.3%, diesel fuel - 57.9%, jet fuel - 58.6% and LPG by 5.6 times.

According to an agreement signed between Russian Federation and the Republic of Armenia in 2013, the delivery of oil products from Russia is indefinitely exempt from customs duties and is imported to Armenia with no customs duties collected in Russia.

Gasoline and Diesel are the main liquid fuels consumed in the country accounting for 37.9% and 30.3%, correspondingly. Jet Kerosene represents 16.6% and LPG 15.2% of liquid fuel consumed.

Road transport apparently is the largest consumer of liquid fuel with a share of 71.2%, followed by Civil (International) Aviation - 16.6%. The consumption by the other categories is much lower, namely: Commercial/Institutional subcategory - 4.5%, Manufacturing Industries and Construction - 2.7%, Off-road transportation - 2.5% and Off-road Vehicles and Other Machinery used on farmland and forests with the share of - 2.4%.

The main reference data for the calculation of GHG emissions from the oil products were derived from official data on fuel consumption published in the Energy Balances 2020, 2021 and 2022, as posted on the website of the SC (**Annex 3.1.2, EnRef-2**).

Diesel fuel imported in the country was consumed by *Manufacturing Industries and Construction*, *Road Transportation* (mainly heavy–duty trucks and buses), *Other Transportation* (Off-road), *Residential* sector and *Agriculture/Forestry/Fishing/Fish Farms* (Off-road Vehicles and Other Machinery) sub-categories. The quantities of diesel used in Agriculture were assessed based on the scope of agricultural work performed (expert judgement by the SC), diesel consumption by *Residential* sub-category was also derived from Energy Balance.

Imported LPG was consumed by Road Transportation (69.7%), Commercial/Institutional (29.3%), and minor accounts in Manufacturing Industries and Construction and Residential subcategories.

Gasoline is almost entirely consumed in transport sector.

Table 4.3 Oil products by fuel types for 2011-2022 (tonnes)

Oil Products	Import, t											
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Gasoline	131,588	130,332	132,219	129,120	130,381	140,556	142,213	138,553	175,446	220,646	226,213	224,873
Diesel Fuel	159,515	144,683	147,326	152,651	128,873	126,660	134,506	113,739	132,658	198,773	195,092	179,636
Jet Kerosene	39,648	40,473	45,900	40,458	30,927	44,055	54,394	61,877	68,980	37,234	51,992	98,164
LPG	7,359	6,909	7,397	6,763	6,914	4,054	6,146	16,004	30,197	51,512	73,565	90,295
Total	338,110	322,397	332,842	328,992	297,095	315,324	337,259	330,173	407,281	508,165	546,862	592,970

Biomass

As it is mentioned in the 2006 IPCC Guidelines, biomass data are generally more uncertain than other data in national energy statistics. This provision fully reflects the realities in Armenia, as data on biomass burning from various sources vary significantly.

Fuelwood

The level of gasification in Armenia is quite high, however, in rural areas, the use of firewood persists due to its availability.

The quantities of fuelwood burned were recalculated into energy based on the quantity of fuelwood official data on volumes of harvested wood, fallen-wood and illegal logging (**LUCFRef-1, LUCFRef-2, LUCFRef-4**).

It is noteworthy that there are significant inconsistencies between data on fuelwood consumption provided by the official statistics (Ministry of Environment) and those from the Household survey carried out by the SC. Currently GHG Inventory team closely collaborates with the SC to ensure consistency of these data.

The volumes of burned fuelwood were converted to energy units considering basic wood density in Armenia as of 0.557 t/m^3 (**Annex 5, Table 5-1**) and using wood default calorific value of 15.6 TJ/Gg (**Volume 2, Table 1.2)** and are provided in **Table 4.4.**

As can be seen from **Table 4.4**, the volume of fuelwood consumption gradually increased since 2011 and reached its maximum value in 2019. The volume of fuelwood in 2022 is also high and is 95.4% of the 2019 figure.

Manure

Manure is largely used as fuel in rural areas of Armenia.

Emissions from manure combustion were calculated using revised data on annual dung excretion per animal and revised data on share of manure used as fuel provided by the Ministry of Economy (Agriculture department), described in detail in the previous report.

Table 4.5 summarizes the annual amounts of manure burned, which were assessed according to official data (**Annex 4.2, Table 4.2.1**) provided by the Ministry of Economy.

Heat produced from manure was calculated using the Net Calorific Value of 11.6 TJ/Gg from the 2006 IPCC Guidelines (**Volume 2, Table 1.2)** for “Other Primary Solid Biomass”.

The annual volumes of manure burned are generally stable, with fluctuations in the 2011-2022 series amounting to about 20%. The data on the dung generated and the manure burned in the Energy Balances of recent years practically coincide with the indicators calculated using the above-mentioned methodology of the National GHG Inventory.

In fact, the annual volumes of burned manure are cross-checked between the figures calculated using the methodology applied in the Energy Balances and those in the national greenhouse gas emission inventories, based on the methodology agreed upon with the Ministry of Economy.

Other Biomass

In GHG emissions estimate from Biomass burning other solid biomass and charcoal were included, in addition to fuelwood and manure.

The values of the other biomass burned were taken from the officially published RA Energy balances for the respective years.

Table 4.6 and **Table 4.7** summarize data on other solid biomass and charcoal.

Heat produced from other solid biomass was calculated using the Net Calorific Value of 11.6 TJ/kt from the 2006 IPCC Guidelines (**Volume 2, Table 1.2)** for “Other Primary Solid Biomass”.

Heat produced from Charcoal was calculated using the Net Calorific Value of 29.5 TJ/kt from the 2006 IPCC Guidelines (**Volume 2, Table 1.2)** for “Charcoal”.

Table 4.4 Fuelwood combusted in 2011-2022

Measure-ment Units	Fuelwood combustion volumes											
Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Volume (m^3)	65,74	85,960	71,551	65,621	76,60	70,246	82,743	90,146	152,271	127,133	134,120	145,250
Weight (t)	36,62	47,880	39,854	36,551	42,666	39,127	46,088	50,212	84,815	70,813	74,705	80,904
Energy (TJ)	571.2	746.92	621.72	570.20	665.59	610.38	718.97	783.30	1,323.11	1,104.68	1,165.40	1,262.11

Table 4.5 Quantity of manure produced, burned and heat received in 2011-2022

Quantity of manure produced, burned and heat received	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Total manure, kt	3,371.3	3,716.3	3,997.5	4,058.6	4,108.2	4,027.7	3,489.7	3,213.2	3,140.3	3,248.9	3,197.6	2,899.8
Total burned, kt	215.6	237.6	255.6	259.5	262.7	257.5	223.1	243.7	238.1	246.4	242.5	219.9
Heat, TJ	2,500.4	2,756.3	2,964.8	3,010.2	3,047.0	2,987.3	2,588.2	2,826.5	2,762.3	2,857.9	2,812.8	2,550.8

Table 4.6 Quantity of other biomass produced, burned and heat received in 2011-2022

Quantity of other solid biomass produced, burned and heat received	2015	2016	2017	2018	2019	2020	2021	2022
Total, other solid biomass, burned, kt	25.18	21.31	28.94	37.82	37.59	42.27	38.90	44.28
Total Heat, TJ	292.03	247.19	335.74	438.75	436.09	490.29	451.24	513.65

Table 4.7 Quantity of charcoal produced, burned and heat received in 2011-2022

Quantity of charcoal produced, burned and heat received	2015	2016	2017	2018	2019	2020	2021	2022
Total charcoal, burned, Gg	0.03	0.04	0.08	0.28	1,57	1.42	0.78	0.54
Total Heat, TJ	1.02	1.29	2.43	8.17	46.35	41.86	23.07	15.86

(1A) Fuel Combustion Activities

Fuel Combustion Activities were calculated using sectoral approach. They are further divided in two main categories: Stationary Combustion and Mobile Combustion.

Stationary Combustion includes *Electricity and Heat Production*, *Manufacturing Industries and Construction* and *Other Sectors* (Residential, Commercial/Institutional, Off-road Vehicles/Other Machinery and Stationery in Agriculture).

The following chapters describe GHG emissions assessment per categories for both Stationary and Mobile Combustion, including the methods applied, activity data, emission factors, time series and uncertainty assessment.

(1A1a) Main Activity Electricity and Heat Public Production

Description of the category

This category comprises emissions from natural gas combustion for public electricity generation from thermal power plants - Hrazdan TPP, Hrazdan-5 TPP, Yerevan CCGT, ArmPower CJSC and 2 small cogeneration-based district heating systems.

The source category *Main Activity Electricity and Heat Public Production* is a key category for CO_2 emissions in terms of level and trend assessment.

Table 4.8 provides electricity generation per type of power plants (**Annex 3.1.3, EnRef-3**).

Table 4.8 Electricity generation structure per type of power plants, mln kWh

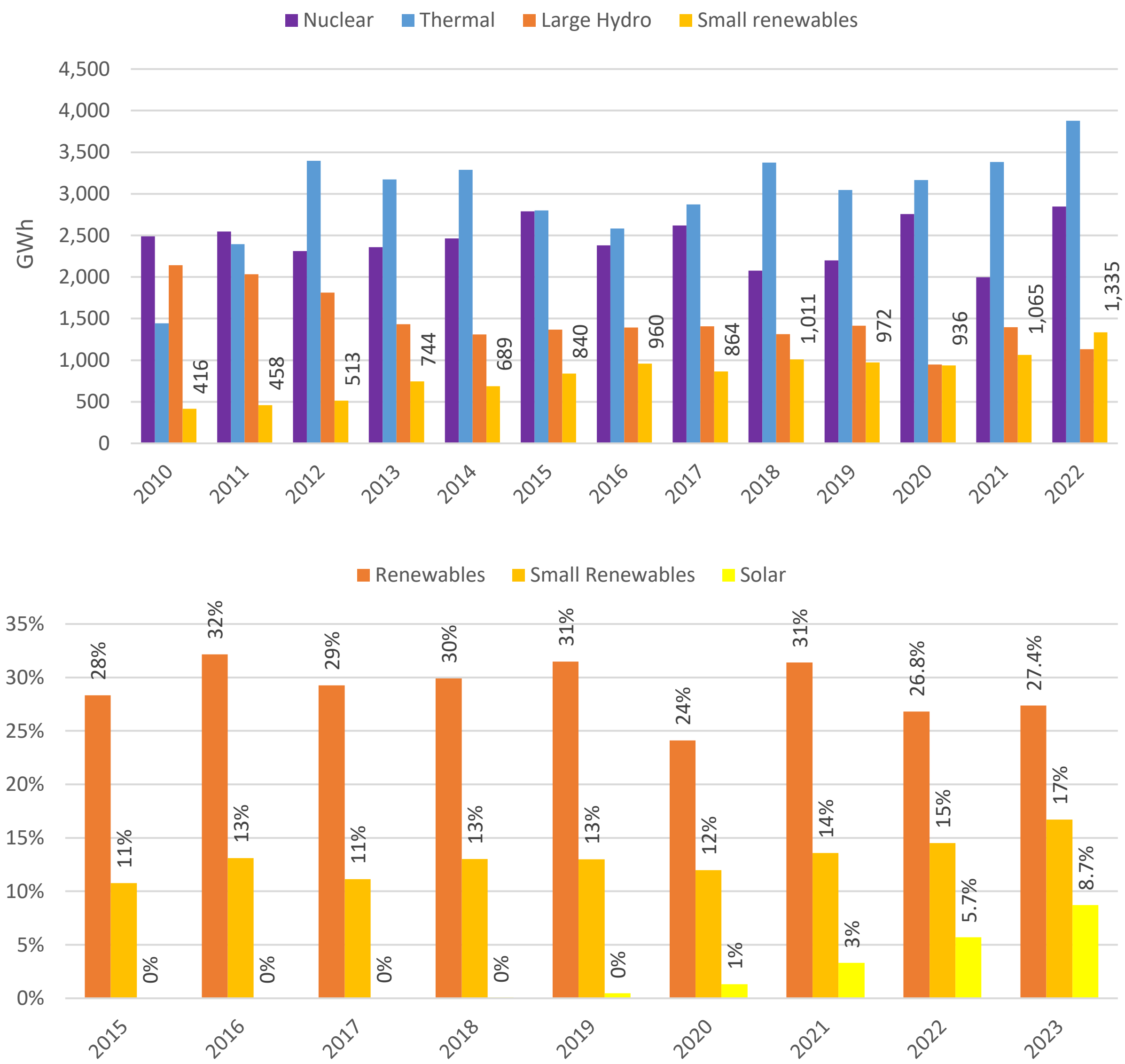
Power Plants	Year												
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Nuclear	2,490	2,548	2,311	2,360	2,465	2,788	2,381	2,620	2,076	2,198	2,756	1,998	2,846
Thermal	1,443	2,395	3,398	3,173	3,289	2,801	2,582	2,872	3,376	3,047	3,166	3,384	3,879
Hydro	2,143	2,033	1,814	1,433	1,308	1,369	1,394	1,407	1,314	1,415	946	1,397	1,131
Small Renewables*	416	458	513	744	689	840	960	864	1,011	972	855	987	1,052
Total*	6,492	7,434	8,036	7,710	7,750	7,798	7,315	7,763	7,777	7,632	7,723	7,766	8,908

*Useful supply of electricity in terms of mutual flows by Autonomous producers and the volumes of electricity (not registered in net metering trade) generated and consumed on-site by Autonomous producers are not included.

In all thermal power plants, electricity production is based solely on the combustion of natural gas. The share of gas-fired TPPs in power generation mix in 2022 was more than 42%. Thermal plants operate to meet season peaks and when the nuclear power plant is offline for maintenance. Yerevan CCGT and ArmPower CJSC TPPs also generate electricity for export to Iran under the gas for electricity swap agreement.

According to the Energy Balance, centralized production of thermal energy (and delivery to other consumers) was not implemented in 2022. According to the 2022 Energy Balance, 16.8 ktoe of thermal energy was produced using solar water heaters, 50% of which, 8.4 ktoe, was consumed in the Residential and the other half in the Commercial/Institutional subcategories.

Electricity generation by plant type for 2010-2022 and electricity generated from renewable energy resources for 2015-2023 (in both cases including the volumes of useful electricity supplied and consumed on-site by Autonomous solar producers) are shown in **Figure 4.8**.



*In the graphs: Renewables, Small Renewables and Solar included the useful supply of electricity in terms of mutual flows by Autonomous producers and the volumes of electricity (not registered in net metering trade) generated and consumed on-site by Autonomous producers.

Figure 4.8 Electricity generation by plant type (mln kWh) for 2010-2022 and electricity generated from renewable energy resources (%) for 2015-2023

Renewable electricity production in Armenia in 2022 amounted to 26.8% of the total (including solar - 5.7%), and in 2023, respectively, it was 27.4% (including solar - 8.7%).

According to the RA Government Resolution No. 1827-L dated 26.10.23, “the share of electricity generated using renewable energy sources in the gross final consumption of electricity by 2030, including large HPPs, will reach about 50%, and by 2040 - about 60%.”

Methodology

Considering both that Armenia imports natural gas from two countries and natural gas supply system structure specifics, natural gas used by different consumers varies in its characteristics.

CO_2 emissions from stationary combustion of natural gas for *1A1ai Public Electricity Generation* and *1A1aii Public Combined Heat and Power Generation* sub-categories were estimated using Tier 3 approach (Volume 2, Chapter 2.3.1.3) based on data at the individual plant level.

CO_2 emissions were estimated based on natural gas consumption by each thermal power plant provided by the PSRC and country-specific emission factors, considering natural gas composition in its delivered state to each thermal power plant.

Activity data

Natural gas consumption by each thermal power plant were derived from the PSRC (**Annex 3.1.4**) and were converted to common energy units (TJ) (**Annex 3.1.5**) considering net calorific values (NCVs) at individual plant level provided by Gazprom Armenia CJSC (**Annex 3.1.6**).

Emission factors

Country-specific emission factors were derived from detailed data on natural gas composition in its delivered state to each thermal power plant, based on the physicochemical characteristics of natural gas imported from the Russian Federation, a mixture (Yerevan GDS 2) and Iran (**Annex 3.1.6**: reference provided by Gazprom Armenia CJSC.

The methodology for calculating Country-specific emission factors and calculation results are presented in **Annex 3.1.5**.

The underlying data for the emission factors were provided by Gazprom Armenia CJSC.

All indicators: NCVs, carbon content, as well as calculated country-specific emission factors are within 95% confidence interval (**Annex 3.1.6**).

Emissions calculations results

Table 4.9 summarizes plant level CO_2 emissions calculation from *Public Electricity Generation* and *Public Combined Heat and Power Generation* sub-categories in 2011-2022

Table 4.9 Country-specific emission factors ($kgCO_2/TJ$), Activity data (TJ, mln m^3) and Plant level CO_2 emissions (kt CO_2) for 2011-2022 CO_2

Stationary Combustion	Country-specific emission factors	Activity data		GHG emissions
	kg CO_2/TJ	TJ	mln m^3	kt CO_2
	2011			
Hrazdan TPP	56,798.0	6,352.74	184.026	360.82
Yerevan CCGT	57,004.9	12,352.12	360.318	704.13
Yerevan Medical University CHP plant	57,004.9	171.44	5.001	9.77
Total 2011		**18,876.30**	**549.345**	**1,074.73**
	2012			
Hrazdan TPP	56,851.70	7,962.90	230.683	452.70
Hrazdan-5 TPP	56,851.70	8,126.21	235.400	461.99
Yerevan CCGT	57,209.21	12,029.63	352.586	688.21
Yerevan Medical University CHP plant	57,209.21	107.10	3.139	6.13
ArmRosCogeneration CHP plant	57,209.21	126.04	3.694	7.21
Total 2012		**28,351.87**	**825.503**	**1,616.23**
	2013			
Hrazdan TPP	56,745.52	6,720.39	193.3202	381.35
Hrazdan-5 TPP	56,745.52	8,996.68	258.8004	510.52
Yerevan CCGT	56,993.61	10,344.33	299.2612	589.56
Yerevan Medical University CHP plant	56,993.61	134.74	3.898	7.68
ArmRosCogeneration CHP plant	56,993.61	128.10	3.706	7.30
Total 2013		**26,324.24**	**758.9858**	**1,496.41**
	2014			
Hrazdan TPP	56,706.16	9,619.33	275.583	545.48
Hrazdan-5 TPP	56,706.16	7,360.96	210.883	417.41
Yerevan CCGT	57,022.93	10,558.56	305.644	602.08
Yerevan Medical University CHP plant	57,022.93	148.86	4.309	8.49
ArmRosCogeneration CHP plant	57,022.93	107.95	3.125	6.16
Total 2014		**27,795.65**	**799.5445**	**1,579.61**
	2015			
Hrazdan TPP	56,419.72	5,671.08	162.509	319.96
Hrazdan-5 TPP	56,419.72	5,185.41	148.592	292.56
Yerevan CCGT	56,655.00	11,656.56	336.813	660.40
Yerevan Medical University CHP plant	56,655.00	134.22	3.878	7.60
ArmRosCogeneration CHP plant	56,655.00	89.15	2.576	5.05
Total 2015		**22,736.41**	**654.3678**	**1,285.58**
	2016			
Hrazdan TPP	56,415.80	4,515.82	129.544	254.76
Hrazdan-5 TPP	56,415.80	5,750.06	164.950	324.39
Yerevan CCGT	56,715.56	10,455.88	303.887	593.01
Yerevan Medical University CHP plant	56,715.56	72.82	2.116	4.13
ArmRosCogeneration CHP plant	56,715.56	111.03	3.227	6.30
Total 2016		**20,905.62**	**603.7255**	**1,182.60**
	2017			
Hrazdan TPP	56,697.39	3,299.70	91.144	187.08
Hrazdan-5 TPP	56,697.39	8,186.01	226.112	464.13
Yerevan CCGT	56,951.34	11,175.67	315.180	636.47

Yerevan Medical University CHP plant	56,951.34	77.19	2.177	4.40
ArmRosCogeneration CHP plant	56,951.34	103.29	2.913	5.88
Total 2017		**22,841.86**	**637.526**	**1297.96**
	2018			
Hrazdan TPP	56,356.67	3,196.52	92.185	180.15
Hrazdan-5 TPP	56,356.67	12,933.10	372.980	728.87
Yerevan CCGT	56,755.47	10,231.84	298.538	580.71
Yerevan Medical University CHP plant	56,755.47	57.08	1.665	3.24
ArmRosCogeneration CHP plant	56,755.47	87.74	2.560	4.98
Total 2018		**26,506.27**	**767.928**	**1,497.94**
	2019			
Hrazdan TPP	56,362.62	5,025.54	143.186	283.25
Hrazdan-5 TPP	56,362.62	7,821.61	222.851	440.85
Yerevan CCGT	56,526.24	11,234.59	322.749	635.05
Yerevan Medical University CHP plant	56,526.24	67.32	1.934	3.81
ArmRosCogeneration CHP plant	56,526.24	35.2,5	1.013	1.99
Total 2019		**24,184.31**	**691.733**	**1,364.95**
	2020			
Hrazdan TPP	56,206.45	6665.53	190.96	374.65
Hrazdan-5 TPP	56,206.45	8838.10	253.202	496.76
Yerevan CCGT	56,436.35	9924.31	286.832	560.09
Yerevan Medical University CHP plant	56,436.35	40.16	1.161	2.27
ArmRosCogeneration CHP plant	56,436.35	66.93	1.934	3.78
Total 2020		**25535.02**	**734.089**	**1,437.54**
	2021			
Hrazdan TPP	56,536.60	16,322.99	462.367	922.85
Hrazdan-5 TPP	56,536.60	76.11	2.156	4.30
Yerevan CCGT	56,592.22	11,585.69	329.86	655.66
ArmPower CJSC	56,592.22	1,241.71	35.353	70.27
Yerevan Medical University CHP plant	56,592.22	57.31	1.632	3.24
ArmRosCogeneration CHP plant	56,592.22	30.25	0.861	1.71
Total 2021		**29,314.06**	**832.229**	**1,658.04**
	2022			
Hrazdan TPP	56,064.77	9,143.44	263.403	512.63
Hrazdan-5 TPP	56,064.77	163.46	4.709	9.16
Yerevan CCGT	56,244.97	12,308.93	356.529	692.32
ArmPower CJSC	56,244.97	8,242.83	238.754	463.62
Yerevan Medical University CHP plant	56,244.97	51.79	1.5	2.91
ArmRosCogeneration CHP plant	56,244.97	0.00	0	0.00
Total 2022		**29,910.45**	**864.895**	**1,680.64**

Changes in country-specific emission factors (kg CO_2/TJ) are directly proportional to the carbon content of natural gas imported to Armenia.

The reduction in country-specific emission factors (kg CO_2/TJ) in 2022 compared to 2019 is due to the reduction in the carbon content of natural gas imported from Russia and Iran (15.37 kg/GJ from Russia in 2019, 15.42 kg/GJ from Iran and 15.29 kg/GJ from Russia, 15.34 kg/GJ from Iran in 2022, respectively) (**Annex 3.1.5, Table 3.1.5-1**).

Table 4.10 summarizes 2022 emissions from *Main Activity Electricity and Heat Public Production* sub-categories and per greenhouse gases.

Table 4.10 Emissions from (1A1a) Main Activity Electricity and Heat Public Production sub-category in 2022 (kt)

Code	Category/Subcategory	Net CO_2	CH_4	N_2O	Total $CO_{2\ eq.}$
1A1a	Main Activity Electricity and Heat Public Production	1,680.6	0.8375	0.7926	1,682.3
1A1ai	Electricity Public Generation	521.8	0.2606	0.2466	522.3
1A1aii	Combined Heat and Power Public Generation	1,158.8	0.5769	0.5460	1,160.0

Figure 4.9 illustrates CO_2 emissions from *Public Electricity Generation* and *Combined Heat and Power Public Generation* sub-categories per plants in 2022.

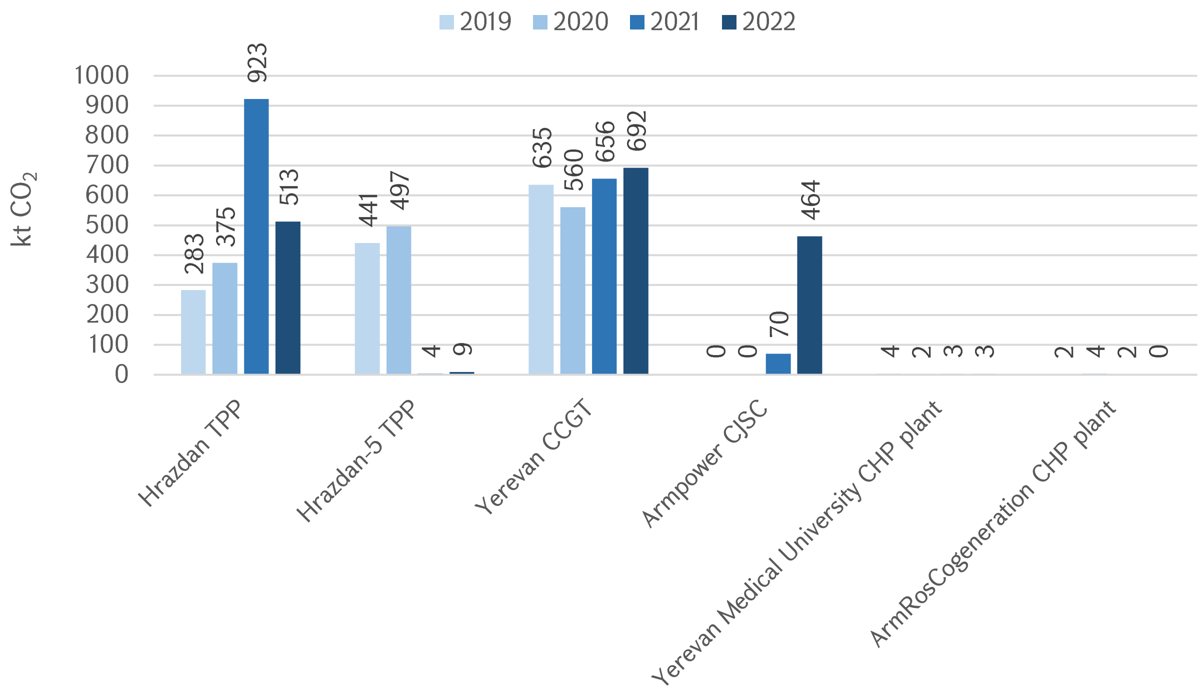


Figure 4.9 CO_2 emissions from Public Electricity and Heat Generation sub-category per plants in 2019-2022, (kt CO_2)

Uncertainty assessment

According to the Guidelines, statistics of fuel combusted at large sources obtained from direct measurement or obligatory reporting are likely to be within 3% of the central estimate (Volume 2, Chapter 2.4.2). Considering that in Armenia combustion data are obtained from direct measurement and are obligatory reported, the uncertainty of activity data on fossil fuel combusted is within 3%.

According to the Guideline, for fossil fuel combustion uncertainties in CO_2 emission factors are relatively low as these emission factors are determined by the carbon content of the fuel and thus there are physical constraints on the magnitude of their uncertainty (Volume 2, Chapter 2.4.1). Therefore, uncertainty in CO_2 emission factors is considered to be within 3% as well.

It is good practice to compare any country-specific emission factor with the default ones given in Tables 2.2 to 2.5 of Volume 2 of 2006 IPCC Guidelines. A comparison with the IPCC default factors (Volume 2, Table 4.2.4) shows that the country-specific emission factors for CO_2 are within the range given for the default factors and could be regarded as consistent with the default value.

An overall uncertainty value for CO_2 emissions from *Main Activity Public Electricity and Heat Production (1A1a)* category could be regarded as 4.24%.

Estimation of combined uncertainties are implemented by Approach 1 – error propagation method. Calculations and results are presented in **Annex 2.3.**

Time series

Figure 4.10 provides 1990-2022 time series of CO_2 emissions from *Main Activity Electricity and Heat Public Production* category.

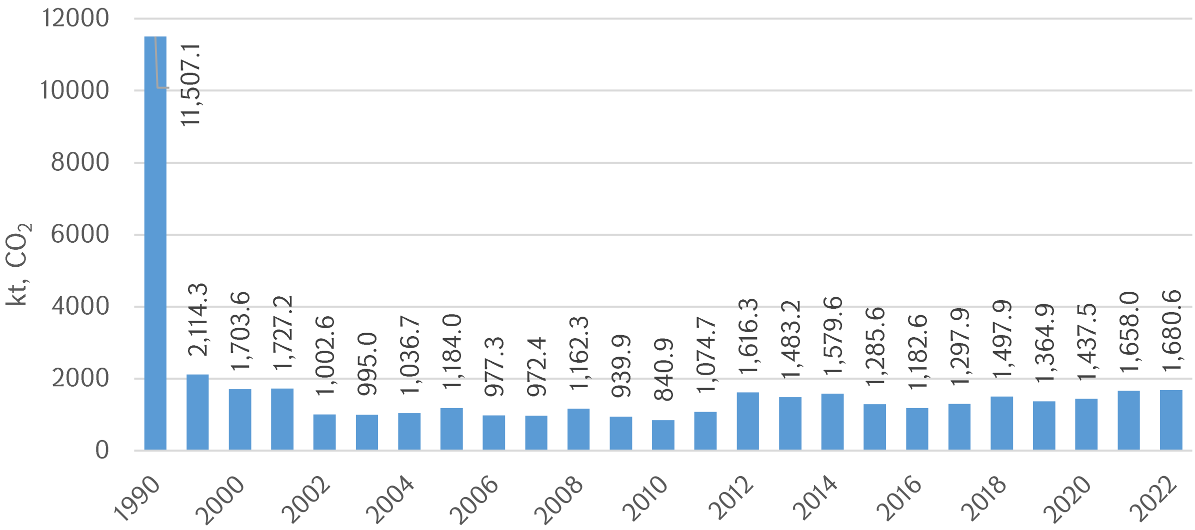


Figure 4.10 Time series of CO_2 emissions from Main Activity Electricity and Heat Public Production, kt, 1990-2022.

The reduction of CO_2 emissions in the early 2000s was due to the increased electricity generation at hydropower plants, with relatively stable annual variance in CO_2 emissions during 2002-2010, while CO_2 emissions growth in 2012 compared to 2010 was due to the increased electricity generation by thermal power plants, mainly because of the increased electricity exports to Iran.

Thus, the volumes of electricity generation at thermal power plants: in 2017 – 2,871.7 GWh or 37% of the total generation, in 2018 – 3,375.6 GWh or 43.4% of the total generation, in 2019 – 3,046.8 GWh or 39.9% of the total generation, which is due to a change in the balance of import/export of electricity. 2017: 1,120.1 GWh, 2018: 1,423.5 GWh, 2019: 958.5 GWh and changes in the volumes of domestic consumption. 2017: 5,620.9 GWh, 2018: 5,388.3 GWh, 2019: 5,802 GWh.

Since 2019, there has been an increase in electricity production (million kWh) at thermal power plants by more than 27%, as well as a steady increase in absolute values of CO2 emissions (more than 23%), while specific values of CO2 emissions tend to decrease. In particular, if in 2019 the total specific emissions at thermal power plants amounted to 0.448 kgCO2/kWh, then in 2022 they amounted to 0.433 kgCO2/kWh (or 3.3% less). The latter indicates the use of low-carbon technologies in the country.

Particularly noteworthy is the commissioning of the combined-cycle power unit (with an average annual capacity of 254 MW) of ArmPower CJSC, part of the Renco Group of Companies, which was fully connected to the grid in the fourth quarter of 2021.

In 2022 the specific emissions of Hrazdan TPP CJSC amounted to 0.567 kgCO_2/kWh, while the specific emissions of ArmPower CJSC were 0.380 kgCO_2/kWh (or 34.1% less).

Actual grid emission factor of the Republic of Armenia, considering non-fossil fuel electricity production [comprising the useful supply of electricity in terms of mutual flows by Autonomous producers and the volumes of electricity (not registered in net metering trade) generated and consumed on-site by Autonomous producers], constitutes accordingly: for 2019 - 0.178 kgCO_2/kWh, for 2020 - 0.184 kgCO_2/kWh, for 2021 - 0.211 kgCO_2/kWh, and for 2022 - 0.183 kgCO_2/kWh.

Naturally, grid emission factor depends on various aspects, primarily on the composition of power plants participating in the electricity generation to the grid, operation modes, the degree of involvement of non-fossil producers (nuclear, hydro, solar, wind), the efficiency of thermal power plants, the composition and characteristics of natural gas consumed, etc.

Category-specific QA/QC

General and category-specific Quality Assurance and Quality Control (QA/QC) was carried out by sectoral experts in accordance with the Armenian National GHG Inventory QA/QC plan presented in **Annex 7**.

Category-specific recalculations

No category-specific recalculations were done.

Category-specific planned improvements (1A1a)

No improvements are currently planned.

(1A2) Manufacturing Industries and Construction

Description of the category

According to the 2006 IPCC Guidelines (Volume 2) the Energy Sector includes activities related to fuel combustion in manufacturing and construction. This category consists of several sub-source categories defined in accordance with the 2006 IPCC Guideline (Volume 2).

The source category *Manufacturing Industries and Construction* is a key category (gaseous fuel) for CO_2 emissions in terms of level and trend assessment (and for liquid fuel - CO_2 emissions, in terms of trend assessment).

This category comprises emissions from combustion of fuels for heat generation for own use in industries and emissions arising from off-road and other mobile machinery in industry.

Energy used for transport by industry have not been reported here, it is done under *Transport* (1A3) category.

Emissions arising from off-road and other mobile machinery in industry have not been broken out as a separate sub-category but were included in corresponding sub-categories.

Methodology

CO_2 emissions from combustion of natural gas were assessed by sub-categories, applying Tier 2 method (Volume 2, Chapter 2.3.1.2) based on the data on the amount of natural gas combusted in the source sub-category (**Annex 3.1.2**) and applying country-specific emission factors for natural gas mixture (weighted average) (**Annex 3.1.5**).

Emissions from diesel fuel and LPG combustion were assessed by applying Tier 1 approach.

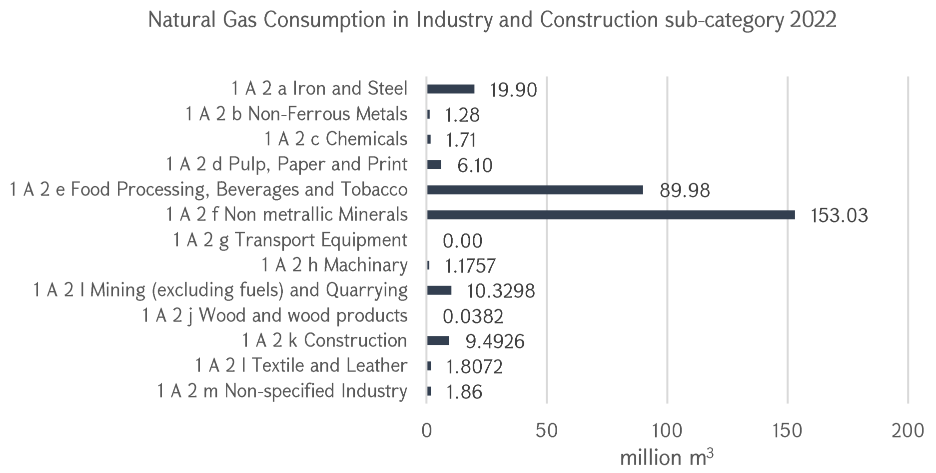
Activity data

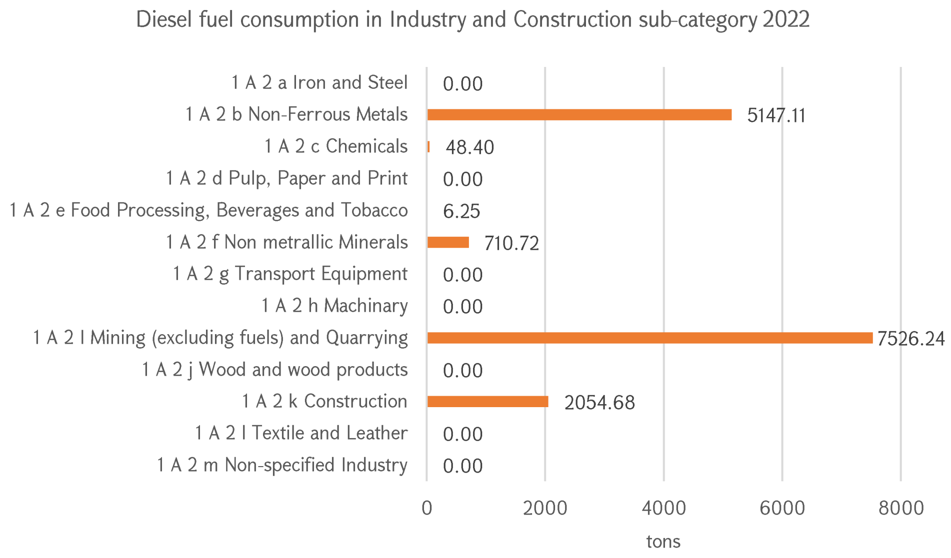
Different types of fuel are used in this category – mostly natural gas, followed by diesel fuel and LPG in a much smaller quantities, while gasoline and mazut consumption is negligible.

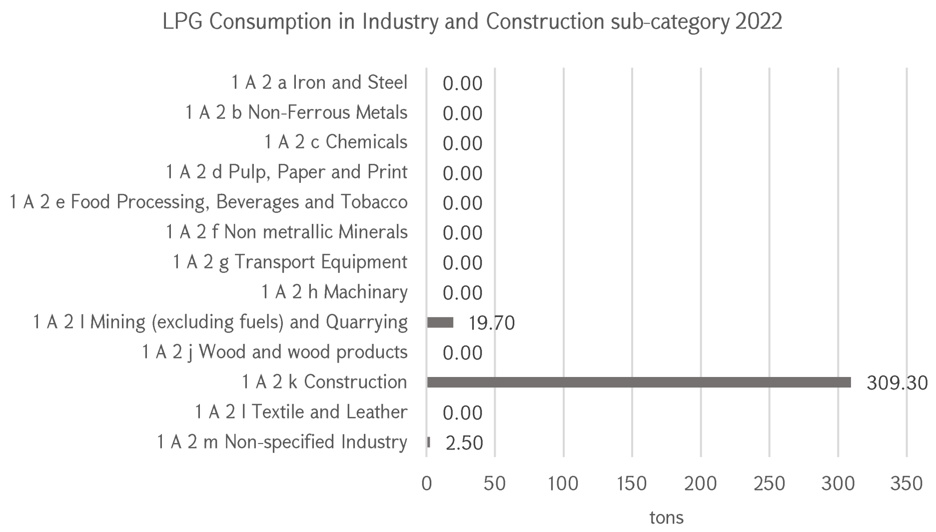
The amounts of natural gas, diesel fuel, LPG and other fuels used by sub-categories were derived from the Energy Balance (**Annex 3.1.2**).

All fuel consumed was converted to common energy units (TJ) applying for natural gas NCVs of natural gas mixture provided by Gazprom Armenia CJSC (**Annex 3.1.5**) and for LPG and diesel – default values provided by 2006 IPCC Guideline **(Volume 2, Table 1.4)**.

Figure 4.11 provides consumption by fuel types specified by physical units [natural gas (million m^3), diesel fuel (tons) and LPG (tons)] and total energy consumption by sub-categories (TJ).







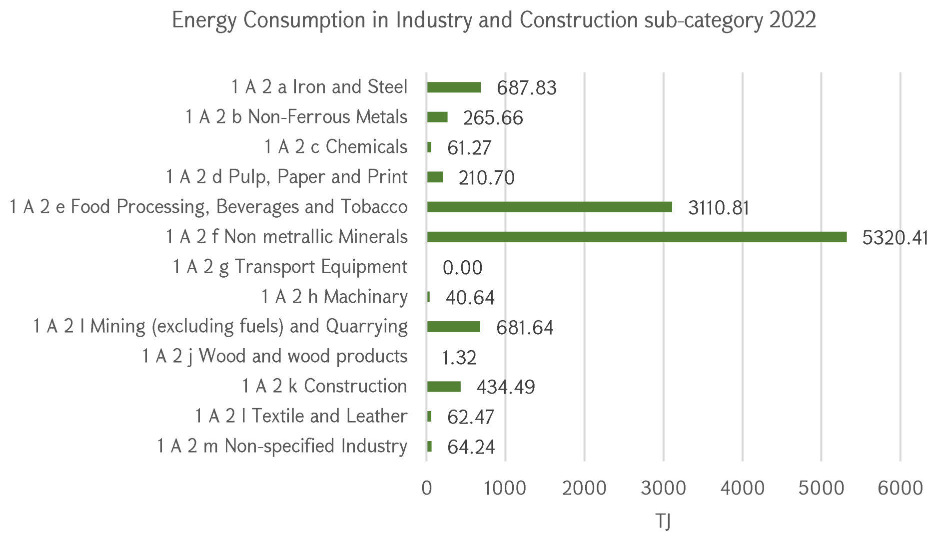


Figure 4.11 Natural gas, diesel fuel, LPG and total energy consumption by sub-categories, 2022

Figure 4.11 shows that in *Manufacturing Industries and Construction* category (1A2f) *Non-Metallic Minerals* and (1A2e) *Food Processing, Beverages and Tobacco* sub-categories were the largest consumers of natural gas.

As for diesel fuel, the main consumers were (1A2i) *Mining and Quarrying* and *(1A2b) Non-Ferrous Metals* sub-categories. LPG main consumers were (1A2k) *Construction* and (1A2i) *Mining and Quarrying*. Gasoline and mazut consumption were negligible in (1A2k) *Construction* sector, coal use is absent in 2022.

The leaders in terms of total energy consumption (TJ) are (1A2f) *Non-Metallic Minerals* and (1A2e) *Food Processing, Beverages and Tobacco* sub-categories.

The main fossil fuel consumed in *Manufacturing Industries and Construction* category were Natural gas (2020 - 92.9%, 2021 - 92.0%, 2022 - 93.7 %), and Diesel fuel (2020 - 6.9%, 2021 - 7.8%, 2022 - 6.1 %).

Emission factors

Country-specific emission factors (**Annex 3.1.5**) calculated for natural gas mixture (**Annex 3.1.6**) were applied for estimating emissions from natural gas combustion, while for diesel, LPG and other fuels default values provided by 2006 IPCC Guideline were applied (**Volume 2, Table 1.4)**.

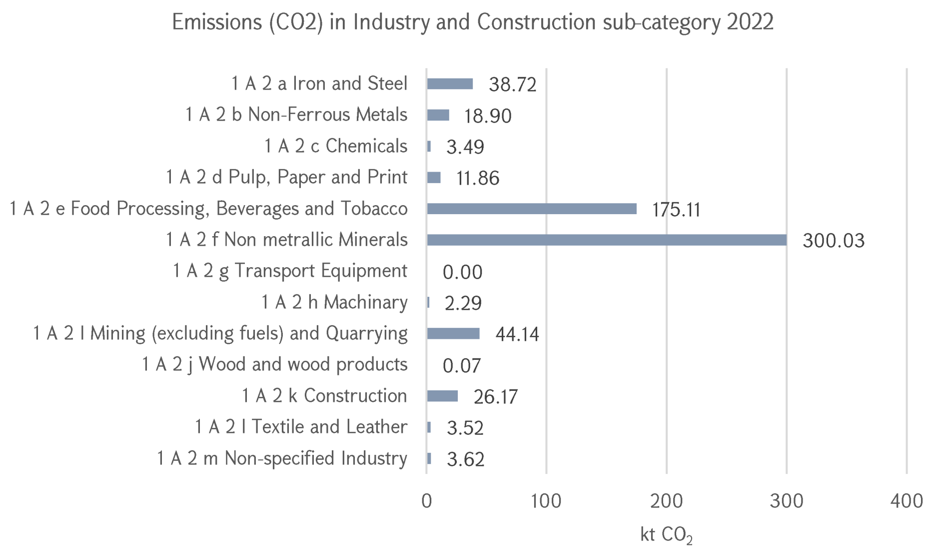
Emissions calculations results

The results of emissions assessment from *Manufacturing Industries and Construction* source category in 2022 are summarized in **Table 4.11**.

Table 4.11 Emissions from Manufacturing Industries and Construction category, kt, 2022

Code	Category/sub-category	Net CO_2	CH_4	N_2O	Total $CO_{2\ eq.}$
1A2	Manufacturing Industries and Construction	627.9	0.0124	0.0014	628.6
1A2a	Iron and Steel	38.7	0.0007	0.0001	38.8
1A2b	Non-Ferrous Metals	18.9	0.0007	0.0001	19.0
1A2c	Chemicals	3.5	0.0001	0.0000	3.5
1A2d	Pulp, Paper and Print	11.9	0.0002	0.0000	11.9
1A2e	Food Processing, Beverages and Tobacco	175.1	0.0031	0.0003	175.3
1A2f	Non-Metallic Minerals	300.0	0.0054	0.0005	300.3
1A2g	Machinery	0.0	0.0000	0.0000	0.0
1A2h	Mining (excluding fuels) and Quarrying	2.3	0.0001	0.0000	2.3
1A2i	Wood and Wood Products	44.1	0.0013	0.0002	44.2
1A2j	Construction	0.1	0.0000	0.0000	0.1
1A2k	Textile and Leather	26.2	0.0006	0.0001	26.2
1A2l	Non-specified Industry	3.5	0.0001	0.0000	3.5
1A2m	Pulp, Paper and Print	3.6	0.0001	0.0000	3.6

Figure 4.12 provides GHG emissions from fuel combustion in Manufacturing Industries and Construction source category per sub-categories in 2022



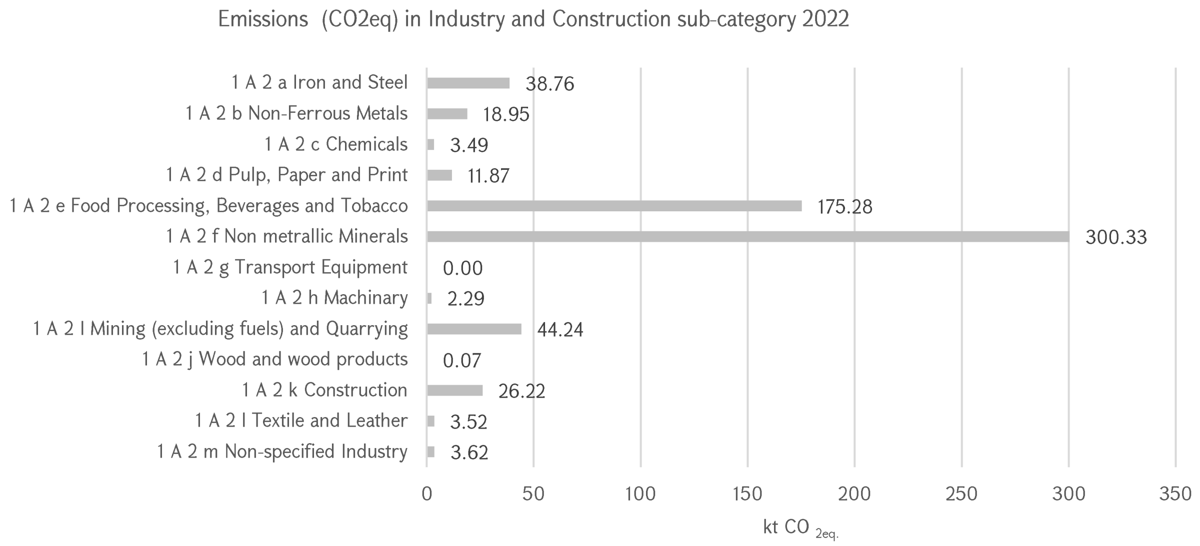


Figure 4.12 Emissions from Manufacturing Industries and Construction source category per sub-categories, 2022 (kt CO_2 and kt $CO_{2\ eq.}$)

Uncertainty assessment

The uncertainty of activity data on natural gas combusted is within 5% and for diesel fuel and LPG is 20% (expert judgement).

Emission factors uncertainty for natural gas is 3% and for diesel fuel and LPG is up to 5%. Therefore, uncertainty for emissions estimate from natural gas combustion could be regarded as 5.83% and from diesel fuel as 20.62%.

Consistent time series

GHG emissions time series for *Manufacturing Industries and Construction* category for 1990-2022 are presented in **Figure 4.13**.

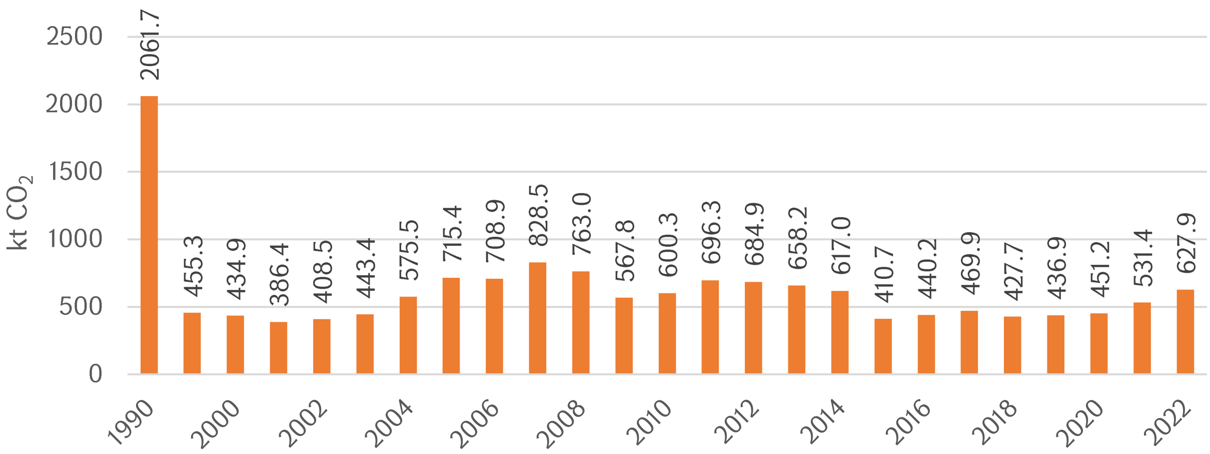


Figure 4.13 Manufacturing Industries and Construction (1A2) CO_2 emissions time series from fuel combustion for 1990-2022, kt CO_2

Figure 4.13 shows the emissions growth in 2000-2007 due to the GDP growth followed by decrease of CO_2 emissions because of the economic downturn and gradual recovery afterwards. A steady growth trend has been noticeable since 2018, driven by economic growth.

Category-specific QA/QC

General and category-specific Quality Assurance and Quality Control (QA/QC) was carried out by sector experts in accordance with the Armenian National GHG Inventory QA/QC plan presented in **Annex 7**.

Category-specific recalculations

No category-specific recalculations were done.

Category-specific planned improvements

No improvements are currently planned.

(1A3) Transport

Description of the category

Mobile sources produce direct greenhouse gas emissions of carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) from the combustion of various fuel types, as well as several other pollutants such as carbon monoxide (CO), Non-methane Volatile Organic Compounds (NMVOCs), sulfur dioxide (SO_2) and nitrogen oxides (NOx).

The following source categories exist in Armenia: *International Aviation (International Bunker)*, *Road Transportation* and *Off-road*.

The emissions from pipeline transport doesn't occur in Armenia, since there are no pumping stations for gas transportation.

Emissions estimated from *International Aviation* are not included in national total and are reported as memo item. Emissions form international marine bunker does not occur in Armenia since it is a landlocked country.

Railways are fully electrified in Armenia therefore emissions from Railways do not occur either.

The structure of fuel consumption in the transport sector of Armenia is quite unique: gasification had a great impact on the transport sector, the consumption of compressed natural gas (CNG) in 2017-2019 amounted to 60-65% of the fuel consumed in transport (there are 357 CNG filling stations in the republic). However, after 2018, there was a noticeable decrease in the use of CNG in transport (consumption in 2022 was 47.4%) and an increase in the use of LPG (in 2022 - 8.1%) because of declining LPG prices (**Figure 4.14**).

Vehicles are also consumers of gasoline (27.0% in 2022) and diesel fuel (17.5% in 2022). Since 2020, there has been a noticeable decreasing trend in diesel fuel consumption, due to the implementation of the Yerevan Public and Private Transport Modernization Program, increased use of CNG, as well as the elimination of VAT exemption for diesel under the new Tax Code effective at 1 January 2018.

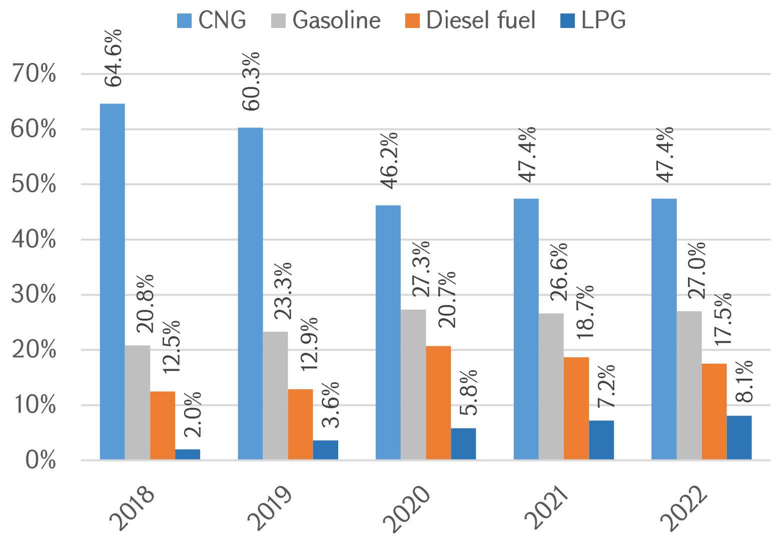


Figure 4.14 Trends in consumption of fuel types (TJ, %) used in the Transport subcategory (1A3) for 2018-2022.

98.3% of 2022 emissions in the Transport category come from Road Transportation.

Road Transportation (1A3b)

The mobile source category *Road Transportation* includes all types of light-duty vehicles, such as automobiles and light trucks, and heavy-duty vehicles, such as tractor trailers and buses, and on-road motorcycles.

In 2022, GHG emissions from the *Road Transportation* subcategory amounted to 2,377.9 kt $CO_{2\ eq.}$, an increase of more than 11.7% compared to 2019. Meanwhile, for the first time since 2000 (excluding minor reductions in 2009 and 2016), a reduction of 1.9% was recorded in the *Road Transportation* subcategory compared to the previous year 2021.

For Key Categories Analysis the emissions from the road transport were separated by type of fuel consumed (gaseous and liquid fuel) and both categories were identified as the key ones (CO_2 emissions) in terms of both level and trend assessment.

The emissions from *Road Transportation* have grown continuously since 2000: during the period 2000–2019 (with the exception of 2009 when the recession also resulted in lower CO_2 emissions from road transport and in 2016, when there was some emission reduction) road transport emissions increased by about 236% due to the growth in traffic volume (the latter being driven by a rise in living standards).

In Armenia prices for CNG, gasoline, diesel fuel and LPG are not regulated, however, the State Commission for the Protection of Economic Competition monitors gasoline, diesel fuel and LPG prices to eliminate cartel pricing, barriers to entry and excess profits in any market segment.

Methodology

According to the 2006 IPCC Guidelines, emissions can be estimated from either the fuel consumed (represented by fuel sold) or the distance travelled by vehicles (Volume 2, Chapter 3). In general, the first approach (fuel sold) is appropriate for CO_2 emissions assessment. In this inventory report emissions were estimated from the fuel consumed, assuming that the total liquid fuel imported into the country in a given year is sold in the same year.

Calculations of CO_2 emissions from CNG combustion were done applying Tier 2 method (**Volume 2, Chapter 3)** based on the quantities of compressed natural gas consumed by gas-filling stations (**Annex 3.1.1**), and country-specific emission factors for natural gas mixture (weighted average) (**Annex 3.1.5**).

CO_2 emissions from gasoline, diesel fuel and LPG combustion were calculated applying Tier 1 method based on the quantities of fuel consumed and by using default emission factors provided in 2006 IPCC Guideline (**Volume 2, Chapter 3, Table 3.2.1)**.

Emissions of CH_4 and N_2O are more difficult to estimate accurately than those for CO_2, because emission factors strongly depend on vehicle technology.

Considering that CH_4 and N_2O emissions from fuel combustion in road transportation are not the key categories and due to the lack of detailed information on this issue, these emissions were calculated by applying Tier 1 method, using the country's activity data and emission factors from the 2006 IPCC Guidelines. Thus, the share of CH_4 and N_2O emissions makes only 3.72% of CO_2 equivalent emissions from *Road transportation* in 2022.

Estimation of indirect greenhouse gas emissions was done applying Tier 1 approach using country's activity data and emission factors specified in EMEP/EEA, 2019 Guidebook.

Activity data

The amounts of natural gas consumed were taken from Gas Balances provided by Gazprom Armenia CJSC (**Annex 3.1.1**), the amounts of consumed gasoline, diesel and LPG were provided by Energy Balance (**Annex 3.1.2**).

All fuel consumed were converted to common energy units (TJ) applying for natural gas NCVs of natural gas mixture provided by Gazprom Armenia CJSC (**Annex 3.1.5**) and for gasoline, diesel and LPG - default values provided by the 2006 IPCC Guideline (**Volume 2, Table 1.2**).

Emission factors

Country-specific emission factors (**Annex 3.1.5**) calculated for natural gas mixture (weighted average) were applied for estimating emissions from CNG combustion (**Annex 3.1.6**) while for gasoline, diesel and LPG default values provided by 2006 IPCC Guideline were applied (**Volume 2, Table 1.2)**.

Off-road transportation (1A3eii)

Description of the category

The sub-category includes combustion emissions from off-road activities not otherwise reported under 1A4c *Agriculture* or 1A2 *Manufacturing Industries and Construction*. All fuel consumed in this category is diesel.

Methodology

CO_2 emissions from combustion of diesel were assessed applying Tier 1 approach.

Activity data

The quantities of diesel consumed were estimated at 10% of the diesel fuel consumed in *Transport* category.

Emission factors

Default values provided by 2006 IPCC Guideline were applied for estimating emissions from diesel combustion (**Volume 2, Table 1.2)**.

Emissions calculations results from *Transport* category

The results of greenhouse gas emissions calculation from (1A3) *Transport* category for 2022 is summarized in **Table 4.12.**

Table 4.12 Greenhouse gas emissions from Transport category, 2022, kt

Code	Category/sub-category	Net CO_2	CH_4	N_2O	Total $CO_{2\ eq.}$
1A3	**Transport**	**2,337.2**	**2.1438**	**0.1258**	**2,430.6**
1A3a	Civil Aviation, *Memo Item* [5]	309.5	0.0022	0.0087	311.9
1A3ai	International Aviation (International Bunkers), *Memo Item*	309.5	0.0022	0.0087	311.9
1A3b	Road Transportation	2,289.5	2.1411	0.1074	2,377.9
1A3eii	Off-road	47.7	0.0027	0.0184	52.7

Uncertainty assessment

CO_2, N_2O and CH_4 contribute typically around 96.3, 2.2 and 1.5 percent of $CO_{2\ eq.}$ emissions from the *Road Transportation* sub-category, respectively (Volume 2, Chapter 3.2.2). Therefore, although uncertainties in N_2O and CH_4 estimates are too high, their impact on total GHG inventory uncertainty is negligible.

For CO_2 the uncertainty in the emission factor for CNG is estimated 3%, for diesel fuel, gasoline and LPG – up to 5%.

Activity data are the primary source of uncertainty in the emission estimates mainly due to the lack of completeness. Activity data uncertainty for natural gas is estimated 5%, for gasoline, LPG and diesel fuel – 20%.

Therefore, uncertainty for emissions estimate from CNG combustion could be regarded as 5.83%, from gasoline, LPG and diesel fuel – 20.62%.

Assessment of uncertainties was made using Approach 1 - the propagation of error **(Annex 2. 3**).

Consistent time series

CO_2 emissions time series for 1990-2022 for *Transport* category are presented in **Figure 4.15.**

[5] According to the 2006 IPCC Guidelines emissions from international bunkers are not included in total national greenhouse gas emissions, however, information on such emissions is reported in National inventory separately as memo item.

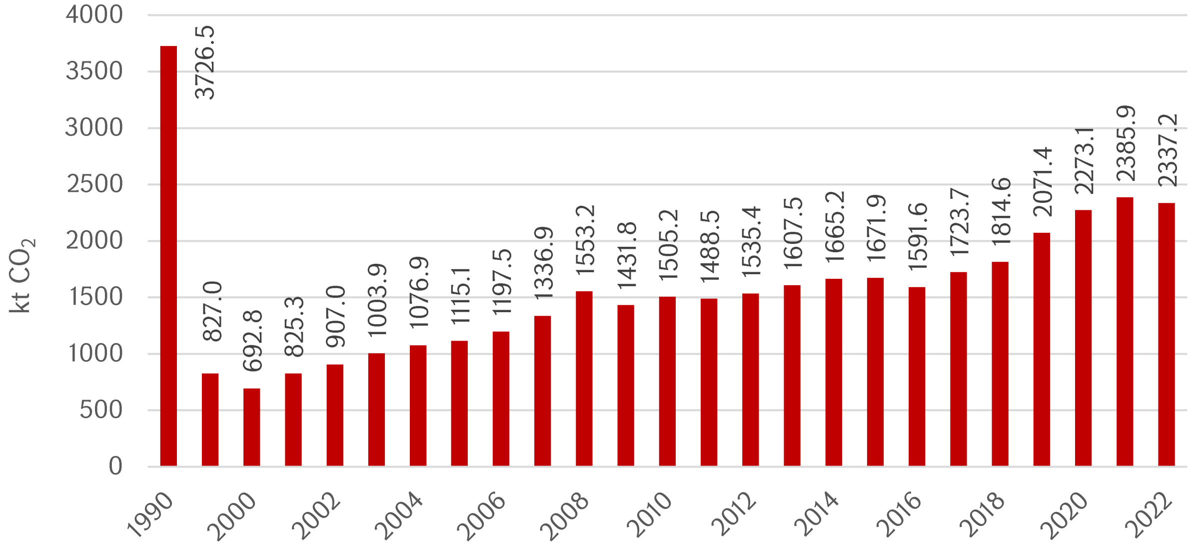


Figure 4.15 CO_2 emissions time series for Transport category, 1990-2022, kt

Figure 4.15 shows that the *Transport* category emissions have grown continuously since 2000 with the exception of 2009, when the recession also resulted in lower CO_2 emissions from transport and some decline in 2016. During 2000–2022 transport emissions increased by about 236% due to the growth in traffic volume.

At the same time, the growth rate of electric vehicle imports to Armenia in 2018-2022 is noteworthy. If 354 cars were imported in 2020 (2018 - 5, 2019 - 149), then 3833 electric vehicles were imported in 2022. In 2024, the quota of 8,000 units for imports without VAT and at 0% customs duty, established by the Council of the Eurasian Economic Commission (EEC), was exhausted.

Replacing a CNG (or other higher emission motor fuel) vehicle with an equivalent electric vehicle can, on average, reduce greenhouse gas emissions by approximately 75% (or about 2-3 tCO_2/year) and also provide financial savings and significant reductions in fuel/energy consumption.

Category-specific QA/QC (1A3)

General and category-specific Quality Assurance and Quality Control (QA/QC) was carried out by sector experts in accordance with the Armenian National GHG Inventory QA/QC plan presented in **Annex7.**

Fuel consumption data was verified to ensure its application only to on-road vehicles.

Category-specific recalculations (1A3)

No category-specific recalculations were done.

Category-specific planned improvements (1A3)

Fuel consumption is not classified by vehicle type.

(1A4) Other Sectors

This category includes *Commercial/Institutional, Residential* and *Agriculture/Forestry/Fishing /Fish Farms* sub-categories.

The source categories *Residential, Commercial/Institutional* and *Agriculture/Forestry/Fishing*

/Fish Farms are key categories (gaseous fuel, CO_2 emissions) in terms of both level and trend assessment.

Other sectors sub-category is the key (liquid fuel, CO_2 emissions) in terms of level assessment, also is the key (solid fuel, CO_2 emissions) in terms of trend assessment.

Commercial/Institutional (1A4a)

Description of the sub-category

This sub-category comprises emissions from fuel combustion for space heating and cooking activities in commercial and institutional buildings. Natural gas, LPG and coal are used as fuel in this sub-category.

Methodology

CO_2 emissions from natural gas combustion were assessed applying Tier 2 method by using country-specific emission factors for natural gas mixture (**Annex 3.1.5**) and data on natural gas consumption (**Annex 3.1.1**).

CO_2 emissions from combustion of LPG and coal were calculated applying Tier 1 method.

Activity data

The volumes of natural gas provided by Gazprom Armenia CJSC (**Annex 3.1.1**) and Energy Balance (**Annex 3.1.2**), the volumes of LPG and coal provided by Energy Balance (**Annex 3.1.2**) were converted to common energy units (TJ) applying for natural gas NCV of natural gas mixture (weighted average) provided by Gazprom Armenia CJSC (**Annex 3.1.5**) and for LPG and Coal default values provided by the 2006 IPCC Guideline (**Volume 2, Chapter 1)**.

Emission factors

Country-specific emission factors for natural gas mixture (weighted average) (**Annex 3.1.5** and **Annex 3.1.6**) were applied for CO_2 emissions estimate from natural gas combustion, default values provided by 2006 IPCC Guideline were applied for estimating emissions from LPG and Coal combustion (**Volume 2, Table 1.4)**.

Residential (1A4b)

Description of the sub-category

The sub-category comprises emissions from fuel combustion for space heating and cooking activities.

According to the data of the Cadastre Committee, the total area of the housing stock of the Republic of Armenia in 2022 made up 105.7 million m^2, including 59.8 million m^2 in urban communities (56.6%) and 45.9 million m^2 (43.4%) in rural communities.

Table 4.13 Key indicators of RA Housing Fund

Multi-apartment buildings			Single family houses		Dormitory and temporary dwellings	Total area per resident
Number unit	Number of apartments unit	Total area, thsd sq.m	Number unit	Total area, thsd sq.m thsd sq.m	thsd sq.m	sq.m
19,339	460,803	30,157,258	427,463	75,247,698	251,971	35.5

The total space of the multi apartment buildings makes up about 30% of the total space of the housing stock. About 68.7% of the multi-apartment buildings are made of stone.

The following fuel types are used by households in Armenia: natural gas, liquid fuel (diesel fuel, LPG, gasoline, other kerosine), coal and biomass (fuelwood, manure, other biomass and charcoal). Natural gas is the main fuel consumed by households, making up to 85.4% of the total fuel consumed (TJ), followed by biomass – 13.2% **(Figure 4.16**). The use of coal (anthracite, brown coal) and liquid fuels (diesel fuel, gasoline, LPG and other kerosene) are rather small. Apparently, the consumption of the biomass (manure, fuelwood and other biomass) occurs in the rural areas.

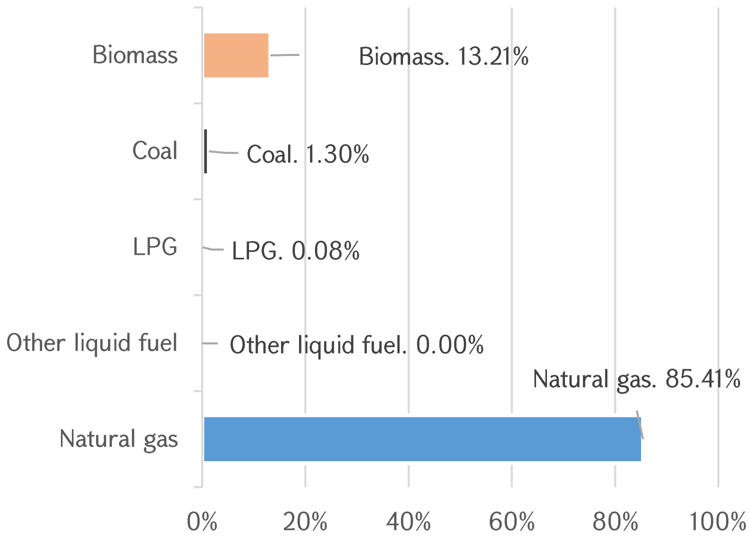


Figure 4.16 Fuel used in the residential sector, 2022, %

Electricity tariffs set by the PSRC are differentiated for daytime and nighttime, for residential consumers (and others with 0.38 kV voltage connection). Tariffs are also differentiated (since February 1, 2022) depending on monthly electricity consumption volumes, being higher in case of high consumption, which promotes energy saving and helps reduce greenhouse gas emissions.

The analysis of energy subsidies in Armenia conducted by the OECD for 2023 revealed that energy-consuming households are beneficiaries of energy subsidies, with discounts likely being available only due to social factors.

Methodology

CO_2 emissions from natural gas combustion were assessed by applying Tier 2 Approach, by using country-specific emission factors (**Annex 3.1.5**) and data on natural gas consumption (**Annex 3.1.1**).

CO_2 emissions from combustion of the other fuels were calculated applying Tier 1 Approach.

CH_4 and N_2O emissions from manure burned were included in GHG Inventory.

Activity data

Activity data for natural gas consumption were taken from the natural Gas Balances provided by Gazprom Armenia CJSC (**Annex 3.1.1**). Activity data for other fuel consumption were derived from Energy Balance (**Annex 3.1.2**).

Data on natural gas consumption were converted to energy units by applying NCV for gas mixture (weighted average) (**Annex 3.1.5**), other fuels were converted applying default values provided by 2006 IPCC Guidelines (**Volume 2, Table 1.2)**.

Emission factors

Country-specific emission factors for natural gas mixture (**Annex 3.1.5**) were applied for CO_2 emissions estimate from natural gas combustion, default values provided by 2006 IPCC Guidelines were applied for estimating emissions from other fuel combustion (**Volume 2, Table 1.4)**.

Emissions from biomass

The greenhouse gas emissions from combustion of biofuels in Residential sector are calculated for manure, fuelwood, other solid biomass and charcoal.

According to 2006 IPCC Guidelines (Volume 2, Chapter 2), CO_2 emissions from combustion of biofuels are reported as information items but not included in the sectoral or national totals to avoid double counting, while methane (CH_4) and nitrogen oxide (N_2O) are included in the National GHG Inventory.

For biomass, only the part of the biomass combusted for energy purposes was estimated and included as an information item in the Energy Sector.

Table 4.14 summarizes the quantities of consumed fuelwood, manure, other solid biomass and charcoal in energy units and CO_2, CH_4 and N_2O emissions from biofuel burning for 2015-2022.

Table 4.14 Biomass consumption (TJ) and greenhouse gas emissions from biomass burning (kt) in 2015-2022,

Year	2015	2016	2017	2018	2019	2020	2021	2022
Biomass Consumption, TJ								
Fuelwood	665.6	610.4	719.0	783.3	1,323.1	1104.7	1165.4	1262.1
Manure	3,047.0	2,987.3	2,588.2	2,826.5	2,763.3	2857.9	2812.8	2550.8
Solid biomass	292.0	247.2	335.7	438.7	436.1	490.3	451.2	513.7
Charcoal	1.0	1.3	2.4	8.2	46.3	41.9	23.1	15.9
Total	**4,005.6**	**3,846.1**	**3,645.4**	**4,056.7**	**4,567.9**	**4494.8**	**4452.5**	**4342.4**
CO_2 emissions from biofuel (memo item), kt								
Fuelwood	74.54	68.36	80.52	87.73	148.19	123.72	130.52	141.36
Manure	304.70	298.73	258.82	282.65	276.23	285.79	281.28	255.08
Solid biomass	29.20	24.72	33.57	43.87	43.61	49.03	45.12	51.37
Charcoal	0.11	0.14	0.27	0.91	5.19	4.69	2.58	1.78
Total	**408.55**	**391.95**	**373.18**	**415.17**	**473.22**	**463.23**	**459.51**	**449.58**
CH_4 emissions from biofuel, kt								
Fuelwood	0.1997	0.1831	0.2157	0.2350	0.3969	0.3314	0.3496	0.3786
Manure	0.9141	0.8962	0.7765	0.8480	0.8287	0.8574	0.8438	0.7653
Solid biomass	0.0876	0.0742	0.1007	0.1316	0.1308	0.1471	0.1354	0.1541
Charcoal	0.0003	0.0004	0.0005	0.0016	0.0093	0.0084	0.0046	0.0032
Total	**1.2017**	**1.1539**	**1.0934**	**1.2162**	**1.3657**	**1.3442**	**1.3335**	**1.3011**
N_2O emissions from biofuel, kt								
Fuelwood	0.002662	0.002441	0.002876	0.003133	0.005292	0.004419	0.004662	0.005048
Manure	0.012188	0.011949	0.010353	0.011306	0.011049	0.011432	0.011251	0.010203
Solid biomass	0.001168	0.000989	0.001342	0.001755	0.001744	0.001961	0.001805	0.002055
Charcoal	0.000001	0.000001	0.000002	0.000008	0.000046	0.000042	0.000023	0.000016
Total	**0.016019**	**0.015379**	**0.014572**	**0.016194**	**0.018086**	**0.017853**	**0.017741**	**0.017322**

Figure 4.17 provides CO_2 emissions time series from biomass burning,1990-2022, kt CO_2.

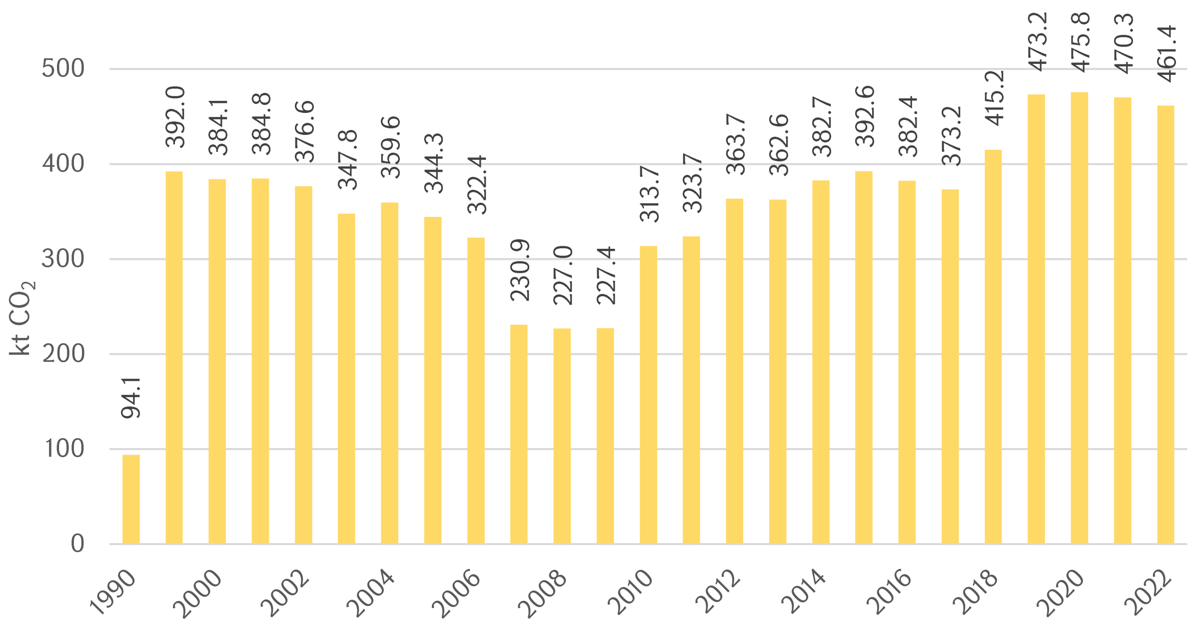


Figure 4.17 CO_2 emissions from biomass burning, 1990-2022, kt CO_2

As can be seen from **Figure 4.17**, in 2018-2019 there was a sharp increase in CO_2 emissions from biomass burning, due to the increase in the use of firewood, especially in 2019: according to official data, approximately 2-fold increase compared to the 2007-2009 levels. In the following years, 2020-2022, biomass consumption has remained stable overall, with a slightly downward trend.

Category-specific QA/QC (1A4b)

To ensure consistency, fuelwood and manure data were cross-checked with data used to estimate carbon losses from forest lands in Land Use, Land Use Change and Forestry (LULUCF) sector and with the data used during the assessment of emissions from manure management in Agriculture sector.

Category-specific recalculations (1A4b)

No category-specific recalculations were done.

Category-specific planned improvements (1A4b)

No improvements are currently planned.

Agriculture/Forestry/Fishing/Fish Farms (1A4c)

The *Off-Road Vehicles and Other Machinery (1A4cii)* subcategory of the *Agriculture/Forestry/Fishing/Fish Farms (1A4c)* category use diesel fuel and kerosene, while natural gas is used in the *Stationary (1A4ci)* subcategory.

The source category *Agriculture/Forestry/Fishing/Fish Farms* is a key category (gaseous fuel, CO_2 emissions) in terms of both level and trend assessment.

Stationary (1A4ci)

GHG emissions in the *Stationary* subcategory (1A4ci) originate from the combustion of natural gas in greenhouses.

Assessment of greenhouse gas emissions in this category became possible in 2019 due to the efforts of Gazprom Armenia CJSC which maintained separate accounting of natural gas consumed in greenhouses and its inclusion in the Armenia's Energy Balance.

Aiming to support the development of the mentioned sector, the RA PSRC, with its Resolution No. 83-N dated 01.03.2022, established a preferential/ feed-in tariffs for natural gas sold to greenhouse farms by Gazprom Armenia CJSC (from April 1, 2022).

Methodology

CO_2 emissions from combustion of natural gas were assessed by sub-categories, applying Tier 2 approach (**Volume 2, Chapter 2.3.1.2)** based on the data on volume of natural gas combusted in the source sub-category (**Annex 3.1.2**) and applying country-specific emission factors for natural gas mixture (weighted average) (**Annex 3.1.5**).

Activity data

For the years 2020, 2021 and 2022 volumes of natural gas are derived from the Energy Balance (**Annex 3.1.2**). Data on natural gas consumption were converted to energy units by applying NCV for gas mixture (weighted average) (**Annex 3.1.6**).

Emission factors

Country-specific emission factors for natural gas mixture (weighted average) (**Annex 3.1.5** and **Annex 3.1.6**) were applied for CO_2 emissions estimate from natural gas combustion.

Off-road Vehicles and Other Machinery (1A4cii)

Methodology

CO_2 emissions from combustion of diesel were calculated applying Tier 1 Approach using the quantities of fuel consumed (**Annex 3.1.2**) and default emission factors from the 2006 IPCC Guidelines (**Volume 2, Table 2.5)**.

Activity data

Data on the volume of diesel fuel were taken from Energy Balance, as estimated by SC based on the amount of fuel required for agricultural works (**Annex 3.1.2**).

The volume of diesel fuel was converted to energy units, using the default factors from the 2006 IPCC Guidelines (**Volume 2, Table 1.2**).

Emission factors

Default emission factors from the 2006 IPCC Guidelines were used for assessing GHG emissions from diesel fuel combustion (**Volume 2, Table 1.4)**.

Emissions estimate for (1A4) Other Sectors category

Table 4.15 summarizes the results of greenhouse gas emissions estimate for *Other Sectors* category for 2022.

Table 4.15 Greenhouse gas emissions from Other Sectors category, kt, 2022

Code	Category/Subcategory	Net CO2	CH_4	N_2O	Total $CO_{2\ eq.}$
1A4	**Other Sectors**	**2,426.71**	**1.6700**	**0.0403**	**2,484.16**
1A4a	Commercial/Institutional	587.97	0.0833	0.0015	590.70
1A4b	Residential	1,622.24	1.5690	0.0208	1,671.67
1A4c	Agriculture/Forestry/Fishing/Fish Farms	216.50	0.0177	0.0180	221.78

Table 4.15 shows that the *Residential* sub-sector produces the largest share of *Other Sectors* emissions - over 67%.

According to 2006 IPCC Guidelines, CO_2 emissions from combustion of biofuels are reported as information items and not included in the sectoral or national totals to avoid double counting.

Uncertainty assessment

Activity data uncertainty for natural gas is estimated 5%, for LPG and diesel fuel – 20% and for coal – 40%. Emission factors uncertainty for natural gas is estimated at 3%, for LPG and diesel – up to 5% and for coal - 10%. Therefore, uncertainty for emissions estimate from CNG combustion may be estimated at 5.83%, from LPG and diesel fuel - 20.62% and from coal – 41.23%.

Estimation of combined uncertainties are implemented by Approach 1- error propagation method. Relevant calculations and results are presented in **Annex 2.3.**

Consistent time series for (1A4) *Other Sectors* category

CO_2 emissions 1990-2022 time series (kt CO_2) for *Other Sectors* category (total and by subcategories) are shown in **Figure 4.18**.

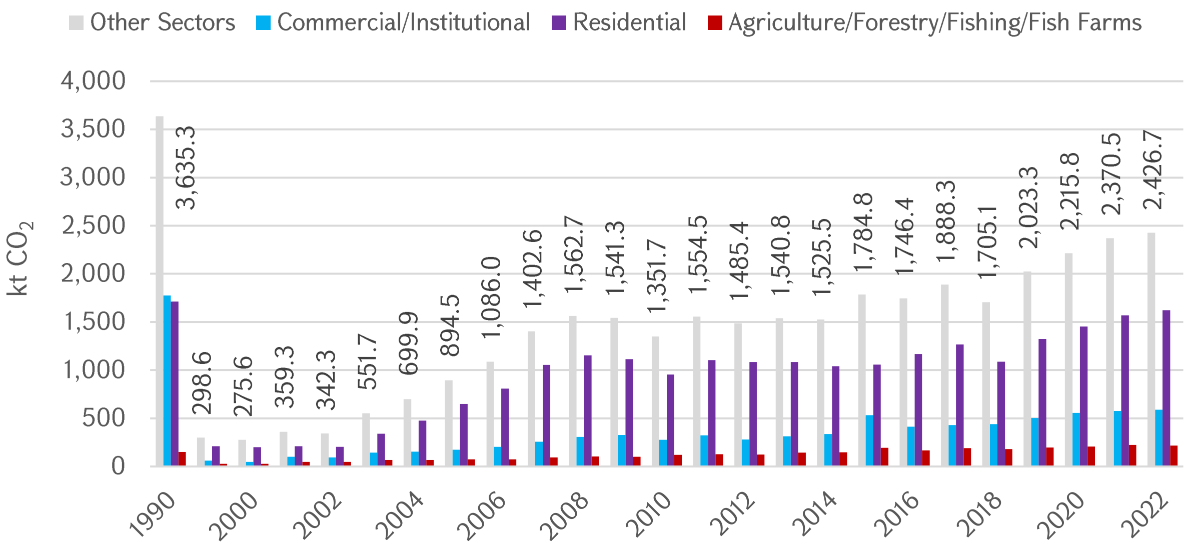


Figure 4.18 CO_2 emissions time series by sub-categories for Other Sectors category, kt

As can be seen from **Figure 4.18**, the majority of GHG emissions in the category (1A4) *Other sectors* are emissions from the *Residential* subcategory, and the increase in GHG emissions is mainly due to the growth of emissions from the *Residential* subcategory. For the years 2017 and 2019 such growth in Residential subcategory is due to weather conditions: the average temperatures in winter months were significantly lower compared to previous years. Another factor worth considering here, is that with gradual improvement in living standards the population tends to achieve higher levels of thermal comfort in their apartments, which is evident in 2020, 2021 and 2022.

Despite some fluctuations in the *Commercial/Institutional* subcategory, emissions demonstrate continuous upward trend.

The time series of CO_2 emissions in the *Agriculture/Forestry/Fishing/Fish Farms* sub-category for 2000-2022 also demonstrates slow growth trends.

To ensure the consistency of time series and to calculate GHG emissions from the *Stationary* (1A4ci) subcategory, the time series in the *Commercial/Institutional (1A4a)* and *Agriculture/Forestry/Fishing/Fish Farms (1A4c)* subcategories of the *Other Sectors (1A4)* category were recalculated, in view of the following factors:

- Setting of preferential tariffs for the sale of natural gas to operating greenhouses;
- Continuous restoration of gas supply and availability during the years 1998-2016;
- Lack of gas supply in 1992-1998;
- Availability of district heating in the 1990s which was discontinued in the early 2000s.

To calculate GHG emissions from natural gas combustion in the relevant years of the time series, country specific emission factors for the mixture (weighted average) of natural gas in the relevant years were used.

In view of the above considerations, the following annual shares were considered for extracting the amount of natural gas used by *Stationary (1A4ci)* subcategory from the total amount of natural gas consumed by *(1A4a) Commercial/Institutional* subcategory (considering that the latter also consumes and, accordingly, emits greenhouse gases from charcoal, liquefied petroleum gas, other bituminous coal, wood/wood waste, etc.)

Before 2003	2003-2006	2007-2009	2010-2012	2013-2016	2017	Since 2018
0	0.05	0.1	0.15	0.18	0.234	AD provided by the "Gazprom-Armenia" CJSC

The Table and Figures below provide data on the CO_2 emissions before and after the recalculation, and illustrates the corresponding changes in emission trends, as well as the percentage of emissions change for the period from 2003 to 2022 (note that no changes occurred before 2003).

Table 4.16 CO_2 emissions in Other Sectors (1A4) before and after the recalculation, 2003-2022 (kt CO_2)

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Before recalculation																				
Other Sectors (1A4)	551.7	699.9	894.4	1086	1402.6	1562.7	1541.3	1351.7	1554.5	1485.3	1540.8	1525.5	1784.8	1746.4	1888.3	1705.1	2023.3	2215.8	2370.5	2426.7
Commercial/ Institutional (1A4a),	150.2	162.8	181.9	214.8	282.5	338.2	360.7	322.4	376.6	322.5	376.6	405.7	646.3	500.9	555.8	439	503.8	556	576.7	588
Residential (1A4b)	340.9	477.6	648	808.9	1053	1152.9	1115.2	956.1	1105.1	1082.8	1085	1040.6	1059	1166.7	1268.5	1086.2	1323.3	1453.3	1571	1622.2
Agriculture/Forestry/Fishing/Fish Farms (1A4c),	60.6	59.5	64.7	62.2	67.1	71.6	65.4	73.2	72.8	80.1	79.2	79.2	79.5	78.9	64	179.9	196.2	206.4	222.8	216.5
Stationary (1A4ci)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	127.4	145	155.5	173.7	170.5
Off-road Vehicles and Other Machinery (1A4cii)	60.6	59.5	64.7	62.2	67.1	71.6	65.4	73.2	72.8	80.1	79.2	79.2	79.5	78.9	64.0	52.5	51.3	50.9	49.1	46.0
After recalculation																				
Other Sectors (1A4)	551.7	699.9	894.4	1086	1402.6	1562.7	1541.3	1351.7	1554.5	1485.3	1540.8	1525.5	1784.8	1746.4	1888.3	1705.1	2023.3	2215.8	2370.5	2426.7
Commercial/ Institutional (1A4a)	143.0	155.1	173.3	204.6	255.4	305.7	325.8	275.7	322.4	278.4	311.9	336.5	533.7	414.3	431.0	439.0	503.8	556.0	576.7	588.0
Residential (1A4b)	340.9	477.6	648	808.9	1053	1152.9	1115.2	956.1	1105.1	1082.8	1085	1040.6	1059	1166.7	1268.5	1086.2	1323.3	1453.3	1571	1622.2
Agriculture/Forestry/Fishing/Fish Farms (1A4c),	67.8	67.3	73.2	72.5	94.1	104.1	100.3	119.9	127.0	124.2	143.9	148.4	192.0	165.5	188.8	179.9	196.2	206.4	222.8	216.5
Stationary (1A4ci)	7.2	7.7	8.6	10.2	27.0	32.5	34.9	46.7	54.2	44.1	64.8	69.2	112.6	86.6	124.8	127.4	144.9	155.5	173.7	170.5
Off-road Vehicles and Other Machinery (1A4cii)	60.6	59.5	64.6	62.2	67.1	71.6	65.4	73.2	72.8	80.1	79.2	79.2	79.5	78.9	64.0	52.5	51.3	50.9	49.1	46.0

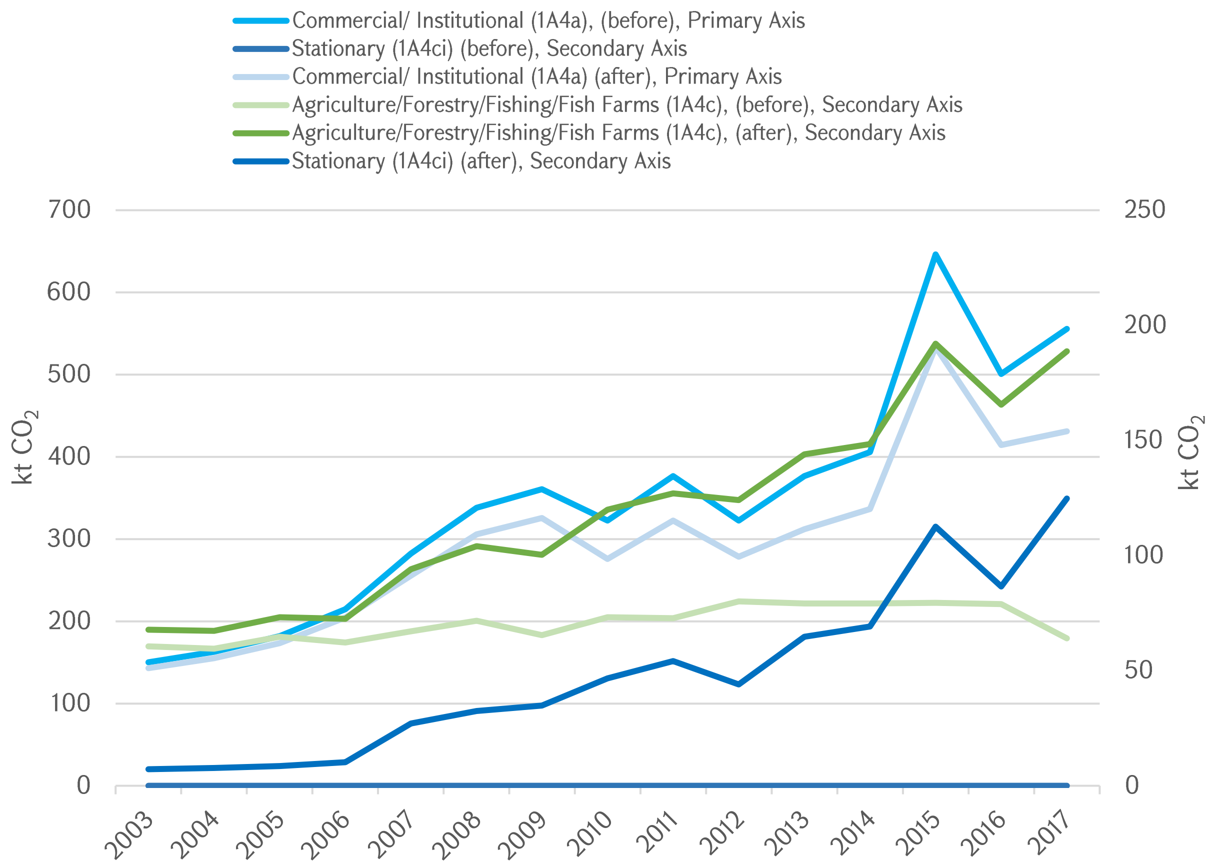


Figure 4.19 CO_2 emissions time series by sub-categories 1A4a, 1A4c and 1A4cii before and after recalculation 2003-2017, kt

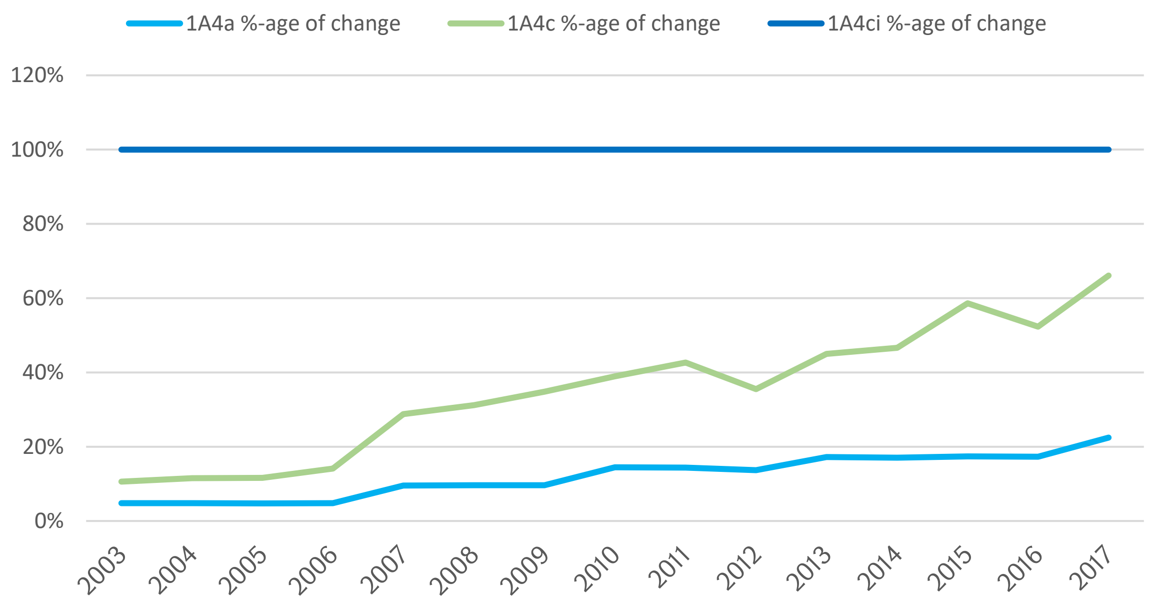


Figure 4.20 Time series of the annual percentage of changes of CO_2 emissions by sub-categories 1A4a, 1A4c and 1A4cii due to recalculations, 2003-2017

Comparison of Reference and Sectoral Approaches

In addition to the Sectoral Approach (1A), CO_2 emissions from fuel combustion are also estimated using the Reference Approach in accordance with the 2006 IPCC Guidelines (Vol. 2, Chapter 6. Reference Approach), which uses primary data on fuel production, imports, stock changes and exports from national Energy Balances.

According to the 2006 IPCC Guidelines, carbon emission factors used are equivalent to those of the Sectoral Approach and therefore represent national data. The CO_2 emission data calculated in similar manner is used to validate the sectoral approach **(Annex 3.1.7**).

The basis for the relevant calculations is the data of the national Energy Balances for primary energy supply.

(1A3ai) Emissions from International Bunkers (memo)

According to the 2006 IPCC Guidelines, emissions from international bunkers are not included in total national greenhouse gas emissions, however, data on such emissions is separately reported in National inventory, as a memo item.

Calculations are made based on fuel consumption data in 2011-2022 provided by the Energy Balances (**Annex 3.1.2**), by applying Tier 1 approach.

The volumes of fuel were converted to common energy units (TJ) applying default values provided in the 2006 IPCC Guideline for jet kerosene (**Volume 2, Table 1.2)**.

Default values provided in the 2006 IPCC Guidelines for jet fuel (**Volume 2, Table 1.4)** were applied for emission estimates.

Table 4.17 provides the consumed fuel and emissions from international aviation by gases.

Table 4.17 Greenhouse gas emissions from International Aviation (bunker) by gases

Years	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Consumption, (TJ)	**1,748.5**	**1,784.9**	**2,024.2**	**1,784.2**	**1,370.1**	**1,951.6**	**2,409.7**	**2,728.8**	**3,042.0**	**1,642.0**	**2,292.9**	**4,329.1**
Emissions, (kt)												
CO_2	125.0	127.6	144.7	127.6	95.90	136.61	168.68	195.11	217.5	117.4	163.9	309.5
CH_4	0.001	0.001	0.0010	0.0009	0.0007	0.0010	0.0012	0.0014	0.0015	0.0008	0.0012	0.0022
N_2O	0.0035	0.0036	0.0040	0.0036	0.0027	0.0039	0.0048	0.0055	0.0061	0.0033	0.0046	0.0087
$CO_{2\ eq.}$	**126.1**	**128.7**	**146.0**	**128.7**	**96.78**	**137.8**	**170.2**	**196.8**	**219.4**	**118.3**	**165.2**	**311.9**

CO_2 emissions (kt CO_2) from *International Bunkers (1A3ai)* in 1990-2022 are presented in **Figure 4.21**.

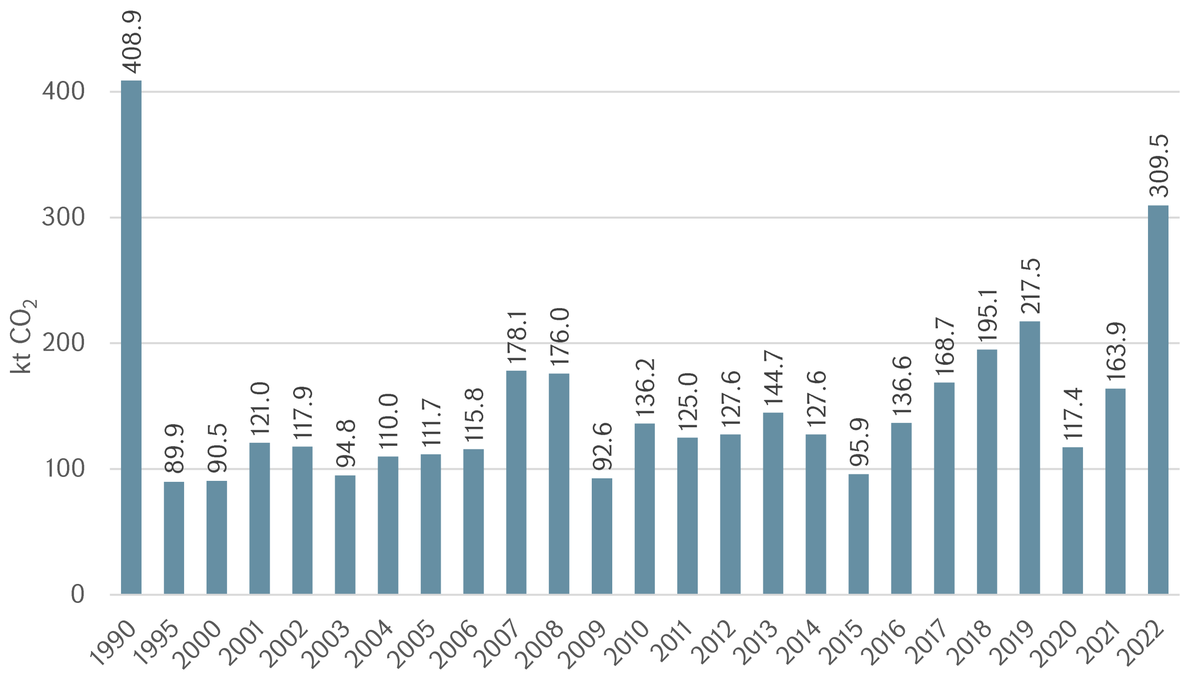


Figure 4.21 CO_2 emissions from International Bunkers in 1990-2022, (kt CO_2)

The decline in international air traffic in 2020 was mainly caused by the COVID-19 pandemic and its subsequent negative economic impact. Unprecedented growth was also observed in 2022, with 7 Armenian companies registering in Armenia. In 2022, Armenian airports served and transported an unprecedented number of passengers - about 3.7 million people, of which more than 916 thousand were carried by Armenian airline companies.

There were no scheduled domestic flights in 2022.

Energy Sector CO_2 emissions time series from *Fuel Combustion Activities (1A)*

Figure 4.22 and **Table 4.18** provide Energy Sector CO_2 emissions time series from fuel combustion by categories for 1990-2022.

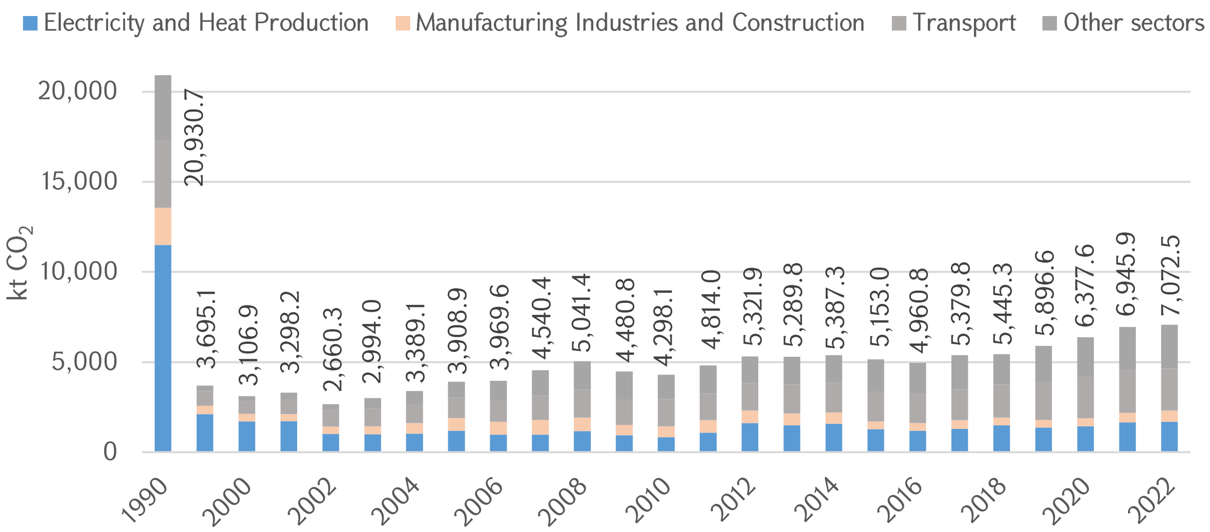


Figure 4.22 Energy Sector CO_2 emission time series from fuel combustion by categories, 1990-2022, kt

Table 4.18 Energy Sector CO_2 emissions time series from fuel combustion by sub-categories, kt, 1990-2022

Subcategory / Year	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Total	**20,931**	**3,695**	**3,107**	**3,909**	**4,298**	**4,814**	**5,322**	**5,290**	**5,387**	**5,153**	**4,961**	**5,380**	**5,445**	**5,897**	**6,378**	**6,946**	**7,072**
Electricity and Heat Public Production	11,507	2,114	1,704	1,184	841	1,075	1,616	1,483	1,580	1,286	1,183	1,298	1,498	1,365	1,438	1,658	1,681
Manufacturing Industries and Construction	2,062	455	435	715	600	696	685	658	617	411	440	470	428	437	451	531	628
Transport	3,727	827	693	1,115	1,505	1,488	1,535	1,608	1,665	1,672	1,592	1,724	1,815	2,071	2,273	2,386	2,337
Other sectors:	3,635	299	276	894	1,352	1,554	1,485	1,541	1,526	1,785	1,746	1,888	1,705	2,023	2,216	2,371	2,427
Commercial/ Institutional	1,775	60	48	173	276	322	278	312	336	534	414	431	439	504	556	577	588
Residential	1,712	211	199	648	956	1,105	1,083	1,085	1,041	1,059	1,167	1,269	1,086	1,323	1,453	1,571	1,622
Agriculture/Forestry/ Fishing/Fish Farms	149	28	29	73	120	127	124	144	148	192	165	189	180	196	206	223	217
Memo Items																	
International Aviation	409	90	91	112	136	125	128	145	128	96	137	169	195	218	117	164	310
Biomass	94	392	384	344	314	324	364	363	383	393	382	373	415	473	476	470	461

As can be seen from the presented calculation results, a significant increase in emissions has been recorded since 2000, which is associated with the restoration of the country's gas supply and the expansion of gasification in these years, resulted in sharp increase of natural gas consumption, especially by the population. A noticeable growth in the Transport sector led to an increased consumption of natural gas and oil products. Downward trend in emissions in 2009 was due to the global economic crisis. As the economy emerged from the downturn and started demonstrating growth in 2011, emission levels recovered and the upward trend resumed.

Since 2010, significant fluctuations in emission were mainly due to changes in the volume of electricity generated by thermal power plants operating on natural gas and changes in the amount of exported electricity. Thus, the sharp growth recorded in the Energy sector in 2012 (compared to 2010) was due to the increased export of electricity generated by thermal power plants (in 2012, the growth in electricity generated by thermal power plants was 135% compared to 2010). Emissions in 2014 exceeded the 2012 level, however subsequently, in 2015 and 2016 emissions were again on a downward trend. In 2017 CO_2 emissions increased and nearly equaled the 2014 level, which is the all-time high throughout the period from 1995 to 2017, resulted from a combined effect of several factors: economic growth, export volumes and cold winter. In 2018 and 2019, exports were growing. In 2018, this was mainly due to increased electricity exports and, accordingly, electricity production at thermal power plants, as well as an higher fuel consumption by transport. In 2019 the increased emissions are mainly due to the growth in natural gas consumption in the residential sector and an unprecedented increase in emissions from transport, - by more than 20% compared to 2017.

Emissions are annually affected by economic activity, the economic situation in the country's energy-intensive industries, weather conditions, the volume of energy generated at hydroelectric power plants, and improved living standards. The latter also leads to an increased consumption of fuel for apartment heating and transport.

At the end of 2021, a new thermal power plant, the combined heat and power unit of Armpower CJSC (with a capacity of 254 MW), was commissioned, with lower specific GHG emissions than those of all other thermal power plants operating in Armenia. Autonomous PV plants are growing exponentially, the import of electric vehicles has been accelerating significantly, projects aimed at improving the energy efficiency of buildings are underway, however, mechanisms targeting low-carbon development have not yet been sufficient to offset GHG emissions growth.

Consistent year-to-year emissions growth can be mitigated through the widespread use of low-carbon technologies.

QA/QC procedures for *Fuel Combustion Activities* (1A)

The quality control of the fuel combustion source categories was carried out using the QA/QC plan of the National Greenhouse Gas Inventory of Armenia presented in **Annex 7.** Using this plan, two types of verifications were carried out: a) general (tier1 methodology) procedures, which are consistent with the 2006 IPCC Guidelines (Vol. 1, Chapter 6: QA/QC and Verification) and focus on procedures and documentation for collecting, checking, using and archiving files, and category-specific procedures (tier2 methodology), which focus on checks and comparisons of emission factors, activity data and methodologies used to estimate emissions from relevant fuel combustion activity sources.

In accordance with the 2006 IPPC Guidelines, additional category-specific QC procedures were performed for more significant emission categories or sources where significant methodological and data updates and upgrades had occurred.

Any significant findings and/or errors in documentation identified are necessarily corrected. The application of these procedures, in particular the category-specific QC procedures and the updates/improvements resulting from the QA processes (reviews by expert, public and UNFCCC technical experts), are subsequently reviewed, recalculated and the improvements are described in the relevant source category sections.

Estimates of CO_2 emissions from fuel combustion prepared using the Sectoral Approach were compared to the results of Reference Approach (**Annex 3.1.7**). Energy Balance served as a basis for the Reference approach.

The Sectoral Approach estimates per type of fuel are presented in **Table 4.19.**

Specific QA/QC procedures are also intended for the Fugitive Emissions category of the Energy sector, which will be presented in the relevant section.

Table 4.19 CO_2 emissions from fuel combustion estimated using the Sectoral Approach, kt CO_2

Types of Fuel			Actual emissions, kt CO_2											
		Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Liquid fossil	Secondary fuel	Gasoline	418.8	400.7	405.9	396.4	400.3	431.5	436.6	425.4	538.6	677.4	694.5	690.4
		Jet kerosene*	124.9	127.6	144.7	127.6	95.9	136.6	168.7	195.1	217.5	117.4	163.9	309.5
		Diesel fuel	489.7	460.7	447.0	462.1	410.6	403.6	428.6	362.4	425.4	633.4	621.6	572.4
		LPG	21.9	20.4	22.1	20.2	20.6	12.1	18.3	47.8	90.1	153.7	219.6	269.5
Total liquid fossil			**930.4**	**881.8**	**875.0**	**878.7**	**831.5**	**847.2**	**883.5**	**835.6**	**1,054.1**	**1464.5**	**1,535.7**	**1,532.2**
Solid fossil		Anthracite, Brown coal	10.2	9.5	3.8	3.1	2.5	4.6	3.9	4.7	10.5	29.2	44.4	44.4
Total solid fossil			**10.2**	**9.5**	**3.8**	**3.1**	**2.5**	**4.6**	**3.9**	**4.7**	**10.5**	**29.2**	**44.4**	**44.4**
Gaseous fossil		Natural Gas	3,858.1	4,405.2	4,397.2	4,487.4	4,303.1	4,094.7	4,473.9	4,605.0	4,831.8	4,880.5	5365.5	5495.8
Total Gaseous fossil			**3,858.1**	**4,405.2**	**4,397.2**	**4,487.4**	**4,303.1**	**4,094.7**	**4,473.9**	**4,605.0**	**4,831.8**	**4,880.5**	**5365.5**	**5495.8**
Total			**4,798.8**	**5,296.5**	**5,276.0**	**5,369.1**	**5,137.2**	**4,946.5**	**5,361.3**	**5,445.3**	**5,896.6**	**6,374.1**	**6945.6**	**7072.5**

*Memo item Note: Since aviation fuel is entirely consumed in international bunkers, the emissions from it are not included in the country's total emissions.

(1B) Fugitive emissions

Fugitive emissions from Natural Gas Transmission and Storage (1B2biii4) and Natural Gas Distribution (1B2biii5)

Description of the sub-categories

Gas supply system

Armenia imports natural gas from Russia, via Georgia, and from Iran. Gas transportation system includes high-pressure main gas pipelines and an underground gas storage facility (GUSF).

The total length of main gas pipelines and branch gas pipelines serviced in the gas transportation system operated by Gazprom Armenia CJSC is approximately 1,668.5 km. Gas transportation is carried out through 1,580.94 km of gas pipelines. The remaining part is in operational reserve mode.

The operating period/service life of 83% of main gas pipelines is 31 years or more, including 100% of pipes with a diameter of 1,220 and 1,020 mm. The operating period of about 50% of gas pipelines exceeds 41 years, and more than 40% of pipes with a diameter of 1,220 and 1,020 mm. The operating period of more than 25% of gas pipelines exceeds 50 years. So, the moral and physical wear and tear of gas pipelines is one of the main reasons for natural gas losses.

The gas distribution network includes 19,617.2 km of high, medium and low-pressure gas pipelines, as well as engineering structures. Gas distribution network includes 2,669 gas control points, 9,194 individual pressure regulators, 1,433 main metering units, and 316 electrochemical protection stations.

As of December 31, 2023, natural gas is consumed by 2,364 industrial, 17,428 municipal and 1,207 agricultural enterprises in Armenia.

In Armenia, there are 863,307 apartments and private households according to the overall gasification scheme, of which 763,357 are gasified, including 564,388 in urban areas and 198,969 in rural areas. Natural gas is supplied through the gas distribution network to 48 cities and 602 rural settlements. The level of gasification with natural gas is 96.33% (taking into account potential gas consumers).

Fugitive emissions were estimated in the following sub-categories:

- (1B2biii4*) Natural Gas Transmission and Storage*
- (1B2biii5) *Natural Gas Distribution.*

All other sources indicated in the 2006 IPCC Guidelines (Volume 2) for the Energy Sector do not exist in Armenia and are not considered in this Inventory.

The source category *Fugitive Emissions from Natural Gas* is a key category (CH_4 emissions) in terms of level and trend assessment.

In Armenia, methane fugitive emissions occur during the operation of natural gas networks, including emergency leaks, losses resulting from operational regulations and standard procedures, and unavoidable technological losses. The magnitude of the losses is also influenced by factors such as weather conditions, altitude (according to the barometric formula), the lack of correctors/adjusters at consumer sites (leading to deviations in the normal cubic meter calculations of natural gas), and errors in metering units.

Methodology

Fugitive emissions from natural gas were assessed according to the 2006 IPCC Guidelines, applying Tier 2 Approach (Volume 2, Chapter 4).

Considering characteristics (official data) of the delivered natural gas (mixture), country-specific emission factors were developed for estimation of fugitive emissions in the following sub-categories: *Natural Gas Transmission and Storage* (1B2biii4) and *Natural Gas Distribution* (1B2biii5).

According to the IPCC 2006 Guidance (Volume 2, Chapter 4, Fugitive Emissions, Section 4.2.2.2), country-specific fugitive emission factors for natural gas should be periodically re-affirmed or updated, to reflect real changes within the sector.

Taking into account that the methodology for estimating country-specific fugitive emission factors in the natural gas transmission (including storage) and distribution systems of Armenia was developed within the scope of Armenia's First Biennial Update report (BUR), under the NIR for 1990-2012, and considering the current changes in the gas supply system, the methodology for calculating country-specific fugitive emission factors has been within the framework of this Inventory. To this aim, the following activities were carried out:

- Assessment and analysis of the planned and ongoing maintenance activities in the gas supply systems of Armenia, and their impact on natural gas losses and, consequently, on the absolute values of fugitive emissions of natural gas;
- Research and assessment of absolute values of losses due to errors in measuring and control devices and uncertainty of data (activity data and EFs) in transmission (including storage) and distribution systems, refinement of the corresponding factors/coefficients in the calculation formula of the methodology;
- Analysis of the impact of compositions and characteristics of natural gas imported from Russia, Iran and a mixture (Yerevan GDS 2) on the country specific fugitive emission factors of natural gas in Armenia;
- Alignment of the methodology for calculating country-specific natural gas fugitive emission factors with the amended version of the reference on the main indicators of the RA gas supply system published on the official website of the Public Services Regulatory Commission (PSRC);
- Inclusion of separate calculations for fugitive emissions in the computation of national emission factors for fugitive emissions in the distribution system, specifically for emissions occurring at the consumer level - prior to the combustion of natural gas in end-use equipment.

Based on the above-mentioned studies and analyses, an updated version of the methodology for calculating country-specific fugitive emission factors in the RA gas supply system has been developed, and subsequently discussed and agreed with Gazprom Armenia CJSC.

Activity data

The volumes of marketable gas and utility sales delivered via the transmission and distribution system were derived based on the official statistics from Annual Gas Balances provided by Gazprom Armenia CJSC (**Annex 3.1.1**).

Emission factors

Country-specific emission factors were calculated for CH_4 using official statistics from Annual Gas Balances provided by Gazprom Armenia CJSC and based on the country-specific annual average characteristics of natural gas in transmission and distribution systems - net-calorific values (NCV), density and gas composition (**Annex 3.1.6**).

For CO_2 the default value from the 2006 IPCC Guidelines was used (**Volume 2, Chapter 4, Table 4.2.5)**.

Calculation of country-specific fugitive emission factors for natural gas transmission system (F_{trans} (kt/mln.m^3)), according to the updated methodology:

$F_{trans} = [(P_{prod}-T_{trans})-k_{trans}*T_{trans}] *\rho_{trans}* CH_{4trans} / T_{trans}$ (kt/mln.m^3)

where:

F_{trans} - Country-specific fugitive emission factor for the natural gas transmission system (kt/mln.m^3)

P_{prod} - Imported natural gas volume (mln.m^3) (1)[6] + volume of natural gas taken from GUSF (mln.m^3) (2)

T_{trans} - Volume of natural gas transmitted (mln.m^3) (6) + Volume of natural gas injected into the GUSF (min.m^3) (5) + Volume of gas used for own needs (mln.m^3) (3)

k_{trans} - **0.0105** Coefficient due to the error of the transmission system metering devices

ρ_{trans} – Natural gas density in transmission system[7] (kt/mln.m^3)

CH_{4trans} - Methane content in transmitted natural gas [8]

Calculation of country-specific fugitive emission factors for natural gas distribution system (F_{dist} (kt/mln.m^3)), according to the updated methodology:

$F_{dist} = [(T_{trans}-T_{sales}-D_{dist})-k_{dist}*D_{dist}+(k_{Res}*D_{Res}+k_{En}*D_{En}+k_{Ind}*D_{Ind}+ k_{Tr}*D_{Tr}+k_{Budg}*D_{Budg}+k_{Other}*D_{Other})] *\rho_{dist}* CH_{4dist} / D_{dist}$ (kt/mln.m^3)

where:

F_{dist} - Country-specific fugitive emission factor for the natural gas distribution system (kt/mln.m^3)

T_{trans} - Volume of natural gas transmitted (6) (mln.m^3)

T_{sales} [9] - Natural gas sales in transmission system (6.1) (mln.m^3)

D_{dist} – Natural gas sales in distribution system (mln.m^3) (10) + Natural gas volume consumed for own needs in distribution system (mln.m^3) (7) + recovered natural gas (mln.m^3) (8)

k_{dist} - **0.0025** Coefficient due to the error of the distribution system metering devices

k_{Res} - **0.0001** Natural gas fugitive emission coefficient in the distribution system of Residential sector consumers

D_{Res} - Natural gas volume sales in the distribution system of Residential sector consumers (mln.m^3) (10.1)

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[6] The corresponding line of the Main indicators of gas supply system (**Annex 3.1.1**) is indicated in brackets.

[7] Mixture (weighted average) natural gas density indicator

[8] CH_4 component index in Mixture (weighted average) natural gas

[9] Applicable for calculations up to and including the year 2021, in calculations for 2022 and subsequent years = 0

k_{En} - 0.0001 Natural gas fugitive emission coefficient in the distribution system of Energy sector consumers

D_{En} - Natural gas volume sales in the distribution system of Energy sector consumers (mln.m^3) (10.2)

k_{Ind} - 0.001 Natural gas fugitive emission coefficient in the distribution system of Industry sector consumers

D_{Ind} - Natural gas volume sales in the distribution system of Industry sector consumers (mln.m^3) (10.3)

k_{Tr} - 0.01224 Natural gas fugitive emission coefficient in the distribution system of Transport sector consumers

D_{Tr} - Natural gas volume sales in the distribution system of Transport sector consumers (mln.m^3) (10.4)

k_{Budg} - 0.001 Natural gas fugitive emission coefficient in the distribution system of State budget sector consumers

D_{Budg} - Natural gas volume sales in the distribution system of State budget sector consumers (mln.m^3) (10.5)

k_{Other} - 0.001 Natural gas fugitive emission coefficient in the distribution system of other sectors consumers

D_{Other} - Natural gas volume sales in the distribution system of other sectors consumers (mln.m^3) (10.6)

ρ_{dist} - Natural gas density in distribution system[10] (kt/ mln.m^3)

$CH_{4\ dist}$ - Methane content in distributed natural gas [11]

Below are all the data sources needed for the calculations:

- All "k" coefficients are determined on the basis of calculations available at Gazprom Armenia CJSC and/or many years of experience and expert assessments of specialists who participated in the preparation of the report.
- The volumes of natural gas import, transmitted, distributed, sold and other volumes are available from the reference/balance sheet of the main indicators of the RA natural gas supply system (annual) available on the official website of the PSRC (**Annex 3.1.1**).
- The density of natural gas and methane content in transmission and distribution systems are available in the reference on average physicochemical indicators of natural gas provided by Gazprom Armenia CJSC (**Annex 3.1.6**).

Emissions calculations results

Table 4.20 provides country-specific emission factors (kt/mln m^3), activity data (mln m^3), and methane fugitive emissions estimates (kt CH_4), for 2011-2022 according to the updated methodology.

[10] Mixture (weighted average) natural gas density indicator

[11] CH_4 component index in Mixture (weighted average) natural gas

Table 4.20 Country-specific emission factors, activity data and fugitive emissions estimate for methane in 2011-2022

Year	Gas Supply System	Country-specific emission factors kt/mln m3	Activity data mln m^3	Methane emissions kt	Fugitive emissions estimates kt
2011	Transmission network	0.023095	2,054.95	47.46	**74.91**
	Distribution network	0.0177916	1,542.72	27.45	
2012	Transmission network	0.0198961	2,443.00	48.61	**75.53**
	Distribution network	0.0166824	1,614.20	26.93	
2013	Transmission network	0.0210598	2,320.61	48.87	**77.79**
	Distribution network	0.0158396	1,825.73	28.92	
2014	Transmission network	0.0210862	2,394.60	50.49	**79.30**
	Distribution network	0.0143132	2,012.90	28.81	
2015	Transmission network	0.0221299	2,285.90	50.59	**76.64**
	Distribution network	0.0142832	1,823.90	26.05	
2016	Transmission network	0.0239219	2,184.20	52.25	**79.44**
	Distribution network	0.0147147	1,847.90	27.19	
2017	Transmission network	0.0236837	2,327.70	55.13	**81.74**
	Distribution network	0.0136753	1,945.60	26.61	
2018	Transmission network	0.0191360	2,427.20	46.45	**65.37**
	Distribution network	0.0087645	2,159.60	18.93	
2019	Transmission network	0.0159096	2,488.90	39.60	**58.59**
	Distribution network	0.0086086	2,205.80	18.99	
2020	Transmission network	0.0100416	2,561.90	25.73	**47.00**
	Distribution network	0.0093910	2,265.9	21.28	
2021	Transmission network	0.0111410	2,755.80	30.70	**53.65**
	Distribution network	0.0099555	2,304.60	22.94	
2022	Transmission network	0.0116572	2,934.40	34.21	**58.02**
	Distribution network	0.0084456	2,820.00	23.82	

Total methane emissions calculated using country specific factors (Tier2) are on average 57.0% higher than the total maximum emissions calculated using the factors in the 2006 IPCC Guidelines, while the difference with the average calculated using the Tier1 methodology for developing countries in accordance with the 1996 IPCC Guidelines is only about 10%.

Fugitive Emissions from Natural Gas (1B2b) per greenhouse gases in 2020, 2021 and 2022 are summarized in **Table 4.21**.

Table 4.21 Emissions calculations results from Natural Gas Fugitive Emissions *(1B2b)* in 2020, 2021, and 2022, kt

2020

Code	Category/Subcategory	Net CO_2	CH_4	N_2O	Total $CO_{2\ eq.}$
1B2b	Fugitive Emissions from Natural Gas	0.2201	47.0045	NA	1,316.35
1B2biii4	Transmission and Storage	0.0037	25.7255	NA	720.32
1B2biii5	Distribution	0.2164	21.279	NA	596.03

2021

Code	Category/Subcategory	Net CO_2	CH_4	N_2O	Total $CO_{2\ eq.}$
1B2b	Fugitive Emissions from Natural Gas	0.2241	53.6457	NA	1,502.31
1B2biii4	Transmission and Storage	0.0040	30.7024	NA	859.67
1B2biii5	Distribution	0.2201	22.9434	NA	624.64

2022

Code	Category/Subcategory	Net CO_2	CH_4	N_2O	Total $CO_{2\ eq.}$
1B2b	Fugitive Emissions from Natural Gas	0.2735	58.0235	NA	1,624.93
1B2biii4	Transmission and Storage	0.0042	34.2069	NA	957.80
1B2biii5	Distribution	0.2693	23.8166	NA	667.13

Uncertainty assessment

Natural gas composition considered to be accurate within ±5% range, on individual components and flow rates have errors of ±5% for transmission and storage and distribution. The uncertainty of the emission factors is estimated to be up to 5% each.

Combined uncertainty for *Transmission/Storage and Distribution* sub-category is considered to be accurate within ±7.07%. Estimation of combined uncertainties are implemented by Approach 1 – error propagation method. Calculations and results are presented in Annex 2.3.

Time series

Methane fugitive emissions time series for 1990-2022 according to the updated methodology are presented in **Figure 4.23**.

According to the 2006 IPCC Guidelines (Volume 1, Chapter 5), the same methodologies and consistent approaches were used for the underlying activity data and emission factors for each reporting year; to the extent possible, time series were calculated using the same method and data sources for all years.

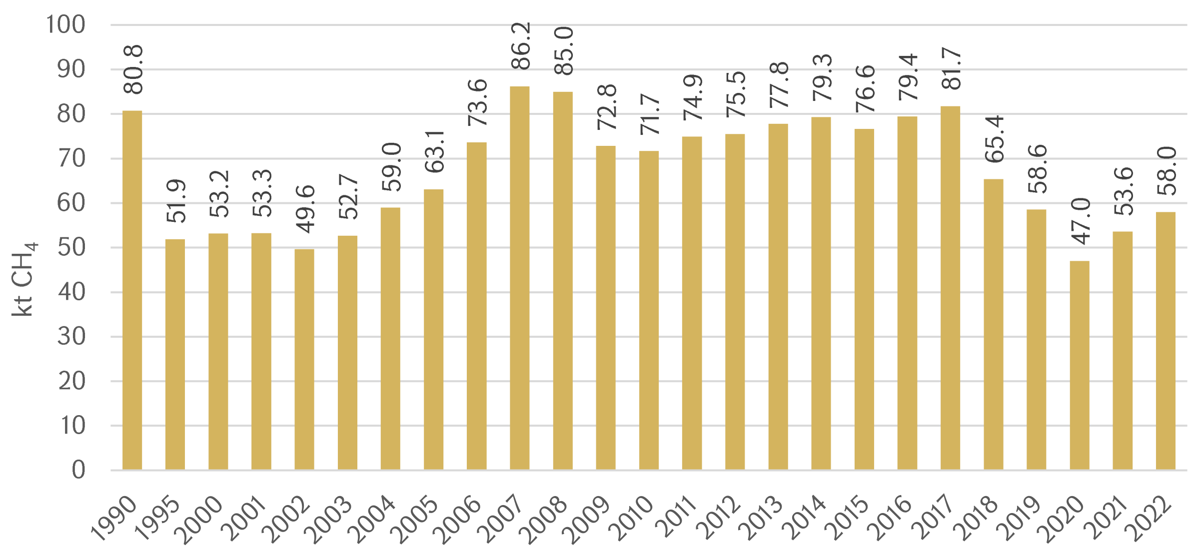

Figure 4.23 Methane fugitive emissions time series, 1990-2022, kt CH_4

To ensure comparability of the 1990-2022 time series of fugitive emissions, they have been recalculated as follows:

- The time series of the subcategories *1B2biii4 Transportation and Storage* and *1B2biii5 Distribution of Natural Gas* have been recalculated.
- The updated methodology for calculating country-specific fugitive emission factors in the RA gas supply system (excluding change due to errors in transmission and distribution system metering devices, which has been applied since 2020 for subsequent years) has been used to recalculate emissions for all years in the 1990-2022 time series of natural gas fugitive emissions.

Figure 4.23 illustrates that methane emissions have grown continuously since 2000, due to the natural gas distribution network's gradual expansion. The biggest methane emissions were recorded in 2007-2008 because of the unprecedented level of natural gas deliverability reached in the country. In 2009, the financial and economic crisis occurred, also affecting natural gas consumption.

Gradual increase of methane emissions since 2010 was due to the growth in electricity export to Iran, met by thermal power plants.

The Figures and Tables below represent the time series of methane fugitive emissions (total, transmission and storage, distribution networks) in the Armenian gas supply system from 2011 to 2022: a) absolute values of methane fugitive emissions (kt CH_4) and b) values of methane fugitive emission country specific factors (kgCH_4/nm^3) before and after recalculation.

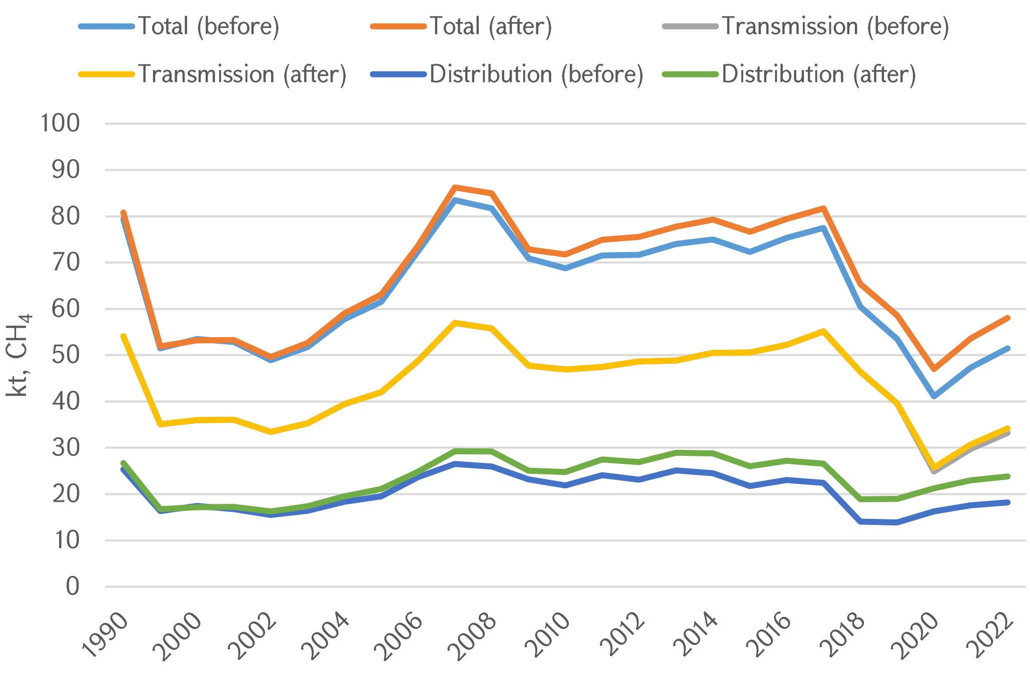

Figure 4.24 Methane fugitive emissions (absolute values) time series, 1990-2022, kt CH_4

Table 4.22 Natural gas methane fugitive emissions (total, transportation and distribution) before and after recalculation, 1990-2022 (kt CH_4)

	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Total (before)	79.38	51.45	53.45	52.83	48.92	51.74	57.80	61.52	72.44	83.47	81.73	70.92	68.79	71.55	71.70	74.02	75.02	72.29	75.31	77.52	60.48	53.47	41.11	47.35	51.45
Total (after)	80.77	51.87	53.18	53.29	49.64	52.68	58.99	63.07	73.63	86.22	84.95	72.83	71.72	74.91	75.53	77.79	79.30	76.64	79.44	81.74	65.37	58.59	47.00	53.65	58.02
Transmission (before)	54.08	35.11	36.00	36.05	33.39	35.32	39.45	41.98	48.79	56.97	55.77	47.76	46.94	47.46	48.61	48.87	50.49	50.59	52.25	55.13	46.45	39.60	24.87	29.78	33.23
Transmission (after)	54.08	35.11	36.00	36.05	33.39	35.32	39.45	41.98	48.79	56.97	55.77	47.76	46.94	47.46	48.61	48.87	50.49	50.59	52.25	55.13	46.45	39.60	25.73	30.70	34.21
Distribution (before)	25.30	16.34	17.45	16.78	15.53	16.43	18.35	19.54	23.65	26.51	25.96	23.16	21.85	24.09	23.10	25.15	24.52	21.71	23.06	22.39	14.04	13.88	16.23	17.57	18.23
Distribution (after)	26.69	16.76	17.18	17.23	16.25	17.37	19.54	21.10	24.84	29.26	29.19	25.07	24.78	27.45	26.93	28.92	28.81	26.05	27.19	26.61	18.93	18.99	21.28	22.94	23.82

As it comes from **Figure 4.24**, it can be stated that as a result of applying the updated methodology, the absolute values of methane fugitive emissions increase on average by 3.3 kt CH_4 or 5.3% [maximum value of increase is 6.6 kt CH_4 or 14.4%, minimum value - 0.5 kt CH_4 or 0.9%], while the main difference occurs in the distribution networks.

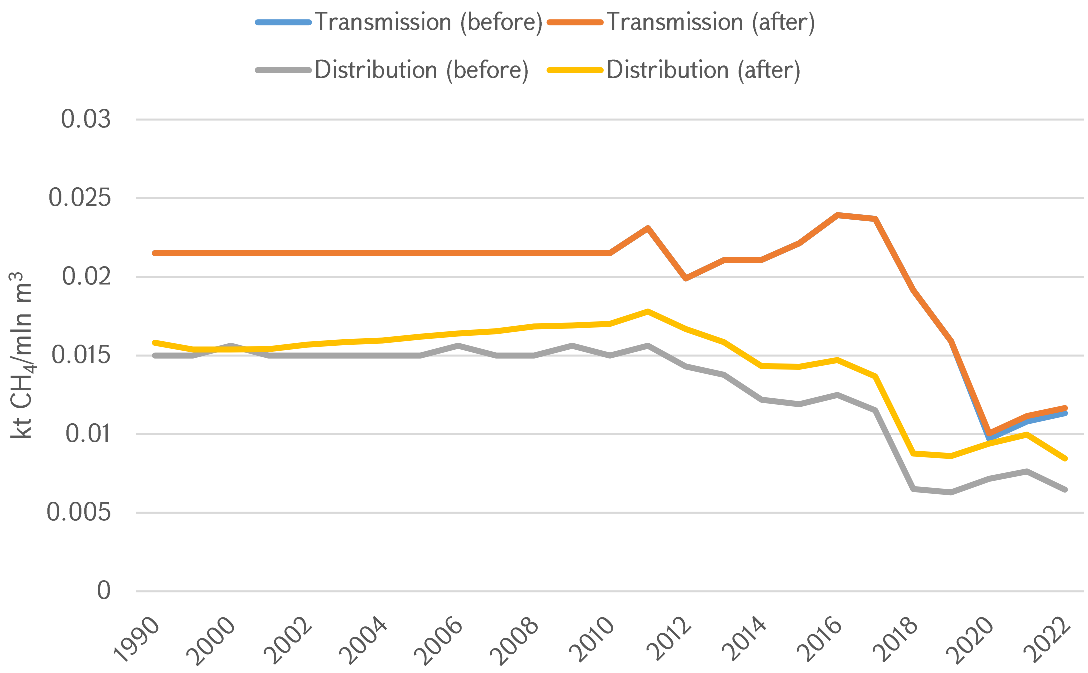

Figure 4.25 Methane country-specific fugitive emission factors (transmission and distribution), before and after recalculation, 1990-2022 (kt CH_4/mln. m^3)

Table 4.23 Natural gas methane country - specific fugitive emission factors (transmission and distribution) before and after recalculation, 1990-2022 (kt CH_4/mln. m^3)

	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Transmission (before)	0.021496	0.021496	0.021496	0.021496	0.021496	0.021496	0.021496	0.021496	0.021496	0.021496	0.021496	0.021496	0.021496
Transmission (after)	0.021496	0.021496	0.021496	0.021496	0.021496	0.021496	0.021496	0.021496	0.021496	0.021496	0.021496	0.021496	0.021496
Distribution (before)	0.014989	0.014989	0.0156172	0.014989	0.014989	0.014989	0.014989	0.014989	0.0156172	0.014989	0.014989	0.0156172	0.014989
Distribution (after)	0.015816	0.0153766	0.015376	0.0153948	0.015689	0.015848	0.015956	0.016184	0.016399	0.016544	0.016853	0.016902	0.016997

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Transmission (before)	0.023095	0.019896	0.02105981	0.021086	0.02213	0.023922	0.023684	0.019136	0.01591	0.009708	0.010806	0.011323
Transmission (after)	0.023095	0.019896	0.02105981	0.021086	0.02213	0.023922	0.023684	0.019136	0.01591	0.010042	0.011141	0.011657
Distribution (before)	0.015617	0.014308	0.01377258	0.012183	0.011902	0.012481	0.011508	0.0065	0.006291	0.007165	0.007624	0.006464
Distribution (after)	0.017792	0.016682	0.01583964	0.014313	0.014283	0.014715	0.013675	0.008765	0.008609	0.009391	0.009955	0.008446

As it follows from the **Figure 4.25**, as a result of the application of the updated methodology, the values of the country specific fugitive emission factors in the transmission network increase on average by 0.05 $gCH4/nm^3$, or 0.4% [maximum value of increase is 0.34 $gCH4/nm^3$ or 3.4%, minimum value - 0.0 $gCH4/nm^3$], and the values of the country specific fugitive emission factors in the distribution network increase on average by 1.65 gCH4/nm3 or 15.5% [maximum increase - 2.38 gCH4/nm3 or 36.8%, minimum - 0.39 $gCH4/nm^3$ or 2.6%].

Fugitive emissions of natural gas are not directly proportional to the volumes of imported natural gas (even, so called resource natural gas, i.e. including natural gas taken from the GUSF). Thus, in 2016, with a decrease in the amount of imported natural gas, there was an increase in the absolute values of losses, while in the years 2018, 2019 and 2020, the contrary trend was observed: in the context of an increased imports of natural gas, losses decreased in absolute values (%-wise progressive reduction of losses). One of the main reasons for the decrease in losses of natural gas imported from the Russian Federation to Armenia is that the Georgian Gas Transportation Company carried out work last year to replace certain sections of the main gas pipeline that had been found to have corrosion and defects.

The increase in the absolute value of natural gas technological losses in 2021 and 2022 is due to the increased volumes of gas supplied to the Republic of Armenia and regulation of the regimes of natural gas supplied through the "Krasni Most" and "Norduz" gas metering stations, the cleaning and purging of the main pipelines and gas regulation stations to ensure the correct flow direction, major capital repairs occurring in the said years, replacement of damaged sections of the main pipelines contributed to the increase of natural gas technological losses.

Category-specific (1B2b) QA/QC for fugitive emissions from natural gas transmission and distribution

General and category-specific quality control and quality assurance were carried out by the experts in accordance with the QA/QC plan for the National GHG Inventory of Armenia presented in **Annex 7**.

For the fugitive emissions subcategory, specific quality assurance and quality control procedures were applied as prescribed in the 2006 IPPC Guidelines for the application of Tier 2 approach, in particular:

- A fugitive emissions quality assurance/quality control process was implemented to provide an independent, objective review of inventory calculations, assumptions and documentation to assess the effectiveness of QA/QC. These expert study/examinations were conducted by experienced and qualified professionals in the field, with through knowledge and understanding of the nature of the emission sources, the sector structure, existing issues and ways to address them.

Summary of greenhouse gas emissions from Energy Sector by sub-categories and gases

The greenhouse gas emissions from Energy Sector by sub-categories and gases for 2022 are summarized in **Table 4.24**.

Table 4.24 Greenhouse gas emissions from Energy Sector sub-categories by gases, kt

Subcategory/ Greenhouse gas (kt)	2022
CO_2	7,072.72
Main Activity Electricity and Heat Public Production	1,680.64
Manufacturing Industries/Construction	627.91
Transport	2,337.19
Other Sectors	2,426.71
Fugitive emissions from natural gas	0.2735
CH_4	61.8795
Main Activity Electricity and Heat Public Production	0.0299
Manufacturing Industries/Construction	0.0124
Transport	2.1438
Other Sectors	1.6700
Fugitive emissions from natural gas	58.0235
N_2O	0.1706
Main Activity Electricity and Heat Public Production	0.0030
Manufacturing Industries/Construction	0.0014
Transport	0.1258
Other Sectors	0.0403
Fugitive emissions from natural gas	NA

Activity data quality control / quality assurance

Official national data on the production/import, supply/delivery, transmission/distribution and sales (perhaps some consumer groups are generalized) of natural gas and electricity is comprehensive and complete.

Energy Balance is officially published since 2015, and is an essential data source for the Energy sector. The National GHG Inventory team works closely with the team of experts involved in the Energy Balance development, to ensure the accuracy and completeness of data.

However, consumption data on some types of liquid fuels is not entirely complete and fails to cover all areas of operation.

Official data and data collected from household surveys on firewood consumption produce significant discrepancies, and works are currently underway to achieve consistency of these data.

National GHG Inventory team works closely with the SC specialists and Energy Balance compilers, aiming to enhance completeness and reliability of activity data.

Application of higher-tier (Tier 2 and Tier 3) methodologies for GHG emissions from combustion of fuels other than natural gas (i.e., liquid or solid fuels) is currently not possible due to the gaps and lack of required level of detail in national data, as well as shortage of equipment to determine fuel composition for calculating carbon content of the fuel and the corresponding national emission factors.

To ensure accuracy and consistency of activity data, they are collected from different available sources and cross-checked to the extent possible.

The required activity data on electricity and natural gas are available on the PSRC website or can be obtained from Settlement Centre, Gazprom Armenia CJSC, Energy Balances and the RA SC.

The assumptions and criteria underlying the selection of activity data, emission factors and other estimation parameters were reviewed. Comparability of data between categories was checked. The current inventory estimates for each category have been compared with the estimates from the previous year. If significant changes or deviations from expected trends have been observed, the estimates have been rechecked, and the differences have been explained.

Additionally, consistency of activity data common to different emission sources was checked, e.g., for the assessment of emissions from the fuelwood and manure combustion, the consistency of data on fuelwood and manure data has been cross-checked in the "Agriculture" and "Land Use, Land Use Change, and Forestry" sectors, specifically with the data used for assessing carbon loss in forested lands and emissions from manure management.

Summary of GHG emissions in Energy Sector

Summary of emissions from Energy Sector for 2022 is presented in **Table 4.25**, and **Table 4.26** demonstrates the complete time series for Energy Sector. Emissions of precursors are presented in **Table 4.27.**

Table 4.25 Energy Sectoral Table, 2022

Sectors/Categories	Emissions (kt)			
	Net CO_2	CH_4	N_2O	Total $CO_{2\ eq.}$
1 - ENERGY SECTOR	7072.72	61.8795	0.1706	8850.55
1.A - FUEL COMBUSTION ACTIVITIES	7072.45	3.8560	0.1706	7225.62
1.A.1 - ENERGY INDUSTRIES	1680.64	0.0299	0.0030	1682.27
1.A.1.a - Electricity and heat public production	1680.64	0.0299	0.0030	1682.27
1.A.1.a.i - Electricity generation	521.79	0.0093	0.0009	522.30
1.A.1.a.ii - Combined heat and power generation	1158.85	0.0206	0.0021	1159.97
1.A.2 - MANUFACTURING INDUSTRIES AND CONSTRUCTION	627.92	0.0124	0.0014	628.64
1A.2.a - Iron and steel	38.72	0.0007	0.0001	38.76
1A.2.b - Non-ferrous metals	18.90	0.0007	0.0001	18.95
1A.2.c - Chemicals	3.49	0.0001	0.0000	3.49
1A.2.d - Pulp, paper and print	11.86	0.0002	0.0000	11.87
1A.2.e - Food processing, beverages and tobacco	175.11	0.0031	0.0003	175.28
1A.2.f - Non-metallic minerals	300.03	0.0054	0.0005	300.33
1A.2.h - Machinery	0.00	0.0000	0.0000	0.00
1A.2.i - Mining (excluding fuels) and quarrying	2.29	0.0001	0.0000	2.29
1A.2.j - Wood and wood products	44.14	0.0013	0.0002	44.24
1A.2.k - Construction	0.07	0.0000	0.0000	0.07
1A.2.l - Textile and leather	26.17	0.0006	0.0001	26.22
1A.2.m - Non-specified industry	3.52	0.0001	0.0000	3.52
1A.2.a - Iron and steel	3.62	0.0001	0.0000	3.62
1.A.3 - TRANSPORT	2337.19	2.1438	0.1258	2430.55
1.A.3.a - Civil Aviation:	309.53	0.0022	0.0087	311.88
1.A.3.ai - International aviation: (memo item)	309.53	0.0022	0.0087	311.88
1.A.3.b - Road transportation	2289.48	2.1411	0.1074	2377.90
1.A.3.e - Other transportation	47.70	0.0027	0.0184	52.66
1.A.3.e.ii - Off-road	47.70	0.0027	0.0184	52.66
1.A.4 - OTHER SECTORS	2426.71	1.6700	0.0403	2484.16
1.A.4.a - Commercial/institutional	587.97	0.0833	0.0015	590.70

1.A.4.b – Residential	1622.24	1.5690	0.0208	1671.67
1.A.4.c - Agriculture/forestry/fishing/fish farms	216.50	0.0177	0.0180	221.78
1.A.4.c.i - Stationary	170.53	0.0151	0.0003	171.03
1.A.4.c.ii - Off-road vehicles and other machinery	45.98	0.0026	0.0177	50.75
1.B - FUGITIVE EMISSIOSN FROM FUELS	0.2735	58.0235	NA	1624.93
1.B.2.b - Natural gas	0.2735	58.0235	NA	1624.93
1.B.2.b.iii.4 - Transmission and storage	0.0042	34.2069	NA	957.80
1.B.2.b.iii.5 - Distribution	0.2693	23.8166	NA	667.13

Note: Emissions from all sub-categories not shown in this table are not occurring in Armenia

Categories	Emissions (kt)			
	CO_2	CH_4	N_2O	Total $CO_{2\ eq.}$
Memo Items				
International Bunkers	309.5270	0.0022	0.0086	311.8820
1.A.3.a.i – International Aviation (International Bunkers)	309.5270	0.0022	0.0086	311.8820
Information Items				
CO_2 from Biomass Combustion for Energy Production	461.3753			

Table 4.26 Time series of GHG emissions from Energy Sector, 1990-2022, kt $CO_{2\ eq.}$

Subcategory / Year	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Total	**23,361**	**5,208**	**4,654**	**5,748**	**6,399**	**7,009**	**7,542**	**7,579**	**7,723**	**7,415**	**7,298**	**7,785**	**7,402**	**7,677**	**7,843**	**8,604**	**8,851**
Electricity and Heat Public Production	11,534	2,117	1,705	1,185	842	1076	1618	1485	1581	1287	1,184	1,299	1,499	1,366	1,439	1,660	1,682
Manufacturing Industries and Construction	2,065	456	435	716	601	697	686	659	618	411	441	470	428	437	452	532	629
Transport	3,814	848	711	1151	1,562	1,547	1,599	1,676	1,737	1,744	1,661	1,798	1,895	2,160	2,362	2,481	2,431
Other sectors:	3,686	334	313	930	1,386	1,591	1,525	1,582	1,566	1,828	1,788	1,929	1,749	2,073	2,273	2,429	2,484
Commercial/ Institutional	1,781	60	48	174	277	323	279	313	337	535	416	432	440	505	559	579	591
Residential	1,755	246	236	683	988	1140	1121	1124	1080	1099	1,206	1307	1,128	1,370	1,502	1,621	1,672
Agriculture/Forestry/Fishing/Fish Farms	150	28	29	74	120	128	125	145	149	193	166	190	181	197	212	228	222
Fugitive emissions from Natural gas	2,262	1453	1,489	1,766	2,008	2,098	2,115	2,178	2,221	2,146	2,225	2,289	1,831	1,641	1,316	1,502	1,625
Memo Items																	
International Aviation	412	91	91	113	137	126	129	146	129	97	138	170	197	219	118	165	312
Biomass	94	392	384	344	314	324	364	363	383	393	382	373	415	473	476	470	461

Table 4.27 Summary report of the Energy sector in 2022

Categories	Emissions and Removals				Emissions CO_2 eq., kt			Emissions kt			
	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	HFCs	PFCs	SF_6	NOx	CO	NMVOCs	SO_2
Total National Emissions and Removals											
1 - Energy	7,072.725		61.8795	0.1706				16.478	47.347	5.152	0.552
1.A - Fuel Combustion Activities	7,072.451		3.8560	0.1706				16.478	47.347	5.152	0.552
1.A.1 - Energy Industries	1,680.636		0.0299	0.0030				2.662	1.167	0.078	0.008
1.A.2 - Manufacturing Industries and Construction	627.915		0.0124	0.0014				1.111	0.343	0.253	0.039
1.A.3 - Transport	2,337.186		2.1438	0.1258				10.863	42.762	4.519	0.020
1.A.4 - Other Sectors	2,426.715		1.6700	0.0403				1.843	3.076	0.302	0.484
1.A.5 - Non-specified	NO		NO	NO				NA, NO	NA, NO	NO	NA, NO
1.B - Fugitive Emissions from Fuels	0.2735		58.0235	NA, NO				NO	NO	NA, NE	NO
1.B.1 - Solid Fuels	NO		NO	NO						NO	
1.B.2 - Oil and Natural Gas	0.2735		58.0235					NO	NO	NE	NO
1.B.3 - Other emissions from Energy Production	NO		NO	NO				NO	NO	NO	NO
1.C - Carbon Dioxide Transport and Storage	NO							NO	NO	NO	NO
Memo Items											
International Bunkers	309.5270		0.0022	0.0087				0.393	0.118	0.187	0.098
1.A.3.a.i - International Aviation (International Bunkers)	309.5270		0.0022	.0087				0.393	0.118	0.187	0.098
1.A.3.d.i - International water-borne navigation (International Bunkers)	NO		NO	NO				NO	NO	NO	NO
1.A.5.c - Multilateral Operations	NO		NO	NO				NO	NO	NO	NO

5. INDUSTRIAL PROCESSES AND PRODUCT USE (CRT SECTOR 2)

Industrial Processes and Product Use (IPPU) sector of the national greenhouse gas inventory of Armenia includes the following emission sources:

- ***(2.A) Mineral Industry (CO_2 emissions)***
  - (2.A.1) Cement production
  - (2.A.2) Lime production
  - (2.A.3) Glass Production
- ***(2.C) Metal Industry (CO_2 and SO_2 emissions)***
  - (2.C.1) Iron and steel production (CO_2 emissions)
  - (2.C.2) Ferroalloys Production (SO_2 emissions)
- ***(2.D) Non-energy Products from Fuels (CO_2 emissions) and Solvent Use (NMVOC)***
  - (2.D.1) Lubricant Use (CO_2 emissions)
  - (2.D.2) Paraffin Wax Use (CO_2 emissions)
  - (2.D.3) Solvents Use (NMVOC emissions)
  - (2.D.4) Bitumen/Asphalt Production and Use (NMVOC emissions)
- ***(2.F) Product uses as Substitutes for Ozone Depleting Substances (HFCs)***
  - (2F1) Refrigeration and Air Conditioning
  - (2F2) Foam Blowing Agents
  - (2F3) Fire Protection
  - (2F4) Aerosols
  - (2F5) Solvents
- ***(2.G) Other Product Manufacture and Use (SF_6 emissions)***
  - (2G1b) Use of Electrical Equipment
- ***(2.H) Other (NMVOC emissions)***
  - (2.H.2) Food and Beverages Industry

Emissions from all other sources indicated in 2006 IPCC Guidelines (Volume 3) for IPPU Sector are not occurring or are not applicable in Armenia. From those listed above, all sources were estimated except for HFC emissions from *solvent use (2F5)*, which have not been estimated due to unavailability of reliable activity data.

The IPPU Sector emissions estimate considers only process-related emissions and does not consider energy-related emissions. Energy-related emissions from these industries are accounted in the Energy Sector, therefore, double counting of GHG emissions is excluded. There are no such industries in Armenia where it is difficult to separate emissions from fuel combustion and from technological processes.

2.A.1 Cement Production (CO_2 emissions) and 2.F.1 *Refrigeration and Air conditioning* (HFCs) are identified as the key source categories both with level and trend assessment in 2022, while 2.F.2 *Foam Blowing Agents* (HFCs) is identified as the key source category *with the trend assessment.*

The IPPU Sector emissions amounted to 1,347.1 kt $CO_{2\ eq.}$ in 2020, 1,477.7 kt $CO_{2\ eq.}$ in 2021 and 1,609 kt $CO_{2\ eq.}$ in 2022, or 11.5%, 11.7% and 12.4% of Armenia's total net emissions in 2020, 2021 and 2022, correspondingly.

Table 5.1 shows GHG emissions in IPPU sector by category and gas in 2020-2022. Emissions of CH_4, N_2O and PFCs do not occur in IPPU sector in Armenia.

CO_2 emissions from the IPPU sector in 2022 amounted to 513.81 kt, which accounts for 31.9% of emissions from the "Industrial Processes and Product Use" sector and 4.0% of the country's total net emissions. The largest source of CO_2 emissions in 2022 was cement production – 471.59 kt CO_2, which accounts for 91.8% of CO_2 emissions from the IPPU sector. The shares of CO_2 emissions from other categories are significantly smaller.

HFC emissions in 2022 amounted to 1091.04 kt $CO_{2\ eq.}$, which accounts for 67.8% of emissions from the "Industrial Processes and Product Use" sector and 8.4% of the country's total net emissions. HFCs emissions from refrigeration and air conditioning predominate in the overall HFCs emissions with the share of 94.2% in 2022. The share of emissions from the other applications is much smaller.

SF_6 emissions from the use of electrical equipment are incomparably small: 4.15 kt $CO_{2\ eq.}$, making up 0.3% of sectoral emissions.

Table 5.1 IPPU sector emissions in 2020-2022

Categories	2020				2021				2022			
	CO_2 kt	HFCs kt CO_2 eq.	SF_6 kt CO_2 eq.	Total kt CO_2 eq.	CO_2 kt	HFCs kt CO_2 eq.	SF_6 kt CO_2 eq.	Total kt CO_2 eq.	CO_2 kt	HFCs kt CO_2 eq.	SF_6 kt CO_2 eq.	Total kt CO_2 eq.
2.A. Mineral industry	391.15			**391.15**	432.94			**432.94**	496.64			**496.64**
2.A.1. Cement production	345.90			**345.90**	385.23			**385.23**	471.59			**471.59**
2.A.2. Lime production	37.64			**37.64**	40.15			**40.15**	17.33			**17.33**
2.A.3. Glass production	7.61			**7.61**	7.56			**7.56**	7.71			**7.71**
2.B. Chemical industry	NO	NO	NO	**NO**	NO	NO	NO	**NO**	NO	NO	NO	**NO**
2.C. Metal industry	3.86	NO	NO	**3.86**	11.02	NO	NO	**11.02**	11.16	NO	NO	**11.16**
2.C.1. Iron and steel production	3.86			**3.86**	11.02			**11.02**	11.16			**11.16**
2.D. Non-energy products from fuels and solvent use	5.15	NO	NO	**5.15**	5.35	NO	NO	**5.35**	6.01	NO	NO	**6.01**
2.D.1. Lubricant use	5.04	NO	NO	**5.04**	5.22	NO	NO	**5.22**	5.89	NO	NO	**5.89**
2.D.2. Paraffin wax use	0.11	NO	NO	**0.11**	0.13	NO	NO	**0.13**	0.12	NO	NO	**0.12**
2.E. Electronic industry		NO	NO	**NO**		NO	NO	**NO**		NO	NO	**NO**
2.F. Product uses as substitutes for ODS		943.43		**943.43**		1 024.56		**1 024.56**		1 091.04		**1 091.04**
2.F.1. Refrigeration and air conditioning		887.16		**887.16**		962.56		**962.56**		1 028.08		**1 028.08**
2.F.2. Foam blowing agents		37.05		**37.05**		40.09		**40.09**		48.41		**48.41**
2.F.3. Fire protection		0.86		**0.86**		0.90		**0.90**		0.94		**0.94**
2.F.4. Aerosols		18.36		**18.36**		21.01		**21.01**		13.62		**13.62**
2.F.5. Solvents		NE		**NE**		NE		**NE**		NE		**NE**
2.G. Other product manufacture and use	NO		3.46	**3.46**	NO		3.84	**3.84**	NO		4.15	**4.15**
2.G.1. Electrical equipment			3.46	**3.46**			3.84	**3.84**			4.15	**4.15**
2.H. Other	NO			**NO**	NO			**NO**	NO			**NO**
TOTAL 5 - IPPU	**400.16**	**943.43**	**3.46**	**1 347.05**	**449.31**	**1 024.56**	3.84	**1 477.71**	**513.81**	**1 091.04**	**4.15**	**1 609.00**

Figure 5.1 presents the trend of GHG emissions in IPPU sector. The GHG emissions from this sector in 2022 have increased 2.5 times since 1990, as there were no HFC emissions in 1990, and by 36.4% since 2019, driven predominantly by the growth of emissions from HFCs and cement production.

Information on emission trends in each sub-category is presented in respective sections.

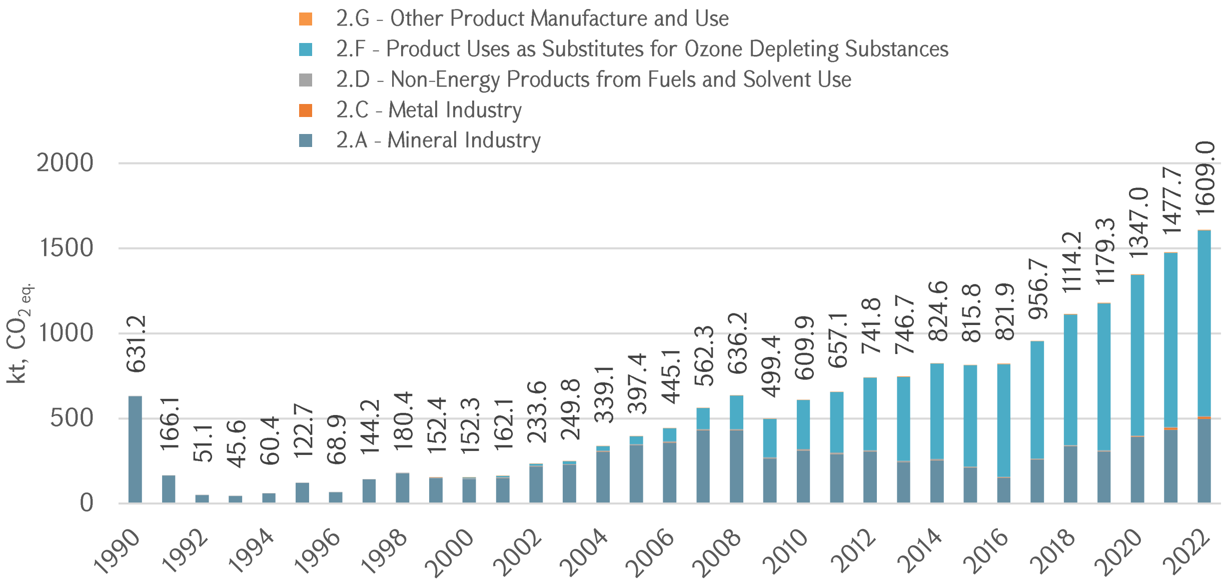

Figure 5.1 Trend of IPPU sector emissions in 1990-2022, kt $CO_{2eq.}$

Figure presents emissions from Industrial processes and product use compared with total emissions (included LULUCF), 2022.

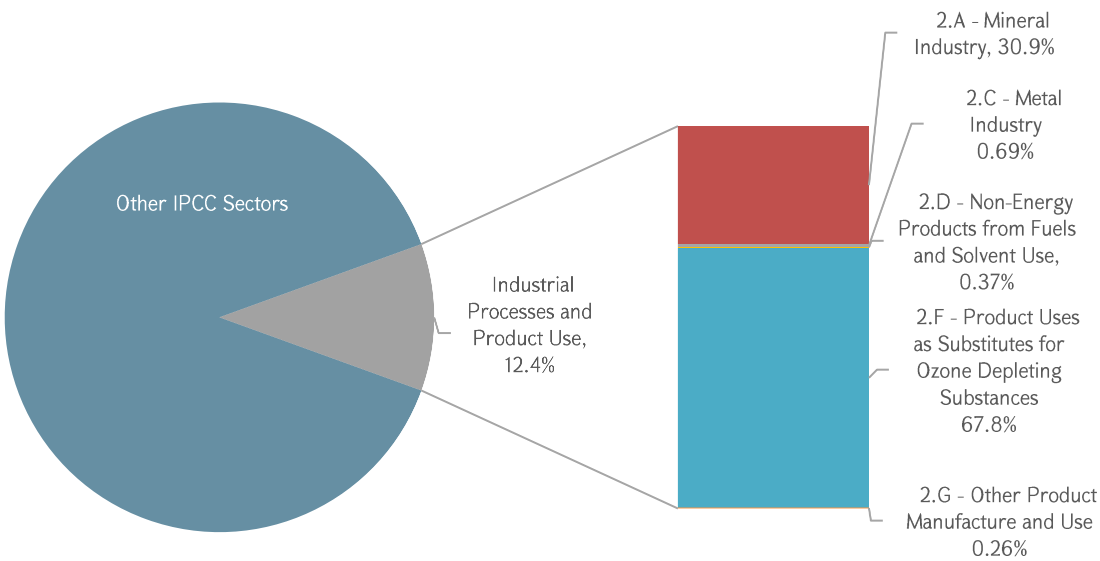

Figure 5.2 Emissions from Industrial processes and product use compared with total emissions, 2022

(2A) Mineral industry

(2A1) Cement Production

Choice of method

In cement manufacture, CO_2 is produced during the production of clinker and the remarks below refer only to production of cement clinkers. Cement production is included solely for reference purposes.

During the production of clinker, limestone, which is mainly calcium carbonate ($CaCO_3$), is heated, or calcined, to produce lime (CaO) and CO_2 as a by-product.

Carbon dioxide emissions from cement production were calculated according to the 2006 IPCC Guidelines by applying Tier 3 approach (Volume 3, Chapter 2, Equation 2.3) which relies on plant specific data and is based on the collection of disaggregated data on the types (compositions) and quantities of carbonate(s) consumed to produce clinker, as well as the respective emission factor(s) of the carbonate(s) consumed.

Cement kiln dust (CKD) may be generated during the manufacture of clinker. According to the 2006 IPCC Guideline, emission estimates should account for emissions associated with the CKD. However, in the absence of reliable data for CKD, an assumption of Fd = 1.00 will result in the correction for CKD to equal zero (Vol 3, Chapter 2.2, p. 2.11). According to the 2006 IPCC Guideline, the CO_2 emissions from non-carbonate carbon in the nonfuel raw materials can be ignored (Vol 3, Chapter 2.2, p. 2.11).

The Tier 3 methodology was used because detailed and complete data (including weights and composition) for carbonate(s) consumed in clinker production are available. The plant-level CO_2 emission estimates were then aggregated to produce national-level emission estimates.

Activity data, emission factors and other parameters

The activity data required for Tier 3 method are available only at individual plant level.

Plant level data were requested by the Ministry of Environment in the format required for assessing emissions and were obtained directly from the producing companies (IndRef-1, IndRef-2):

Plant-specific data on cement and clinker production, quantity and composition of raw materials are provided below.

Table 5.2 Annual production and quantity of main raw materials, thousand t, 2020-2022 (Plant 1)

Year	Annual production		Quantity of main raw materials	
	Cement	Clinker	Limestone	Clay
2020	534.329	417.947	576.019	177.491
2021	612.837	467.659	642.747	200.277
2022	736.220	579.254	788.926	242.710

Table 5.3 The average composition of Calcium oxide in primary raw material, %, (Plant 1)

Year	Chemical component	Limestone	Clay
2020 - 2022	Cao	58.7	24.66

Table 5.4 Cement and Clinker annual production and quantity of main row materials consumed, thousand t, 2020-2022 (Plant 2)

Year	Annual production		Quantity of main raw materials	
	Cement	Clinker	Limestone	Clay
2020	100.0	98.0	110.0	12.45
2021	110.0	98.0	120.0	13.0
2022	123.0	99.317	145.0	23.333

Table 3.5 The average composition of Calcium oxide in primary raw material, %, (Plant 2)

Year	Chemical component	Limestone	Clay
2020 - 2022	CaO	52.78	4.8

Data on the composition of raw materials provided by cement producers as CaO input were recalculated to $CaCO_3$.

Table 5.6 Total CaO input, t, annually

Year	Plant 1	Plant 2
	CaO input	CaO input
2020	381,874.7	58,655.6
2021	426,660.8	63,960.0
2022	522,950.0	77,651.0

Calculation of CaO to $CaCO_3$ is provided below.

CaO (56) $\longrightarrow$ $CaCO_3$ (100)

The method for calculating carbonate is provided below:

$Ca\ CO_3 = Q \times L \times 100/56$, where:

Q = amount of carbonate-containing raw material, t

L = CaO content in raw material, share

100/56 = Calcium oxide to carbonate conversion factor.

GHG emissions estimates for 2020-2022 are provided in **Table 5.7** and **Table 5.8**, and carbon dioxide emissions are summarized in **Table 5.9**.

Table 5.4 Carbon dioxide emission calculation, 2020-2022, kt (Plant 2)

CO_2 emissions calculation	2020	2021	2022
EFi = emission factor for the particular carbonate i, tonnes CO_2/tonne carbonate	0.43971	0.43971	0.43971
Mi =weight or mass of carbonate i consumed in the kiln, tonnes	681,919.1	761,894.2	933,839.3
Fi = fraction calcination achieved for carbonate i, fraction	1	1	1
Fd = fraction calcination achieved for CKD not recycled to kiln, fraction	1	1	1
CO_2 emissions, kt	299.847	335.013	410.618

Table 5.5 Carbon dioxide emission factors and calculation results, 2020-2022, kt (Plant 1)

CO_2 emissions calculation	2020	2021	2022
EFi = emission factor for the particular carbonate i, tonnes CO2/tonne carbonate	0.43971	0.43971	0.43971
Mi =weight or mass of carbonate i consumed in the kiln, tonnes	104,742.1	114,214.3	138,662.4
Fi = fraction calcination achieved for carbonate i, fraction	1	1	1
Fd = fraction calcination achieved for CKD not recycled to kiln, fraction	1	1	1
CO_2 emissions, kt	46.056	50.221	60.971

Table 5.6 CO_2 emissions from cement production, kt/y

Year	CO_2 emissions from cement production		
	Plant1	Plant 2	Total
2020	299.847	46.0562	345.903
2021	335.013	50.2212	385.234
2022	410.618	60.9713	471.590

Time series consistency and recalculations

For this category, no recalculations have been made, and the time series is consistent.

Figure 5.3 provides CO_2 emissions from Cement production for 1990-2022.

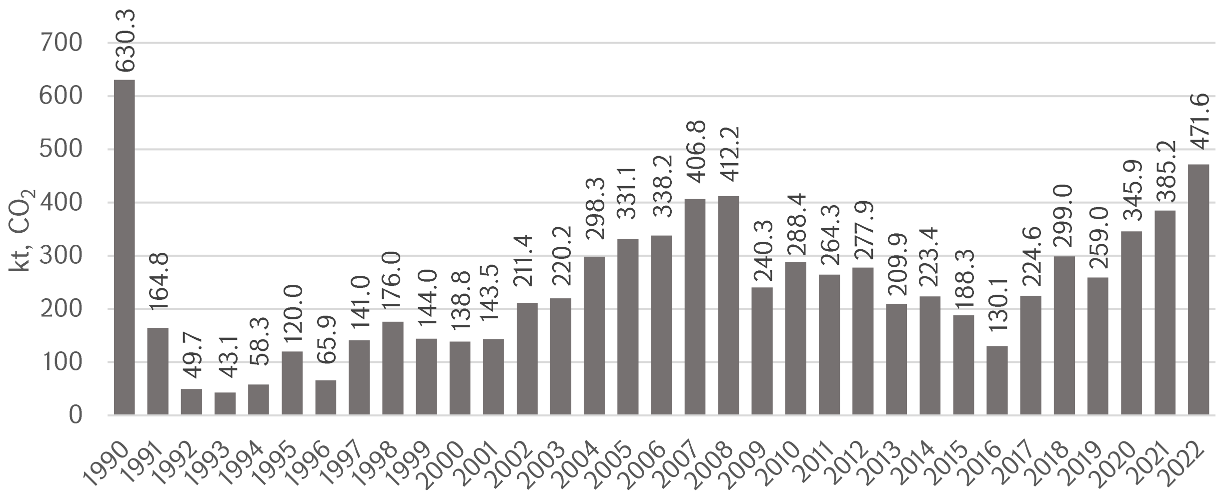

Figure 5.3 CO_2 emissions from Cement production, kt CO_2

CO_2 emissions from cement production are mainly driven by changes in construction volumes.

Thus, in 2000-2008 due to economic and, consequently, construction growth CO_2 emissions from cement production have been on a growth trend, which was followed by a sharp decline in 2009, caused by economic downturn. In 2010, construction recovery resulted in increased CO_2 emissions from cement production, and since 2012 the variance of CO_2 emissions is accounted for by changes in construction volumes. Thus, sharp decline of CO_2 emissions in 2015 and 2016 was due to the declining construction volumes recorded in those years.

It is noteworthy, that in 2018, a certain amount of the clinker produced was not used for cement production in the same year. These stockpiles were used for cement production in 2019, which led to reduced emissions in 2019.

2020 - 2022 emissions are increasing compared to previous years, driven by increased construction volumes, with the growth coming mainly from Plant 1.

Compared to 1990, the emission reductions for 2020, 2021, and 2022 are 45.1%, 38.9%, and 25.2%, respectively.

Uncertainty assessment

The uncertainties of activity data and emission factors were determined based on expert judgement as follows:

- Activity data: 5%
- Emission factors: 10 %

Combined uncertainty of the emissions estimate is 11.2%.

Category-specific QA/QC and verification

QC of the activity data has been done including technical review of the accuracy and completeness of the data. The discrepancies were discussed with the manufacturer's representatives, subsequently clarified and used for the calculations.

Other general and category-specific quality checks and quality assurance were carried out by sectoral experts in accordance with Armenia's QA/QC plan presented in Annex 7 of the inventory.

Category-specific planned improvements

No improvements are planned at present.

(2A2) Lime Production

Choice of method

Calcium oxide (CaO or quicklime) is formed by heating limestone to decompose the carbonates. This is usually done in shaft or rotary kilns at high temperatures and the process releases CO_2.

Carbon dioxide emissions from lime production were calculated by applying Tier 1 approach from 2006 IPCC Guidelines. The Tier 1 method is based on applying a default emission factor to national level lime production data (Volume 3, Chapter 2, Equation 2.6):

Activity data, emission factors and other parameters

The quantities of lime produced were taken from the SC (Ref-1).

Lime production data: 2020 - 50,183.2 t, 2021 - 53,530 t, 2022 - 23,113.0 t.

Time series consistency and recalculations

No recalculations have been made for this category, and the time series is consistent.

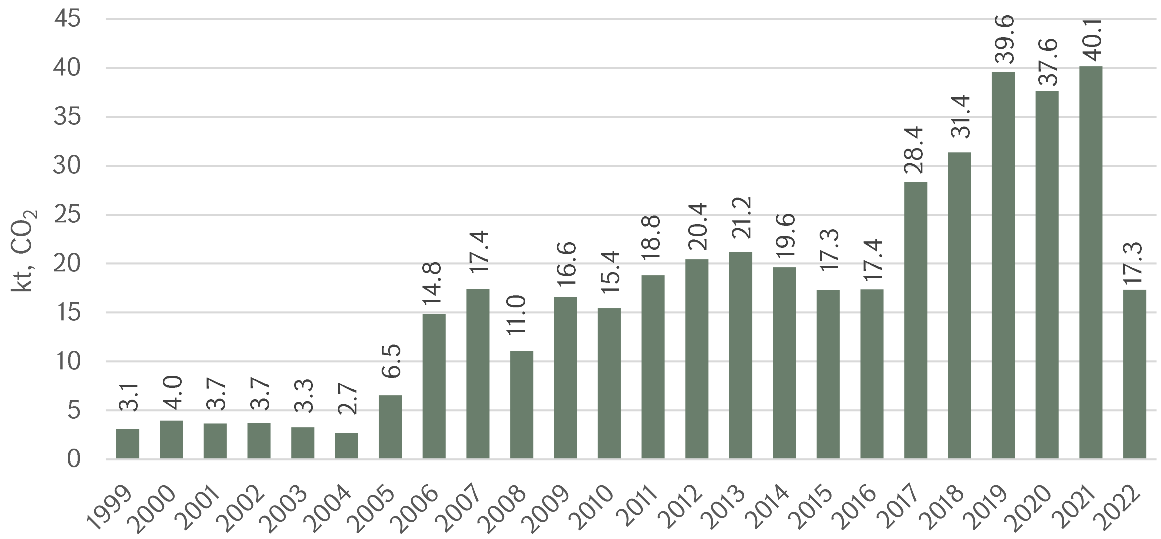

Figure **Figure 5.4** provides CO_2 emissions from Lime production for 1990-2022.

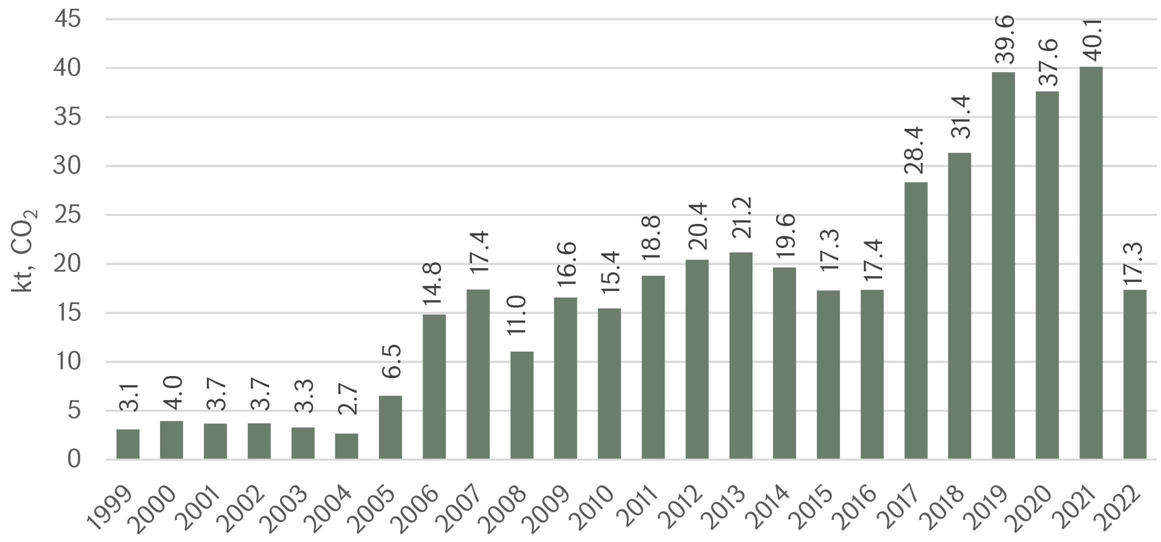

Figure 5.4 CO_2 emissions from Lime production, kt CO_2

Carbon dioxide emissions from lime production are growing dynamically, but a drastic decline was observed in 2022. It can be assumed that in previous years a certain amount of lime was accumulated (thus, in 2020 carbon dioxide emissions from lime production recorded the highest value) and was subsequently used in 2022.

Uncertainty assessment

The Uncertainty values for activity data and emission factors are based on expert judgment:

- Activity data: 5%
- Emission factors: 6%

The uncertainty of GHG emissions from this category were calculated according to the 2006 IPCC Guidelines (Volume 1, Equation 3.1) and equal 7.8%.

Category-specific QA / QC and verification

The general and category-specific quality checks and quality assurance were carried out by sectoral experts in accordance with Armenia's QA/QC plan presented in Annex 7 of the inventory.

Category-specific planned improvements

No improvements are planned at present.

(2A3) Glass Production

Choice of method

Armenia's glass industry produces container glass. Currently there is one glass producer in Armenia.

The process-related CO_2 emissions under consideration are released from the raw-material carbonates during the melting process in the furnace. CO_2 emissions (the main pollutant) are calculated applying Tier 1 method according to the 2006 IPCC Guidelines (Volume 3, Chapter 2, Equation 2.10).

Activity data, emission factors and other parameters

Tier 1 applies a default emission factor, based on a ‘typical’ raw material mixture, to national glass production data. A ‘typical’ soda-lime batch might consist of sand (56.2 weight percent), feldspar (5.3 percent), dolomite (9.8 percent), limestone (8.6 percent) and soda ash (20.0 percent). Based on this composition, one metric tonnes of raw materials yield approximately 0.84 tonnes of glass, losing about 16.7 percent of its weight as volatiles, in this case virtually entirely CO2.

According to the Equation 2.13 [Volume 3, Chapter 2], Tier 1 default emission factor for glass production is:

EF = 0.167 / 0.84 = 0.20 t CO_2 / t glass.

Activity data for emission assessment were obtained directly from the manufacturing company. (IndRef-3).

Mass of glass produced and cullet ratio used are provided in the **Table 5.10.**

Table 5.10 Mass of glass produced and cullet ratio used

Year	Mass of glass produced, t	Cullet ratio, %
2020	53.598	29
2021	54.005	30
2022	55.102	30

Time series consistency and recalculations

No recalculations have been made for this category, and the time series is consistent.

Figure 5.5 provides CO_2 emissions from Glass production for 1990-2022.

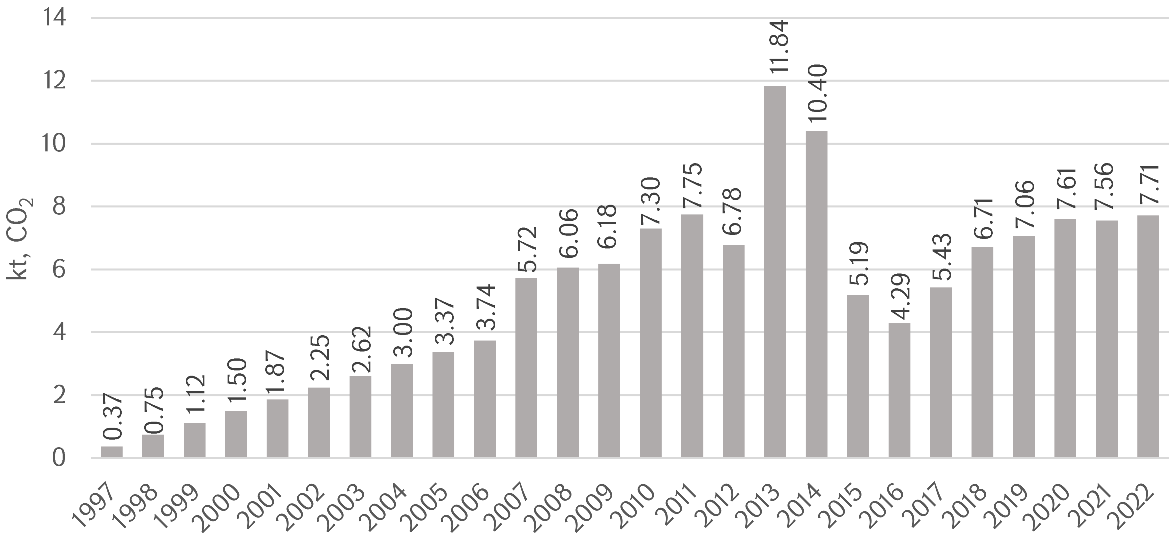

Figure 5.5 CO_2 emissions from Glass production, kt CO_2

Carbon dioxide emissions from glass production have increased by 5 times since 2000, due to increased construction volumes.

Uncertainty assessment

According to 2006 IPCC Guidelines (Volume 3, Chapter 2.4.2.1), uncertainty associated with the use of Tier 1 emission factor and cullet may be on the order of +/- 60%. In this report cullet ratio provided by the glass producer was used, therefore the level of uncertainty is lower.

The Uncertainty values for activity data and emission factors are based on expert estimates:

- Activity data: 5 %
- Emission factors: 40 %

The uncertainty of GHG emissions from this category were calculated according to the 2006 IPCC Guidelines (Volume 1, Equation 3.1) and equal to 40.3%.

Category-specific QA / QC and verification

The general and category-specific quality checks and quality assurance were carried out by sectoral experts in accordance with Armenia's QA/QC plan presented in Annex 7 of the inventory.

Category-specific planned improvements

No improvements are planned at present.

(2C) Metal Industry

(2C1) Iron and Steel Production

Choice of method

In Armenia Steel production occur at secondary facilities, which produce steel mainly from recycled steel scrap in electric arc furnaces (EAF).

CO_2 emissions from steel production are calculated applying Tier 1 approach according to the 2006 IPCC Guidelines (Volume 3, Chapter 4, Equation 4.4). The Tier 1 approach for emissions from iron and steel production is to multiply default emission factors by national production data, as shown in Equation 4.4.

Activity data, emission factors and other parameters

The quantity of steel produced were taken from the Statistical Yearbook of Armenia (Ref-1).

Emission factor equals to 0.08 tonnes CO_2/tonne of steel produced, (Vol.3, Chapter 4, Table 4.1)

Time series consistency and recalculations

No recalculations have been made for this category, and the time series is consistent.

Figure 5.6 provides CO_2 emissions from secondary steel production.

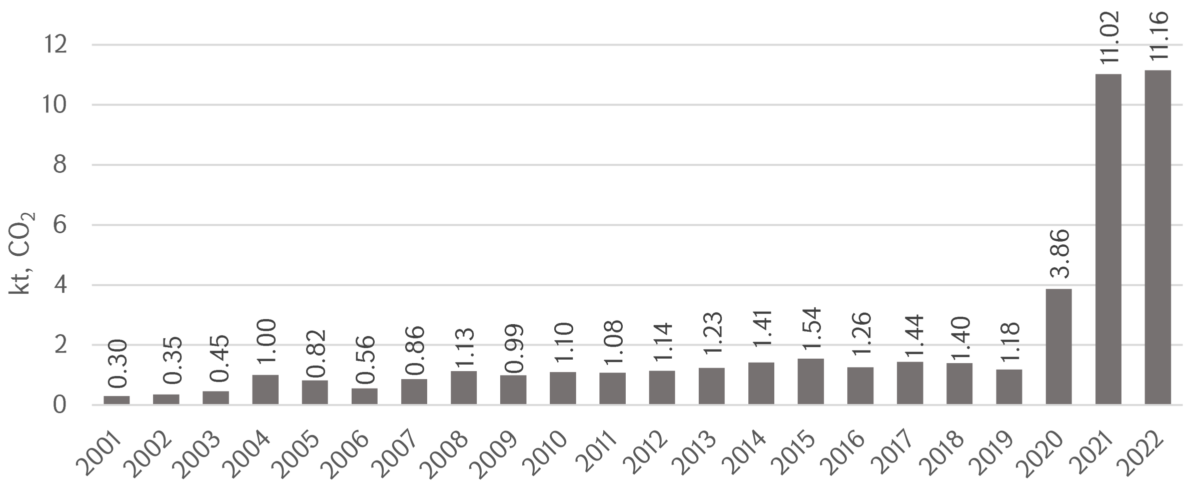

Figure 5.6 CO_2 emissions from Secondary Steel production, kt CO_2

Until 2001, there was no secondary steel production in Armenia.

Due to the lack of raw materials (scrap metal), secondary steel production was very low. After the scrap export ban in 2019, the amount of scrap metal increased sharply, leading to a sharp increase in production and, consequently, CO_2 emissions.

Uncertainty assessment

Uncertainties in estimating greenhouse gas (CO_2) emissions from steel production are related to uncertainties in activity data and the default emission factors.

According to the 2006 IPCC Guidelines, for Tier 1 method the following values for uncertainties were applied (Volume 3, Chapter 4, Table 4.4):

- Activity data: ± 10%
- Emission factors: ± 25%

The uncertainty of GHG emissions from this category were calculated according to the 2006 IPCC Guidelines (Volume 1, Equation 3.1) and equal to 26.9%.

Category-specific QA / QC and verification

The general and category-specific quality checks and quality assurance were carried out by sectoral experts in accordance with Armenia's QA/QC plan presented in Annex 7 of the inventory.

Category-specific planned improvements

No improvements are planned at present.

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

(2D1) Lubricant Use

Choice of method

Lubricants are mostly used in industrial and transportation applications. Lubricants are produced either at refineries through separation from crude oil or at petrochemical facilities. They can be subdivided into (a) motor oils and industrial oils, and (b) greases, which differ in terms of physical characteristics (e.g., viscosity), commercial applications, and environmental fate.

The use of lubricants in engines is primarily for their lubricating properties and according to the 2006 IPCC Guidelines associated emissions are therefore considered as non-combustion emissions to be reported in the IPPU Sector (Volume 3, Chapter 5.2).

Emissions from the use of lubricants were estimated according to the 2006 IPCC Guidelines applying Tier 1 method. Tier 1 method relies on applying one default Oxidized During Use (ODU) factor to total lubricant activity data.

CO_2 emissions are calculated according to Equation 5.2 (Volume 3, Chapter 5.2) with aggregated default data for the limited parameters available and the ODU factor based on a default composition of oil and greases in total lubricant figures (in TJ units).

Activity data, emission factors and other parameters

Activity data were taken from the RA Energy balances (non-energy consumption).

According to the 2006 IPCC Guidelines, having only total consumption data for all lubricants (i.e., no separate data for oil and grease), the weighted average ODU factor for lubricants as a whole is used as default value in the Tier 1 method. Assuming that 90 percent of the mass of lubricants is oil and 10 percent is grease, applying these weights to the ODU factors for oils and greases yields an overall (rounded) ODU factor of 0.2 (Volume 3, Chapter 5.2, Table 5.2). This ODU factor can then be applied to an overall carbon content factor, which may be country-specific or the default value for lubricants to determine national emission levels from this source when activity data on the consumption of lubricants is known (Equation 5.2).

Time series consistency and recalculations

No recalculations have been made for this category, and the time series is consistent.

Figure 5.7 provides CO_2 emissions from lubricant use for 1990-2022.

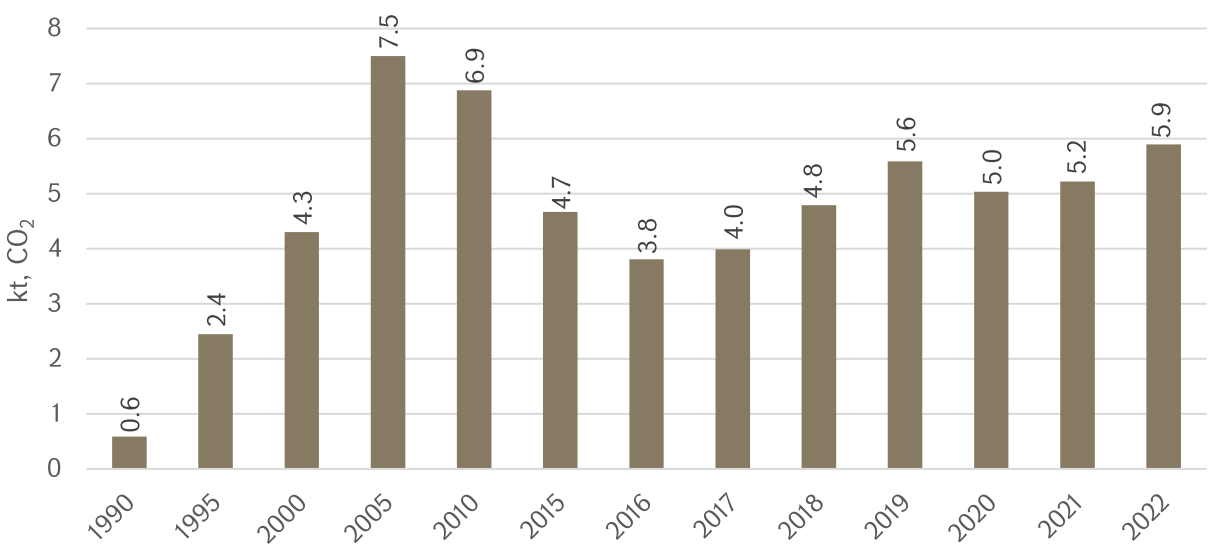

Figure 5.7 CO_2 emissions from Lubricant use, kt CO_2

Emissions from the use of lubricants have been relatively stable in recent years.

Uncertainty assessment

The default ODU factors developed are very uncertain, as they are based on limited knowledge of typical lubricant oxidation rates. 2006 IPCC Guidelines suggests (Expert judgment) using a default uncertainty of 50 percent (Volume 3, Chapter 5.2.3).

According to the 2006 IPCC Guidelines, the carbon content coefficients are based on two studies of the carbon content and heating value of lubricants, from which an uncertainty range of about ±3 percent is estimated (U.S.EPA, 2004)

Much of the uncertainty in emission estimates is related to the difficulty in determining the quantity of non-energy products used in individual countries.

According to the 2006 IPCC Guidelines, a default of 5 percent may be used in countries with well-developed energy statistics (Volume 3, Chapter 5.2.3).

Considering that Armenia has well-developed energy statistics - Energy Balances, which serve as activity data source, a default value of 5 percent was used according to the 2006 IPCC Guidelines.

Therefore, the following uncertainty values have been used for calculations:

- Activity data: 5%
- Emission factors: 50%

The uncertainty of GHG emissions from this category were calculated according to the 2006 IPCC Guidelines (Volume 1, Equation 3.1) and equal to 50.2%.

Category-specific QA / QC and verification

The RA Energy Balance activity data on lubricant Use (non-energy consumption) were verified with import values, according to the RA foreign trade statistics (according to the 10-digit classification of the commodity nomenclature of the EAEU foreign economic activity), published by the RA SC.

Other general and category-specific quality checks and quality assurance were carried out by sectoral experts in accordance with Armenia’s QA/QC plan presented in Annex 7 of the inventory.

Category-specific planned improvements

No improvements are planned at present.

(2D2) Paraffin Wax Use

Choice of method

Waxes are used in a number of different applications. Paraffin waxes are used in applications such as: candles, corrugated boxes, paper coating, board sizing, food production, wax polishes, surfactants (as used in detergents) and many others.

Emissions from the use of paraffin were estimated according to the 2006 IPCC Guidelines applying Tier 1 method (Volume 3, Chapter 5.3, Equation 5.4). Tier 1 method relies on applying default emission factors to activity data.

Activity data, emission factors and other parameters

Activity data were taken from the RA Energy balances (non-energy consumption) (Ref-4).

According to the 2006 IPCC Guidelines, default carbon content of 20.0 kg C/GJ was applied. (Table 1.3, Chapter 1, Volume 2).

It was assumed that 20 percent of paraffin waxes are used in a manner leading to emissions, mainly through the burning of candles, leading to a default ODU factor of 0.2 (Volume 3, Chapter 5.3, Equation 5.4).

Time series consistency and recalculations

CO_2 emissions from *(2D2) Paraffin Wax Use* were recalculated for the entire time period due to the adjustment of activity data. This resulted in a change of emissions in 2019 by 17% and in 2017 - by 16 %.

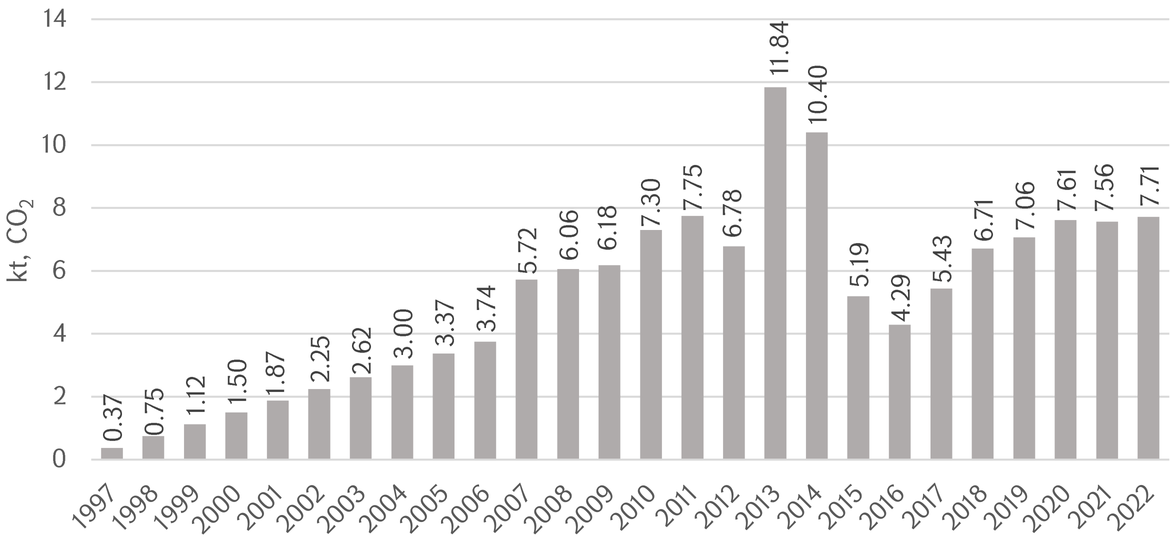

Figure 5.8 provides CO_2 emissions from paraffin wax use for 1990-2022.

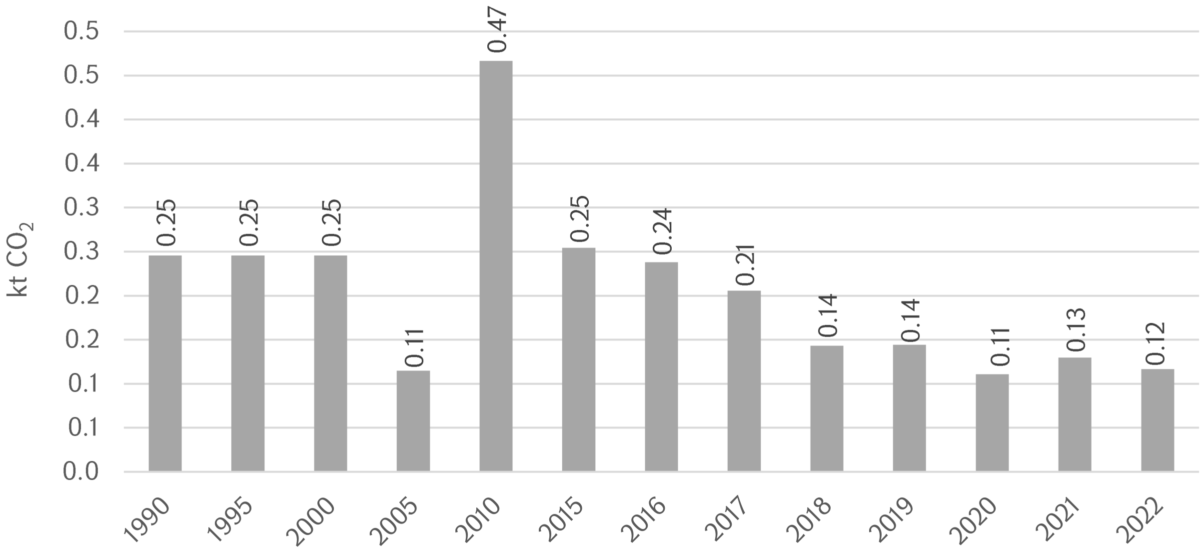

Figure 5.8 CO_2 emissions from Paraffin Wax use, kt CO_2

Uncertainty assessment

Emission Factor Uncertainties

The default emission factors are highly uncertain because knowledge of national circumstances of paraffin wax fates is limited.

According to the 2006 IPCC Guidelines, the default carbon content coefficient is subject to an uncertainty range of ±5 percent (U.S.EPA, 2004). However, the ODU factor is highly dependent on specific-country conditions and policies and the default value of 0.2 exhibits an uncertainty of about 100 percent (Volume 3, Chapter 5.3.3).

Activity Data Uncertainties

Much of the uncertainty in emission estimates is related to the difficulty in determining the quantity of non-energy products used and discarded in individual countries.

According to the 2006 IPCC Guidelines, a default of 5 percent may be used in countries with well-developed energy statistics (Volume 3, Chapter 5.3.3). As Armenia has well-developed energy statistics, reported through the national Energy Balances, serving as activity data source, a default value of 5 percent was used.

Therefore, the following uncertainty values have been used for calculations:

- Activity data: 5%
- Emission factors: 50%

The uncertainty of GHG emissions from this category was calculated according to the 2006 IPCC Guidelines (Volume 1, Equation 3.1) and equal to 50.2%.

Category-specific QA / QC and verification

The RA Energy Balance activity data (non-energy consumption) were cross-checked with import values, according to the RA foreign trade statistics (according to the 10-digit classification of the commodity nomenclature of the EAEU foreign economic activity), published by the RA SC.

Other general and category-specific quality checks and quality assurance were carried out by sectoral experts in accordance with Armenia's QA/QC plan presented in Annex 7 of the inventory.

Category-specific planned improvements

No improvements are planned at present.

Summary of CO_2 emissions in IPPU sector

Table 5.11 and **Figure 5.9** provide CO_2 emissions time series from the IPPU sector by categories, 1990-2022, kt.

Table 5.11 CO_2 emissions time series from the IPPU sector by categories, 1990-2022, kt

Category/Year	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022
2.A Mineral industry	**630.33**	**120.00**	**144.30**	**341.02**	**311.14**	**210.74**	**151.80**	**258.34**	**337.04**	**305.61**	**391.15**	**432.94**	**496.64**
2.A.1 Cement production	630.33	120.00	*138.85*	*331.11*	*288.39*	188.25	130.15	224.55	298.97	258.95	345.90	385.23	471.59
2.A.2 Lime production			*3.95*	*6.53*	*15.45*	17.30	17.36	28.35	31.36	39.59	37.64	40.15	17.33
2.A.3 Glass production			*1.50*	*3.37*	*7.30*	5.19	4.29	5.43	6.71	7.06	7.61	7.56	7.71
2.C Metal industry				**0.82**	**1.10**	**1.54**	**1.26**	**1.44**	**1.40**	**1.185**	**3.86**	**11.02**	**11.16**
2.C.1 Iron and steel production				0.82	1.10	1.54	1.26	1.44	1.40	1.185	3.86	11.02	11.16
2.D Non-energy products from fuels and solvent use	**0.835**	**2.692**	**4.549**	**7.617**	**7.342**	**4.921**	**4.045**	**4.197**	**4.933**	**5.732**	**5.15**	**5.3499**	**6.011**
2.D.1 Lubricant use	0.589	2.446	4.303	7.502	6.876	4.667	3.807	3.991	4.790	5.588	5.04	5.2199	5.894
2.D.2 Paraffin wax use	0.246	0.246	0.246	0.115	0.466	0.254	0.238	0.206	0.143	0.144	0.111	0.130	0.117
Total	**631.2**	**122.7**	**148.8**	**349.5**	**319.6**	**217.2**	**157.1**	**264.0**	**343.4**	**312.5**	**400.2**	**449.3**	**513.8**

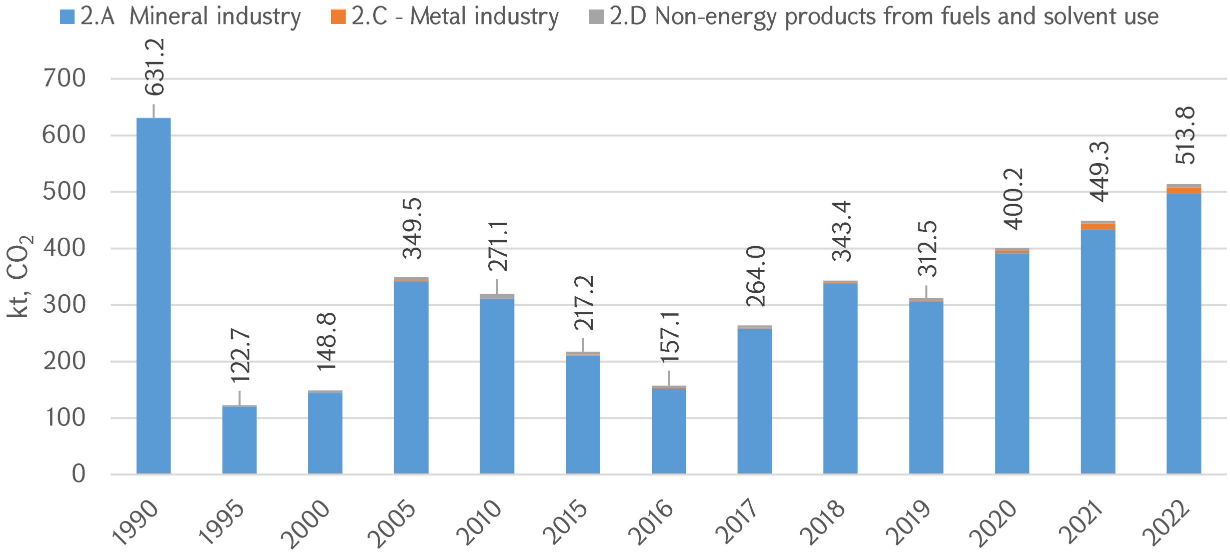

Figure 5.9 CO_2 emissions time series from the IPPU sector by categories, 1990-2022, kt CO_2

(2F) Product Uses as Substitutes for Ozone Depleting Substances

Overview of the category

In Armenia, as well as globally, Hydrofluorocarbons (HFCs) are used as alternatives to ozone depleting substances (ODS) which are being phased out under the Montreal Protocol. By ratifying the *Vienna Convention for the Protection of the Ozone Layer* and the *Montreal Protocol on Substances that Deplete the Ozone Layer,* Armenia has taken commitments to phase out ODS.

In 2019, the Republic of Armenia ratified the Kigali amendment to the Montreal Protocol "On Substances that Deplete the Ozone Layer" of the Vienna Convention "On Protection of the Ozone Layer", thereby committing to reduce the use of Hydrofluorocarbons.

Armenia has never had domestic production of HFCs. The country imports them as chemicals from UAE, occasionally from Iran and Turkey, while they are contained in products or equipment (sub-applications) imported from a large number of other countries.

Armenia started importing products and equipment containing HFCs after 2005, when the country launched its first country program for the phase-out of CFCs, although such imports had begun in small quantities since 2000. Iin particular: Armenia adopted the Law on Substances that Deplete the Ozone Layer and sub-legislative acts for ensuring enforcement of the Law; later, Armenia limited CFC import and completely banned it in 2010. In parallel, the country launched HCFCs phase-out program. All these measures resulted in a sharp increase of the import of equipment with HFCs since 2010.

From all HFCs, HFC-134a has the widest application area, due to its multifunctional character: it is widely used both as an individual chemical and a blend (R-404A, R-410A, R-407C) component in all sub-applications of RAC which is the country's HFC key application area, and is also contained in aerosols as a propellant and in foam blowing as a foam blowing agent.

Table 5.12 HFCs application areas in Armenia

HFCs	Refrigeration and Air Conditioning	Aerosols (propellant)	Foam Blowing Agents	Fire Protection
HFC-134a	x	x	x	
HFC-32	x			
HFC-125	x			
HFC-143a	x			
HFC-227ea				x
HFC-245fa			x	
HFC-365mfc			x	
HFC-152a		x	x	

(2F1) Refrigeration and Air Conditioning (RAC)

Choice of method

Refrigeration and Air Conditioning category is divided into the sub-applications of commercial refrigeration, domestic refrigeration, industrial refrigeration, transport refrigeration, mobile and stationary air conditioning systems.

Since the average filling volumes of industrial refrigeration systems operating in the domestic market and medium and large commercial systems are close, and taking into account the market features and the similarities in maintenance methods of this equipment, as well as the fact that industrial refrigeration systems are assembled in the local market, industrial refrigeration are considered in the medium and large commercial refrigeration sub-application.

Since RAC is defined as a key application within the category and disaggregated activity data is available for calculations, HFCs emissions from RAC were estimated in accordance with the 2006 IPCC Guidelines using the Tier 2a method – Emission-factor approach (estimation performed at a disaggregated level with country-specific data by sub-application and a default emission factor selected by sub-application from the 2006 IPCC Guidelines).

In all RAC sub-applications, emissions were calculated using the Equations 7.10 - 7.14 (Volume 3, Chapter 7) and the emission factors provided in the Table 7.9 (Volume 3, Chapter 7). When selecting an emission factor, experts were guided by the country-specific conditions/characteristics for each sub-application.

In a Tier 2a calculation, refrigerant emissions at a year t from each of the six sub-applications of refrigeration and air conditioning systems are calculated separately. These emissions result from:

$E_{containers,t}$ = emissions related to the management of refrigerant containers

$E_{charge,t}$ = the emissions of refrigerant due to the charging process of new equipment are related to the process of connecting and disconnecting the refrigerant container to and from the equipment when it is initially charged

$E_{lifetime,t}$ = annual emissions from the banks of refrigerants associated with the six sub-applications during operation (fugitive emissions and ruptures) and servicing

$E_{end\text{-}of\text{-}life,t}$ = amount of HFC emitted at system disposal in year t, kg

All these quantities are expressed in kilograms and have been calculated for each type of HFC used in the six different sub-applications.

$E_{total,t} = E_{containers,t} + E_{Charge,t} + E_{lifetime,t} + E_{end-of-life,t}$ (Equation 7.10, Volume 3, Chapter 7)

Activity data, emission factors and other parameters

Data on the quantities of imported fluorinated substitutes for ODS (F-gases), as well as on goods containing them classified by the country of origin have been received from the RA State Revenue Committee (SRC) in response to the official inquiry of the RA Ministry of Environment (IndRef-4).

Refrigerant management of containers: The emissions related to the refrigerant container management comprise all the emissions related to the refrigerant transfers from bulk containers down to small capacities. Emission factor of HFC container management (c) of the current refrigerant market estimated to be 10 percent for all sub-applications (Volume 3, Chapter 7, Equation 7.11).

Refrigerant charge emissions of new equipment: The emissions of refrigerant due to the charging process of new equipment are related to the process of connecting and disconnecting the refrigerant container to and from the equipment when it is initially charged. Since there are no relevant production in Armenia, emissions during system manufacture/assembly $E_{charge,\,t} = 0$, with the exception of large and medium commercial and industrial refrigeration, as large and medium commercial and industrial refrigeration equipment is imported not charged with refrigerant.

Emissions during lifetime (operation and servicing) and Emissions at end-of-life: Annual leakage from the refrigerant banks represents fugitive emissions, i.e., leaks from fittings, joints, shaft seals, which is calculating based on the amount of HFC banked in existing systems in year t (per sub-application) and annual emission rate (i.e., emission factor) of HFC of each sub-application bank during operation, accounting for average annual leakage and average annual emissions during servicing, percent. The amount of refrigerant released from decommissioned systems depends on the amount of refrigerant left at the time of disposal, and the portion recovered, which was calculated using default emission factors provided in the Table 7.9 (V 3, Ch 7). These parameters are provided below for each application separately.

Stand-alone Commercial Applications

According to the expert judgement, 18% of refrigeration equipment imported into the country are stand-alone commercial systems: 50% of which work on R-134a and 50% on R-404A. The average refrigerant charge of each equipment was estimated to be 1 kg.

The emission factor for equipment operation (EFx) lie within the range proposed in Vol. 3, Table 7.9 of the 2006 IPCC Guidelines and equal to 15 %.

The average lifetimes are 15 years.

The residual charges, with respect to initial charge (p), average is 40%.

50% of emissions calculated for this sub-application are due to R-134a and 50% - to refrigerant blend R-404A (HFC-125-44% / HFC-143a-52% / HFC-134a-4%).

Medium and Large commercial and industrial refrigeration

According to the expert judgement, 2% of all the imported refrigeration equipment are large and medium-sized commercial and industrial refrigeration equipment, which arrive in the country with no refrigerant charged in.

After installation, 20% of them were charged with R-134a and 80% - with R-404A. Average refrigerant charge for each equipment was estimated to be 11 kg.

The EF_{use} used lie within the range proposed in Vol. 3, Table 7.9 of the 2006 IPCC Guidelines and equal to 35 %.

The EF_k used lie within the range proposed in Vol. 3, Table 7.9 of the 2006 IPCC Guidelines and equal to 3 %.

Initial Charge Remaining (p) is 70%, lie within the range proposed in Vol. 3, Table 7.9 of the 2006 IPCC Guidelines.

20% of the emissions calculated for this application are caused by R-134a and 80% by the refrigerant mixture R-404A.

Domestic Refrigeration

Since no domestic production takes place, no domestic production emissions occur.

According to the expert judgement, 80% of all refrigeration equipment imported to Armenia in 2022 are domestic refrigerators, 60% of which operate with HC-600aand 40% - on HFC-134a. The average amount of refrigerant contained in each household refrigerator was estimated by expert judgement to be 120 g.

EFx = annual emission rate (i.e., emission factor) during operation, accounting for average annual leakage and average annual emissions during servicing, percent, estimated to be 2% based (expert judgement), due to improper handling and maintenance of the equipment.

The average lifetimes are 20 years.

Transport Refrigeration

As per expert judgements, 5% of trucks imported into Armenia are fitted with refrigeration equipment - 50% of them work on R-134a and the other 50% - on R-404A. Average refrigerant quantities were estimated to be 7 kg.

The EFuse used lie within the range proposed in Vol. 3, Table 7.9 of the 2006 IPCC Guidelines and equal to 50 %.

The average lifetimes are 9 years.

The residual charges (p), average is 45%.

50% of the total emissions from this sub-application fall to R-134a and the other 50% - to R-404A (HFC-125-44% / HFC-143a-52% / HFC-134a-4%).

Mobile air-conditioning

As per expert judgements, 80% of cars imported into Armenia have air-conditioning systems based on R-134a. The average refrigerant charge for each mobile air-conditioner was estimated to be 700 g.

The EFuse used lie within the range proposed in Vol. 3, Table 7.9 of the 2006 IPCC Guidelines and equal to 20 %.

The average lifetimes prior to disposal are 12 years.

The residual charges (p), average is 45%, lie within the range proposed in Vol. 3, Table 7.9 of the 2006 IPCC Guidelines.

Stationary Air Conditioning

As per expert judgements, in 2022, 20% of the total number of imported air conditioning equipment operates with R-134a, 30% - with R-407C, and 50% - with R-410A.

Taking into consideration that this sub-application includes window air-conditioners, split air-conditioning systems, chillers, central systems with heat exchangers and others, the average refrigerant charge for each air conditioning equipment is estimated by expert judgement to be 2 kg.

EFx estimated to be 20 %, due to improper handling and maintenance of the equipment.

The average lifetimes are 20 years.

Initial charge remaining (p), average is 40%, lie within the range proposed in Vol. 3, Table 7.9 of the 2006 IPCC Guidelines.

For this sub-application 20% of all the emissions fall to R-134a, 30 % - for blend R-407C (HFC-32-23% / HFC-125-25% / HFC-134a-52%) and 50% - for blend for 410A (HFC-32-50% / HFC-125-50%).

Time series consistency and recalculations

The time series of HFC emissions from RAC applications have been recalculated for the entire period. In the previous inventory reports, the software allowed data entry for only 2 specific sub-applications: (2.F1.a) Refrigeration and Stationary Air Conditioning and (2.F1.b) Mobile Air Conditioning.

That is, all data collected in the applications Domestic Refrigeration, Medium & Large Commercial Refrigeration, Stand-alone Commercial Applications, Transport Refrigeration and Residential and Commercial A/C were entered into a software in subcategory 2.F1.a, and the average annual emission factors were estimated for every refrigerant used in the sub-application.

Instead, emissions for these sub-applications are currently calculated for each sub-application using the appropriate factors provided in the 2006 Guidelines.

HFCs emissions from the *RAC* application are provided in **Figure 5.10.**

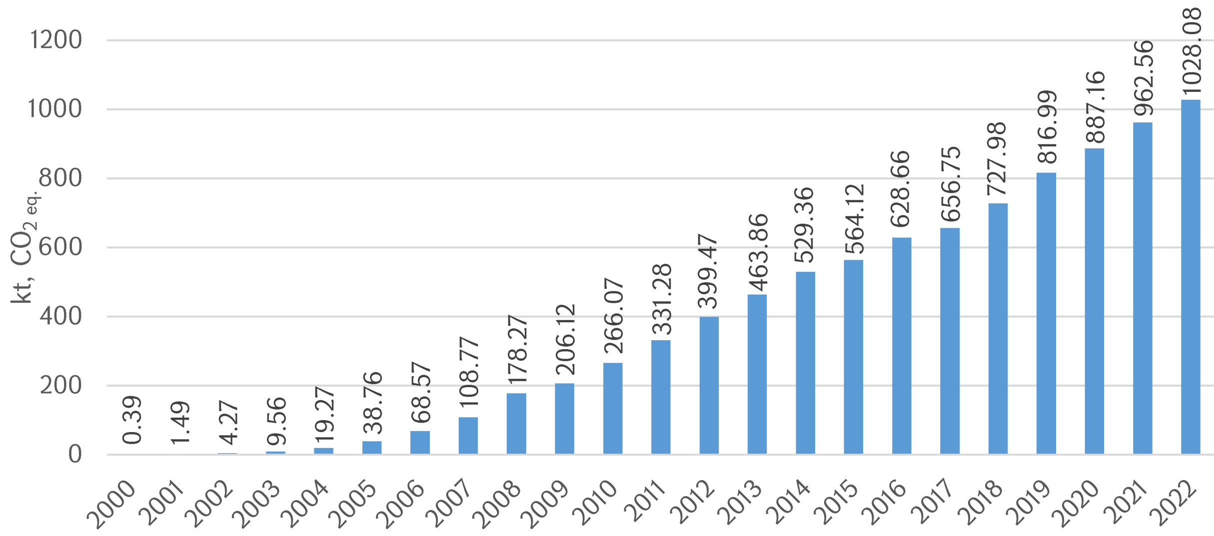

Figure 5.10 HFCs emissions time series from the *RAC* application, kt $CO_{2\ eq.}$, 2000-2022

As shown in Figure 5.10, emissions from *RAC* application have grown continuously and markedly - from 2006 to 2022, they increased by about 15 times as F-gases were used to replace ozone depleting substances in many refrigeration and cooling devices and applications. This is because, in Armenia, as well as globally, and particularly in developing countries, HFCs are still considered the main substitutes for CFCs and HCFCs regulated under the Montreal Protocol, despite the active campaign to use natural refrigerants (mainly, ammonia, carbon dioxide, and carbon) as alternatives to ODS.

Uncertainty assessment

In the *RAC* application area activity data were collected by sub-applications (Tier 2a approach) which already ensures their relatively low uncertainty. The activity data collected were cross-checked with the other official data published by the SC. As a result, activity data uncertainty for the application was estimated to be 30%.

For *RAC* emissions calculations the inventory compilers used the default emission factors provided in the 2006 IPCC Guidelines. Since the factors might differ from the country-specific ones, the average uncertainty of the emission factors was estimated as 25%.

The uncertainty of GHG emissions from this category was calculated according to the 2006 IPCC Guidelines (Volume 1, Equation 3.1) and equal to 39.1%.

Category-specific QA / QC and verification

Customs codes sometimes indicate very broad category of goods and the information obtained from the State Revenue Committee is sometimes very general and is not sufficient to track specific equipment, the type of chemical in the product and its quantity.

The import figures for Armenia are available, on an annual basis, from the publicly accessible statistics of the RA SC. Thus, starting from 2018, SC publishes statistics on Foreign Trade of the Republic of Armenia (According to the EEU Commodity Nomenclature of External Economic Activity at 10-digit level).

So, data on the refrigerants containing imported equipment and refrigerants imported in bulk were crosschecked and clarified with the data from statistics on Foreign Trade of the Republic of Armenia.

In addition, the data has undergone expert analysis, in view of country-specific conditions of each sub-application.

There are also some small companies in the country, assembling stand-alone, medium-sized and large commercial refrigeration equipment. However, since they get their product just by putting together individual components imported into the country, it was decided not to hold separate calculations of the amount of HFCs used in this process, but include them in calculations on the quantities of refrigeration equipment imported during the reporting period

Other general and category-specific quality checks and quality assurance were carried out by sectoral experts in accordance with Armenia's QA/QC plan presented in Annex 7 of the Inventory.

Category-specific planned improvements

The following survey and research activities are planned:

- Data collection from the field to break down data into the sub-applications by equipment type, as HFC emissions vary widely depending on the type of equipment
- Survey on the refrigerants used and on average refrigerant quantities per sub-application
- Review of statistical data and literature on emission factors used for each sub-application
- Survey to distinguish the refrigerant sold into different sub-applications so that only refrigerant sold for the given sub-application is used in the calculations.

(2.F.2) Foam Blowing Agents

Choice of method

Due to the lack of disaggregated activity data on the application, Tier 1a approach was applied for emissions assessment.

In this report emissions from *Foam Blowing Agents* application were estimated based on the approach provided in 2006 IPCC Guidelines: the amounts of HFCs were calculated for each type of the foam product imported into the country. Though this approach for emissions calculation can't be considered as of a higher tier, it allows getting a more realistic and complete view of the situation.

Activity data, emission factors and other parameters

Activities conducted under this report enabled to obtain data on HFC-134a, HFC-245fa, HFC-365mfc HFC-152a contained in the closed-cell foams imported into the country for further insulation applications. Here, they mainly substitute formerly used CFC-11, as well as HCFC-141b contained in imported foam.

Emissions estimate was done based on the amount of the imported foam product provided by the RA State Revenue Committee (Ref-5; IndF.Ref-4).

Emissions from closed-cell foams were calculated according to the 2006 IPCC Guidelines (Vol 3, Ch 7.4, Equation 7.7).

First, the amount of imported closed-cell foam was estimated based on data provided by the RA GA SRC. Then, based on a number of foreign articles and studies, the quantities of the HFCs (by chemicals) contained in the imported foam were calculated by foam sub-applications. The emission factor for first-year loss (EFFYLL) was considered to be equal to 0 assuming that the emissions had been released in the producing country before the foam crossed the borders of Armenia, and the annual emissions factor (EFAL) caused by the loss was estimated as 4.5% (Volume 3, Chapter 7.4, Table 7.7).

Time series consistency and recalculations

No recalculations have been made for this category, and the time series is consistent.

Figure 5.11 provides HFC emissions from *Foam Blowing Agents.*

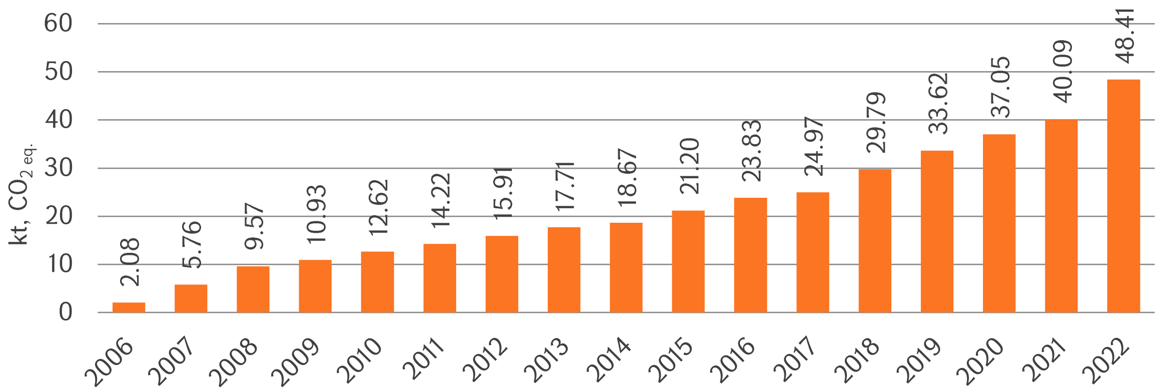

Figure 5.11 HFC emissions from *Foam Blowing Agents*, kt $CO_{2\ eq.}$

As can be seen from the Figure 4.23, emissions from the *Foam Blowing Agents* application are significantly lower compared to those from the *RAC* application. One of the reasons is that HFCs are not the only optimal substitutes for the ODS used here. Natural substances such as hydrocarbons and carbon dioxide are also used as alternatives in *Foam Blowing Agents*.

Uncertainty assessment

Data for *Foam Blowing Agents* were collected and calculated by using Tier 1a method. Emissions have been estimated based on data provided by the customs service, with almost no information from local consumers, which would have allowed for cross-checking of the data.

The Uncertainty values for activity data and emission factors are based on expert estimations:

- Activity data: 50%
- Emission factors: 25%

Uncertainty of GHG emissions from this category was calculated according to the 2006 IPCC Guidelines (Volume 1, Equation 3.1) and equal 55.9%.

Category-specific QA / QC and verification

The general and category-specific quality checks and quality assurance were carried out by sectoral experts in accordance with Armenia's QA/QC plan presented in Annex 7 of the inventory.

Category-specific planned improvements

No improvements are planned at present.

(2.F.3) Fire Protection

Choice of method

In fire extinguishers and other fire suppression systems, HFCs are used as both a propellant and an active substance. In this application area HFCs replace the halons previously used in fire suppression systems, such as Halon-1211 in portable fire extinguishers and Halon-1301 in fixed systems.

In Armenia, HFC-227ea is used in this application. It is used only in fire suppression automatic systems.

For *Fire Protection* application, emissions were calculated according to the 2006 IPCC Guidelines Tier 1 methodology (Volume 3, Chapter 7.6, Equation 7.17).

Activity data, emission factors and other parameters

Emissions in this application were estimated based on the data published by the RA Statistics Committee, as well as market research findings and judgements, estimates of a number of companies and specialists/experts.

The fraction of agent in equipment emitted each year equal to 4% according to the 2006 IPCC Guidelines (Volume 3, Chapter 7.6.2.2).

Recovery Release or Loss parameter, which represents emissions of agent during recovery, recycling or disposal at the time of removal from use of existing fire protection equipment in year t, is estimated to be 0% for Armenia due to few numbers of such fixed systems in the country and lack of data on the agent's recovery or recycling.

Time series consistency and recalculations

No recalculations have been made for this category, and the time series is consistent.

Figure 5.12 provides HFC emissions from *Fire Protection.*

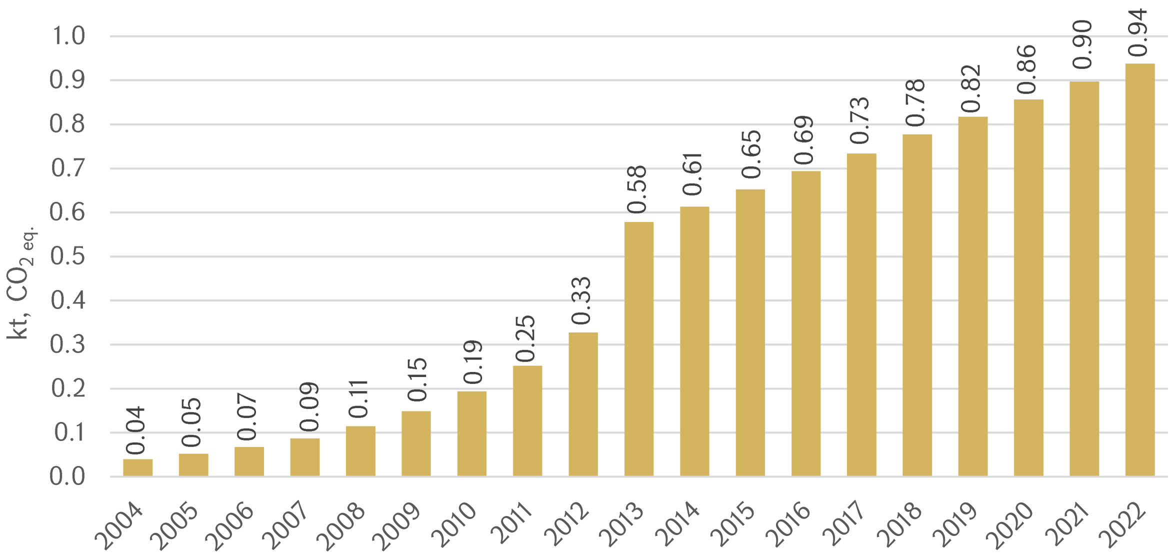

Figure 5.12 HFC emissions from *Fire Protection*, kt CO_2 eq.

HFCs emissions from the *Fire Protection* application are insignificant, because such natural substances as nitrous oxide, carbon dioxide and pressurized air serve as alternative ODS substitutes as well.

Uncertainty assessment

Taking into account the general 1A Method used for data collection and calculation, as well as the lack of data in this field, the uncertainty has been estimated by the expert judgement, as follows:

- Activity data: 40%
- Emission factors: 25%

The uncertainty of GHG emissions from this category were calculated according to the 2006 IPCC Guidelines (Volume 1, Equation 3.1) and equal to 47.2 %.

Category-specific QA / QC and verification

The general and category-specific quality checks and quality assurance were carried out by sectoral experts in accordance with Armenia's QA/QC plan presented in Annex 7 of the Inventory.

Category-specific planned improvements

No improvements are planned at present.

(2.F.4) Aerosols

Choice of method

Here HFCs are used as propellants or solvents. The following sub-applications exist in Armenia: Metered Dose Inhalers (MDIs), Personal Care Products (e.g., hair care, deodorants, shaving cream), Household Products (e.g., air-fresheners, oven and fabric cleaners) and Industrial Products (e.g., special cleaning sprays, aerosol paints).

The survey mainly covered the usage of HFCs exclusively as a propellant in aerosols and not as a solvent. Propellants used in aerosols imported by Armenia include: HFC-134a and HFC-152a, which mainly substitute not only CFC-12 formerly used in this sector but also CFC-11, and sometimes CFC-114. As a result of the survey no other HFCs were discovered.

HFCs emissions from *Aerosols* were calculated according to Equation 7.6 of the 2006 IPCC Guidelines (Volume 3, Chapter 7.3.2.1).

Activity data, emission factors and other parameters

The emissions assessment was done based on the aerosol products import data provided by the Customs Service of the RA State Revenue Committee (IndF.Ref-4).

The entire amount of the imported products, the average gross weight (the weight with a container) and the net weight (the weight without a container), were estimated based on the local market survey results and the experts' judgements.

A default emission factor of 50 percent of the initial charge per year for the broad spectrum of aerosol products was used when assessed at the application level (Tier 1a) (Volume 3, Chapter 7.3.2.2).

Time series consistency and recalculations

No recalculations have been made for this category, and the time series is consistent.

Figure 5.13 provides HFC emissions from *Aerosols*.

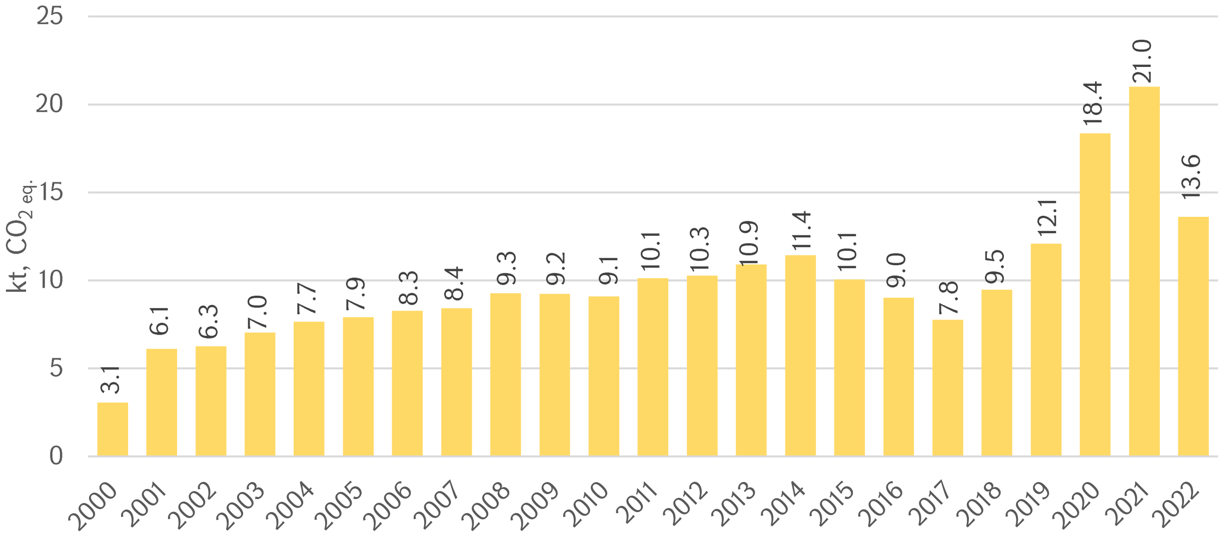

Figure 5.13 HFC emissions from *Aerosols*, kt $CO_{2\ eq.}$

Uncertainty assessment

The Uncertainty values for activity data and emission factors are based on expert judgement:

- Activity data: 30%
- Emission factors: 25%

The uncertainty of GHG emissions from this category were calculated according to the 2006 IPCC Guidelines (Volume 1, Equation 3.1) and equal to 39.1%.

Category-specific QA / QC and verification

The general and category-specific quality checks and quality assurance were carried out by sectoral experts in accordance with Armenia's QA/QC plan presented in Annex 7 of the Inventory.

Category-specific planned improvements

No improvements are planned at present.

Summary of HFC emissions in IPPU sector

Tables 5.13, Figure 5.14 and **Table 5.14** provide HFCs emissions time series by applications for 2000-2022 and Summary Report for HFC emissions (in tonnes and kt CO2 eq.) by chemicals and applications for 2022. **Figure 5.15** shows HFCs total emissions by application for 2022.

Table 5.13 HFCs emissions time series by applications for 2000-2022, kt $CO_{2\ eq.}$

Year	RAC kt CO_2 eq.	Aerosols kt CO_2 eq.	Foam Blowing Agents kt CO_2 eq.	Fire Protection kt CO_2 eq.	Total kt CO_2 eq.
2000	0.39	3.06	0	0	3.44
2001	1.49	6.12	0	0	7.60
2002	4.27	6.26	0	0	10.53
2003	9.56	7.03	0	0	16.59
2004	19.27	7.65	0	0.040	26.97
2005	38.76	7.90	0	0.052	46.71
2006	68.57	8.28	2.08	0.067	79.00
2007	108.77	8.43	5.76	0.087	123.04
2008	178.27	9.28	9.57	0.115	197.23
2009	206.12	9.24	10.93	0.149	226.43
2010	266.07	9.09	12.62	0.194	287.97
2011	331.28	10.13	14.22	0.252	355.88
2012	399.47	10.27	15.91	0.328	425.97
2013	463.86	10.91	17.71	0.578	493.05
2014	529.36	11.44	18.67	0.613	560.08
2015	564.12	10.05	21.20	0.653	596.03
2016	628.66	9.02	23.83	0.694	662.22
2017	656.75	7.77	24.97	0.734	690.21
2018	727.98	9.47	29.79	0.777	768.01
2019	816.99	12.09	33.62	0.817	863.52
2020	887.16	18.36	37.05	0.857	943.43
2021	962.56	21.01	40.09	0.898	1024.56
2022	1028.08	13.62	48.41	0.938	1091.04

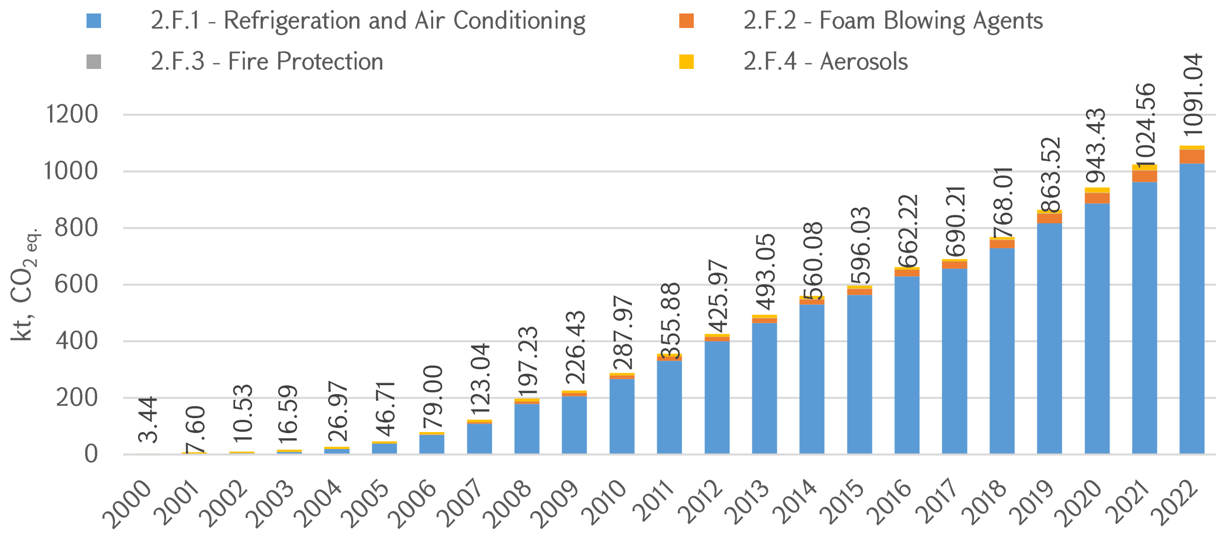

Figure 5.14 HFCs emissions time series by applications for 2000-2022, kt $CO_{2\ eq.}$

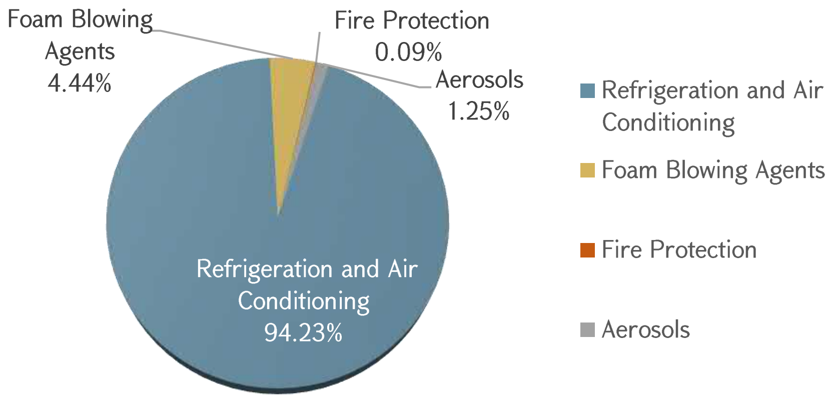

Figure 5.15 HFCs total emissions by application for 2022.

Table 5.14 Summary Report for HFC emissions (in tonnes and kt $CO_{2\ eq.}$) by chemicals and applications for 2022.

Categories	HFC-32	HFC-125	HFC-134a	HFC-152a	HFC-143a	HFC-227ea	HFC-245fa	HFC-365mfc	Total HFCs
AR5 GWPs (100-year time horizon) Conversion Factor (1)	677	3170	1300	138	4800	3350	858	804	
Emissions in original mass unit (tonne)									
2.F - Product Uses as Substitutes for Ozone Depleting Substances	74.757	129.856	237.007	16.333	63.461	0.280	8.139	7.325	
2.F.1 - Refrigeration and Air Conditioning	74.757	129.856	200.931	0	63.461	0	0	0	
2.F.1.a - Refrigeration and Stationary Air Conditioning	74.757	129.856	141.271	0	63.461				
2.F.1.b - Mobile Air Conditioning			59.660	0					
2.F.2 - Foam Blowing Agents			26.056	12.038			8.139	7.325	
2.F.3 - Fire Protection			0	0		0.280			
2.F.4 - Aerosols			10.02	4.295					
2.F.5 - Solvents									
Emissions in CO2 equivalent unit (Gg CO2)									
2.F - Product Uses as Substitutes for Ozone Depleting Substances	50.611	411.645	308.110	2.254	304.615	0.938	6.984	5.889	**1091.045**
2.F.1 - Refrigeration and Air Conditioning	50.611	411.645	261.211	0	304.615	0	0	0	**1028.082**
2.F.1.a - Refrigeration and Stationary Air Conditioning	50.611	411.645	183.653	0	304.615				**950.523**
2.F.1.b - Mobile Air Conditioning			77.558	0					**77.558**
2.F.2 - Foam Blowing Agents			33.873	1.661			6.984	5.889	**48.406**
2.F.3 - Fire Protection			0	0		0.938			**0.938**
2.F.4 - Aerosols			13.026	0.593					**13.619**
2.F.5 - Solvents									

(2.G) Other product manufacture and use

Overview of the category

The category 2.G includes SF6 emissions from electrical equipment (2.G.1).

(2.G.1) Electrical Equipment

Electrical equipment is the largest consumer and most important use of Sulphur hexafluoride (SF6) as an electrical insulator and interrupter in equipment that transmits and distributes electricity. It is used in gas-insulated switchgears and substations, gas circuit breakers, although some SF6 is used in high voltage gas-insulated lines (GIL), outdoor gas-insulated instrument transformers and other equipment.

SF_6 has been employed in Armenia since the 1999 because of its dielectric strength and arc-quenching characteristics. SF6 has replaced flammable insulating oils in many applications and has also replaced explosive air circuit breakers, allowing for more compact substations and improving operational safety.

Choice of method

This category consists of manufacture, use and disposal of electrical equipment.

In Armenia this category consists of use of electrical equipment (2.G.1b) only because:

- Armenia has no production of electrical equipment and imports all necessary electrical equipment.
- Since electrical equipment have long service lifetimes (40 years), while the first use of SF6 dates from the 1999, therefore there are no disposal emissions in Armenia.

In electricity transmission and distribution, SF6 is used primarily in gas circuit breakers (GCB) and in less amount - in gas-insulated switchgears (GIS). It serves as an arc-extinguishing and insulation gas.

According to the 2006 IPCC Guideline, the aforementioned applications may be divided into two categories of containment. The first category is “Sealed Pressure Systems” or “Sealed-for-life Equipment”, which is defined as equipment that does not require any refilling (topping up) with gas during its lifetime. Distribution equipment normally falls into this category.

The second category is “Closed Pressure Systems”, which is defined to include equipment that requires refilling (topping up) with gas during its lifetime. Transmission equipment normally falls into this category.

The estimates of emissions from electrical equipment are comprised of emissions from electric power system. According to the 2006 IPCC Guidelines, a Tier 1 method (the default emission-factor approach) was used (V3, Ch 8, Equation 8.1). Emissions were estimated by multiplying default regional emission factors by the nameplate SF6 capacity of the equipment.

Activity data, emission factors and other parameters

Data on electrical equipment containing SF6 were provided by the Ministry of Territorial Administration and Infrastructure per energy system utilities in response to the detailed “questionnaire”, sent by the Ministry of Environment, including information from utilities on the country of origin of the equipment they have installed and the SF6 content in the installed equipment, as indicated on the equipment nameplate (IndRef-5).

Reported data on SF6 containing equipment for electricity transmission and distribution include data on high-voltage GCB installed in the power plants also, as well as data on MV gas-insulated switchgears (GIS) for ensuring own needs of the power plants.

Table 5.15 presents the SF_6 content in medium and high voltage equipment (Closed Pressure Systems) electrical equipment, while **Table 5.16** presents the SF6 content in Sealed Pressure distribution equipment within the power system.

Table 5.15 SF_6 content in medium and high voltage equipment (Closed Pressure Systems)

Year	220 kV Equipment		110 kV Equipment		35 kV Equipment		Cumulative	
	Number of installed equipment (pcs)	SF_6 content in the installed equipment (kg)	Number of installed equipment (pcs)	SF_6 content in the installed equipment (kg)	Number of installed equipment (pcs)	SF_6 content in the installed equipment (kg)	Number of installed equipment (pcs)	SF6 bank (t)
1999	0	0.00	8	68.00	0	0.00	8	**0.068**
2000	0	0.00	0	0.00	0	0.00	8	**0.068**
2001	0	0.00	0	0.00	0	0.00	8	**0.068**
2002	5	110.00	0	0.00	3	14.40	16	**0.1924**
2003	12	281.10	28	318.00	0	0.00	56	**0.7915**
2004	32	768.00	45	398.80	2	9.20	135	**1.9675**
2005	2	47.00	0	0.00	0	0.00	137	**2.0145**
2006	15	392.60	8	48.00	0	0.00	160	**2.4551**
2007	0	0.00	0	0.00	0	0.00	160	**2.4551**
2008	0	0.00	0	0.00	0	0.00	160	**2.4551**
2009	0	0.00	29	290.00	43	215.00	232	**2.9601**
2010	10	259.00	32	314.30	43	215.00	317	**3.7484**
2011	0	0.00	3	25.50	0	0.00	320	**3.7739**
2012	0	0.00	22	138.60	0	0.00	342	**3.9125**
2013	8	160.00	0	0.00	0	0.00	350	**4.0725**
2014	0	0.00	11	91.30	0	0.00	361	**4.1638**
2015	0	0.00	0	0.00	0	0.00	361	**4.1638**
2016	0	0.00	0	0.00	0	0.00	361	**4.1638**
2017	0	0.00	0	0.00	0	0.00	361	**4.1638**
2018	8	168.00	19	133.00	13	64.70	401	**4.5295**
2019	20	458.00	28	196.00	13	64.70	462	**5.2482**
2020	8	168.00	19	133.00	13	93.60	502	**5.6428**
2021	12	288.00	33	233.80	13	93.60	560	**6.2582**
2022	8	168.00	27	213.00	20	128.60	615	**6.7678**
	140	**3267.70**	**312**	**2601.30**	**163**	**898.80**		**6.7678**

Table 5.16 SF_6 content in Sealed Pressure distribution equipment

Year	Number of installed equipment (pcs)	SF_6 content in the installed equipment (kg)	Cumulative	
			Number of installed equipment (pcs)	SF6 bank (kg)
2003	2	18.20	2	18.20
2004	0	0.00	2	18.20
2005	0	0.00	2	18.20
2006	2	18.20	4	36.40
2007	0	0.00	4	36.40
2008	0	0.00	4	36.40
2009	0	0.00	4	36.40
2010	65	88.73	69	125.13
2011	0	0.00	69	125.13
2012	0	0.00	69	125.13
2013	0	0.00	69	125.13
2014	0	0.00	69	125.13
2015	0	0.00	69	125.13
2016	0	0.00	69	125.13
2017	0	0.00	69	125.13
2018	3	50.60	72	175.73
2019	3	50.60	75	226.33
2020	2	22.00	77	248.33
2021	13	68.80	90	317.13
2022	2	22.00	92	339.13
			92	**339.13**

For sealed pressure electrical equipment (MV Switchgear) containing SF_6 default emission factors provided for Europe and equaling to 0.002 have been used (Volume 3, Chapter 8, Table 8.2). This default emission factor enables to consider all emissions generated from the installed equipment (including leakage, major failures/arc faults and maintenance losses).

For closed pressure electrical equipment (HV switchgear) containing SF_6 default emission factors provided for Europe and equaling to 0.026 have been used (Volume 3, Chapter 8, Table 8.3).

Time series consistency and recalculations

Emissions from closed pressure electrical equipment from 1999 to 2022 were recalculated based on reported activity data from utilities. The change of emissions due to recalculation is 2.1% in 2017 and nearly 1% in 2019.

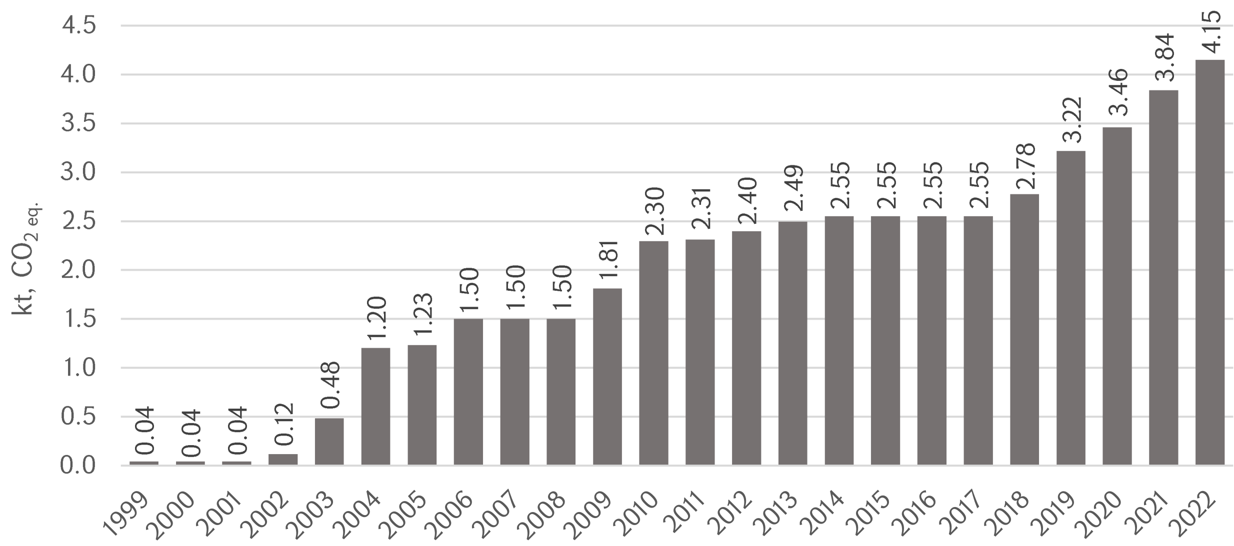

Figure 5.16 SF_6 emissions from electrical equipment, kt $CO_{2\ eq}$,

SF_6 emissions from closed pressure electrical equipment have grown continuously due to the ongoing reconstruction of the existing substations and the construction of new facilities with SF6 containing gas circuit breakers (GCB), while the emissions of SF6 from Sealed Pressure distribution equipment are negligible.

Uncertainty assessment

Uncertainties in the Default Emission Factors for Use of Closed-Pressure Electrical Equipment are estimated ±30 % (Volume 3, Chapter 8, Table 8.5).

Uncertainties in AD were estimated ± 5%.

Combined uncertainty equals to 30.4%

Category-specific QA / QC and verification

The general and category-specific quality control and quality assurance were carried out by the relevant technical experts through application of the Inventory QA/QC plan outlined in Annex 7.

Activity data quality control was performed by the energy sector expert through analysis of acquired data and related materials, discussions with data providers following by adjustments if any, as well as comparison with publicly available equipment passport data produced by the manufacturers.

Category-specific planned improvements

No improvements are planned at present.

Emissions of Indirect Gases

(2.C.2) Ferroalloys production

Choice of method

The molybdenum concentrate used in ferromolybdenum production in Armenia contains no carbon practically and raw materials for the production of ferromolybdenum (batch, mixture) do not contain carbon (coal, coke) as well, which is a source of greenhouse gas emissions (CO_2, CH_4). So, there are no emissions of CO_2 and CH_4 from ferromolybdenum production in Armenia.

This section assesses emissions of sulfur dioxide from ferromolybdenum production.

Considering that EMEP/EEA air pollutant emission inventory guidebook does not include a methodology for calculating emissions from ferromolybdenum production, therefore, in this case, process parameters, material balances and chemical formulas were used.

SO_2 emissions were calculated using the equation proposed by the national experts for copper production, as the technology of ferromolybdenum production is similar to those of copper production:

Based on the plant specific data for the previous years, the weighted average national emission factor of 1.07 t SO_2 per 1 t of ferromolybdenum produced was calculated.

Activity data, emission factors and emissions

The quantity of ferromolybdenum produced were taken from the Statistical Yearbook of Armenia (Ref-2).

It amounted to:

2020 – 7,709 t

2021 – 8,335 t

2022 – 9,167 t

Accordingly, SO_2 emissions made:

Table 5.17 The quantity of ferromolybdenum produced and SO_2 emissions

Year	The quantity of ferromolybdenum produced, t	SO_2 emissions, kt
2020	7,709	8.2
2021	8,335	8.9
2022	9,167	9.8

The amount of sulfur dioxide emissions from ferromolybdenum production depends on the efficiency of gas cleaning system, but due to the lack of verifiable data on the efficiency of these systems, this estimate does not take into account the reduction of emissions as a result of the operation of the gas cleaning system.

Time series before 2002 have not been calculated due to the lack of official statistical data.

(2.D.3) Solvent Use

Choice of method

The use of solvents manufactured using fossil fuels as feedstocks can lead to evaporative emissions of various non-methane volatile organic compounds (NMVOC). Methodologies for estimating these NMVOC emissions recommended in the EMEP/CORINAIR Emission Inventory Guidebook (EEA, 2019) were used.

Activity data, emission factors and emissions

According to the EMEP/CORINAIR Emission Inventory Guidebook (EEA, 2019), emissions of NMVOCs from domestic solvent use were calculated by using the emission factor of 1.2 kg per capita and population, according to the RA Statistics Committee data (Ref-1).

Calculations for paint application are based on data on quantities of produced, imported and exported paints, according to the RA foreign trade statistics (according to the 10-digit classification of the commodity nomenclature of the EAEU foreign economic activity), published by the RA Statistics Committee (Ref-5).

According to the EMEP/CORINAIR Emission Inventory Guidebook (EEA, 2019), emissions of NMVOCs from paint application were calculated by using the emission factor of 200 kg/ton of used paint.

Emissions of NMVOCs from domestic solvent make:

2020 - 3.55 kt

2021 -3.56 kt

2022- 3.55 kt

Emissions of NMVOCs from paint application make:

2020 – 6.33 kt

2021 -2.02 kt

2022- 2.48 kt

Emissions of NMVOCs from *(2D3a) Domestic Solvent Use* has been recalculated for the entire period due to the change in the emission factor.

Time series for *(2D3d*) *Paint Application* is calculated from 2000 due to the lack of official statistical data.

(2.D.4) Bitumen/Asphalt Production and Use

Choice of method

This source category comprises the non-combustion emissions from the production of asphalt and its application such as paving operations. The production and use of asphalt results mainly in emissions of NMVOCs.

Emission methodologies and default emission factors for NMVOC are presented in the EMEP/CORINAIR Emission Inventory Guidebook. The calculation was made applying Tier 1 Approach due to insufficient data for applying Tier 2 Approach.

Activity data, emission factors and emissions

Bitumen quantities are taken from the publications of the SC (Ref-3). EF pollutant used was default emission factor for NMVOC, 16 g/t bitumen (EMEP/EEA).

The bitumen content in the asphalt mixture was cross-checked with road-paving companies and correspondingly adjusted, and bitumen content of 7% in the asphalt mixture was used in the calculations, according to the ГОСТ 9128-2013 Appendix Г.

Thus:

2020: ARproduction = 14 x 81124 = 1,158,910 t

2021: ARproduction = 14 x 84278 = 1,203,975 t

2022: ARproduction == 14 x 87325 = 1,247,493 t

Table 5.18 provides NMVOCs emissions calculated using the quantities of bitumen and the asphalt mix produced on its basis

Table 5.18 NMVOCs emissions from the Use of Bitumen, kt

Year	Quantity of bitumen, t	Quantity of asphalt mix, t	NMVOCs emission, kt
2020	81,124	1,158,910	0.0185
2021	84,278	1,203,975	0.0193
2022	87,325	1,247,493	0.02

The time series of NMVOC emissions from *(2D4) Bitumen/Asphalt Production and Use* has been recalculated for the entire period due to the adjustment for the bitumen content in the asphalt mixture.

(2.H.2) Food and Beverages

Choice of method

This source category comprises NMVOCs emissions arising during cereal and fruit processing, as well as during meat, margarine, pastry and bread production.

Emissions estimate has been done according to the EMEP/CORINAIR Emission Inventory Guidebook (EEA, 2019), applying Tier 2 method - taking into account technological features.

Activity data, emission factors and emissions

The production volumes required for the calculation are taken from the Statistical Yearbooks of Armenia (Ref-2). Due to changes in statistical data formats, the quantity of confectionery in 2019 was calculated by the aggregation of cakes, pastry, biscuits, honey-cakes and other similar products.

Emissions factors from the EMEP/CORINAIR Emission Inventory Guidebook (EEA, 2019) (EMEP/EEA, 2019թ.) have been applied.

The values of factors are provided below.

Table 5.19 Food and beverage production. NMVOC emissions factors

Product type	Measurement unit	Emission factor
Meat	kg/t	0.3
Bread	kg/t	4.5
Confectionery	kg/t	1
Wine	kg/100 l	0.08
Beer	kg/100 l	0.035
Liqueur-vodka	kg/100 l	15
Cognac	kg/100 l	3.5
Whiskey	kg/100 l	7.5

Table 5.20 Food and beverage production. Product quantity

Product type	Measurement unit	Product quantity		
		2020	2021	2022
Meat	t	85,000	85,000	81,000
Bread	t	269,000	264,000	266,000
Confectionery	t	12,955	13,103	13,881
Wine	hectoliter	106,560	128,290	118,980
Beer	hectoliter	235,100	281,810	307,390
Liqueur-vodka	hectoliter	51,590	20,830	15,630
Cognac	hectoliter	402,810	186,790	215,000
Whiskey	hectoliter	3,480	2,690	5,930

The time series of NMVOC emissions from *(2H2) Food and Beverages* was recalculated for the entire period due to the change in the methodology applied - EMEP/EEA Manual Tier 2 methodology has been applied, considering technological features.

Thus, emissions of NMVOCs from (2H2) Food and Beverages make:

Year	NMVOC
2020	3.4754933
2021	2.23311955
2022	2.28723305

Summary of indirect emissions in IPPU sector

Table 5.21 shows time series of NMVOC Emissions from the IPPU Sector, and Table 5.22 shows time series of SO_2 Emissions from the IPPU Sector

Table 5.21 Time Series of NMVOC Emissions from the IPPU Sector, kt

Category	2.D.3.a Domestic Solvent Use	2.D.3.d Paint Application	2.D.4 Bitumen/Asphalt Production and Use	2.H.2 Food and Beverages	NMVOC emissions
1990	4.29	0	0	3.46	**7.75**
1995	4.52	0	0.0002	2.98	**7.50**
2000	3.87	0.79	0.0008	1.63	**6.29**
2002	3.85	1.1	0.0127	3.11	**8.07**
2003	3.83	1.33	0.0082	3.11	**8.28**
2004	3.81	1.5	0.0066	3.54	**8.86**
2005	3.79	1.59	0.0068	3.76	**9.15**
2006	3.76	1.68	0.0073	3.6	**9.05**
2007	3.74	2.57	0.0122	3.78	**10.10**
2008	3.72	3.28	0.0092	3.76	**10.79**
2009	3.69	3.11	0.0099	3.71	**10.52**
2010	3.67	3.29	0.0073	3.61	**10.58**
2011	3.62	3.5	0.0068	3.29	**10.42**
2012	3.63	3.26	0.0082	3.54	**10.44**
2013	3.63	3.16	0.0076	3.59	**10.39**
2014	3.62	3.23	0.007	3.44	**10.30**
2015	3.61	2.68	0.0079	3.44	**9.74**
2016	3.6	2.39	0.0057	3.44	**9.44**
2017	3.58	3.5	0.0074	3.51	**10.59**
2018	3.57	4.76	0.009	3.14	**11.48**
2019	3.56	5.63	0.0145	3.75	**12.95**
2020	3.55	6.33	0.0185	3.48	**13.38**
2021	3.56	2.02	0.0193	2.23	**7.83**
2022	3.55	2.48	0.02	2.29	**8.34**

Table 5.22 Time Series of SO_2 Emissions from the IPPU Sector, kt

Category	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
2.C.2 Ferroalloys production	1.60	1.80	2.90	6.00	5.20	6.40	5.70	5.50	5.50	5.90	6.20	7.10	7.00	6.00	7.00	7.00	7.80	8.30	8.2	8.9	9.8
2.C.8 Copper Production	0.00	0.00	0.00	0.00	26.86	21.25	19.80	20.95	23.35	28.96	29.13	31.18	31.40	35.24	36.88	41.32	27.40	0.00	-	-	-
Total SO_2 emissions	**1.60**	**1.80**	**2.90**	**6.00**	**32.06**	**27.65**	**25.50**	**26.45**	**28.85**	**34.86**	**35.33**	**38.28**	**38.40**	**41.24**	**43.88**	**48.32**	**35.20**	**8.30**	**8.2**	**8.9**	**9.8**

6. AGRICULTURE (CRT SECTOR 3)

Overview of GHG emissions in CRT Sector 3

Agriculture sector of the national greenhouse gas inventory of Armenia includes the following emission sources:

- ***(3.A) Enteric Fermentation (CH_4 emissions)***
  - (3.A.1) Cattle
  - (3.A.2) Sheep
  - (3.A.3) Swine
  - (3.A.4) Other livestock
- ***(3.B) Manure Management (CH_4 and N_2O emissions)***
  - (3.B.1) Cattle
  - (3.B.2) Sheep
  - (3.B.3) Swine
  - (3.B.4) Other livestock
  - (3.B.5) Indirect N_2O emissions
- ***(3.D) Agricultural soils (N_2O emissions)***
  - (3.D.1) Direct N_2O emissions from managed soils
  - (3.D.2) Indirect N_2O Emissions from managed soils
- ***(3.F) Field burning of agricultural residues (CH_4 and N_2O emissions)***
- ***(3.H) Urea application (CO_2 emissions)***

Emissions from all other sources indicated in CRT sector 3 do not occur in Armenia.

From those listed above, emissions from the field burning of agricultural residues (3.F) are presented in this chapter, however in CRT tables they are included elsewhere, specifically under cropland category in LULUCF sector. This is how the IPCC software and ETF reporting tools allocated them. Therefore, the total emissions from the agriculture sector do not match those presented in the CRT, differing by the emissions from the field burning of agricultural residues.

(3.A) Enteric Fermentation (CH_4 emissions) and *(3.D.1) Direct N_2O emissions from managed soils* and (3.D.2) *Indirect N_2O Emissions from managed soils* are identified as key source categories, both in terms of level and trend assessment in 2022, while *(3.D.2) Indirect N_2O Emissions from managed soils* are identified as key source categories in terms of level assessment.

Agriculture sector emissions amounted to 2,084.65 kt $CO_{2\,eq.}$ in 2020, 2,102.02 kt $CO_{2\,eq.}$ in 2021 and 1,989.89 kt $CO_{2\,eq.}$ in 2022, or 17.8%, 16.6% and 15.4% of Armenia’s total net emissions in 2020, 2021 and 2022, correspondingly.

Table 5.1 shows GHG emissions in agriculture sector by category and gas in 2020-2022.

CO_2 emissions from agriculture in 2022 amounted to 3.79 kt, totally occurring *from Urea application (3.H)*.

CH_4 emissions in 2022 amounted to 1,270.17 kt CO_{2eq} which accounts for 61.8% of emissions from the agriculture sector and 9.8% of the country's total net emissions. The largest source of CH_4 emissions in 2022 was *Enteric Fermentation from Cattle (3.A.1)* – 1,042.54 kt $CO_{2\ eq}$, which accounts for 81.2% of CH_4 emissions from the agriculture.

N_2O emissions in 2022 amounted to 715.94 kt $CO_{2\ eq}$., which accounts for 36.0% of emissions from the agriculture and 5.5% of the country's total net emissions. *Direct N_2O emissions from managed soils (3.D.1)* predominate in the overall N_2O emissions from Agriculture sector, with a share of 72.1% in 2022.

Table 6.7 Agriculture sector emissions in 2020-2022

Categories	2020				2021				2022			
	CO_2 kt	CH_4 kt	N_2O kt	Total kt $CO_{2\ eq}$	CO_2 kt	CH_4 kt	N_2O kt	Total, Gg $CO_{2\ eq}$	CO_2 kt	CH_4 kt	N_2O kt	Total kt $CO_{2\ eq}$
3.A. Enteric fermentation		45.83		1 283.13		46.30		1 296.32		43.63		1 221.53
3.A.1. Cattle		39.53		1 106.92		39.84		1 115.55		37.23		1 042.54
3.A.2. Sheep		5.06		141.77		5.27		147.50		5.27		147.50
3.A.3. Swine		0.48		13.45		0.42		11.63		0.39		11.01
3.A.4. Other livestock		0.75		21.01		0.77		21.64		0.73		20.47
3.B. Manure management		1.83	0.26	119.32		1.73	0.27	119.30		1.64	0.26	114.84
3.B.1. Cattle		0.58	0.01	18.35		0.59	0.01	18.52		0.55	0.01	17.23
3.B.2. Sheep		0.17	0.15	43.39		0.18	0.15	45.16		0.18	0.15	45.31
3.B.3. Swine		0.96	0.01	29.96		0.83	0.01	25.91		0.79	0.01	24.54
3.B.4. Other livestock		0.12	0.02	8.29		0.13	0.02	8.77		0.13	0.02	8.48
3.B.5. Indirect N2O emissions			0.07	19.33			0.08	20.94			0.07	19.28
3.C. Rice cultivation		NO		NO		NO		NO		NO		NO
3.D. Agricultural soils		NA	2.55	675.84		NA	2.56	677.73		NA	2.44	646.28
3.D.1. Direct N2O emissions from managed soils			2.04	541.06			2.04	541.68			1.95	516.06
3.D.2. Indirect N2O Emissions from managed soils			0.51	134.78			0.51	136.05			0.49	130.23
3.E. Prescribed burning of savannahs		NO	NO	NO		NO	NO	NO		NO	NO	NO
3.F. Field burning of agricultural residues		0.11	0.003	3.67		0.11	0.003	3.77		0.10	0.003	3.45
3.G. Liming	NO			NO	NO			NO	NO			NO
3.H. Urea application	2.69			2.69	4.90			4.90	3.79			3.79
3.I. Other carbon-containing fertilizers	NO			NO	NO			NO	NO			NO
3.J. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Total	**2.69**	**47.77**	**2.81**	**2 084.65**	**4.90**	**48.13**	**2.83**	**2 102.02**	**3.79**	**45.36**	**2.70**	**1 989.89**

Figure 6.1 provides an overview of the development of greenhouse gas emissions in CRT Sector 4 since 1990.

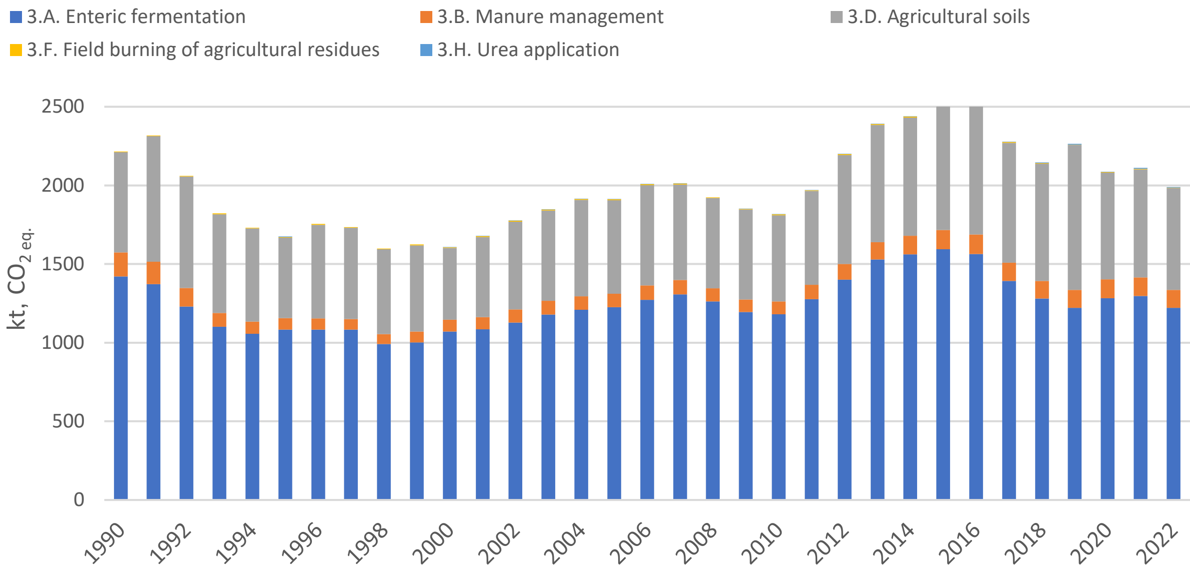

Figure 6.1 Overview of GHG emissions in CRT Sector 3 (kt, $CO_{2\ eq.}$)

Agriculture Sector Greenhouse Gas Emission Sources are presented in **Figure 6.2**

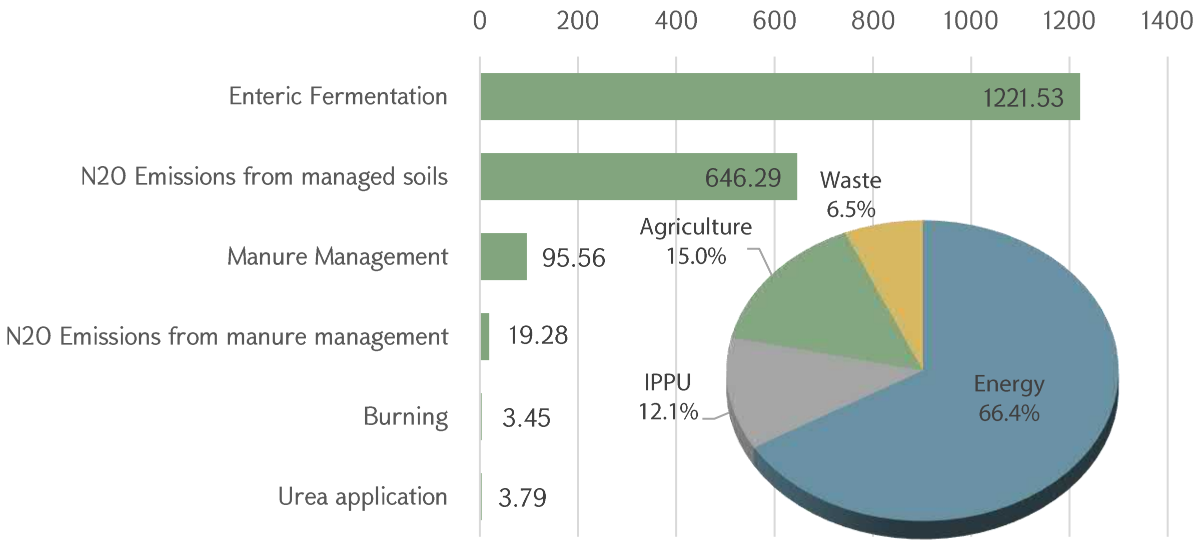

Figure 6.2 Agriculture Sector Greenhouse Gas Emission Sources, 2022 (LULUCF excluded)

Activity data for livestock population (3A, 3B)

Livestock categories

According to the 2006 IPCC Guidelines, the methods for estimating CH_4 and N_2O emissions from livestock require definitions of livestock subcategories, annual populations and, for higher Tier methods, feed intake and characterization (Vol 4, Ch 10.1).

For calculation of emissions from animal husbandry in Armenian agriculture, animal stocks are divided into sub-categories, to permit description of sub-stocks.

Table 6.2 presents CRT animal categories, and the subdivisions used for reporting GHG emissions.

Table 6.2 CRT animal categories, and the subdivisions used for purposes of Armenia's emissions reporting (3.A, 3.B)

	CRT animal categories	Animal categories in the Armenian inventory
1	Dairy Cows	"Low Producing (Local) Cows"
		"High Producing Cows"
2	Other Cattle	"Low Producing (Local) Bulls"
		"High Producing Bulls"
		"Low Producing (Local) Growing Cattle"
		"High Producing Growing Cattle"
3	Buffalo	"Buffalo"
4	Sheep	"Mature ewes"
		"Other Mature Sheep (>1 year) "
		"Growing Lambs"
5	Goats	"Goats"
6	Horses	"Horses"
7	Mules and Asses	"Mules and Asses"
8	Swine	"Swine"
9	Poultry	"Laying hens"
		"Broilers"
10	Rabbits	˝Rabbits"
11	Fur bearing animals	"Fur bearing animals"

Average annual livestock population by category was calculated based on published official statistical data and based on the information provided by authorized state bodies (AGR.Ref-3, Annex 4.1). As a whole, for the calculation of the average annual livestock population and emission factors, the following activity data were used, according to the sources:

1. Data published by the RA SC:

- Livestock population (by category and sub-categories) as of January 1 of each year
- Animals and poultry sold for slaughter (total live-weight, thousand tonnes, quarterly and annually)
- Animals and poultry sold for slaughter (total slaughter weight, thousand tonnes, quarterly and annually)
- Export and import of live animals (quantity), according to the 10-digit classification of the commodity nomenclature of foreign economic activity of the EAEU
- Annual average milk production.
- Average annual wool produced from one sheep

2. Data on the average live-weight of domestic animals (kg), feed digestibility (%), growing cattle average weight gain per day (kg/day), number of off spring produced per year, manure

dumping and the shares of manure used for burning and as fertilizer provided by the RA Ministry of Economics.

3. Expert assessments of data on the number and activity of high-producing cow (Estimates are calculated based on surveys conducted among experts and farmers). Apart from data on the import of high-producing cow, no other official information is available on the number. The numbers were estimated based on the percent of females that give birth in a year of high-producing cows and the number of imported animals.

The following activity data were used to calculate livestock annual average population by species/categories:

- population data at the beginning and at the end of year, livestock import and export data as well as estimates of the number of slaughtered, lost and young born livestock.
- data on sales of meat and slaughtered animals per categories, as most of the animal raised for meat production (calves, lambs, swine, birds, rabbits) are alive just for a limited time during the year and their number is neither reflected in the official statistics of the beginning-of-the-year nor at the end of the year.
- The number of slaughtered cattle, swine and poultry was estimated quarterly, based on the volume of meat produced quarterly and the average live weight of one animal. The number of lost animals was distributed proportionally by months.
- Newborn animals were distributed on monthly basis, based on the practice of organizing animal births in Armenia.

Thus, the average annual population of cattle, sheep, goats and swine were calculated as the arithmetic average of the quarters, not the arithmetic average of the head counts at the beginning and end of the year. This calculation approach results in difference between official statistics on livestock population as of January 1 (SC and FAO data) and data on livestock average population used in GHG Inventory.

For the calculation of the annual average poultry population the following data were used: the number as of the beginning and at the end of the year, export and import data, as well as the number of broiler poultry grown and slaughtered during the year. The export data for poultry did not include 1-2 daily chicks.

In accordance with the 2006 IPCC Guidelines "broiler chickens are typically grown approximately 60 days before slaughter. Estimating the annual average population as the number of poultry grown and slaughtered over the course of a year would greatly overestimate the population, as it would assume each bird lived the equivalent of 365 days. Instead, one should estimate the average annual population as the number of animals grown divided by the number of growing cycles per year." (Volume 4, Chapter 10, p. 10.8).

In 2020-2022, the poultry meat in slaughter weight amounted to 12.4, 12.6, 14.6 thousand tonnes, correspondingly, and the total number of poultry for slaughter was estimated at 7,294.8 and 8,588.2 thousand heads, respectively. Based on this, the annual average population of broilers intended for slaughtering was calculated using Equation 10.1 from the 2006 IPCC Guidelines:

$$AAP = (\text{Days alive}) \cdot \frac{NAPA}{365}$$

Where:

AAP = annual average population

NAPA = number of animals produced annually

Thus, the average annual population of poultry was calculated by adding the number of poultry slaughtered during the year to the arithmetic average of the number at the beginning and end of the year.

Similarly, the average annual rabbit livestock population for 2020-2022 was calculated. Many households in Armenia are engaged in rabbit breeding for meat and as fur-bearing animals. The average annual number of slaughtered rabbits was calculated using Equation 10.1, based on the following data:

- Estimated number of rabbits - 70% of rabbits' arithmetic average at the beginning and at the end of the year
- The number of young born per mother rabbit - is estimated at 6 heads
- Life expectancy of slaughtered rabbits - 120 days
- This data is then added to the arithmetic average of rabbits at the beginning and at the end of the year.

For the average annual population of buffaloes, horses, mules and asses, and fur-bearing animals, the arithmetic averages of the population at the beginning and end of the reporting periods (2020-2022) were used.

As a result of the calculations, the following data on annual population were obtained (Table 6.3), which were used for calculating greenhouse gas emissions from livestock.

Time series on annual population per categories presented in **Table 6.3**

Table 6.3 Animal-place figures used in reporting (3.A, 3.B)

	Dairy Cows	Other Cattle	Buffalo	Sheep	Goats	Horses	Mules and Asses	Swine	Poultry	Fur bearing animals	Rabbits
1990	283,685	478,303	298	1,293,400	1,03,000	6,548	2,300	446,413	12,402,582	12,635	96,417
1995	299,856	278,089	698	636,019	58,649	12,101	6,302	114,475	3,356,669	5,570	42,826
2000	273,501	308,435	461	662,610	61,425	11,450	7,108	98,162	4,897,044	3,364	59,826
2005	293,565	389,317	401	729,676	60,219	12,100	7,089	123,824	5,840,400	4,235	64,057
2010	273,213	395,662	458	654,018	41,006	10,410	4,445	159,744	4,541,152	4,659	64,894
2015	370,959	487,402	706	993,100	43,771	11,416	3,102	366,156	5,046,989	3,067	66,750
2016	360,461	481,068	703	983,369	40,717	11,017	2,450	404,384	4,794,468	4,817	67,870
2017	329,232	399,885	719	909,043	34,671	10,340	1,949	395,128	5,080,991	9,502	66,604
2018	297,671	375,360	696	845,951	31,045	10,399	1,697	418,850	5,425,299	16,066	66,432
2019	295,738	374,365	680	847,043	32,298	11,058	1,555	477,530	5,527,809	10,637	77,774
2020	306,192	393,734	735	895,874	33,585	12,230	1,492	480,188	5,658,055	2,890	90,427
2021	308,414	389,193	754	932,555	32,881	13,490	1,355	415,376	6,029,090	3,049	95,325
2022	291,566	355,633	635	936,073	30,180	13,528	1,145	393,359	5,944,251	3,962	90,813

Quality Assurance/Quality Control for livestock population

Before using the data, it is necessary to analyze how the data was collected, processed and aggregated by the data provider - SC and Ministry of Economy, and to what extent the data reflect the actual situation. For example, as was stated above, data on the population of livestock are published by the SC of RA as of January 1 of each year, which does not reflect the number of livestock born, lost or committed for slaughter during the year. To this purpose, additional data were collected and analyzed enabling to get complete information on the livestock annual population which means that according to the 2006 IPCC Guidelines, the impact of production cycles and seasonal changes has been taken into account in calculating the annual average population of livestock.

To ensure data completeness and reduce uncertainties, calculations were done using official statistical data as well as the adjustment of the annual average livestock population, based on quarterly data on volume of meat, slaughter and animal losses. Such approach yielded more accurate figures on livestock population.

In addition, some livestock parameters, received through an official letter from the RA Ministry of Economy, were cross-checked with the parameters analyzed and agreed upon as a result of consultations with the RA Ministry of Agriculture and GHG Inventory expert teams in 2017.

The methodology for estimating livestock population and the uncertainty of the obtained data can be refined after the publication of the results of the second nationwide agricultural census conducted by the RA SC in 2024.

(3A) Enteric fermentation

Choice of method

Enteric fermentation from cattle is a key source category both in terms of level and trend assessment (CH_4 emissions) in 2022, accounting for a significant share of the country's total emissions.

GHG emissions from cattle, buffalo, sheep and goats' enteric fermentation were estimated according to the 2006 IPCC Guidelines Tier 2 Approach (Vol 4, Ch 10.3) by applying country-specific emission factors.

Methane emissions from enteric fermentation of other livestock categories were estimated by Tier 1 Approach applying enteric fermentation emission factors for Tier 1 method (Vol 4, Ch 10.3).

Activity Data

Activity data for this category are presented in the section “Activity data for livestock population”.

Emission factors and other parameters

The emissions from enteric fermentation of cattle, as well as buffalo, sheep and goats were estimated using country-specific data on gross energy intake and methane conversion factors (Vol 4, Ch 10.3.1).

Emissions from enteric fermentation of other animals were estimated by using default emission factors that are most appropriate for the country's livestock characteristics for each animal category (Vol 4, Ch 10.3, Table 10.10).

An emission factor for each animal category was developed following Equation 10.21 (Vol 4, Ch 10.3.2):

Calculation of the national emission factors along with data required for the estimates, are provided in Annex 4.1, including: animal live weight, milk production per day (kg/day) and fat content (%), daily gross energy intake for cattle, feed digestibility (%), methane conversion factor (percentage of feed energy converted to methane), feeding situation.

As a result, the following country-specific emission factors for cattle have been obtained:

- Low Producing (Local) Cows - 78.4 kg methane/head/year
- High Producing Cows – 101.7 kg methane/head/year
- Low Producing (Local) Bulls - 57.6 kg methane/head/year
- High Producing Bulls - 64.3 kg methane/head/year
- Low Producing (Local) Growing Cattle – 37.0 kg methane/head/year
- High Producing Growing Cattle – 39.0 methane/head/year
- Buffalo - 71.8 kg methane/head/year
- Mature Ewes – 7.3 kg methane/head/year
- Other Mature Sheep (>1 year) – 4.8 kg methane/head/year
- Lambs – 3.1 kg methane/head/year

Adjusted data on cattle activity (in particular, live weight, digestible energy, live weight of young animals and live weight of adult cattle) were used, based on analysis and consultations with RA Ministry of Agriculture specialists and experts.

The differences between default emission factors from the 2006 IPCC Guidelines and the national ones are caused by differences in regional characteristics (activity data). Thus, in the Guidelines for Asia, average milk production of 1,650 kg per head/yr (4.5 kg per day), with an average live weight of dairy cows of 275-350 kg (Table 10A.1) and default emission factor of 68 kg methane/year are provided for cattle (Volume 4, Table 10.11). While in Armenia, according to the SC, in 2020-2022 the average annual milk production of cows was 2,398- 2,467 kg / head/year or approximately 6.5-6.8 kg / head/day. Similarly, the average live weight of cows, according to the agreed estimate of scientists, experts and specialists from the RA Ministry of Economy, is 395 kg.

In case of buffalo, bulls and young, the differences are much greater, which has led to a greater variance between the country-specific emission factor and the default ones (Volume 4, Chapter 10).

Table 6.4 provides comparison of default emission factors (Volume 4, Table 10.11, Asia) and country-specific ones.

Table 6.4 Comparison of emission factors (kg/head/year)

	Cows		Bulls		Growing cattle		Buffalo		Sheep	
	Guide-line	Country-specific	Guide-line	Country-specific	Guide-line	Country-specific	Guide-line	Country-specific	Guide-line	Country-specific
2020	68	77.02	47	62.1	47	38.0	55	71.8	5	6.4
2021	68	77.6	47	60.5	47	38.1	55	71.8	5	6.3
2022	68	78.4	47	57.6	47	37.0	55	71.8	5	6.3

Time series consistency and recalculations

Table 6.5 presents methane emissions from enteric fermentation in 2020-2022 and their comparison with 1990 emissions.

Table 6.5 Methane emissions from enteric fermentation in 2020-2022 and their comparison with 1990

Category	Activity	Gas	1990 kt CO_2 eq.	2020 kt CO_2 eq.	2021 kt CO_2 eq.	2022 kt CO_2 eq.	Trend 1990-2020	Trend 1990-2021	Trend 1990-2022
(3A) Enteric Fermentation	Dairy Cows	CH_4	576.57	667.83	681.06	656.29	15.83%	18.12%	13.83%
(3A) Enteric Fermentation	Other cattle	CH_4	569.63	439.09	434.49	386.26	-22.92%	-23.72%	-32.19%
(3A) Enteric Fermentation	Other animals	CH_4	274.66	176.22	180.77	178.98	-35.84%	-34.18%	-34.83%
Total		**CH_4**	**1,420.86**	**1,283.13**	**1,296.32**	**1,221.53**	**-9.69%**	**-8.76%**	**-14.03%**

Compared to 1990, methane emissions from enteric fermentation decreased by 14.03% due to a decrease in methane emissions from enteric fermentation from Other cattle and 3.A.2 - 3.A.4 categories, while emissions from 3.A.1.a Dairy Cow category increased by 13.83%. The increase in methane emissions from enteric fermentation of a Dairy Cow in 2020-2022 compared to 1990 was 13-18%.

Based on official statistical data and sample surveys conducted among farmers and following discussions with specialists from the RA Ministry of Economy, the data required for estimating emissions from enteric fermentation have been refined for the years 1990–2019.

Time series have been recalculated and consistent time series have been developed for 1990-2022 due to adjustment of data required for assessing emissions from enteric fermentation, as well as due to the subdivision of animal categories in low producing (local) and high producing animals.

The following data were adjusted: percent of females that give birth in the year, number of young cattle and lambs born, average annual animal loss, live-weight and slaughter-weight data, average weight gain per day for calves and lambs, average daily milk production and milk fat content, feed digestibility rates.

Time series of methane emissions from livestock enteric fermentation from 1990 to 2022 are presented in **Figure 6.3.**

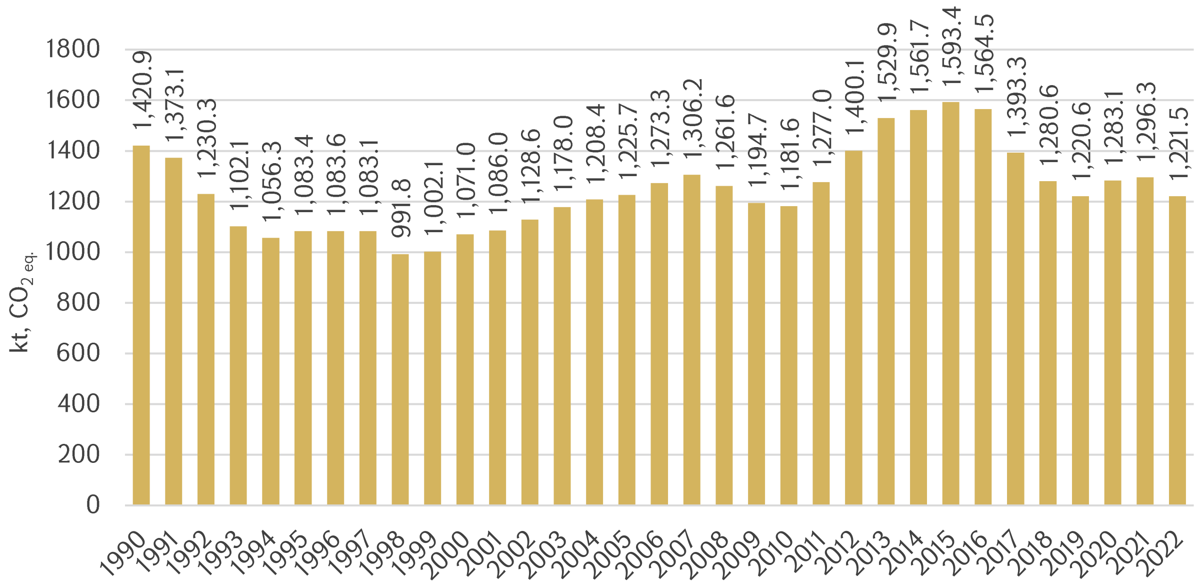

Figure 6.3 Methane emissions from livestock enteric fermentation, kt $CO_{2\ eq.}$

The change in methane emissions from enteric fermentation in 2020-2022 was mainly due to changes in the Cattle population.

As can be seen from the time series, five phases of changes in the volume of emissions from enteric fermentation are visible during 1990-2022. This was mainly due to the changes in livestock population (the change in other factors affecting emissions in 1990-2022 was insignificant, except for milk production, which continuously increased during the observed period).

In 1990s the structural changes in agriculture resulted in a sharp decline in the livestock population which consequently led to a continuous reduction in emissions until the year 2000.

During 2000-2007 the economic growth in the country has also contributed to the development of livestock breeding in agriculture and corresponding increase of emissions. The 2008-2010 crisis also affected agriculture, which led to a decrease in emissions accordingly.

n 2011–2016, due to the recovery of the economy and the favorable socio-economic conditions in the country, an increase in the livestock population was recorded. In particular, the cattle population grew, which consequently led to an increase in emissions.

Since 2016, another phase of reducing livestock population and emissions has begun: for example, in 2020, the number of livestock in the RA as of January 1 amounted to 579.3 thousand heads. The indicator has decreased by 15.9% compared to 2016.

Since 2018, a livestock subsidy program has been implemented in Armenia, under which financial support is provided by the government to farms engaged in breeding of high-productivity cattle breeds, as well as those participating in the “Smart Farms” program. Due to these state programs, population of high-breed cattle in the country has significantly increased in recent years.

Along with the growth of high-breed cattle, a decrease in the number of local breed cattle has been recorded in recent years.

Uncertainty assessment

According to the 2006 IPCC Guidelines, the uncertainty associated with populations will vary widely depending on source, but shouldn’t exceed the ± 20% range.

The variances between the data obtained from calculations and the animal subject to slaughter is ±4.2%. At the same time, according to the monitoring conducted by the Agriculture department of RA SC, population data variances were assessed up to 3%, as of January 1. As a result, the possible uncertainty of population is estimated to be about 8% to ±10% due to the existing deviations in data on livestock population.

Emission factor estimates using the Tier 2 method are within the range of ±20% (Volume 4, Chapter 10), therefore, uncertainty of the emission factor for the cattle was estimated ±20%.

Category-specific QA / QC and verification

General and category-specific quality control and quality assurance have been carried out by the relevant technical experts through application of the Inventory QA/QC plan outlined in Annex 7.

Category-specific planned improvements

No specific improvements are planned at present.

(3B) Manure management

CH_4 emissions

Choice of Method

According to the 2006 IPCC Guidelines, the main factors affecting CH_4 emissions are the amount of manure produced and the portion of the manure that decomposes anaerobically. The former depends on the rate of waste production per animal and the number of animals, and the latter - on how the manure is managed. When manure is stored or treated as a liquid (e.g., in lagoons, ponds, tanks, or pits), it decomposes anaerobically and can produce a significant quantity of CH_4. The temperature and the retention time of the storage unit greatly affect the amount of methane produced. When manure is handled as a solid (e.g., in stacks or piles) or when it is deposited on pastures and rangelands, it tends to decompose under more aerobic conditions and less CH4 is produced (Vol 4, Ch 10.4).

In Armenia, according to the RA Ministry of Economics data of the (AGR.Ref-3, Annex 4.2) and expert judgement, up to 27% of manure is left in pastures, up to 1% is stored and used as a liquid (in farms) and the rest is handled as a solid and used as organic fertilizers and burned as fuel.

Methane emissions from manure management were calculated using Tier 2 approach for cattle, buffalo and sheep, as these particular livestock species/categories, with the exception of buffalos, are responsible for the significant share of the country’s emissions.

Tier 1 method was used for livestock other categories, using livestock population data by animal species/category and 2006 IPCC Guidelines default emission factors (Vol 4, Ch 10.4.1).

Activity Data

According to the 2006 IPCC Guidelines, there are two main types of activity data for estimating CH4 emissions from manure management: (1) animal population data; and (2) manure management system usage data (Vol 4, Ch 10.4.3).

Emissions from manure management are calculated for all categories of livestock. The following manure management systems used in Armenia have been considered in making the estimates:

1. Pasture/Range/Paddock
2. Daily spread
3. Solid storage
4. Liquid/Slurry
5. Poultry manure with litter
6. Poultry manure without litter.

Based on official statistical data and a sample survey conducted among farmers and as a result of discussions with specialists from the Ministry of Economy, activity data required for assessing emissions from manure management have been adjusted for the years 1990-2019. The following activity data were adjusted:

Durations of grazing and nursery regimes of cattle and sheep, amounts of manure left on pasture and not collected, other data on manure management systems.

Now 53% as fuel and 47% as fertilizer, instead of former 70% as fuel and 30% as fertilizer.

The quantities of manure used as fuel calculated with the adjusted data correspond to the quantities of manure in the Energy Balance of Armenia obtained as a result of the Household Survey conducted by the SC of RA.

Emission factors and other parameters

Detailed information on animal characteristics and manure management practices were used to develop country-specific emission factors. In the meantime, considering that country-specific data is available for only a portion of the variables, country-specific emission factors were calculated using the data in Tables 10A-4 through 10A-9 to fill gaps (Volume 4, Chapter 10.4.2, p.10.42).

For the Tier 1 method default manure management emission factors for developing countries were used, considering that annual average temperature in Armenia is below 10°C (Vol 4, Ch 10, Table 10.15).

Time series consistency and recalculations

The consistent time series have been calculated for the 1990-2022 period with adjusted activity data.

Time series of methane emissions from manure management are presented in **Figure 6.4.**

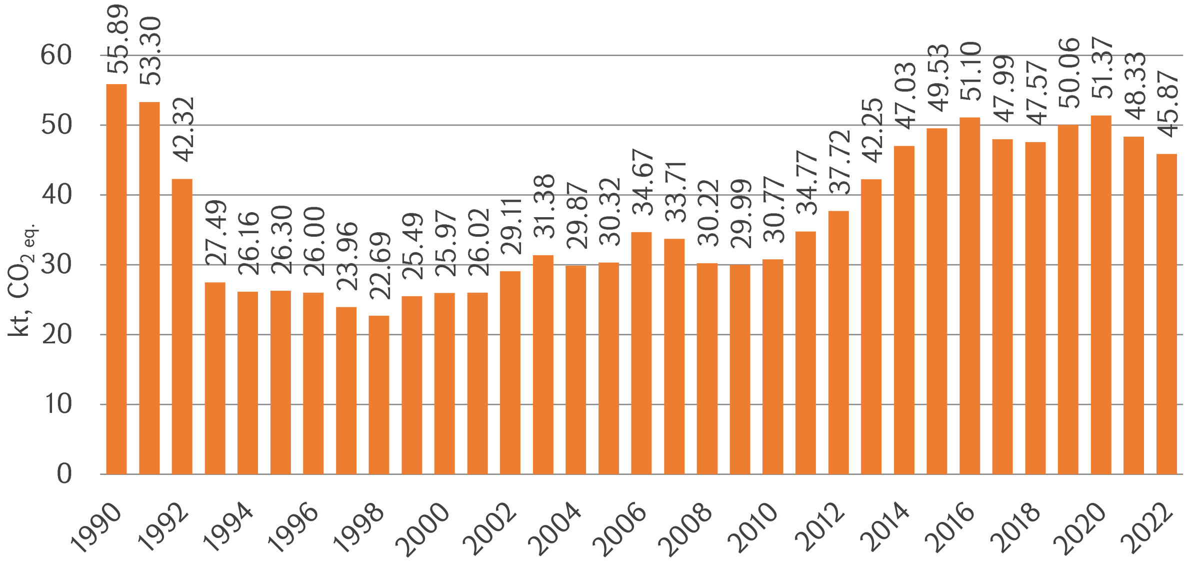

Figure 6.4 Methane emissions from manure management, 1990-2022, kt $CO_{2\ eq.}$

In 2020, methane emissions from manure management increased by 2.6% compared to the previous year, and decreased by 5%-6% in subsequent years.

Uncertainty assessment

The uncertainty of the emissions from manure management is due to the uncertainty of the activity data (the number of animals per species and management systems usage data) and the uncertainty of the emission factors.

For countries that rely almost exclusively on a single type of management system the uncertainty associated with management system usage data can be 10% or less (Volume 4, Chapter 10, Page 50). However, for countries where there is a variety of management systems used with different operating practices locally, the uncertainty range in management system usage data can be much higher. Considering that in Armenia there are six types of manure management systems, the activity data uncertainty was estimated at the level of 25%.

The uncertainty range for the default emission factors is estimated to be +30% (Volume 4, Chapter 10 p.4.4).

As a result, the combined uncertainty of methane emissions was estimated to be 39%.

N_2O emissions

Choice of method, activity data and emission factors

Direct N_2O emissions

Nitrous oxide emissions from manure management of the cattle, buffalos and sheep were calculated using Tier 2 methodology, and for other livestock categories - using Tier 1 methodology with country-specific activity data and using the default emission factors per manure management system (Volume 4, Table 10.21).

The Tier 1 method entails 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 (Volume 4, Ch 10.5.1, Equation 10.25). Emissions are then summed over all manure management systems. The Tier 1 approach is applied using IPCC default N2O emission factors, default nitrogen excretion data, and default manure management system data (Annex 10A.2, Tables 10A-4 to 10A-8 for default management system allocations).

The Tier 2 approach follows the same calculation equation as Tier 1 but includes the use of country-specific data for some or all of these variables. Annual N excretion rates for livestock categories were calculated applying Equation 10.31 (Volume 4) and using country-specific data.

Indirect N_2O emissions

Tier 1 and Tier 2 calculations of N volatilization in forms of NH3 and NOx from manure management systems are 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 (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 (Volume 4, Annex 10A.2, Tables 10A-4 to 10A-9) and default fractions of N losses from manure management systems due to volatilization (Volume 4, Table 10.22).

Time series consistency and recalculations

Time series has been recalculated and consistent time series has been assessed for the 1990-2022 period with adjusted activity data.

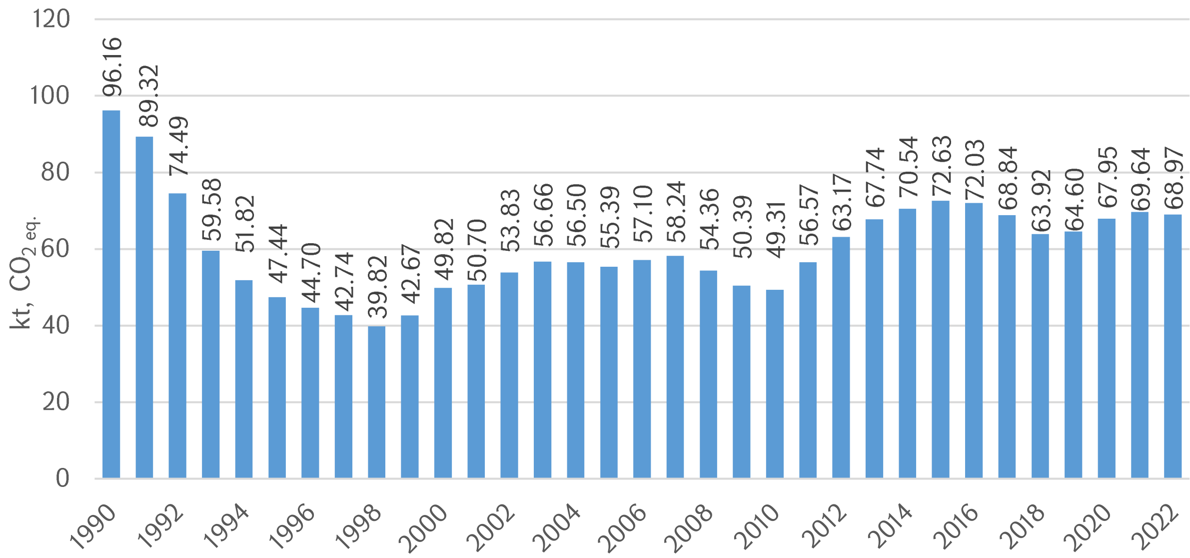

Figure 6.5 Nitrous oxide emissions from manure management, 1990-2022, kt $CO_{2\ eq.}$

In 2020 and 2021, nitrous oxide emissions from manure management increased by 5.2% and 2.9%, respectively, compared to the previous year, and in 2022, they decreased by 0.67% compared to the previous year.

Uncertainty assessment

The uncertainty of the emissions from manure management is due to the uncertainty of the activity data (the number of animals per species) and the uncertainty of the emission factors.

The uncertainties of activity data and emission factors were determined based on expert judgement as follows:

- Activity data: 5%
- Emission factors: 30%

As a result, the combined uncertainty of N_2O emissions was estimated to be 39.1%.

Category-specific QA / QC and verification

General and category-specific quality control and quality assurance have been carried out by the relevant technical experts through application of the Inventory QA/QC plan outlined in Annex 7.

Category-specific planned improvements

No specific improvements are planned at present.

Summary of emissions from livestock

Table 6.6 below provides methane and nitrous oxide emissions from livestock *Enteric Fermentation* and *Manure Management*.

Table 6.6 Methane and nitrous oxide emissions from Livestock Enteric Fermentation and Manure Management, kt

Livestock Categories	2020		2021		2022	
	CH_4	N_2O	CH_4	N_2O	CH_4	N_2O
3. Total	**47.661**	**0.256**	**48.023**	**0.267**	**45.264**	**0.260**
3.A Enteric Fermentation	**45.826**	**NA**	**46.297**	**NA**	**43.626**	**NA**
3.A.1 Cattle	39.533		39.841		37.234	
3.A.1.a.i Dairy Cows	23.851		24.324		23.439	
3.A.1.a.ii Other Cattle	15.682		15.518		13.795	
3.A.2 Sheep	5.063		5.268		5.268	
3.A.3 Swine	0.015		0.014		0.011	
3.A.4.a. Buffalo	0.053		0.054		0.046	
3.A.4.d. Goats	0.366		0.358		0.329	
3.A.4.e. Horses	0.000		0.000		0.000	
3.A.4.f. Mules and Asses	0.220		0.243		0.244	
3.A.4.g. Poultry	0.087		0.095		0.092	
3.A.4.h. Other animals (3A.4.h.i Rabbits and 3.A.4.h.iv Fur bearing animals)	0.480		0.415		0.393	
3.B. Manure management	**1.835**	**0.256**	**1.726**	**0.267**	**1.638**	**0.260**
3.B.1.a Cattle	0.581	0.008	0.587	0.008	0.546	0.007
3.B.1.a.i. Dairy Cows	0.342	0.005	0.351	0.005	0.342	0.005
3.B.1.a.ii. Other Cattle	0.239	0.003	0.236	0.003	0.204	0.003
3.B.2 Sheep	0.171	0.146	0.178	0.152	0.178	0.152
3.B.3 Swine	0.001	0.000	0.001	0.000	0.001	0.000
3.B.4.a. Buffalo	0.001	0.000	0.001	0.000	0.001	0.000
3.B.4.d. Goats	0.011	0.005	0.011	0.005	0.010	0.005
3.B.4.e. Horses	0.000	0.000	0.000	0.000	0.000	0.000
3.B.4.f. Mules and Asses	0.013	0.000	0.015	0.000	0.015	0.000
3.B.4.g. Poultry	0.960	0.012	0.831	0.010	0.787	0.009
3.B.4.h. Other animals (3A.4.h.i Rabbits and 3.A.4.h.iv Fur bearing animals)	0.087	0.013	0.095	0.014	0.092	0.013
3.B.5. Indirect N2O emissions		0.073		0.074		0.073

Figure 6.6 shows GHG emissions from *Livestock* in 1990-2022.

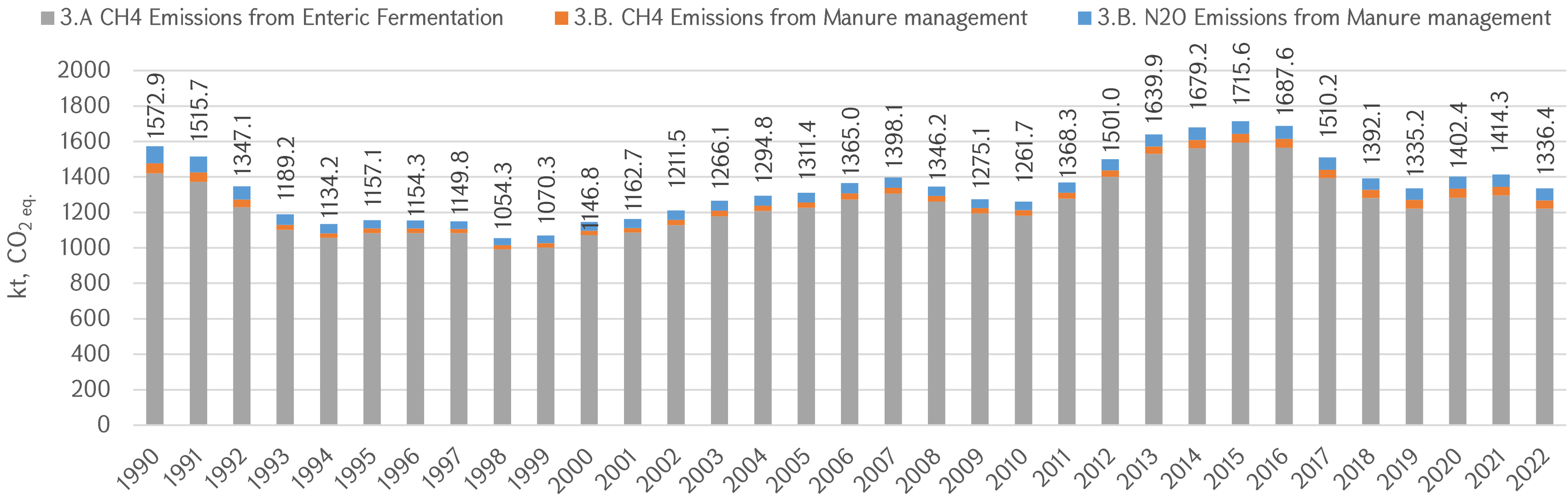

Figure 6.6 GHG emissions from *Livestock*, 1990-2022, kt $CO_{2\ eq.}$

3.D Agricultural Soils

3.D.1 Direct N2O Emissions from Managed Soils

The source category *Direct N_2O emissions from managed soils* is a key category for N_2O emissions, in terms of both emissions level and trend.

Choice of method

Direct N_2O emissions from managed soils are estimated by Tier 1 method, using Equation 11.1 (Vol 4, Ch 11.2.1) with country specific activity data and default emission factors (EF), which are required for estimating direct N_2O emissions from managed soils.

Activity data

The source of activity data was official statistics published by the SC, namely External Trade of the Republic of Armenia (According to the EEU Commodity Nomenclature of External Economic Activity at 10-digit level). (Ref-5)

The following N sources were considered for estimating direct N_2O emissions from managed soils:

- Applied synthetic fertilizer (chemical nitrogen import volumes by fertilizer type were used)
- Mineral or chemical nitrogen fertilizers
- Mineral or chemical fertilizers, phosphoric
- Mineral or chemical potash fertilizer
- Mineral or chemical fertilizers (containing two or three elements) with a net mass of <10 kg
- Urine and dung from grazing animals (Organic nitrogen used as fertilizer in the form of animal manure (including urine))
- Nitrogen from manure, urine and poultry litter remaining in pastures (specific gravities of manure and poultry litter were used according to their management method).
- Nitrogen in crop residues, including from nitrogen-fixing crops and forage crops (data on land area and harvested dry matter were used to estimate the volumes of crop residues) .

Emission factors and other parameters

According to the 2006 IPCC Guidelines, three emission factors (EF) are required for assessing direct N_2O emissions from managed soils. The default values summarized in Table 11.1. ((Vol 4, Ch 11.2.1.2) were used in the Tier 1 equation:

- the first EF (EF1) refers to the amount of N_2O emitted from the various synthetic and organic N applications to soils, including crop residue and mineralization of soil organic carbon in mineral soils due to land-use change or management.
- the second EF (EF2) refers to the amount of N_2O emitted from an area of drained/managed organic soils,
- the third EF (EF3PRP) estimates the amount of N_2O emitted from urea and dung N deposited by grazing animals on pasture, range and paddock.

Summary of Direct N_2O emissions from managed soils

Table 6.7 presents Direct N_2O Emissions from Managed Soils

Table 6.7 Direct N_2O Emissions from Managed Soils

Category	Activity data			Emissions		
	Total amount of N applied (kt N/yr)			N_2O (kt)		
	2020	2021	2022	2020	2021	2022
3.D.1 Direct N_2O emissions from managed soils	**96.36**	**90.79**	**86.71**	**2.04**	**2.04**	**1.95**
3.D.1.a Inorganic N fertilizers	27.89	27.91	26.23	0.44	0.44	0.41
3.D.1.b Organic N fertilizers	15.35	16.37	16.04	0.24	0.26	0.25
3.D.1.c Urine and dung deposited by grazing animals	45.96	45.63	43.56	1.35	1.33	1.27
3.D.1.d Crop residues	0.16	0.18	0.17	0.002	0.003	0.003
3.D.1.e Mineralization/immobilization associated with loss/gain of soil organic matter	7.01	0.70	0.70	0.01	0.01	0.01

3.D.2 Indirect N_2O Emissions from Managed Soils

The source category *Indirect N_2O emissions from managed soils* is a key category for N_2O emissions in terms of emissions level.

Choice of method

Nitrous oxide (N_2O) indirect emissions from managed soils are estimated by Tier 1 method. The N_2O emissions from atmospheric deposition of N volatilized from managed soil are estimated using Equation 11.9 and the N_2O emissions from leaching and runoff in regions where leaching and runoff occurs are estimated using Equation 11.10 (Volume 4, Chapter 11.2.2.1)

The nitrogenous fertilizer most commonly used in Armenia is ammonium salt (NH4NO3), which contains 34.6% nitrogen in the form of ammonium and nitrate ions. Ammonium salts are predominant in nitrogen fertilizers, as half of the nitrogen is in the form of readily moveable nitrate and the other half in the form of hard-moving ammonium. It is used both in the form of basic fertilization during preliminary cultivation and in the form of fertilization and nutrition of saplings. Ammonium salts can be used for fertilizing all agricultural crops. For example, the proportion of nitrogen fertilizers for cereal crops ranges between 30-90 kg/ha, for vegetable crops during the whole vegetation period the proportion is 60-120 kg/ha of nitrogen in case of fertilization with 20-30 tons / ha of manure, for potato 60-90 kg/ha for fruits 60-90 kg/ha, sometimes up to 120 kg/ha, and for berries - 45-60 kg/ha, depending on the degree of soil fertility, etc.

Multiple factors, including increased prices of agricultural products in Armenia in recent years, combined with the expansion of export opportunities, Government support (e.g. subsidies for fertilizers), and the growth in income levels from farming have contributed to higher volumes of inorganic fertilizer use in crops.

Activity Data and emission factors

According to the 2006 IPCC Guidelines, the following N sources of indirect N_2O emissions from managed soils arising from agricultural inputs of N are considered (Vol 4, Ch 11.2.2):

- synthetic N fertilizers (FSN)
- organic N applied as fertilizer (e.g., animal manure, compost, sewage sludge, rendering waste and other organic amendments) (FON);
- urea and dung N deposited on pasture, range and paddock by grazing animals (FPRP);
- N in crop residues (above- and below-ground), including N-fixing crops and forage/pasture renewal returned to soils (FCR).

Source of activity data was official statistics published by the SC, namely External Trade of the Republic of Armenia (According to the EEU Commodity Nomenclature of External Economic Activity at 10-digit level). (Ref-5)

Summary of indirect N_2O emissions from managed soils

Table 6.8 shows *Indirect N_2O Emissions from Managed Soils (3.D.2)* and from *Manure management (3.B.5)*.

Table 6.8 Indirect N_2O Emissions from Managed Soils (3.D.2) and from Manure management (3.B.5.)

Categories	2020 Activity Data Total amount of N applied / excreted (kt N / yr)	2020 Emissions N_2O (kt)	2021 Activity Data Total amount of N applied / excreted (kt N / yr)	2021 Emissions N_2O (kt)	2022 Activity Data Total amount of N applied / excreted (kt N / yr)	2022 Emissions N_2O (kt)
3.D.2 Indirect N_2O Emissions from managed soils		**0.512**		**0.517**		**0.491**
3.D.2.a From atmospheric deposition of N volatilized from managed soils from agricultural inputs of N (synthetic N fertilizers; organic N applied as fertilizer; urine and dung N deposited on pasture, range and paddock by grazing animals	89.635	0.194	90.471	0.197	91.025	0.187
Unspecified	61.749	0.194	62.565	0.197	64.796	0.187
Cropland	27.886		27.906		26.229	
3.D.2.b From N leaching/runoff from managed soils (i.e. from synthetic N fertilizers; organic N applied as fertilizer; urine and dung N deposited on pasture, range and paddock by grazing animals; N in crop residues; and N mineralization/immobilization associated with loss/gain of soil organic matter resulting from change of land use or management of mineral soils)	91.369	0.317	92.232	0.321	92.775	0.304
Unspecified	61.749	0.218	62.565	0.221	64.796	0.211
Cropland	27.887	0.099	27.908	0.099	26.231	0.093
Grassland	0.858	0.001	0.884	0.001	0.874	0.001
Other Land	0.875		0.875		0.875	
3.B.5 - Indirect N2O Emissions from manure management	39.714	0.073	40.561	0.074	39.617	0.073

Time Series consistency and recalculations (3.D.1), (3.D.2)

Based on the data from the "External Trade of the Republic of Armenia (according to the 8- and 10-digit classification of the Commodity Nomenclature of External Economic Activity)" of the RA SC, the time series of direct and indirect nitrous oxide emissions from managed soils were recalculated for the entire period. Emissions were estimated by types of inorganic fertilizers.

Due to data gaps on years 1990-1995, emissions for 1990-1995 were estimated by linear interpolation assuming a constant annual decrease in emissions from 1990-1995.

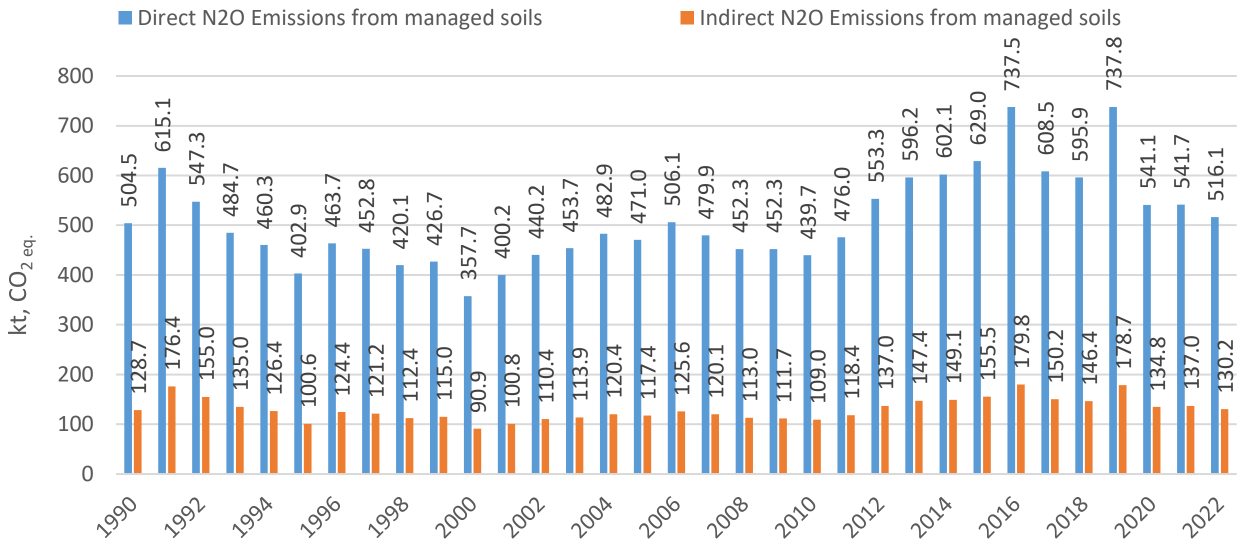

Figure 6.7 Time Series of *Direct and Indirect N_2O Emissions from Managed Soils*, kt $CO_{2\ eq.}$

Category-specific QA / QC and verification

General and category-specific quality control and quality assurance have been carried out by the relevant technical experts through application of the Inventory QA/QC plan outlined in Annex 7.

Category-specific planned improvements

No specific improvements are planned at present.

(3.F.) Field burning of agricultural residues

Choice of method

Emissions from Field burning of agricultural residues were estimated using Tier 1 method (Equation 2.27, Vol 4, Annex 2).

Activity data

Emissions of CH_4, N_2O, CO and NO_x were estimated using expert data on cereal crop areas and area burned with agricultural residues.

Emission factors

Default emission factors have been used from the 2006 IPCC Guidelines (Vol.4, Annex 2)

Summary of emissions from burning of agricultural residues

Table 6.9 shows emissions from *Field burning of agricultural residues*.

Table 6.9 Emissions from Field burning of agricultural residues

Categories	Activity data		Emissions				
	Unit	Value	CO_2 (kt)	CH_4 (kt) Biomass	N_2O (kt)	NOx (kt)	CO (kt) Bio-mass
				2020			
3.F Burning of agricultural residues on croplands.				0.105	0.003	0.097	3.581
Controlled burning	ha	9732		0.105	0.003	0.097	3.581
				2021			
3. Burning of agricultural residues on croplands.				0.108	0.003	0.100	3.678
Controlled burning	ha	9994		0.108	0.003	0.100	3.678
				2022			
3.F Burning of agricultural residues on croplands.				0.099	0.0025	0.092	3.368
Controlled burning	ha	9153		0.099	0.0025	0.092	3.368

Time series consistency and recalculations

No recalculations were performed for this category.

Figure 6.8 presents GHG emissions from the burning of agricultural residues in 1990–2022.

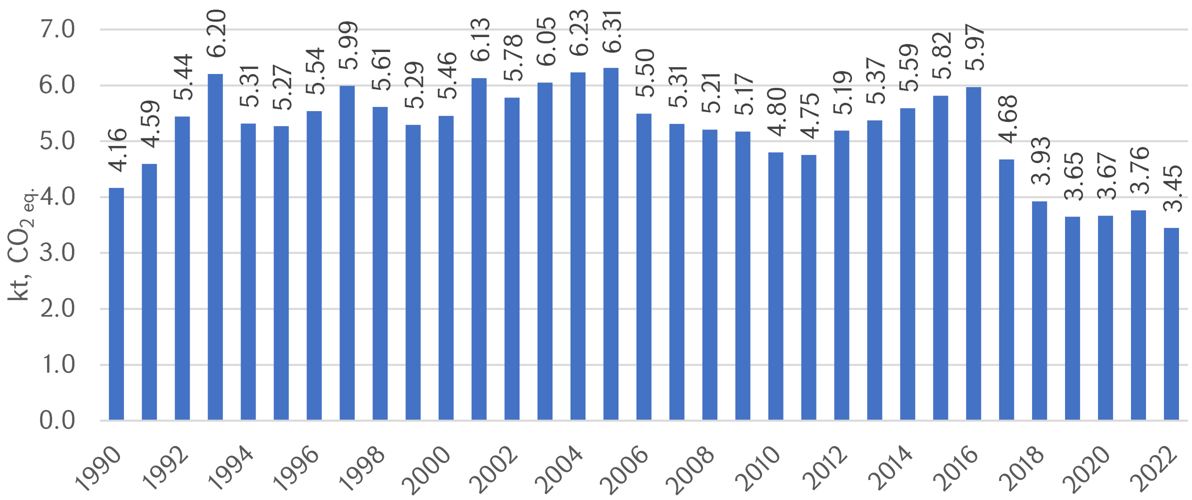

Figure 6.8. GHG emissions from the burning of agricultural residues in 1990–2022, kt $CO_{2\ eq.}$

Category-specific QA / QC and verification

General and category-specific quality control and quality assurance have been carried out by the relevant technical experts through application of the Inventory QA/QC plan outlined in Annex 7.

Category-specific planned improvements

No specific improvements are planned at present.

3.H Urea application

Choice of method

CO_2 emissions from urea fertilization were estimated by the Tier 1 method with Equation 11.13 (Volume 4, Chapter 11.4.1).

Activity data

Import data on urea were used from External Trade of the Republic of Armenia (According to the EEU Commodity Nomenclature of External Economic Activity at 10-digit level) - from a group of imported mineral or chemical nitrogen fertilizer products (product code: 3102 10, 3102 90) to estimate the amount of urea applied to soils on an annual basis, assuming that all available urea in a particular year is immediately added to soils (Volume 4, Chapter 11.4.3).

Year	Category	Annual amount of carbonate N-fertilizer (tonne/year)
2020	3.H. Urea application	3,668
2021	3.H. Urea application	6,683.3
2022	3.H. Urea application	5,162.2

Emission factors

The default emission factor of 0.20 for carbon emissions from urea applications was used (Volume 4, Chapter 11.4.2).

Time series consistency and recalculations

No recalculations have been made for this category, and the time series is consistent.

Figure 6.9 shows emissions from urea application from early 2000s to 2022.

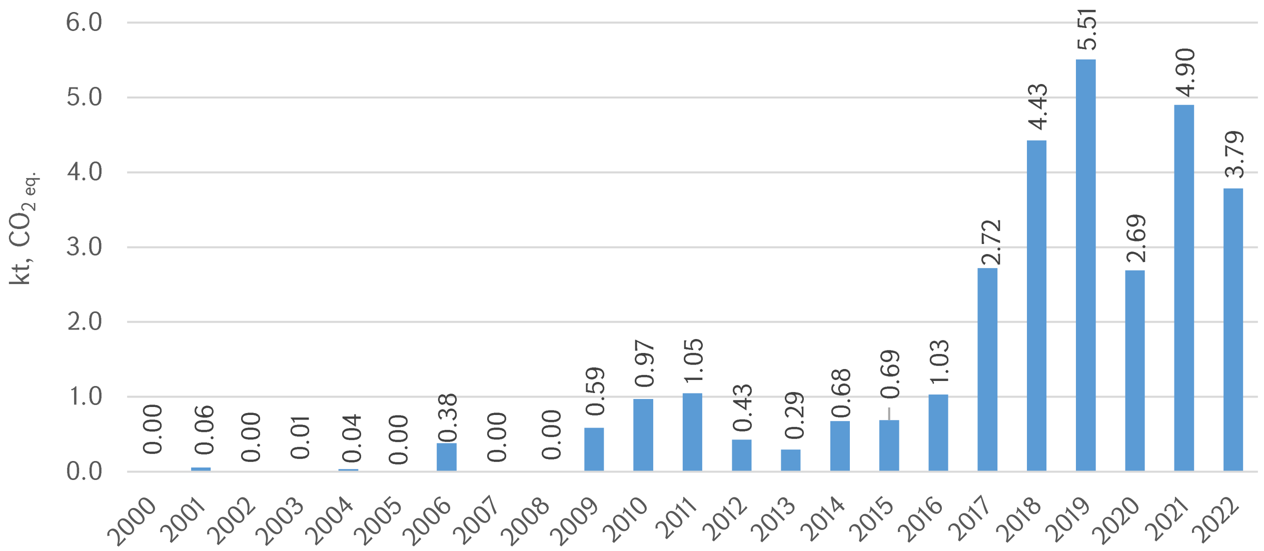

Figure 6.9 CO_2 emissions from urea application, kt

Category-specific QA / QC and verification

General and category-specific quality control and quality assurance have been carried out by the relevant technical experts through application of the Inventory QA/QC plan outlined in Annex 7.

Category-specific planned improvements

No specific improvements are planned at present.

7. LAND USE, LAND-USE CHANGE AND FORESTRY (CRT SECTOR 4)

Overview of GHG emissions in CRT Sector 4

Emissions and removals from the LULUCF sector were calculated according to the 2006 IPCC Guidelines. The land area is divided into six land-use categories and into the subcategories "lands remaining in the same land-use category for the last 20 years" and "lands converted to present land use during the past 20 years", i.e., in reporting on emissions/removals of greenhouse gases in each land-use category, a distinction is made between areas which, during the reporting period, undergo no land-use changes and undergo land-use changes.

(4.A) Forest land

(4.A.1) Forest land Remaining Forest land

(4.A.2) Land Converted to Forest land

(4.B) Cropland

(4.B.1) Cropland Remaining Cropland

(4.B.2) Land Converted to Cropland

(4.C) Grassland

(4.C.1) Grassland Remaining Grassland

(4.C.2) Land Converted to Grassland

(4.D) Wetland

(4.D.1) Wetland Remaining Wetland

(4.D.2) Land Converted to Wetland

(4.E) Settlement

(4.E.1) Settlements Remaining Settlements

(4.E.2) Land Converted to Settlements

(4.F) Other Land

(4.F.1) Other land Remaining Other land

(4.E.2) Land Converted to Other land

(4.G) Harvested wood products

N_2O and CH_4 emissions from biomass burning (wildfires) are also inventoried.

The following carbon pools are considered:

- Biomass (above-ground and below-ground biomass)
- Dead organic matter (dead wood, litter),
- Soil carbon (organic and mineral soils)

4.A.1 Forest Land Remaining Forest Land is identified as the key source category both with level and trend assessment in 2022.

Net LULUCF sector removals amounted to 390.33 kt $CO_{2\ eq.}$ in 2020, 383.7 kt $CO_{2\ eq.}$ in 2021 and 381.88 kt $CO_{2\ eq.}$ in 2022.

Table 7.1 shows GHG emissions in LULUCF sector by category and gas in 2020-2022. The discrepancy between this table and CRT table 4 is caused by the fact that non-CO_2 emissions from croplands represent the emissions from the field burning of agricultural residues (3.F) and are presented in the chapter for agriculture (see **Table 6.9**).

Table 7.1 LULUCF sector emissions in 2020-2022

Categories	2020				2021				2022			
	Net CO_2, kt	CH_4, kt	N_2O, kt	Total, kt $CO_{2\ eq.}$	Net CO_2, kt	CH_4, kt	N_2O, kt	Total, kt $CO_{2\ eq.}$	Net CO_2, kt	CH_4, kt	N_2O, kt	Total, kt $CO_{2\ eq.}$
4.A. Forest land	-476.73	0.01	0.00	-476.12	-471.36	0.04	0.00	-469.77	-458.00	0.05	0.00	-456.04
4.A.1. Forest land remaining forest land	-475.31	0.01	0.00	-474.70	-469.94	0.04	0.00	-468.35	-456.58	0.05	0.00	-454.62
4.A.2. Land converted to forest land	-1.42	NA	NA	-1.42	-1.42	NA	NA	-1.42	-1.42	NA	NA	-1.42
4.B. Cropland	-6.03	NA	NA	-6.03	-6.02	NA	NA	-6.02	-6.00	NA	NA	-6.00
4.B.1. Cropland remaining cropland	0.60	NA	NA	0.60	0.61	NA	NA	0.61	0.63	NA	NA	0.63
4.B.2. Land converted to cropland	-6.63	NA	NA	-6.63	-6.63	NA	NA	-6.63	-6.63	NA	NA	-6.63
4.C. Grassland	25.65	0.00	0.01	27.83	25.65	0.00	0.01	27.74	25.65	0.00	0.01	27.73
4.C.1. Grassland remaining grassland	NA	0.00	0.00	0.13	NA	0.00	0.00	0.04	NA	0.00	0.00	0.03
4.C.2. Land converted to grassland	25.65	NA	0.01	27.70	25.65	NA	0.01	27.70	25.65	NA	0.01	27.70
4.D. Wetlands (5)	18.34	0.02	0.00	18.85	13.29	0.02	0.00	13.80	21.34	0.02	0.00	21.86
4.D.1. Wetlands remaining wetlands	18.34	0.02	0.00	18.85	13.29	0.02	0.00	13.80	21.34	0.02	0.00	21.86
4.D.2. Land converted to wetlands	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
4.E. Settlements	10.90	NA	NA	10.90	20.06	NA	NA	20.06	-0.48	NA	NA	-0.48
4.E.1. Settlements remaining settlements	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
4.E.2. Land converted to settlements	10.90	NA	NA	10.90	20.06	NA	NA	20.06	-0.48	NA	NA	-0.48
4.F. Other land (6)	32.10	NA	0.01	35.74	32.10	NA	0.01	35.74	32.10	NA	0.01	35.74
4.F.1. Other land remaining other land												
4.F.2. Land converted to other land	32.10	NA	0.01	35.74	32.10	NA	0.01	35.74	32.10	NA	0.01	35.74
4.G. Harvested wood products (7)	-1.50			-1.50	-5.25			-5.25	-4.69			-4.69
4.H. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Total	**-397.28**	**0.03**	**0.02**	**-390.33**	**-391.54**	**0.05**	**0.02**	**-383.70**	**-390.08**	**0.06**	**0.02**	**-381.88**

Figure 7.1 provides time series for GHG emissions and removals (sum of CO_2, CH_4 and N_2O) (kt $CO_{2\ eq.}$) in the LULUCF sector since 1990, by sub-categories. Please note that the categories of land conversion to lands other than forest land have been estimated only after 2011, as data is not available for the earlier years.

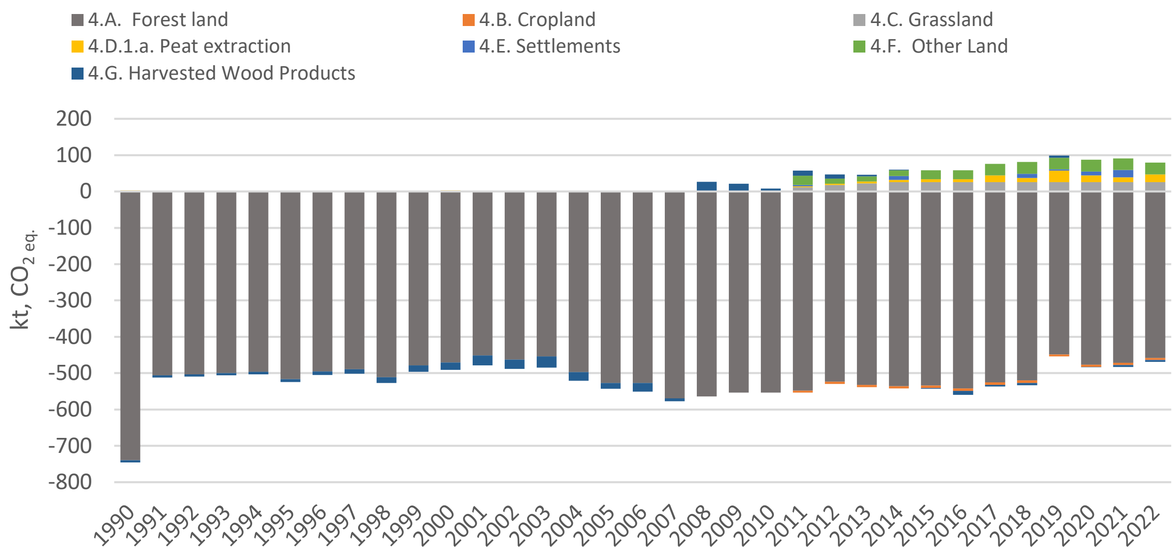

Figure 7.1 Time series for GHG emissions and removals (kt $CO_{2\ eq.}$) in the LULUCF sector since 1990, by sub-categories.

The LULUCF sector has been a sink during the whole time series from 1990 to 2022. The main factor behind this trend was *Forest Land*. Fluctuation in net biomass removals in the *Forest Land* category is driven primarily by changes in the annual volumes of fuelwood harvested and illegal logging.

The predominating greenhouse gas in this sector is carbon dioxide (CO_2) - the LULUCF sector is a considerable net sink for this greenhouse gas.

Land representation

Country's national land-use classification system does not match categories described in the 2006 IPCC Guidelines (V 4. Ch 3.2).

According to the Land Code of the Republic of Armenia the country's land stock is classified by purpose of use as follows:

1) Agricultural lands
2) Settlements
3) Industrial, sub-soil use and other industrial purpose lands
4) Energy, transport, communication, public utility infrastructure lands
5) Specially protected areas
6) Special significance
7) Forest
8) Water land
9) Reserve lands.

According to the 2006 IPCC Guidelines, if a country's national land-use classification system does not match categories described in the 2006 IPCC Guidelines, the land-use classifications should be combined or disaggregated in order to represent the categories presented in the

Guidelines and countries should report on the procedure adopted for the reallocation (V 4. Ch 3.2).

Based on the "Land Cover Classification Procedure of the Republic of Armenia" approved by the RA Government's Resolution No. 431-N of April 11, 2019, the following steps have been taken to align the national classification of the Land Code with the IPCC 2006 Guidelines classification:

1. The following were included in the Forest Land:

- 100% of forests on forest land,
- Forests of specially protected areas,
- Shelter forests from agricultural land.

2. The following were included in the Cropland:

- From agricultural lands: 100% of arable land and 100% of perennial plants,
- From forest land: 100% of arable land,
- From Settlements: 60% of home garden plots and gardening lands.

3. The following were included in the Grassland:

- From agricultural lands: 100% of hay-land, 100% of pasture and 20% of other lands,
- From Settlements: mixed construction and general use lands, public and other lands,
- From specially protected areas: non-Forest land and non-flooded areas,
- From areas of special significance: non-Forest land and non-flooded areas,
- From forest lands: 100% of hay-land and pastures and 20% of other land.

4. The following were included in the Wetlands:

- From subsoil use lands those used for peat extraction,
- Areas of lakes, reservoirs, hydro-technical and other water engineering facilities.

5. The following were included in Settlements:

- From Settlements: 100% of lands for housing construction, 40% of home garden plots and gardening lands
- From Industrial, sub-soil use and other industrial purpose lands with the exception of subsoil use lands: lands without vegetation
- Energy, transport, communication, public utility infrastructure lands
- From Specially protected areas: lands intended for healthcare, recreation, as well as of cultural and historical significance

6. In Other Lands were included lands without vegetation (shores of lakes and rivers, sandstones, bare rocks and mother rocks), in particular:

- From agricultural lands: 80% of other lands,
- From forest land: 80% of other lands,
- A portion of sub-soil use lands and lands of Special significance,
- From specially protected areas: areas of lakes and ponds,
- Offshore land areas, river and canal areas,
- Reserve lands.

“Report on the availability and distribution of the Land Fund of the Republic of Armenia (Land Balance)” of the State Cadastre Committee of the Republic of Armenia provides the data on conversions that have occurred between all categories of the national land classification and served as the basis for aligning the National Land Use Classification with the categories provided for in the Guidelines.

Table 7.2 provides the harmonization of the country’s national land-use classification with 2006 IPCC Guidelines Land Use categories, as of 2022.

Table 7.2 Harmonization of the national land-use classification with 2006 IPCC Guidelines Land Use categories, thousands ha, 2022

National land-use classification	RA Land Balance, ha	IPCC Guidelines Land Use categories, thousands ha						
		3B1 Forestland	3B2 Cropland	3B3 Grassland	3B4 Wetland	3B5 Settlement	3B6 Other Land	Total, ha
1. Agricultural	2042.08	0.92	481.88	1248.12			311.16	2042.08
1.1. arable land	442.73		442.73					442.73
1.2. perennial plants	39.15		39.15					39.15
1.3. hay-land	121.10			121.10				121.10
1.4. pastures	1049.66			1049.66				1049.66
1.5. other types of lands	389.44	0.92		77.36			311.16	389.44
2. Settlements	152.40		56.75	52.70		42.96		152.40
2.1 housing construction	99.70		56.75			42.96		99.70
2.1.1 home garden plots	89.89		53.93			35.96		89.89
2.1.2 gardening lands	5.18		2.81			2.37		5.18
2.1.3						4.63		4.63
2.2 public building	4.63			7.84				7.84
2.3 Mixed construction	7.84			2.43				2.43
2.4 Common use lands	2.43			18.46				18.46
2.5 Other Lands	18.46			23.96				23.96
3. Industrial, sub-soil use and other industrial purpose lands	39.52				3.56	35.96		39.52
3.1 industrial facilities	10.95					10.95		10.95
3.2 agricultural production facilities	12.78					12.78		12.78
3.3 storages	0.67					0.67		0.67
3.4 Land allocated for the use of subsoil	15.11				3.56	11.55		15.11
4. Energy, transport, communication, public utilities infrastructures lands	14.11					14.11		14.11
4.1 energy	2.47					2.47		2.47
4.2 communication	1.21					1.21		1.21
4.3 transport	9.10					9.10		9.10
4.4 Utility Infrastructure Objects	1.33					1.33		1.33
5. Specially protected areas	335.46	60.90	15.95	115.50		25.62	117.49	335.46
5.1 Nature protection	310.38	60.90	15.95	115.50	0	0.54	117.49	310.38
5.1.1 conservancy area	35.24	14.15	5.23	15.86				35.24
5.1.2 specially protected area	47.96	22.68	3.36	21.92				47.96

5.1.3 national park	227.19	24.08	7.36	77.72		0.54	117.49	227.19
5.2 healthcare	7.53					7.53		7.53
5.3 recreation	2.79					2.79		2.79
5.4 cultural and historical	14.75					14.75		14.75
6. Special significance	30.39			18.30		12.09		30.39
7. Forestry	333.85	289.83	11.06439	25.9681		6.99		333.85
7.1 forest	289.83	289.83						289.83
7.2 bush	10.81		10.81					10.81
7.3 arable land	0.26		0.26					0.26
7.4 hay-land	13.91			13.91				13.91
7.5 pasture	10.90			10.90				10.90
7.6 other lands	8.15			1.16		6.99		8.15
8. Water	25.83				6.29		19.55	25.83
8.1. rivers	8.30						8.30	8.30
8.2. reservoirs	3.11						3.11	3.11
8.3. lakes	5.03						5.03	5.03
8.4. canals	3.11						3.11	3.11
8.5. Hydro-technical and other water engineering facilities	6.29				6.29			6.29
9. Reserve	0.62						0.62	0.62
9.1. salts	0.00							0
9.2. sands	0.00							0
9.3. swamps	0.00							0
9.4. other unused lands	0.62						0.62	0.62
Total	2,974.26	351.65	565.64	1,460.58	9.85	137.49	449.04	2,974.26

The **Table 7.3** presents Land-Use conversion matrix for 2022.

Table 7.3 Land-use matrix of RA, thousand ha, 2022

FROM: \ TO: (kha)	Forest land (managed)	Forest land (unmanaged)	Cropland	Grassland (managed)	Grassland (unmanaged)	Wetlands (managed)	Wetlands (unmanaged)	Settlements	Other land	Total unmanaged land	Initial area
Forest land (managed) (2)	351.65	NO	NO	NO	NO	NO	NO	NO	NO	NO	351.65
Forest land (unmanaged) (2)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Cropland (2)	NO	NO	565.64	NO	NO	NO	NO	NO	NO	NO	565.64
Grassland (managed) (2)	NO	NO	NO	1 460.58	NO	NO	NO	NO	NO	NO	1 460.58
Grassland (unmanaged) (2)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Wetlands (managed) (2)	NO	NO	NO	NO	NO	9.85	NO	NO	NO	NO	9.85
Wetlands (unmanaged) (2)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Settlements (2)	NO	NO	NO	NO	NO	NO	NO	137.49	NO	NO	137.49
Other land (2)	NO	NO	NO	NO	NO	NO	NO	NO	449.04	NO	449.04
Total unmanaged land (3)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Final area	**351.65**	**NO**	**565.64**	**1 460.58**	**NO**	**9.85**	**NO**	**137.49**	**449.04**	**NO**	**2 974.26**

The method for determining land-use changes in the LULUCF sector provides an assessment of both the net losses or gains in the area of specific land-use categories and what these conversions represent (i.e., changes both from and to a category), thus it includes information on conversions between categories and pursuant to the 2006 IPCC Guidelines (Vol. 4 Chapter 3.3.1), thus it can be classified as an “Approach 2.”

4.A Forest Land

Sub-sector description

Armenia is distinguished by its strong vertical zonation and continental climate, where long-term anthropogenic (negative) activity, as well as changes in climatic factors, have had a negative impact on the development of forest ecosystems.

Forests and forest lands of the Republic of Armenia are under the jurisdiction of the RA Ministry of Environment.

Forest management and forest use activities are conducted both in the “Forestry” branches of “ArmForest” SNCO as well as in the forests included in the Specially protected areas, and Forest conservation measures are being implemented by the eco-patrol service under the Ministry of Environment.

Data on areas of RA Forest Stock by land types as well as regarding areas (ha) of forest lands covered by tree species, accumulated stock (cubic m), age, completeness and other required data for assessment of Forest category were collected from the ArmForest SNCO (LUCFref.1) and Specially Protected Areas of Nature (SPAN) SNCOs(LUCFref.2), and are based on the forests and forest land allocation according to the existing and former Forest Management Plans of ArmForest SNCO and the SPANs Management Plans.

According to RA Forest Code (LUCFref-3), forest lands are defined as lands covered with forests for the preservation of fauna and flora, nature protection, as well as lands not covered with forest but provided or intended for forestry needs , which may be:

1. Areas under forests
2. Non-adherent forest cultures
3. Young forest plantings
4. Non-forest areas that are divided into:
   - Rare forests (biological or anthropogenic),
   - Fired or dead trees,
   - Clear logged areas,
   - Forest glades.

Table 7.4 provides Forest stock data by land types compiled from the forest management plans.

Table 7.4 Forest stock by land type

Year	Forest land, ha					Non-Forest land, ha				Total
	Forest covered	Non-adherent forest cultures	Nurseries	Non-forest	Total forest lands	Hay-land	Pastures	Other Land (orchard, arable land and others)	Total non-forest land	
	Total			Fired areas, totally logged areas, forest glades, rare forests (Anthropogenic, biological)						
2020	349,377.11	3,791	135.9	51,296.8	419,344,7	2,943.2	24,617.49	75,207.96	102,768,65	522,050,35
2021	351,695.51	3,791	135.9	51,296.6	419,930.78	2,943.2	24,617.49	75,207.96	102,768.65	522,599.43
2022	351,655.11	3,791	135.9	51,296.6	419,930.78	2,943.2	24,617.49	75,207.96	102,768.65	522,599.43

According to the 2006 IPCC Guidelines, Forest Land includes:

- 4.A.1 *Forest Land Remaining Forest Land* - these lands (forests) should not have undergone land use change during 20 years prior to accounting year. For this sub-category, lands that did not undergo land use change in the past 20 years have been assessed. The area of this type of forests was 349,377.11 ha in 2020, in 2021 - 351,695.51 ha, and in 2022 - 351,655.11 ha (Table 7.4). The data was collected from the ArmForest SNCO and SPANs SNCOs.
- 4.A.2 *Lands Converted to Forest Land* - these lands are in transition stage and as a result of land use change during 20 years prior to accounting year they are converted to forest lands. For this sub-category, lands that were converted to forest land due to land use change over the past 20 years have been assessed. Since 2019, 26.4 ha have been converted to forest land.

4.A.1 Forest Land Remaining Forest Land

According to the 2006 IPCC Guidelines, GHG inventory for this sub-category involves estimation of changes in carbon stock from five carbon pools (i.e., above-ground biomass, below-ground biomass, dead wood, litter and soil organic matter).

As per the 2006 IPCC Guidelines, Tier 1 method assumes that the dead wood and litter carbon stocks are in equilibrium so that the changes in carbon stock in the Dead Organic Matter (DOM) pools are assumed to be zero, and due to incomplete scientific basis and resulting uncertainty, it is assumed in the Tier 1 method that forest soil C stocks do not change with management (Vol 4, Ch 4) .

Thus, changes in carbon stock were estimated for above-ground biomass and below-ground biomass.

This sub-category is a major source of carbon sequestration, accounting for nearly 99.7% of annual carbon sequestration from the *Forest Land* category.

Choice of method

The annual change in carbon stocks in biomass was estimated according to the 2006 IPCC Guidelines, using the gain-loss method. The method requires the biomass carbon loss to be subtracted from the biomass carbon gain (Volume 4, Chapter 4, Equation 2.7). Gains include total (above-ground and below-ground) biomass growth.

Annual gain in biomass (ΔCG) is a product of mean annual biomass increment (G_{TOTAL}), area of land (A) and carbon fraction of dry matter (CF) (Volume 4, Chapter 2, Equation 2.9):

$$\Delta CG = \Sigma ij \ (A \times GTOTAL \times CF)$$

G_{TOTAL} is calculated by using values of annual above-ground biomass growth (GW), below-ground biomass to above-ground biomass ratio (R) and considering basic wood density (BCEFR) (Volume 4, Chapter 2, Equation 2.10).

Biomass loss (ΔCL) is a sum of annual loss due to wood removals ($L_{removals}$), fuel wood gathering ($L_{fuelwood}$) and disturbances ($L_{disturbance}$), (Chapter 2, Equation 2.11).

As mostly country-specific data were used (wood annual average growth, basic wood density, etc.), calculated based on findings from the regional surveys (LUCFRef 6- 20), it can be concluded that the estimate for carbon stocks in biomass was done by Tier 2 method (Volume 4, Chapter 2).

Activity data

Other than land area and conversion, methodology also requires activity data for the losses. To assess the volume of wood removed from the forest in 2020-2022, data on harvested wood provided by the ArmForest SNCO (Forestry branches) and SPANs ("Sevan", "Dilijan", and "Arevik" National parks), as well as data on illegal logging identified by various organizations under the Ministry of Environment as a result of annual inspections were studied (LUCFRef-1, 2,4).

Annual volumes of harvested fuelwood, including illegal logging and timber harvested) are shown in **Figure 7.2**.

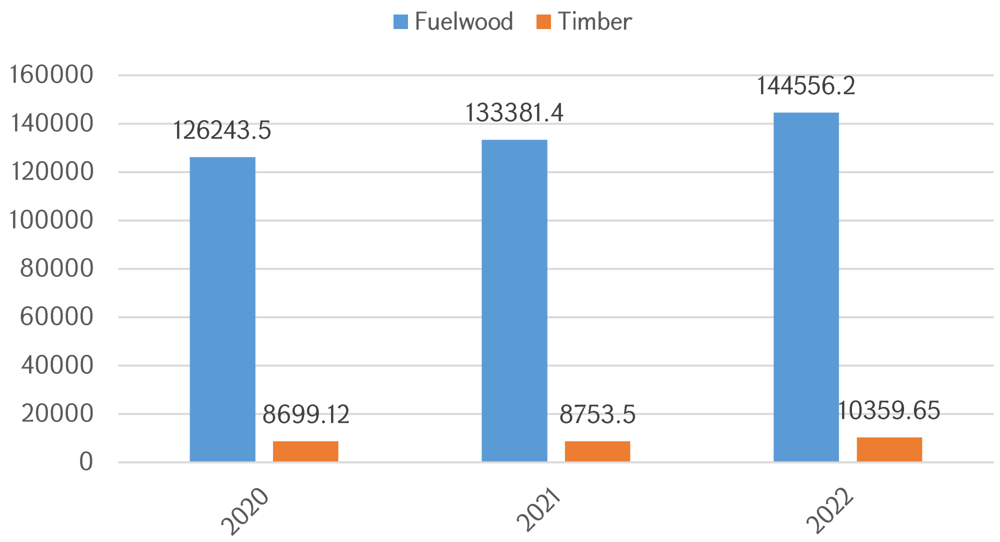

Figure 7.2. Annual volumes of harvested fuelwood, including illegal logging and of timber harvested, cubic m

Emission factors

The average annual above-ground biomass growth for a specific woody vegetation type was taken as GW = 0.835 tonnes d.m. /ha.

The GW was derived from the regional surveys (Ref-8, LUCFRef 7 - 22) and has been calculated based on biomass annual average growth per 1 ha of forest covered areas – 1.5 cubic meters (Annex 3.3, Table 3.3.2) and basic wood density - 0.557 oven-dry tonnes/moist cubic meter (Annex 5, Table 5.1).

GW = 1.5 cubic m/ha x 0.557 oven-dry tonnes/moist cubic m= 0.835 tonnes d.m./ha

GW estimate for Armenia shows that the figure is in the ecological zone of temperate mountain systems (Volume 4, Chapter 4, Table 4.9):

Below-ground biomass to above-ground biomass ratio (R) provided for temperate climatic zone and temperate mountains systems ecological zone in the 2006 IPCC Guidelines (Volume 4, Chapter 4, Table 4.4, referencing to Table 4.7 for above-ground biomass) was used for above-ground biomass of 75 - 150 t /ha, R = 0.23 tonne d.m. / (tonne d.m.).

Annual biomass increment equals to G_{TOTAL} = 0.835 tonnes d. m. annual /ha x (1+0.23) = 1.027 (Equation 2.10)

Carbon fraction of dry matter was equal to CF = 0.48 tonne C / (tonne d.m.) – the value provided for temperate climatic zone (Volume 4, Chapter 4, Table 4.3) was used.

Calculation of carbon stock changes

Since this is a key category the calculation of the increase in carbon stock is provided in detail below.

Estimates of carbon annual gain for 2020-2022 are the following:

2020: ΔCG = (349,377.11 - 968. 8) ha x 1.02705 tonne d.m./ha x 0.48 tonne C/ (tonne d.m.) = 171,759. 7 tonne C/annual

2021: ΔCG = (351,695.51 - 968. 8) ha x 1.02705 tonne d.m./ha x 0.48 tonne C/ (tonne d.m.) = 172,902. 6 tonne C/annual

2022: ΔCG = (351,655.11 - 968.8) ha x 1.02705 tonne d.m./ha x 0.48 tonne C/ (tonne d.m.) = 172,882.7 tonne C/annual

Annual carbon loss in biomass due to the harvested fuelwood and timber is shown in **Figure 7.3.**

As can be seen from the Figure 7.3, in 2022, 98.3% of annual carbon loss were caused by harvested fuelwood and 1.7% - by harvested timber.

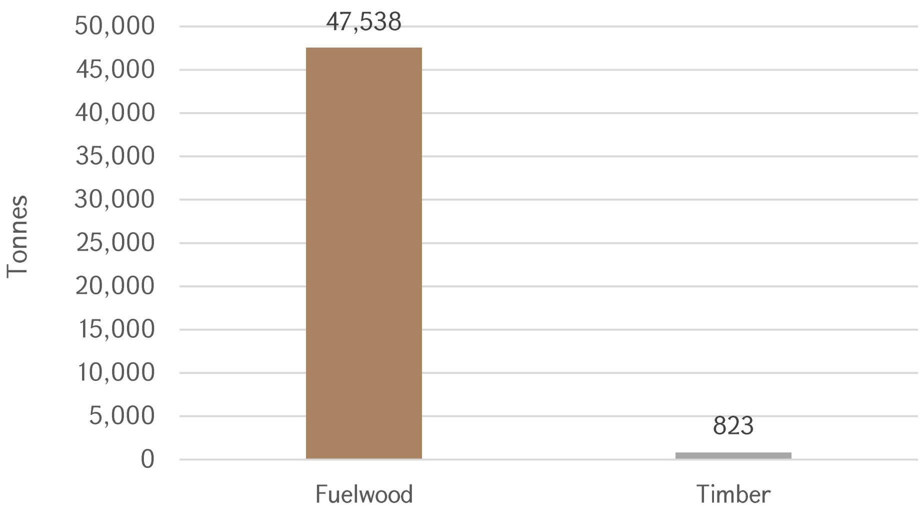

Figure 7.3 Carbon loss (tonne) caused by harvested fuelwood and commercial felling

Calculation of the annual change in carbon for 2020-2022 is provided below.

Table 7.5 Annual increase in biomass carbon stock

Indicators	2020
Covered area, ha	348,408.31
Biomass annual average growth per 1 ha, cubic meters	1.5
Carbon annual gains, C t/year	171,759. 7
Annual volume of harvested fuelwood, including illegal logging and fallen wood, cubic m,	126,423.5
Annual volume of timber harvested (commercial felling), cubic m	8,699.12
Annual carbon loss, C t/year	42,129.9

Indicators	2021
Covered area, ha	350,726.71
Biomass annual average growth per 1 ha, cubic meters	1.5
Carbon annual gains, C t/year	172,902.6

Annual volume of harvested fuelwood, including illegal logging and fallen wood, cubic m,	133,381.4
Annual volume of timber harvested (commercial felling), cubic m	8,573.5
Annual carbon loss, C t/year	44,737.7

Indicators	2022
Covered area, ha	350,686.31
Biomass annual average growth per 1 ha, cubic meters	1.5
Carbon annual gains, C t/year	172,882.7
Annual volume of harvested fuelwood, including illegal logging and fallen wood, cubic m,	144,556.2
Annual volume of timber harvested (commercial felling), cubic m	10,359,62
Annual carbon loss, C t/year	48,360.9

Time series consistency and recalculations

Figure 7.4 provides Carbon dioxide removals in *Forest Land Remaining Forest* Land sub-category

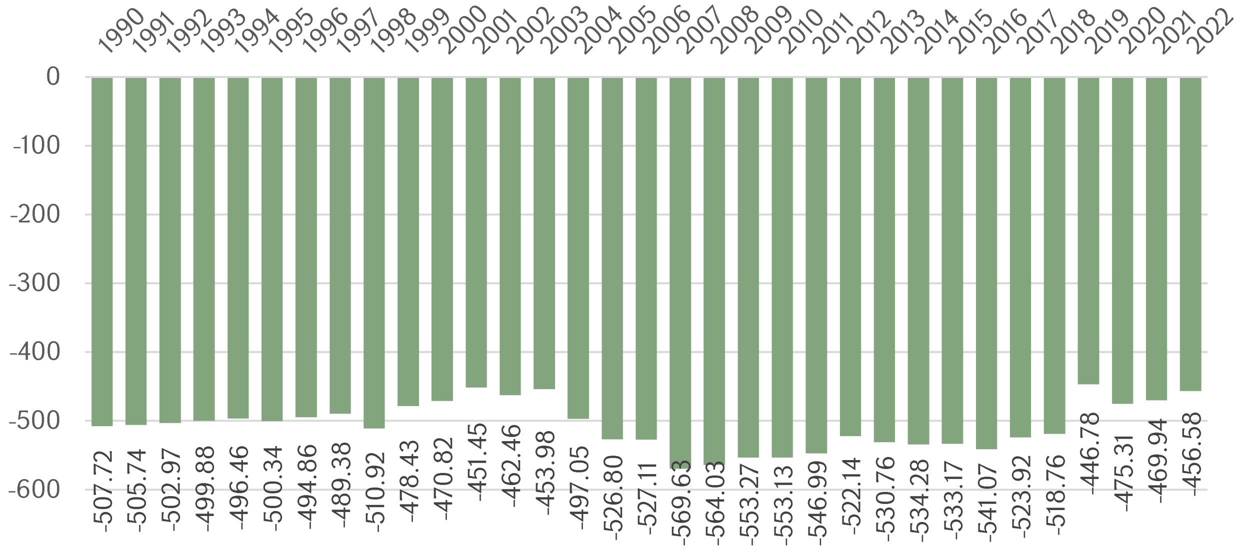

Figure 7.4 Carbon dioxide removals in *Forest Land Remaining Forest Land* sub-category, kt

Variations in carbon dioxide removals are primarily due to changes in the annual volumes of fuelwood harvested.

No recalculations have been done.

4.A.2. Land Converted to Forest Land

This subcategory refers to areas converted to forest land as a result of afforestation activity and natural afforestation during the last 20 years.

Choice of method

Tier 2 of biomass gains and loss method was applied to estimate GHG emissions and removals. These areas do not yet have the status, which would assume harvesting that result in carbon losses. Therefore, the calculation was made considering only carbon gains, which account for about 0.3% of annual total removals by all forest lands.

Activity data

Since 2019, the area under this sub-category has increased by 26.4 ha (Ref-8, LUCFRef -5).

Table 7.6 Area of tree species under Lands Converted to Forest Land sub-category as of 2022

N/N	Species	Area, ha
1	Pine-tree	602.6
2	Oak-tree	74
3	Ash-tree	113.1
4	Maple	34
5	Birch-tree	2.9
6	Poplar	5.5
7	Pear	31.6
8	Apple-tree	63.2
9	Walnut tree	15.6
10	Sea-buckthorn	3.6
11	Locust	2.3
12	Siberian pea shrub	10.5
13	Plum tree	0.9
14	Other species	7
	Total	**968.8**

Emission factors

The fraction of pine tree accounts for the prevailing part (about 62%) of the area covered by 14 tree species as well as of the cumulative stock (Table 7.6), therefore the weighted average factors derived for carbon stock change in living biomass mainly refer to pine trees.

The ratio of below-ground biomass to above-ground biomass (R) from the 2006 IPCC Guidelines (Vol. 4, Chapter 4, Table 4.4) was used, selected for the temperate climate zone and the temperate montane ecological zone.

Calculation of carbon stock changes

Table 7.7 Annual change in carbon stock of living biomass (including aboveground and belowground biomass)

Indicator	2020
Covered area, ha	968,8
Biomass annual average growth per 1 ha, cubic m	1.5
Carbon annual gains, C t/year	387.97
Indicator	**2021**
Covered area, ha	968,8
Biomass annual average growth per 1 ha, cubic m	1.5
Carbon annual gains, C t/year	387.97
Indicator	**2022**
Covered area, ha	968,8
Biomass annual average growth per 1 ha, cubic m	1.5
Carbon annual gains, C t/year	387.97

Time series consistency and recalculations

Figure 7.5 provides Carbon dioxide removals in *Land Converted to Forest Land* sub-category in 2011-2022

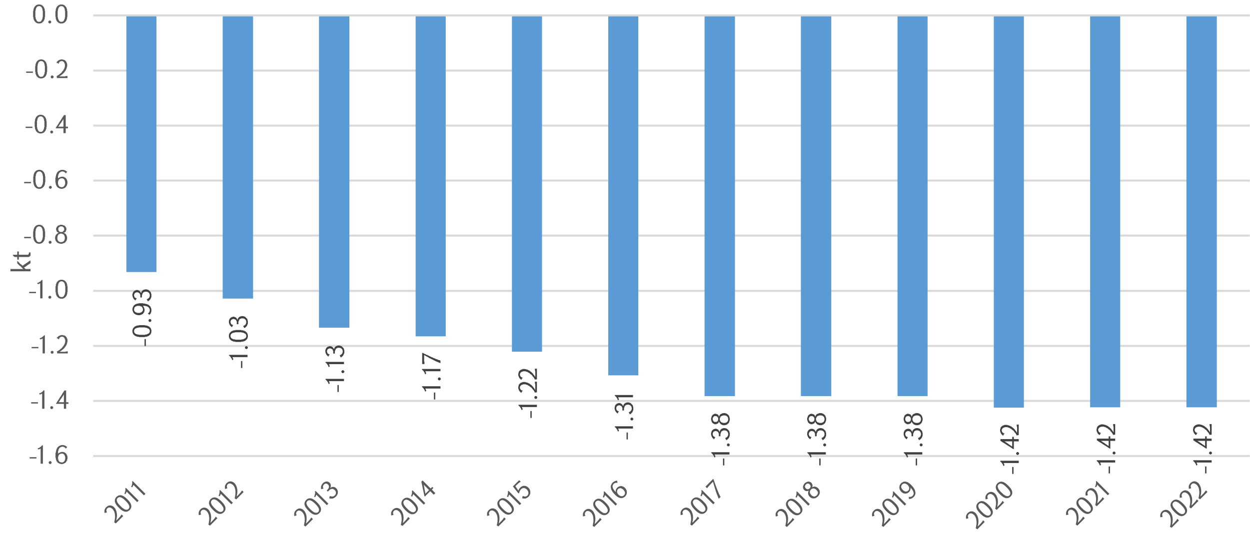

Figure 7.5 Carbon dioxide removals in *Land Converted to Forest Land* sub-category in 2011-2022, kt

Carbon dioxide removals have remained stable in recent years.

No recalculations have been done.

Category-specific planned improvements

No specific improvements are planned at present.

Uncertainty assessment

There is a lack of complete and reliable data on the recent changes in forest lands because of the above 20-year absence of forest inventory. Thereby, activity data, in particular, on deforestation, afforestation, reforestation, and on disturbances caused by fire, insects and diseases have high uncertainty. Due to the absence of forest inventory, the information on forest is missing or incomplete, in particular – on the area occupied by tree species, on accumulated stock, on annual average growth, etc.

The greatest uncertainty relates to forest-covered areas, volume of fuelwood and timber loss due to wildfires.

In recent years, a National Forest Inventory System has been introduced in Armenia, which aims to mitigate the uncertainties in assessing GHG removals in forest lands, as well as will be a useful source for estimating changes in carbon stock from other carbon pools.

Activity data uncertainty is estimated at approximately 5%.

EF uncertainty is estimated at approximately 105 %.

Combined uncertainty is estimated at 105.1%.

4.B Cropland

Sub sector description

According to the 2006 IPCC Guidelines, Cropland includes all annual and perennial crops as well as temporary fallow land (i.e., land set at rest for one or several years before being cultivated again) (Vol 4, Ch 5). Annual crops include cereals, oils seeds, vegetables, root crops and forages. Perennial crops include trees and shrubs, in combination with herbaceous crops (e.g., agroforestry) or as orchards, vineyards and plantations, except where these lands meet the criteria for categorization as Forest Land. Arable land, which is normally used for cultivation of annual crops, but which is temporarily used for forage crops or grazing as part of an annual crop-pasture rotation (mixed system) is included under *Cropland.*

Distribution of agricultural land according to the crop types in the categories Cropland and Grassland is based on data on crop areas published by RA SC.

According to the 2006 IPCC Guidelines (Vol 4, Ch 5.1), relevant carbon pools for cropland are: biomass (above-ground biomass, below-ground biomass), dead organic matter (dead wood, litter) soils (soil organic matter).

4.B.1 Cropland Remaining Cropland

Choice of method

According to the 2006 IPCC Guidelines, the change in biomass is only estimated for perennial woody crops (Vol 4, Ch 5.2.1).

Carbon stock change in biomass is estimated according to the 2006 IPCC Guidelines, using default Tier 1 method (Equation 2.7 in Chapter 2, Vol 4).

Lands are subdivided according to three climate regions available in Armenia: warm moderate dry, cold moderate dry and cold moderate humid. Annual crops were classified according to Armenian agricultural practices.

According to the 2006 IPCC Guidelines:

- For Tier 1 the default assumption is that there is no change in below-ground biomass of perennial trees in agricultural systems (Vol 4, Ch 5.2.1).
- The assumption in Tier 1 is that the DOM carbon stocks in all *Cropland Remaining Cropland* are insignificant or are not changing and therefore no emission/removal factors and activity data are needed (Vol 4, Ch 5.2.2).
- For mineral soils Tier 1 method is used (Vol 4, Ch 5.2.3) to estimate change in soil organic C stocks.

Thus, in 4.B.1. *Cropland Remaining Cropland* category CO_2 emissions and removals have been calculated due to changes of carbon stocks in above-ground biomass and in mineral soils.

Activity data

The source of activity data is the reports of the Cadastre Committee on the availability and distribution of the land fund (land balance) of the RA and data on crop areas published by RA SC.

Emission factors

Table 5.1 from the 2006 IPCC Guidelines was used for estimates of biomass stocks and biomass growth rates and losses for agricultural systems (Vol 4, Ch 5.2.1.2).

For mineral soils, Table 5.5 (Chapter 5.5) was used for Tier 1 default stock change factors for land use (FLU), input (FI) and management (FMG). The default time period for stock changes (D) is 20 years.

Soil organic C stock (SOC) from mineral soils is zero and no emissions/removal occur.

Time series consistency and recalculations

Figure 7.6 provides Carbon dioxide emissions/removals *in Cropland remaining cropland* sub-category in 1990 and 2011-2022

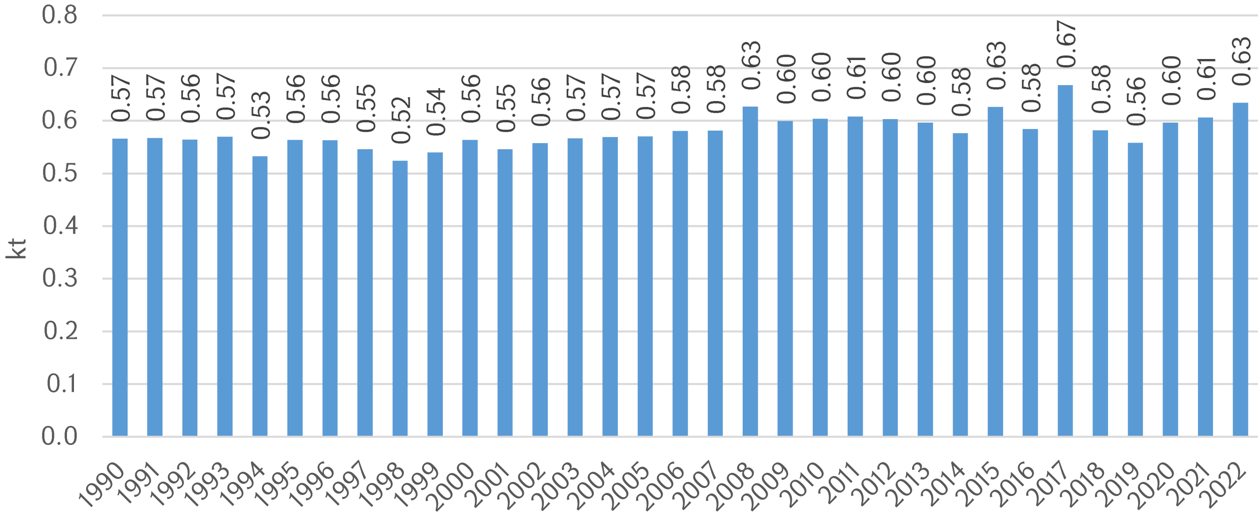

Figure 7.6 Carbon dioxide emissions in *Cropland remaining cropland* sub-category in 1990-2022, kt

Recalculations of the time series for the entire period have been done due to the adjusted activity data. The removals in 2019 changed from 0.67 kt CO_2 to 0.56 kt CO_2.

4.B.2 Land Converted to Cropland

Choice of method

According to the 2006 IPCC Guidelines (Vol 4, Ch 5.3.), relevant carbon pools for Land Converted to Cropland are: Biomass (above-ground biomass, below-ground biomass), Dead organic matter (dead wood, litter) Soils (soil organic matter).

Tier 1 method was used for calculating carbon stock change in biomass due to the conversion of land from natural conditions and other uses to Cropland, considering only carbon stock change in above-ground biomass since limited data are available on below-ground carbon stocks in perennial Cropland. (Vol 4, Ch 5.3.1.1). At Tier 1, carbon stocks in biomass immediately after conversion are assumed to be zero and in following years change in biomass of annual crops are considered to be zero.

According to the 2006 IPCC Guidelines (Vol 4, Ch 5.3.1.1) it is assumed that there will be no DOM in Cropland.

Thus, in 4.B.2. *Land Converted to Cropland* category CO_2 emissions and removals have been calculated due to changes of carbon stocks in mineral soils.

Soil organic C stock changes for mineral soils are estimated for land-use conversion to Cropland using Equation 2.25 in Chapter 2. For Tier 1, the initial (pre-conversion) soil organic C stock (SOC(0-T)) and C stock in the last year of the inventory time period (SOC0) are computed from the default reference soil organic C stocks (SOCREF) and default stock change factors (FLU, FMG, FI). Annual rates of stock changes are estimated as the difference in stocks (over time) divided by the time dependence (D) of the Cropland stock change factors (default is 20 years).

Activity data

According to the 2006 IPCC Guidelines (Vol 4, Ch 5.3.1.3), the estimates were done per areas of lands converted to Cropland from initial land uses to final crop land type.

According to the data of the State Cadastre Committee of the Republic of Armenia, in 2020 and 2021, 755.4 ha and 1218 ha of land have been converted from other categories to the category of agricultural land, respectively.

Emission factors

The default values for reference soil organic C stocks (SOC_{REF}) and stock change factors (F_{LU}, F_{MG}, F_I) have been used.

Time series consistency and recalculations

Figure 7.7 provides Carbon dioxide emissions/removals in *the Land Converted to Cropland* in 1990 and 2011-2022

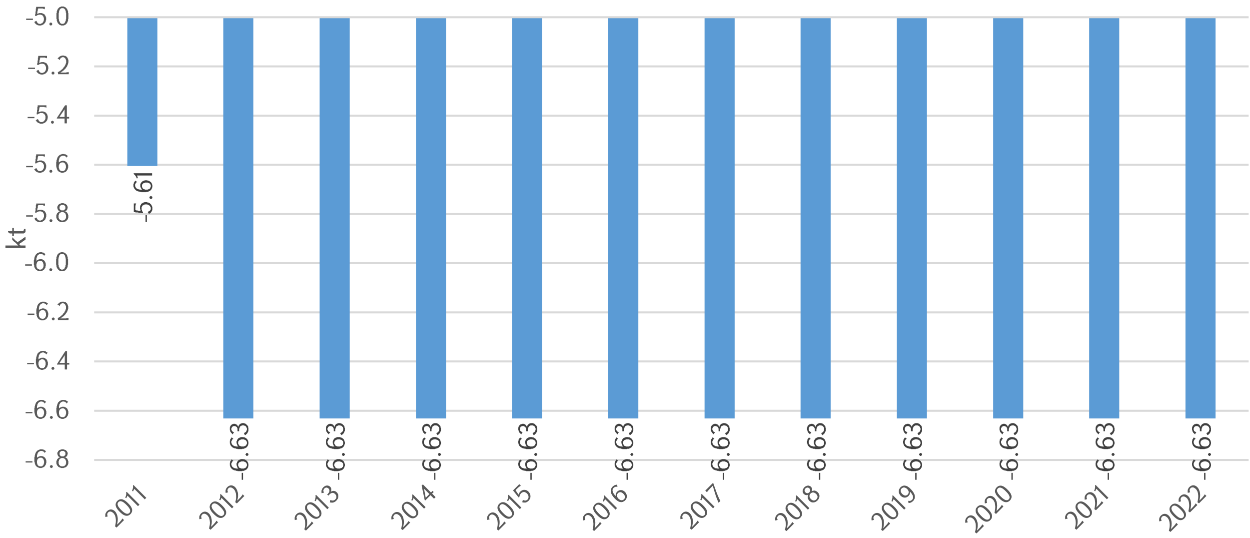

Figure 7.7 Carbon dioxide emissions in *Land Converted to Cropland* sub-category in 2011-2022, kt

The time series shows CO_2 emissions for land converted to Cropland starting from 2011, as data on land conversions before 2011 are not available. Conversions to Cropland only occurred in 2011 and 2012.

Recalculations of the time series for 2011-2022 have been done due to the updated data and corrections to it.

Category-specific planned improvements

No specific improvements are planned at present.

Uncertainty assessment

Activity data uncertainty is estimated of approximately 5%.

Emission factor uncertainty is estimated at approximately 50%.

Combined uncertainty is estimated to be 50.2%.

4.C Grassland

Sub-sector description

Grassland category included hay-land and pastures. According to the 2006 IPCC Guidelines, *Grassland Remaining Grassland* includes managed grassland which have always been under grassland vegetation and pasture use or other land categories converted to grassland more than 20 years ago. *Land converted to grassland* includes all land that has been converted to grassland during last 20 years.

A greenhouse gas inventory for the land-use category *Grassland* involves estimation of changes in carbon stock from five carbon pools (i.e., above-ground biomass, below-ground biomass, dead wood, litter, and soil organic matter).

According to the 2006 IPCC Guidelines, considering that *Grassland* is not a key source and there are no significant emissions or removals in Grassland, estimation is done using a Tier 1 approach.

The area of lands classified under the Grassland category has been adjusted in accordance with the "Procedure for Classification of Land Cover of the Republic of Armenia" RA Government Decision No. 431-N of April 11, 2019, and based on land balance data.

4.C.1 Grassland Remaining Grassland

Choice of method

A Tier 1 (Vol 4, Ch 6.2.1.1) approach assumes no change in biomass in *Grassland Remaining Grassland.*

According to the 2006 IPCC Guidelines, the Tier 1 method assumes that the dead wood and litter stocks are at equilibrium, so there is no need to estimate the carbon stock changes for these pools (Vol 4, Ch 6.2.2.1).

For mineral soils a Tier 1 approach is used (Vol 4, Ch 6.2.3.1). Soil organic C stock (SOC) from mineral soils is zero and no emissions/removal occur.

Thus, no emissions/removal occur from *Grassland Remaining Grassland* and a notation key ‘NA’ is reported.

4.C.2 Land converted to Grassland

Choice of method

CO_2 emissions and removals in 4.C.2 Land *Converted to Grassland* sub-category are estimated according to the 2006 IPCC Guidelines, using Tier 1 method (Vol 4, Ch 6.3).

According to the 2006 IPCC Guidelines, the Tier 1 method assumes that:

- All biomass is lost immediately from the previous ecosystem after conversion and residual biomass is assumed to be zero (Vol 4, Ch 6.3.1.1)

- Removal of all dead wood and litter during conversion and that there is no dead wood or litter that remains or accumulated in Land converted to Grassland (Vol 4, Ch 6.3.2.1)

Soil organic C stock changes for mineral soils can be estimated for land-use conversion to Grassland using Equation 2.25 in Chapter 2. For Tier 1, the initial (pre-conversion) soil organic C stock (SOC(0-T)) and C stock in the last year of the inventory time period (SOC0) are computed from the default reference soil organic C stocks (SOC_{REF}) and default stock change factors (F_{LU}, F_{MG}, F_I). Annual rates of stock changes are estimated as the difference in stocks (over time) divided by the time dependence (D) of the Grassland stock change factors (default is 20 years).

Activity data

According to the 2006 IPCC Guidelines, the estimates were done per areas of lands converted to grassland from initial land uses.

According to the data of the RA State Cadastre Committee, 5924 ha of land have been converted from other categories to grassland until 2022.

Emission factors

The default values for reference soil organic C stocks (SOC_{REF}) and stock change factors (F_{LU}, F_{MG}, F_I) have been used.

Time series consistency and recalculations

Figure 7.8 provides Carbon dioxide emissions/removals in the Land Converted to grassland in 2011-2022

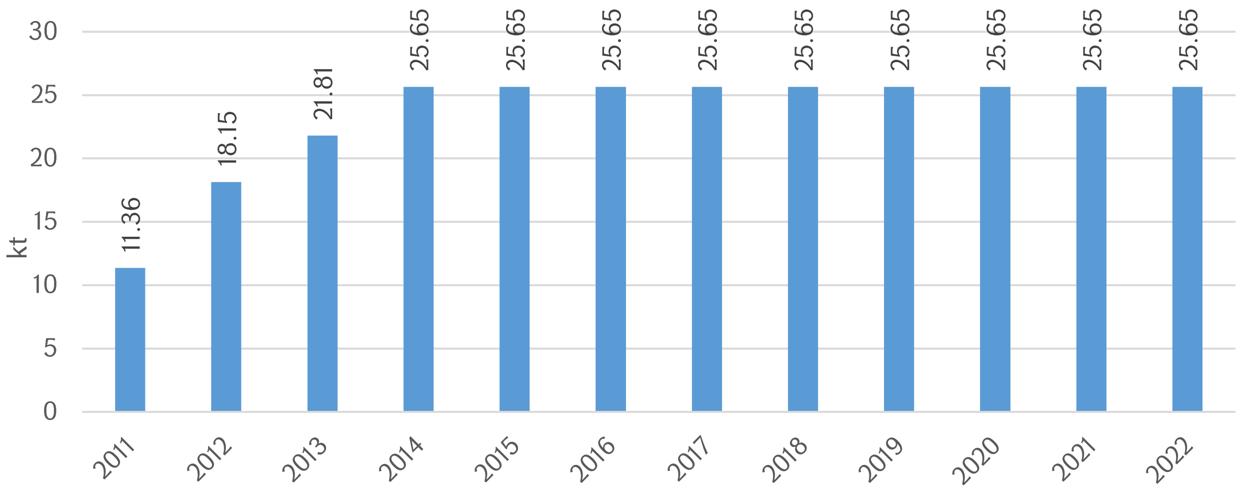

Figure 7.8 Carbon dioxide emissions in *Land Converted to Grassland* sub-category in 2011-2022, kt

The time series shows CO_2 emissions for land converted to Grassland starting from 2011, as data on land conversions before 2011 are not available. Conversions to Grassland occurred in 2011 - 2014.

Recalculations of the time series for 2011-2022 have been done due to the updated data and corrections to it.

Category-specific planned improvements

No specific improvements are planned at present.

Uncertainty assessment

Activity data uncertainty is estimated at approximately 5%.

Emission factor uncertainty is estimated at approximately 50%.

Combined uncertainty is estimated to be 50.2%.

(4.D) Wetlands

Sub-sector description

In Armenia Wetlands cover around 1800 sq.km, slightly over 6% of the country's territory. Of these, 90% are open waters (lakes, ponds, rivers, reservoirs, canals), 8% are temporarily flooded area (including saline lands), and only 2% are permanent wetlands, marshes, and peat bogs. The area of peatlands (mires) is estimated at 42 sq.km, or just 0.14% of the country's total area.

4.D.1 Wetlands remaining wetlands

Peat occurs on 1.5% of Armenia's territory. Peatlands are of lowland origin and formed from sedges with 10-40% addition of reeds.

The area of peat mines is 489 ha, and more than 1,065 ha is occupied by peat occurrences. Peat stocks estimated 1,005,375 tones. Armenian peat is used as fertilizer, fuel, in balneology and is subject of export.

The emissions and removals are estimated from the category Peat Extraction Remaining Peat Extraction.

Choice of approach

According to the 2006 IPCC Guidelines, Tier 1 approach was used. Default methodology covers on-site CO_2 emissions and the horticultural use of peat (Vol 4, Ch 7, Equations 7.2 to 7.5).

Off-site emission estimates are made by converting the annual peat production data (volume or air-dry weight) to the weight of carbon (Equation 7.5). All carbon in horticultural peat is assumed to be emitted during the year when extraction occurs.

Activity data

All Tiers require data on areas of peatlands managed for peat extraction and peat production data by weight or volume of air-dry peat.

The default methodology assumes that a country has estimates of the total area on which peat is extracted currently and was extracted previously.

Official data on the volumes of peat extracted, imported and exported in Armenia in 2013-2022 were collected from the following sources:

- Statistical Publications of the RA SC (Environment and Natural Resources in the Republic of Armenia, Environmental Statistics of Armenia (LUCFref-21, LUCFref-22) and Foreign Trade of the Republic of Armenia (according to the 10-digit classification of the Commodity Nomenclature of Foreign Economic Activity (Ref-5),
- Reports of the RA Ministry of Environment

Due to the lack of official data on the volumes of peat actually extracted in 2020-2022, they were estimated as the difference between the volumes of imported and exported peat and amounted to 6,450 tons, 8,343.9 tons and 7,627.5 tons, respectively.

Emission factors

According to the 2006 IPCC Guidelines, implementation of Tier 1 method requires the application of default on-site emission factors and default carbon fractions of peat by weight or by volume to estimate off-site emissions from production data in weight or volume, respectively. Default values are provided in Table 7.4 and Table 7.5.(Vol 4, Ch 7).

Time series consistency and recalculations

Figure 7.9 provides CO_2 emissions from *Wetlands.*

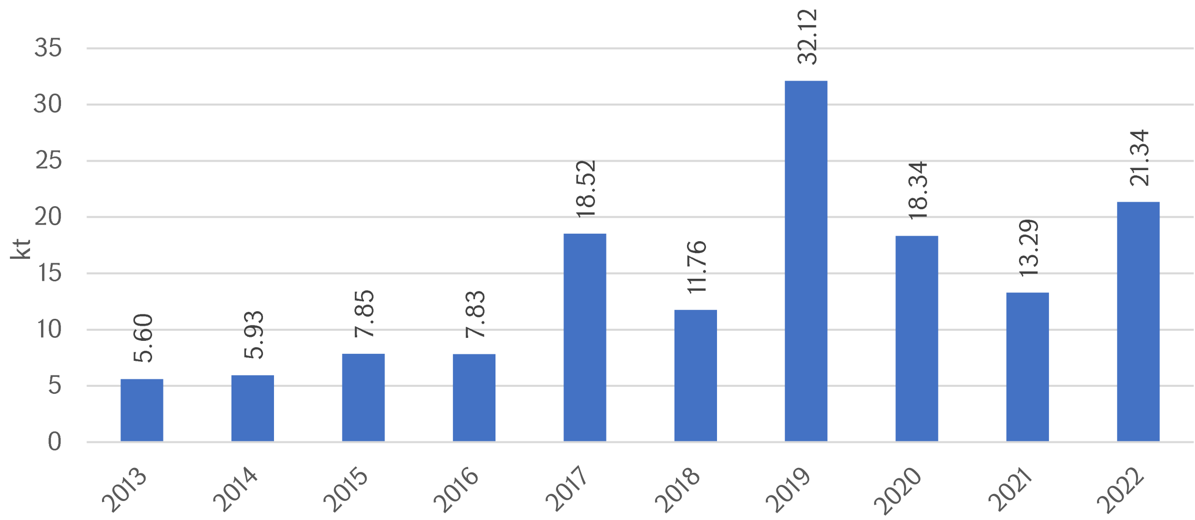

Figure 7.9 Annual emissions of CO_2 from *Wetlands*, kt CO_2

Data on the volume of peat extraction are not available before 2013.

The increase in CO_2 emissions in certain years is due to the increase in peat extraction volume in these years: thus, in 2017 it was 9,905.7 t compared to 3,422.7 in 2016; in 2019 it was 18,148.15 t compared to 5,807.25 in 2018; and 11,615 t in 2022 compared to 6,735 t in 2021.

No recalculations have been done.

Category-specific planned improvements

No specific improvements are planned at present.

Uncertainty assessment

- Activity data uncertainty is estimated at approximately 5%.
- Emission factor uncertainty is estimated of approximately 50%.

Combined uncertainty is estimated to be 50,2%.

4.E Settlements

Sub-sector description

According to the 2006 IPCC Guidelines (Volume 4, Chapter 8), Settlements include all developed land - i.e. residential, transportation, commercial, and production (commercial, manufacturing) infrastructure of any size, unless it is already included under other land-use categories. The land-use category Settlements include soils, herbaceous perennial vegetation such as turf grass and garden plants, trees in rural settlements, homestead gardens and urban areas. Examples of settlements include land along streets, in residential (rural and urban) and commercial lawns, in public and private gardens, in golf courses and athletic fields and in parks, provided such land is functionally or administratively associated with particular cities, villages or other settlement types and is not accounted for in another land-use category.

4.E.1 Settlements Remaining Settlements

Choice of methodology

According to the 2006 IPCC Guidelines, emissions and removals of CO_2 in this category are estimated by the subcategories of changes in carbon stocks in biomass, in DOM, and in soils.

Emissions assessment was done applying Tier 1 method.

According to the 2006 IPCC Guidelines, Tier 1 assumes:

no change in carbon stocks in live biomass in *Settlements Remaining Settlements*, in other words, that the growth and loss terms balance (Vol 4, Ch 8.2.1), no activity data are needed.

the dead wood and litter stocks are at equilibrium, and so there is no need to estimate the carbon stock changes for these pools (Vol 4, Ch 8.2.2.1).

inputs equal outputs so that settlement soil C stocks do not change in Settlements Remaining Settlements. (Vol 4, Ch 8.2.3.1).

Thus, no emissions/removal occur from Settlements Remaining Settlements category, and a notation key 'NA' is reported.

4.E.2 Land converted to settlements

Choice of methodology

Emissions assessment was done applying Tier 1 method.

According to the 2006 IPCC Guidelines, Tier 1 methods requires estimates of the biomass of the land use before conversion and after conversion.

Tier 1 default assumes all carbon contained in dead wood and litter is lost during conversion and does not take account of any subsequent accumulation (Vol 4, Ch 8.3. 2). Therefore, the carbon stock change in DOM pool assumed to be zero.

According to the 2006 IPCC Guidelines, it is assumed that all biomass is cleared when preparing a site for settlements, thus, the default for biomass immediately after conversion is 0 tonnes. Table 8.4 provides default values for biomass before conversion (Vol 4, Ch 8.3.1.2).

The immediate change in live biomass accruing from the conversion to Settlements is calculated by Equations 2.16 in Chapter 2 (Vol 4, Ch.2).

Change in soil organic C stocks was estimated for mineral soils with land-use conversion to Settlements using Equation 2.25 in Chapter 2 (Vol 4).

Time series consistency and recalculations

Recalculations of the time series for 2011-2022 have been done due to the updated data on land-use conversion to Settlements and corrections to it. Data on land-use conversion to Settlements are not available before 2011.

The increase in CO_2 emissions in certain years is due to the conversion of Cropland and Grassland to Settlements in these years - thus in 2021 it was converted 1,191.7 ha, compared to 660.5 ha converted in 2020.

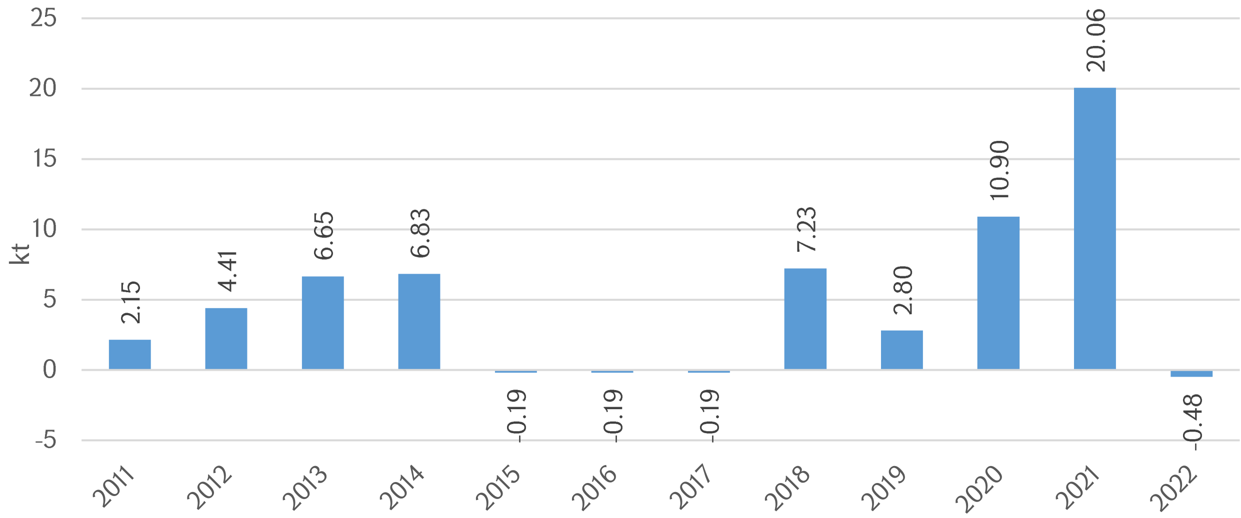

Figure 7.10 Annual emissions of CO_2 from *Settlements,* kt CO_2

Category-specific planned improvements

No specific improvements are planned at present.

Uncertainty assessment

- Activity data uncertainty is estimated of approximately 5%.
- Emission factor uncertainty is estimated of approximately 50%.

Combined uncertainty is estimated to be 50.2%.

4.F Other Land

Sub-sector description

Other land category includes unmanaged reserve lands, bare soil, rock, ice, and all land areas that do not fall into any of the other five categories, i.e. lands without vegetation.

4.F.1 Other Land remaining other land

According to the 2006 IPCC Guidelines, *Other Land* is often unmanaged, and in that case changes in carbon stocks and non-CO_2 emissions and removals are not estimated (Vol 4, Ch.9.1).

4.F.2 Land converted to Other land

Land converted to Other land is not a key category of GHG emissions/removals.
In this land use category are included areas considered to be devoid of vegetation according to the "Classification Procedure of the Land Cover of the Republic of Armenia" (such as shores of lakes and rivers, sand dunes, bare rocks, and mother rocks), in particular:

- From agricultural lands: 80% of other types of agricultural land

- From forest land: 80% of other types of forest land
- Parts of sub-soil use lands and lands of Special significance
- From specially protected areas: areas of lakes and ponds, offshore land areas, river and canal areas
- Reserve lands
- Other land areas not subject to management, which are not included in the previous five categories.

Choice of method

Emissions assessment was done applying Tier 1 method (Equation 2.16, Vol 4, Ch 2).

According to the 2006 IPCC Guidelines (Vol 4, Ch 9.3):

The default assumption for the Tier 1 calculation is that all carbon in biomass is released to the atmosphere immediately (in the year of conversion).

It is assumed that no carbon remains in biomass or dead organic matter after conversion to *Other Land.*

The change in soil organic C stocks is estimated for mineral soils (Equation 2.25) accounting for the impact of land-use conversion to *Other Land.*

Activity data

According to the 2006 IPCC Guidelines, the estimates were done per areas of lands converted to other land from initial land uses.

According to the data of the State Cadastre Committee of the Republic of Armenia, 5,305 ha of land have been converted from other categories to *Other land* until 2022.

Emission factors

The default values fort reference soil organic C stocks (SOC_{REF}) and stock change factors (F_{LU}, F_{MG}, F_{I}) have been used.

Time series consistency and recalculations

Figure 7.11 provides Carbon dioxide emissions/removals in *Land Converted to Other Land* sub-category in 2011-2022

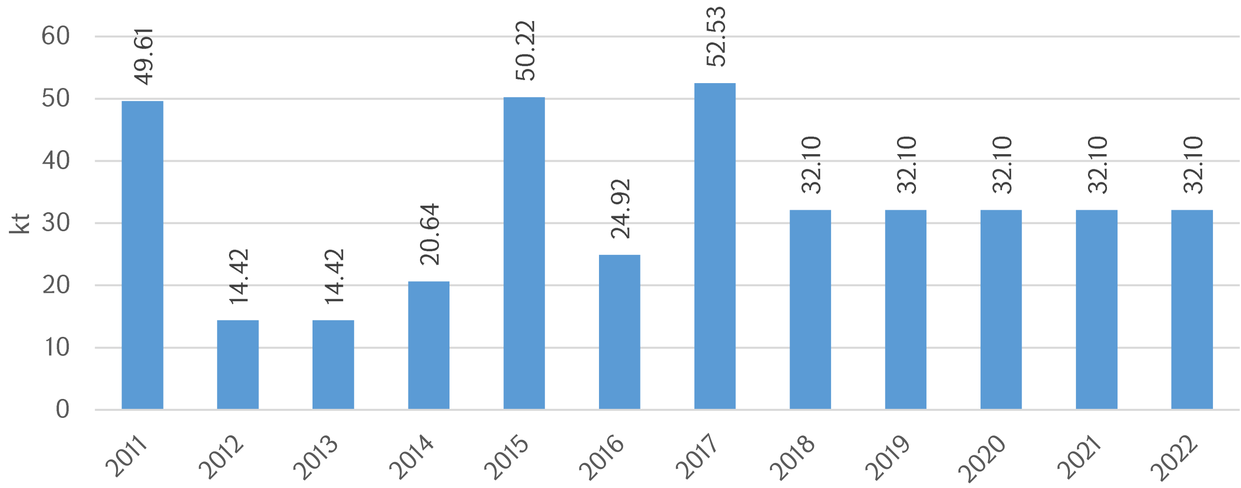

Figure 7.11 Carbon dioxide emissions in Land converted to Other land sub-category in 2011-2022, kt

Carbon dioxide emissions in *Land converted to other land* sub-category are stable in the recent years while variations are caused by the conversions from other categories to *Other land.* Recalculations of the time series for 2011-2022 was done due to the updated data on land-use conversion to *Other land* and corrections to it. Data on land use conversion are not available before 2011.

Category-specific planned improvements

No specific improvements are planned at present.

Uncertainty assessment

- Activity data uncertainty is estimated at approximately 5%.
- Emission factor uncertainty is estimated at approximately 50%.

Combined uncertainty is estimated to be 50.2%.

Summary of Net CO_2 emissions from Lands

Carbon stock changes by pools, (4.A – 4.F categories), 2022

Table 7.8 Carbon stock change by pools, (4.A – 4.F categories), 2022

Categories	Activity Data	Net carbon stock change and CO_2 emissions					
		Biomass			DOM	Soils	Net CO_2 emissions ($kt\ CO_2$)
	Total Area (ha)	Increase (kt C)	Decrease (kt C)	Net carbon stock change (kt C)	Net carbon stock change (kt C)	Net carbon stock change in mineral soils (kt C)	
3.B - Land	2964407.5	247.2	122.5	124.7	0	-13.8	**-406.7**
3.B.1 - Forest land	351654.31	173.3	48.4	124.9	0	0	**-458.0**
3.B.1.a - Forest land Remaining Forest land	350686.31	172.9	48.4	124.5	0		-456.6
3.B.1.b - Land Converted to Forest land	968	0.4	0	0.4	0	0	-1.4
3.B.1.b.i - Cropland converted to Forest Land	968	0.4		0.4	0	0	-1.4
3.B.1.b.ii - Grassland converted to Forest Land	0			0	0		0
3.B.1.b.iii - Wetlands converted to Forest Land	0			0	0		0
3.B.1.b.iv - Settlements converted to Forest Land	0			0	0		0
3.B.1.b.v - Other Land converted to Forest Land	0			0	0		0
3.B.2 - Cropland	565642.99	73.9	74.1	-0.2	0	1.8	**-6.0**
3.B.2.a - Cropland Remaining Cropland	563806.99	73.9	74.1	-0.2	0		0.6
3.B.2.b - Land Converted to Cropland	1836	0	0	0	0	1.8	-6.6
3.B.2.b.i - Forest Land converted to Cropland	0			0	0		0
3.B.2.b.ii - Grassland converted to Cropland	1793			0	0	1.8	-6.7
3.B.2.b.iii - Wetlands converted to Cropland	0			0	0		0
3.B.2.b.iv - Settlements converted to Cropland	43			0	0	-0.01155	0.0
3.B.2.b.v - Other Land converted to Cropland	0			0	0		0
3.B.3 - Grassland	1460578.7	0	0	0	0	-7.0	**25.7**
3.B.3.a - Grassland Remaining Grassland	1454654.7			0	0		0
3.B.3.b - Land Converted to Grassland	5924	0	0	0	0	-7.0	25.7
3.B.3.b.i - Forest Land converted to Grassland	0			0	0		0
3.B.3.b.ii - Cropland converted to Grassland	2984			0	0	-4.9	18.1

3.B.3.b.iii - Wetlands converted to Grassland	0			0	0		0
3.B.3.b.iv - Settlements converted to Grassland	0			0	0		0
3.B.3.b.v - Other Land converted to Grassland	2940			0	0	-2.0724	7.6
3.B.4 - Wetlands (3)	0	0	0	0	0	0	**0**
3.B.5 - Settlements	137489.4	0	0	0	0	0.1	**-0.5**
3.B.5.a - Settlements Remaining Settlements	133268.2			0	0		0
3.B.5.b - Land Converted to Settlements	4221.2	0	0	0	0	0.1	-0.5
3.B.5.b.i - Forest Land converted to Settlements	0			0	0		0
3.B.5.b.ii - Cropland converted to Settlements	2632.2			0	0	0	0
3.B.5.b.iii - Grassland converted to Settlements	1589			0	0	0.1	-0.5
3.B.5.b.iv - Wetlands converted to Settlements	0			0	0		0
3.B.5.b.v - Other Land converted to Settlements	0			0	0		0
3.B.6 - Other Land	449042.1	0	0	0	0	-8.8	**32.1**
3.B.6.a - Other land Remaining Other land	442805.3			0	0		0
3.B.6.b - Land Converted to Other land	6236.8	0	0	0	0	-8.8	32.1
3.B.6.b.i - Forest Land converted to Other Land	931.8			0	0		0
3.B.6.b.ii - Cropland converted to Other Land	4327			0	0	-7.1	26.2
3.B.6.b.iii - Grassland converted to Other Land	978			0	0	-1.6	5.9
3.B.6.b.iv - Wetlands converted to Other Land	0			0	0		0
3.B.6.b.v - Settlements converted to Other Land	0			0	0		0

Category-specific QA / QC and verification (4A- 4F categories)

The estimates of GHG inventory in Land use, land-use change and forestry sector are strongly influenced by the quality and consistency of national data. The estimates in this sector are based on Land Balances approved for each year by the RA Government where Land categories are presented as the aggregate groups - 9 categories.

The harmonization between the country's national land-use classification system with the 2006 IPCC Guidelines Land Use categories as well as data calculation, have been carried out based on the official statistical data of the RA SC and RA Ministry of Economy.

General and category-specific quality control and quality assurance have been carried out by the relevant technical experts through application of the Inventory QA/QC plan outlined in Annex 7.

Consistent with the 2006 IPCC Guidelines, additional category-specific QC procedures were performed for more significant emission categories or sources where significant methodological and data updates had occurred.

Quality Assurance was ensured through external review of inventory data and emissions assessment (expert, public, and UNFCCC technical expert reviews).

Non-CO_2 emissions from Biomass burning

This category includes greenhouse gas emissions (CH_4, N_2O) and other air emissions (NOx and CO) from wildfires on *Forest Land* and *Grassland.*

Choice of method and emission factors

2006 IPCC Guidelines Tier 1 method was applied using national activity data and default emission factors from the Guidelines.

According to the 2006 IPCC Guidelines, Equation 2.27 was used to estimate emissions from biomass burning (Vol 4, Ch 2).

Under Tier 1, non-CO_2 emissions are estimated using the fuel consumption values for fires provided in Table 2.4, appropriate emission factors (Table 2.5) and combustion factor (Table 2.6) (Volume 4, Chapter 2).

Activity data

Emissions were calculated for forest lands (4(IV). A.1.b.) and grasslands (4(IV). C.1.b.) using the activity data of the burned area in forest lands and grasslands. The information source for the area of wildfires were the RA SC publications – “Environment and Natural Resources in the Republic of Armenia” and “Environmental Statistics of Armenia” Publications (LUCFref-21, LUCFref-22).

Calculation results

Tables 7.9 - 7.11 present the results on emissions calculation from Biomass Burning on Forest Land and Grassland for 2020 - 2022.

Table 7.9 Emissions from Biomass Burning, kt, 2020

Category	Activity data		Emissions			
	unit	value	CH_4 (kt)	N_2O (kg)	CO (kt)	NOx (kt)
4(IV). – Emissions from Biomass Burning			0.016	0.00122	0.013	0.394
4(IV).A.1.b.– Biomass burning in Forest Land			0.014	0.001	0.009	0.326
Wildfire	ha	342.4	0.014	0.001	0.009	0.326
4(IV).C.1.b. Biomass burning in Grassland			0.002	0.00022	0.004	0.068
Grassland remaining Grassland			0.002	0.00022	0.004	0.068
Wildfire	ha	255.4	0.002	0.00022	0.004	0.068

Table 7.10 Emissions from Biomass Burning, kt, 2021

Category	Activity data		Emissions			
	unit	value	CH_4 (kt)	N_2O (kt)	CO (kt)	NOx (kt)
4(IV). – Emissions from Biomass Burning			0.038	0.0021	0.025	0.872
4(IV).A.1.b.– Biomass burning in Forest Land			0.037	0.002	0.024	0.848
Wildfire	ha	889.6	0.037	0.002	0.024	0.848
4(IV).C.1.b. Biomass burning in Grassland			0.001	0.0001	0.001	0.024
Grassland remaining Grassland			0.001	0.0001	0.001	0.024
Wildfire	ha	89.6	0.001	0.0001	0.001	0.024

Table 7.11 Emissions from Biomass Burning, kt, 2022

Category	Activity data		Emissions			
	unit	value	CH_4 (kt)	N_2O (kt)	CO (kt)	NOx (kt)
4(IV). – Emissions from Biomass Burning			0.047	0.00305	0.03	1.062
4(IV).A.1.b.– Biomass burning in Forest Land			0.046	0.003	0.029	1.048
Wildfire	ha	1099.4	0.046	0.003	0.029	1.048
4(IV).C.1.b. Biomass burning in Grassland			0.001	0.00005	0.001	0.014
Grassland remaining Grassland			0.001	0.00005	0.001	0.014
Wildfire	ha	54.1	0.001	0.00005	0.001	0.014

Time series consistency and recalculations

Figure 7.12 provides CH_4 and N_2O emissions from biomass burning

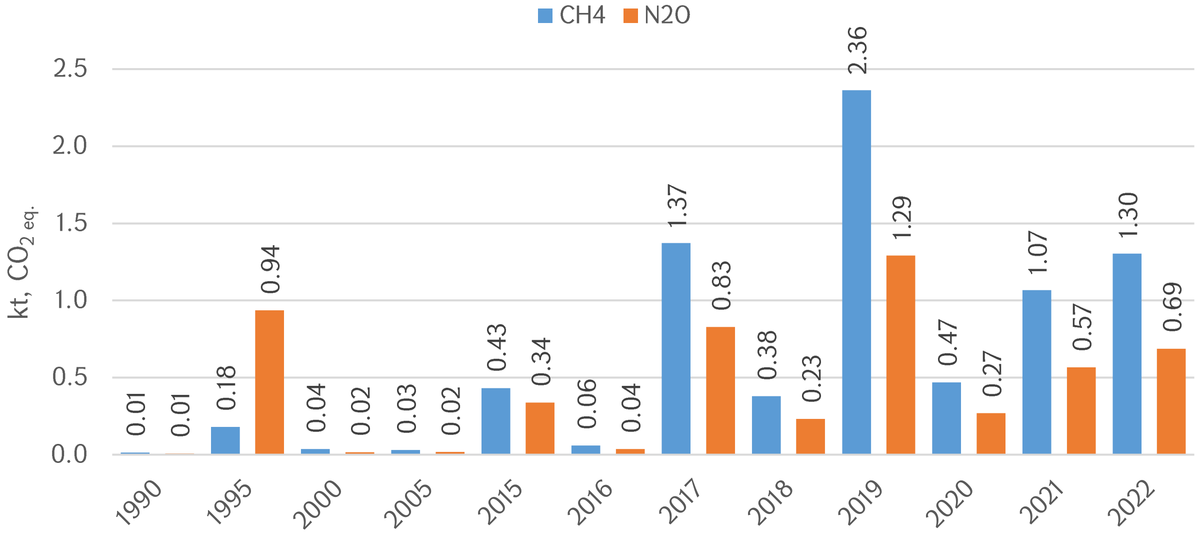

Figure 7.12. CH_4 and N_2O emissions from biomass burning, kt

No recalculation has been performed.

Category-specific planned improvements

No specific improvements are planned at present.

Uncertainty assessment

- Activity data uncertainty is estimated at approximately 5%.
- Emission factor uncertainty is estimated at approximately 105%.

Combined uncertainty is estimated to be 105.1%.

Category-specific QA / QC and verification

General and category-specific quality control and quality assurance have been carried out by the relevant technical experts through application of the Inventory QA/QC plan outlined in Annex 7.

4.G Harvested wood products

Choice of method

According to the 2006 IPCC Guidelines, the Production Approach is used to estimate the carbon stock change in HWP (Vol. 4, Annex 12.A.1). The Production Approach estimates changes in carbon stocks in the forest pool (and other wood producing lands) and the wood products pool containing products made from wood harvested in the country.

Activity data, emission factors and other parameters

Activity data were taken from national statistics. All other parameters are default values from the 2006 IPCC Guidelines.

Times-series consistency and recalculations

Estimates of emissions from this category were performed for the first time in Armenia's previous GHG inventory (1990-2019). Within the framework of this inventory, the entire time series has been recalculated due to the adjusted activity data.

As a result, the 1990 GHG emissions have changed from -40.24 kt CO_2 to 6.35 kt CO_2, and 2019 GHG emissions have changed from - 5.669 kt CO_2 to 6.41 kt CO_2. The table below presents the calculation results for the complete time-series of 1990-2022.

Table 7.12 HWP calculation results for the complete time-series of 1990-2022

	Variable Number										
	kt C/yr									kt CO_2/yr	
Year	1A Annual Change in stock of HWP in use from consumption	1B Annual Change in stock of HWP in SWDS from consumption	2A Annual Change in stock of HWP in use produced from domestic harvest	2B Annual Change in stock of HWP in SWDS produced from domestic harvest	3 Annual Imports of wood, and paper products + wood fuel, pulp, recovered paper, roundwood/ chips	4 Annual Exports of wood, and paper products + wood fuel, pulp, recovered paper, roundwood/ chips	5 Annual Domestic Harvest	6 Annual release of carbon to the atmosphere from HWP consumption (from fuelwood & products in use and products in SWDS)	7 Annual release of carbon to the atmosphere from HWP (including fuelwoood) where wood came from domestic harvest (from products in use and products in SWDS)	8 HWP Contribution to AFOLU CO_2 emissions/removals	9 Approach used to estimate HWP Contribution
1990	10.91		1.73		0.50	0.05	2.72	-7.75	0.99	-6.35	Production approach
1991	10.84		1.69		0.53	0.05	3.01	-7.35	1.32	-6.20	Production approach
1992	10.84		1.68		0.56	0.06	3.15	-7.19	1.47	-6.16	Production approach
1993	10.95		1.73		0.60	0.06	3.71	-6.70	1.98	-6.36	Production approach
1994	11.22		1.80		0.63	0.06	4.12	-6.52	2.33	-6.59	Production approach
1995	11.49		2.13		0.66	0.06	4.53	-6.36	2.39	-7.82	Production approach
1996	12.65		2.67		0.68	0.06	5.48	-6.55	2.81	-9.78	Production approach
1997	14.06		3.30		0.71	0.06	6.63	-6.79	3.33	-12.09	Production approach
1998	16.05		4.40		0.73	0.06	8.02	-7.36	3.62	-16.13	Production approach
1999	17.41		4.85		0.76	0.06	9.70	-7.01	4.86	-17.78	Production approach
2000	18.65		5.59		0.89	0.07	11.32	-6.51	5.73	-20.50	Production approach
2001	21.69		7.34		0.76	0.07	14.15	-6.85	6.80	-26.93	Production approach
2002	10.09		7.10		0.64	0.07	19.63	10.11	12.53	-26.05	Production approach
2003	21.06		8.45		1.83	0.04	19.86	0.60	11.41	-30.98	Production approach

2004	26.24	6.58	2.72	0.06	11.76	-11.83	5.18	-24.12	Production approach
2005	30.44	4.49	1.33	0.06	6.61	-22.57	2.12	-16.46	Production approach
2006	53.12	6.54	1.53	0.03	10.08	-41.55	3.53	-23.98	Production approach
2007	54.96	2.11	2.00	0.00	9.74	-43.23	7.62	-7.75	Production approach
2008	130.69	-6.55	2.48	0.01	2.93	-125.31	9.48	24.03	Production approach
2009	32.29	-5.21	6.19	0.01	3.59	-22.53	8.80	19.10	Production approach
2010	47.43	-1.62	7.23	0.03	2.55	-37.68	4.17	5.94	Production approach
2011	45.08	-3.84	8.31	0.01	1.62	-35.16	5.46	14.09	Production approach
2012	46.03	-3.03	9.70	0.05	2.26	-34.13	5.29	11.10	Production approach
2013	38.37	-1.08	4.45	0.07	2.70	-31.28	3.78	3.94	Production approach
2014	86.28	-0.28	3.70	0.06	1.65	-80.98	1.93	1.01	Production approach
2015	34.18	0.40	3.52	0.11	2.96	-27.82	2.56	-1.45	Production approach
2016	121.94	2.88	1.79	0.09	3.33	-116.91	0.45	-10.56	Production approach
2017	76.55	1.18	2.91	0.21	3.29	-70.57	2.11	-4.32	Production approach
2018	181.79	1.66	3.66	0.12	3.48	-174.77	1.82	-6.10	Production approach
2019	183.39	-1.75	6.35	0.06	1.51	-175.59	3.26	6.41	Production approach
2020	198.14	0.41	4.32	0.12	2.90	-191.04	2.49	-1.50	Production approach
2021	151.85	1.43	4.35	0.14	3.50	-144.16	2.06	-5.25	Production approach
2022	174.14	1.28	4.82	0.15	3.60	-165.86	2.32	-4.69	Production approach

Category-specific planned improvements

No specific improvements are planned at present.

Uncertainty assessment

- Activity data uncertainty is estimated of approximately 50%.
- Emission factor uncertainty is estimated of approximately 50%.

Combined uncertainty is estimated to be 70.7%.

Category-specific QA / QC and verification

General and category-specific quality control and quality assurance have been carried out by the relevant technical experts through application of the Inventory QA/QC plan outlined in Annex 7.

8. WASTE (CRT SECTOR 5)

Overview of greenhouse-gas emissions in CRT Sector 5

The Waste Sector of the national GHG inventory of Armenia includes the following categories and sub-categories:

(5.A) Solid Waste Disposal (CH_4 emissions)

(5.C) Incineration and Open Burning of Waste

(5.C.1) Waste Incineration (CO_2, CH_4, N_2O emissions)

(5.C.2) Open Burning of Waste (CO_2, CH_4, N_2O emissions)

(5.D) Wastewater Treatment and Discharge (CH_4, N_2O emissions)

(5.D.1) Domestic Wastewater Treatment and Discharge (CH_4, N_2O)

(5.D.2) Industrial Wastewater Treatment and Discharge (CH_4)

The other sources mentioned in the IPCC 2006 Guidelines are not occurring in Armenia.

5.A Solid Waste Disposal (CH_4 emissions) and *5.D Wastewater Treatment and Discharge* (CH_4 emissions) are identified as the key source category *both with the level and trend assessment, while 5.D Wastewater Treatment and Discharge* (N_2O emissions) is identified as the key source category *with the level assessment in 2020 - 2022.*

The Waste Sector emissions amounted to 810.75 kt $CO_{2\ eq}$. in 2020, 864.07 kt $CO_{2\ eq}$. in 2021 and 864.63 kt $CO_{2\ eq.}$ in 2022, or 6.9%, 6.8% and 6.7% of Armenia's total net emissions in 2020, 2021 and 2022, correspondingly.

Table 8.1 shows GHG emissions in waste sector by category and gas in 2020-2022.

Table 8.81 Waste sector emissions in 2020-2022

Categories	2020				2021				2022			
	CO_2, kt	CH_4, kt	N_2O, kt	Total, kt $CO_{2\ eq}$	CO_2, kt	CH_4, kt	N_2O, kt	Total, kt $CO_{2\ eq}$	CO_2, kt	CH_4, kt	N_2O, kt	Total, kt $CO_{2\ eq}$
5.A - Solid Waste Disposal		19.47		**545.09**		21.15		**592.13**		20.78		**581.79**
5.B - Biological Treatment of Solid Waste		NO	NO	**NO**		NO	NO	**NO**		0.00	NO	**NO**
5.C - Incineration and Open Burning of Waste	30.86	0.85	0.01	**57.38**	30.89	0.84	0.01	**57.33**	30.90	0.84	0.01	**57.28**
5.C.1. Waste incineration	0.29	0.00	0.00	**0.31**	0.42	0.00	0.00	**0.44**	0.51	0.00	0.00	**0.55**
5.C.2. Open burning of waste	30.57	0.85	0.01	**57.07**	31.47	0.84	0.01	**56.88**	30.39	0.84	0.01	**56.74**
5.D - Wastewater Treatment and Discharge		5.00	0.26	**208.28**		5.20	0.26	**214.61**		5.58	0.26	**225.55**
5.D.1. Domestic wastewater		3.24	0.26	**159.14**		3.24	0.26	**159.78**		3.24	0.26	**160.12**
5.D.2. Industrial wastewater		1.75	NO	**49.13**		1.96	NO	**54.84**		2.34	NO	**65.44**
5.D.3. Other		NO	NO	**NO**		NO	NO	**NO**		NO	NO	**NO**
5.E - Other (please specify)	NO	NO	NO	**NO**	NO	NO	NO	**NO**	NO	NO	NO	**NO**
TOTAL 5 - Waste	**30.86**	**25.31**	**0.27**	**810.75**	**30.89**	**27.19**	**0.27**	**864.07**	**30.90**	**27.20**	**0.27**	**864.63**

The prevailing part of emissions from the Waste sector are the landfill emissions, which accounted for 67.2% of Waste sector emissions in 2020 and 4.7% of the country's total net emissions, 68.5% of Waste sector emissions in 2021 and 4.7% of the country's total net emissions and 67.3% of Waste sector emissions in 2022 and 4.5% of the country's total net emissions. The emissions from the wastewater treatment accounted for 26.1% of sectoral emissions in 2022, while the emissions from the waste incineration and open burning accounted for remaining 6.6% in 2022.

Figure 8.1 Figure presents the trend of GHG emissions in Waste sector. In 2022 GHG emissions from this sector have increased by 56 % compared to 1990, driven predominantly by the growth of emissions from solid waste disposal sites. Data on emission trends in each sub-category is presented in respective sections.

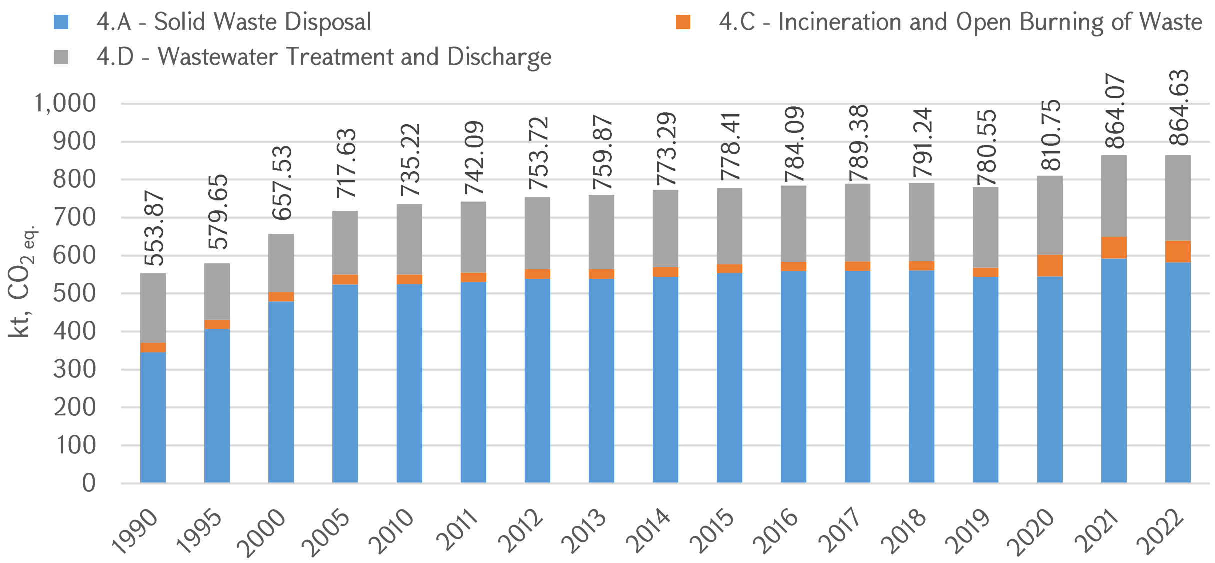

Figure 8.1 Overview of greenhouse-gas emissions in CRT Sector 5

5.A Solid Waste Disposal

Description of the category

The largest landfill in the country is the Nubarashen landfill (with an area of 52 hectares), which has served as a place to dispose of municipal solid waste (MSW) generated in Yerevan since the 1960s. There are around 300 landfill sites in Armenia that do not meet urban planning, environmental, or sanitary-hygienic standards and serve merely as dumping grounds.

Industrial waste is also deposited in MSW landfills and since country-specific waste generation and waste composition data was used, it can be assumed that industrial waste is included in the calculation of emissions from Solid Waste Disposal Sites (SWDS).

Choice of method

To estimate CH_4 emissions from *Solid Waste Disposal* (SWDS), the First Order Decay (FOD) method was applied, as recommended in the 2006 IPCC Guidelines (Vol 5, Ch 3).

There is an improvement in estimation method for 2020-2022 GHG inventory - the data of waste composition has been used for estimating emissions, instead of bulk waste, which has been used in previous inventories.

The country-specific activity data with default values for other parameters were used for GHG estimates. So, it can be considered as a Tier 2 method.

Activity data

The following activity data was used to calculate solid waste deposed at SWDS and available for decay:

- The number of urban and rural populations for all years was taken from the RA SC (Ref-2).
- Per capita waste generation rate for MSW selected for Yerevan is 315 kg/capita/year (WRef-2), for Gyumri and Vanadzor - 274 kg/capita/year (WRef-3), for other cities - 219 kg/capita/year (WRef-3) and for rural areas –146 kg/capita/year (WRef-3).
- Open burning of waste at SWDS occurs in unmanaged solid waste disposal sites. Therefore, the amount of waste available for decay at SWDS was adjusted to the amount burned using the assumption on the share of solid waste that is burnt, that matches the MCF value of unmanaged SWDS.

Using the above-mentioned data, the amount of waste generated during the reporting period, and the amount of the waste available for decay were estimated. The amount of the waste that is open burnt at the SWDSs has been also calculated and the corresponding emissions were estimated in the (*5.C.2) Open Burning of Waste* category.

The table below shows the calculation.

Table 8.2 Calculation of the amount of waste decomposed at SWDS and openly burnt.

Year	Region/SWDS	Population	Waste per capita (kg/cap/year)	Total waste generated (kt)	share of waste open burnt (%)	Amount of waste burnt (kt)	Share of waste decomposed at SWDS	Amount of waste decomposed at SWDS (kt)
2022	Yerevan	1 084 000	315.0	341.46	0.0%	-	1.00	341.46
	Gyumri and Vanadzor	189 600	274.0	51.95	20.0%	10.39	0.80	41.56
	Other Cities	618 500	219.0	135.45	60.0%	81.27	0.40	54.18
	Rural going to deep SWDS	604 262	146.0	88.22	20.0%	17.64	0.80	70.58
	Rural going to shallow SWDS	463 338	146.0	67.65	60.0%	40.59	0.40	27.06
	Total	**2 959 700**	**231.4**	**684.73**	**21.9%**	**149.89**	**78.1%**	**534.84**
2021	Yerevan	1 091 700	315.0	343.9	0.0%	-	100%	343.89
	Gyumri and Vanadzor	189 000	274.0	51.8	20.0%	10.36	80%	41.43
	Other Cities	614 900	219.0	134.7	60.0%	80.80	40%	53.87
	Rural going to deep SWDS	604 318	146.0	88.2	20.0%	17.65	80%	70.58
	Rural going to shallow SWDS	463 382	146.0	67.7	60.0%	40.59	40%	27.06
	Total	**2 963 300**	**231.6**	**686.22**	**21.8%**	**149.39**	**78.2%**	**536.83**
2020	Yerevan	1 092 800	315.0	344	0.0%	-	100.0%	344.23
	Gyumri and Vanadzor	187 400	274.0	51	20.0%	10.27	80.0%	41.08
	Other Cities	612 000	219.0	134	60.0%	80.42	40.0%	53.61
	Rural going to deep SWDS	605 167	146.0	88	20.0%	17.67	80.0%	70.68
	Rural going to shallow SWDS	464 033	146.0	68	60.0%	40.65	40.0%	27.10
	Total	**2 961 400**	**231.5**	**685.71**	**21.7%**	**149.01**	**78.3%**	**536.70**

For waste composition, the data from the "Study on the Quantity and Composition of Waste in the Republic of Armenia", (March 2020) (WRef-5) were used for both the (5.A) *Solid Waste Disposal* and (5.C) *Waste Incineration and Open Burning of Waste* categories. The next table shows waste composition data that was used for calculations for 2020-2022.

Table 8.3 Waste composition

Type of waste	share (%)
Food Waste	46.22
Garden and park	12.15
Disposable Nappies	3.18
Paper and Carboard	5.59
Textile	7.32
Wood	0.42
Petroleum products, Solvents, Plastics	11.85
Other	1.76
Inert	11.51

The methane capture and flaring occur at Nubarashen landfill. The amount of methane captured and flared there was taken from the assessments of "SHIMIZU Co., Ltd." for ongoing "Nubarashen" CDM project (WRef-5). According to this source 13.053 kt $CO_{2\ eq.}$, 0 kt $CO_{2\ eq.}$ and 7.323 kt $CO_{2\ eq.}$ were captured and flared in 2020-2022, correspondingly.

Emission factors and other parameters

The following parameters were used for calculation:

- Region: - Asia – Western and Middle East
- Climate: Boreal and temperate dry
- Starting year: 1950
- Dalay time; 6 months
- Fraction of methane in developed gas: 0.5

Default values from the 2006 IPCC Guidelines and IPCC software were taken for DOC, DOCf and k parameters for each considered waste type from Table 8 3.

For assessing methane emissions from solid waste disposal sites (SWDS), classification was made by the cities and rural areas of RA, by using Methane Correction Factor (MCF) default values (Vol.5, Ch.3, Table 3.1).

- Capital City of Yerevan (Nubarashen SWDS) – was considered to be an anaerobic managed SWDS[12]; MCF = 1.0
- Gyumri and Vanadzor cities – unmanaged SWDS having depths of greater than or equal to 5 meters; MCF = 0.8.
- Other 45 cities and towns of the country – unmanaged shallow SWDS, having depths of less than 5 meters; MCF = 0.4.
- Of the total volume of municipal solid waste collected in 960 rural settlements of the country, 43.4% was disposed to the unmanaged shallow SWDS (MCF = 0.4) and 56.6% - unmanaged deep SWDS having depths of greater than or equal to 5 meters; MCF = 0.8.

[12] With depth of more than 5 m

Time series consistency and recalculations

In the current submission the time series for category 5.A. is not consistent due to the changes in methodology and activity data. For 1990-2019, emissions were calculated using bulk waste and for 2020-2022 emissions are calculated using waste composition information. Furthermore, the methodology for calculating total waste has been also updated with the new approach considering the total population of Armenia (both urban and rural), whereas in the previous version only urban population was considered. Therefore, the methane emissions for 1990-2019 need to be recalculated. This requires additional data collection for previous years, identifying all data gaps and considering various splicing techniques from IPCC Guidelines to identify those that are most suitable for recalculation of this category. This improvement is planned for the next inventory cycle.

The figure below shows methane emission from this category in 1990-2022. The observed increase in 2021 is reduction of the methane flared. The increase between 1990 and 2005 is due to the increase in methane collection rates and waste per capita values.

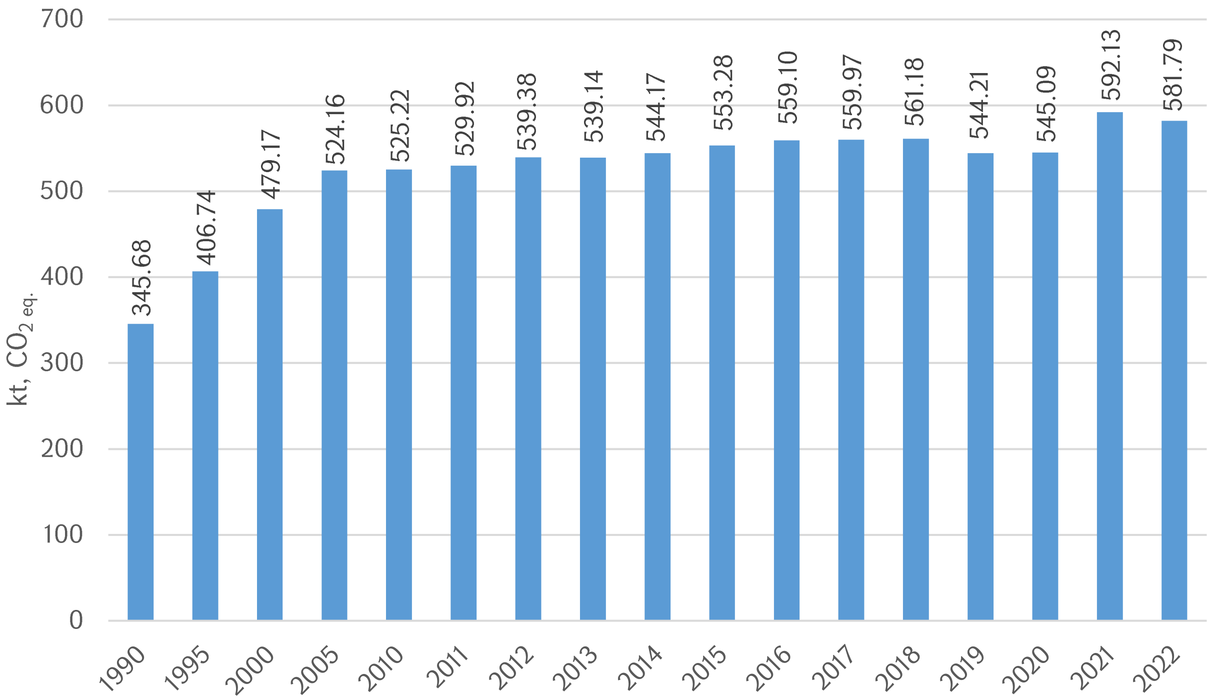

Figure 8.2 Methane emissions from SWDSs, kt CO_2 eq.

Uncertainty assessment

According to the 2006 IPCC Guidelines, the FOD method is a simple model of a very complex and poorly understood system (Volume 5, Chapter 3). However, uncertainty is mainly caused by the activity data and emission factors.

The uncertainties of these values, which were selected from the 2006 IPCC Guidelines, are provided in Table 4.57 (Vol 5, Ch 3, Table 3.5).

Table 8.4 Uncertainty of activity data and parameters

Activity data and parameters	Uncertainty range
Total Municipal Solid Waste (MSW_T)	±30%
Fraction of MSWT sent to SWDS (MSW_T)	±30%
Total uncertainty of Waste composition	
Degradable Organic Carbon (DOC)	±20%
Fraction of Degradable Organic Carbon Decomposed (DOC_f)	±20%
Methane Correction Factor (MCF)	
= 1.0	-10%, +0%
= 0.8	±20%
= 0.4	±30%
Fraction of CH_4 in generated Landfill Gas (F) = 0.5	±5%
Methane Recovery (R)	±10%

Activity data, emission factors and general uncertainty were calculated according to the 2006 IPCC Guidelines (Volume 1, Equation 3.1):

- Activity data: 55.68%
- Emission factors: 30%
- General uncertainty: 62.65 %

Category-specific QA / QC and verification

The general and category-specific quality checks and quality assurance were carried out by sector experts in accordance with Armenia's QA/QC plan presented in Annex 7 of the inventory.

Category-specific planned improvements

For the next inventory cycle, it is planned to recalculate emissions for 1990-2019 using waste composition data and updated population numbers (including urban and rural population).

5.C.1. Waste incineration

Description of the category

According to the 2006 IPCC Guidelines (Vol 5, Ch 5), Waste incineration is defined as the combustion of solid and liquid waste in controlled incineration facilities. Emissions from waste incineration without energy recovery are reported in the Waste Sector. Emissions from waste incineration include CO_2, methane (CH_4) and nitrous oxide (N_2O) emissions. Consistent with the 2006 IPCC Guidelines (Vol 5, Ch 5.1), only CO_2 emissions resulting from oxidation, during incineration and open burning of carbon in waste of fossil origin (e.g., plastics, certain textiles, rubber, liquid solvents, and waste oil) are considered net emissions and should be included in the national CO_2 emissions estimate.

All incineration facilities operating during the reporting period have been included, and an individual (facility-level) approach was applied during quality control of activity data - both in terms of the quantity and types of incinerated waste. Therefore, it can be concluded that completeness for this category has been ensured at an appropriate level.

Choice of Method

CO_2 emissions were estimated by Tier 2a method (Vol 5, Ch 5), using country-specific activity data on the waste composition and default data on other parameters for MSW (Equation 5.2).

CO_2 emissions from incineration of fossil liquid waste were estimated using Equation 5.3. (Vol 5, Ch 5.2.1.4) and the default values for emission factors provided in Table 5.2 (Vol 5, Ch 5.4.1). and in Tables 2.3-2.6 (Vol 5, Ch 2).

The calculation of CH_4 emissions was done by Tier 1 method using Equation 5.4. (Vol 5, Ch 5.2.2.1) and the default values for emission factors provided in Table 5.3 (Vol 5, Ch 5.4.2).

The calculation of N_2O emissions was done by Tier 1 method using Equation 5.5. (Vol 5, Ch 5.2.3.1) and the default values for emission factors provided in Table 5.6 (Vol 5, Ch 5.4.3).

Activity data

According to the 2006 IPCC Guidelines, types of waste incinerated include municipal solid waste (MSW), industrial waste, hazardous waste, clinical waste and sewage sludge (Vol 5, Ch 5.1). Most of the waste incinerated in Armenia consists of medical waste and industrial waste, however some hazardous[13] waste is also incinerated.

The management of hazardous waste in Armenia is classified as a licensed activity and, therefore, may only be carried out by organizations that hold the appropriate license.

Taking the above into account, information on the types and quantities of waste incinerated in Armenia during the reporting period was obtained through the analysis of Form 1 Waste administrative statistical reports for the respective years, as well as from licensed organizations based on written official inquiries.

Based on the written inquiries conducted and additional clarifications obtained by the experts, the waste types were identified and matched with the specific categories provided in the 2006 IPCC Guidelines. The summarized data are presented in the table below (Table 8.5). The information in the table covers data from all facilities operating in Armenia during the reporting period.

Table 8.5 Activity data by waste types and years

2020		2021		2022	
Waste type	Mass/t	Waste type	Mass/t	Waste type	Mass/t
clinical	401.91	clinical	508.674	clinical	597.69
plastics	19.624	plastics	35.109	plastics	54.86633
textiles	0.496	textiles	55.769	textiles	26.68
paper	0.312	paper	0.146	paper	38.83
food	415.49	food	687.324	food	688.78
rubber	1.288	rubber	9.33	rubber	1.75
waste oils	-	lacquers	1.713	waste oils	-
garden and park	32.216	garden and park	19.793	garden and park	18.13
sludge	-	sludge	0.843	sludge	-
				wood	169.86

[13] In this sentence, the term "hazardous waste" is used in the meaning defined by the 2006 IPCC Guidelines. In Armenia, hazardous waste also includes medical waste and the majority of industrial waste (all waste classified under categories I–IV).

Emission factors and other parameters

The following data and emission factors were used for emissions calculation:

- dm - dry matter content
- CF- fraction of carbon in the dry matter
- FCF - fraction of fossil carbon in the total carbon
- OF - oxidation factor
- CH_4 emission factor for incineration of MSW
- N_2O emission factors
- CL - carbon content of fossil liquid waste type

Table 2.6 (Vol 5, Ch 2.3.4, p. 2.16), Table 5.2 (Vol 5, Ch 5.4.1) Table 5.3 (Vol 5, Ch 5. 4.2), Table 5.6, (Vol 5, Ch 5.4), Table 2.4 (Vol 5, Ch 2.3.1) were used.

Time series consistency and recalculations

The figure below shows GHG emissions from this category in 2018-2022.

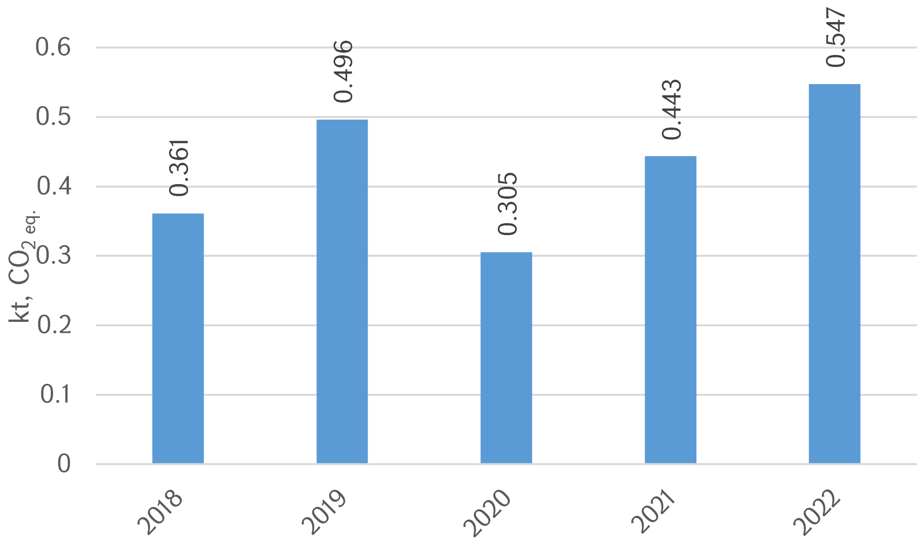

Figure 8.3 GHG emissions from *Waste Incineration*, kt CO_2 eq.

No recalculations have been done for this category.

Uncertainty assessment

The uncertainty values for activity data and emission factors are taken as default values from 2006 IPCC Guidelines (Volume 5, Ch 5.7):

- Activity data: 40%
- Emission factors: 40%

The uncertainty of GHG emissions from this category were calculated according to the 2006 IPCC Guidelines (Volume 1, Equation 3.1) and equal to 56.6%.

Category-specific QA / QC and verification

The general and category-specific quality checks and quality assurance were carried out by sectoral experts in accordance with Armenia's QA/QC plan presented in Annex 7 of the inventory.

An individual (facility-level) approach was applied during quality control of activity data - both in terms of the quantity and types of incinerated waste.

Category-specific planned improvements

No improvements are planned at present.

5.C.2 Open Burning of Waste

Description of the category

The open Burning of waste takes place in unmanaged SWDS and the corresponding emissions have been estimated in this category.

Choice of method

Calculations were made according to Equations 5.4, 5.5, 5.7 (Vol 5, Ch 5).

Activity data

The calculation of the total MSW was described under *5.A. Solid Waste Disposal* and values are shown in **Table 8.2**. The composition of waste that is burnt is shown in **Table 8.3**.

Emission factors and other parameters

Default values were applied for waste parameters (dry matter content, carbon content and other input parameters) (Vol 5, Ch 5).

B_{frac} - the fraction of MSW for which carbon content is converted to CO_2, B_{frac} is *0.6* (Volume 5, Chapter 5, Table 5.1, p. 5.17).

dm_i - total dry matter content in the MSW is 0.78 (Vol 5, Ch 5, page 5.17).

CF_i - carbon content in the dry waste type is 0.34 (Vol 5, Ch 5, page 5.17-18).

FCF_i - fraction of fossil carbon in the waste type *i* of the MSW is 0.08 (Vol 5, Ch 5, page 5.19-20).

OF_i - oxidation factor is 0.58 (Vol 5, Ch 5, Table 5.2, page 5.18).

CH_4 emission factor is 6500 g / t MSW wet weight (Vol 5, Ch 5.4.2, page 5.20).

N_2O emission factor is 150 g N_2O / t MSW dry weight (Vol 5, Ch 5.4, page 5.22).

Time series consistency and recalculations

The figure below shows GHG emissions from this category in 1990-2022.

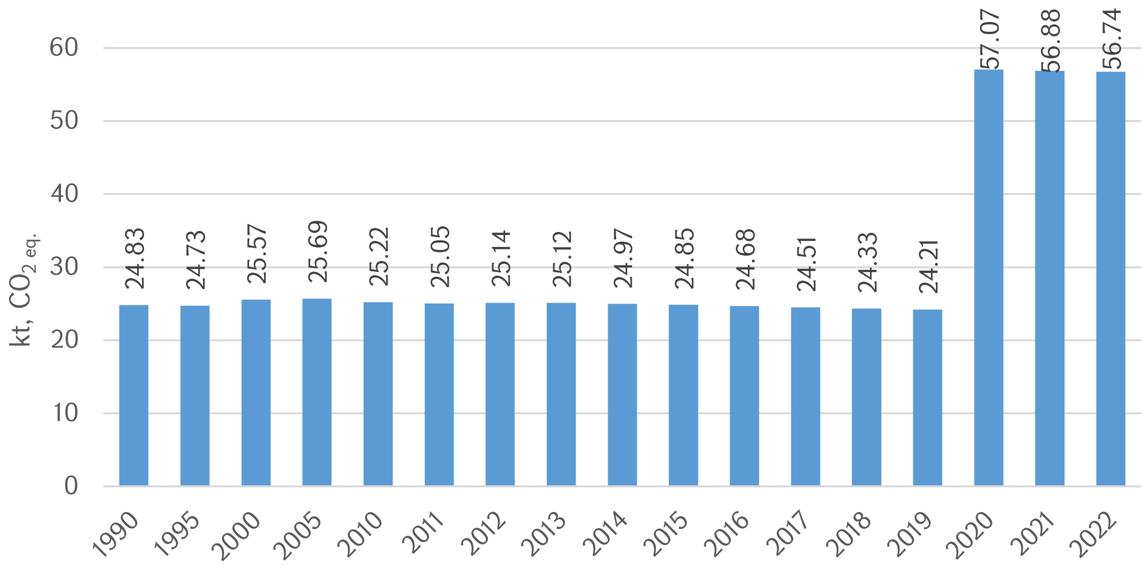

Figure 8.4 GHG emissions from open burning of waste, kt $CO_{2\ eq.}$

The sharp increase in CO_2 emissions during 2020–2022 is due to the increase in the amount of waste subjected to open burning during those years, resulting from improvements in activity data, based on information received from the RA Ministry of Territorial Administration and Infrastructure in response to the formal inquiry of the RA Ministry of Environment.

No recalculations have been done for this category.

Uncertainty assessment

The Uncertainty values for activity data and emission factors are taken as default values from 2006 IPCC Guidelines (Volume 5, Ch 5.7):

- Activity data: 40%
- Emission factors: 40%

The uncertainty of GHG emissions from this category were calculated according to the 2006 IPCC Guidelines (Volume 1, Equation 3.1) and equal to 56.6%.

Category-specific QA / QC and verification

The general and category-specific quality checks and quality assurance were carried out by sectoral experts in accordance with Armenia's QA/QC plan presented in Annex 7 of the inventory.

Category-specific planned improvements

No improvements are planned at present.

5.D.1 Domestic Wastewater (methane emissions)

Description of the category

From 1990 to 2022, in Yerevan and other cities of Armenia, domestic wastewater was mainly removed through sewerage systems, while in rural settlements - through latrines and holes.

Armenia operates a limited number of wastewater treatment plants, all of which provide mechanical treatment only. There is a lack of centralized biological treatment of domestic wastewater, sludge removal, and methane capturing. In recent years, certain efforts have been made to improve the wastewater treatment system, and treatment plants are being constructed. However, due to the small capacities of these treatment plants, they have not been considered in this report.

Choice of Method

The estimation of methane emissions from domestic wastewater has been carried out according to the 2006 IPCC Guidelines in three steps, using Equations 6.1, 6.2, and 6.3 (Volume 5, Chapter 6).

Activity data

The activity data for this source category is the total amount of organically degradable material in the wastewater (TOW). This parameter is a function of human population **(P)** and biochemical oxygen demand (BOD) generation per person.

P - country population in inventory year, (person) [Ref-1], which is classified by the size of income group, where:

- population in large cities (Yerevan, Gyumri, Vanadzor) with centralized and branched sewerage system is considered as high-income population group,
- other urban population – as middle-income population group,
- rural population - as low-income population group (Volume 5, Chapter 6).

Tj - degree of utilization of treatment/discharge pathway or system

The RA SC has published data on access to sewerage systems for the population of Yerevan city, as well as other cities and rural areas of the country. Within the framework of this inventory, these data were studied, and missing data were completed using interpolation and extrapolation methodologies. Based on this, the shares of the population with access to centralized sewerage system were calculated. Yerevan city was considered as the high-income population group, other cities of Armenia as the middle-income population group, and the rural population as the low-income group (Volume 5, Chapter 6).

The table below presents these shares for the years 2018–2022 (Ref-2).

Table 8.6 Shares of the population for the years 2018-2022

Residence	Wastewater	2018	2019	2020	2021	2022
Yerevan, %	**Centralized sewerage system**	0.986	0.968	0.997	0.995	0.987
	Latrines	0.014	0.032	0.003	0.005	0.013
Other cities, %	**Centralized sewerage system**	0.975	0.977	0.978	0.992	0.972
	Latrines	0.025	0.023	0.022	0.008	0.028

Rural, %	**Centralized sewerage system**.	0.286	0.381	0.486	0.475	0.486
	Latrines	0.286	0.381	0.486	0.475	0.486

***BOD* - country-specific per capita BOD in inventory year, g/person/day**

The 2006 IPCC Guidelines do not provide specific values for the countries of the South Caucasus or the former USSR countries. Therefore, the value of **18,250 kg/1,000 persons/year (50 g/person/day)**, proposed for former USSR countries in the 1996 IPCC Guidelines (Gen-2, page 6.23), has been used. This value has also been applied in all previous GHG Inventory calculations for Armenia.

Sludge removal and **methane recovered**. The default for sludge removal is zero, **S** = 0. The default for CH_4 recovery is zero, **R** = 0 (Vol 5, Ch 6, p.6.9)

The calculations were done by using both Excel spreadsheets and the IPCC 2006 Software.

Emission factors and other parameters

According to the 2006 IPCC Guidelines, the following default values of emission factors were used:

- **Bo = 0.6 (kg CH_4/kg BOD) _ Maximum methane producing capacity** for domestic wastewater (Volume 5, Chapter 6, Table 6.2).
- **I = 1 Correction factor for additional industrial BOD discharged into sewers** (for collected the default is 1.25, **for uncollected the default is 1.0**) (Volume 5, page 6.14). I = 1 is selected as methane emissions from organic residues of industrial and/or commercial origin were calculated in the *Industrial Wastewater* (5D2) category
- **MCF_J _ Methane correction factor (fraction)** indicates the extent to which the CH_4 producing capacity (Bo) is realized in each type of treatment and discharge pathway and system.
  - **MCF** $_{\text{Sea, river and lake discharge}}$ = *0.1* was selected for removals through the sewer system which complies with removal of collected and untreated domestic wastewater that are eventually discharged in rivers, lakes and river mouths (Volume 5, Chapter 6, Table 6.3). Methane emissions from anaerobic processes in mechanical treatment systems are insignificant, and they were not taken into account in the calculations.
  - **MCF** $_{\text{Latrine}}$= *0.1* In the case of latrines was selected for MCF factor which complies with the arid climate areas where the level of subterranean water is below the depth of latrines or holes of small family (3-5 persons) [Gen-1 Volume 5, Chapter 6, Table 6.3].

Time series consistency and recalculations

When compiling the time series, the newly published data by the RA SC (Ref-2) regarding the share of different population groups (urban, rural, and/or high-, middle-, and low-income groups) with access to sewerage systems were taken into account.

To ensure time series consistency, a recalculation was performed for the entire time series with the updated data, considering that the values of the population's access to the sewerage system in the previous inventories were based on expert judgment.

The time series of methane emissions from domestic wastewater is presented in Figure 8.5 for the entire time period, based on the newly reviewed data (1990–2022).

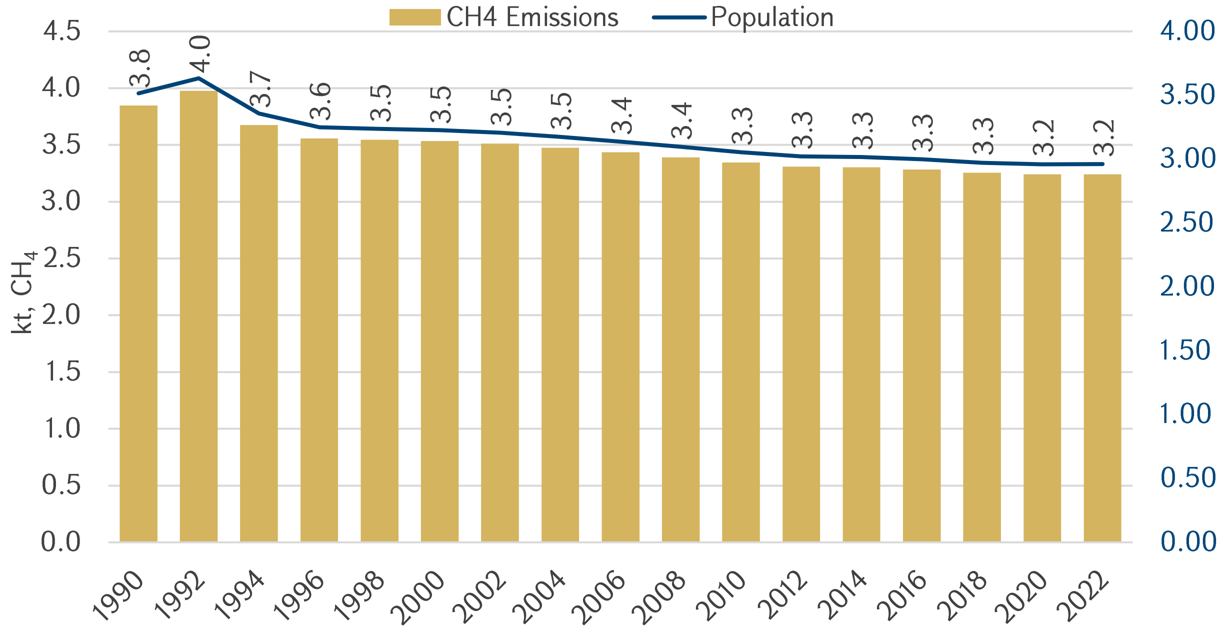

Figure 8.5 Methane emissions from domestic wastewater (kt) and population dynamics

From the **Figure 8.5** it is evident that the decrease in methane emissions from domestic wastewater is due to the decline in the country's population.

Figure 8.6 shows the trend in methane emissions from the domestic wastewater by different population groups: population of the large cities (Yerevan), urban and rural population.

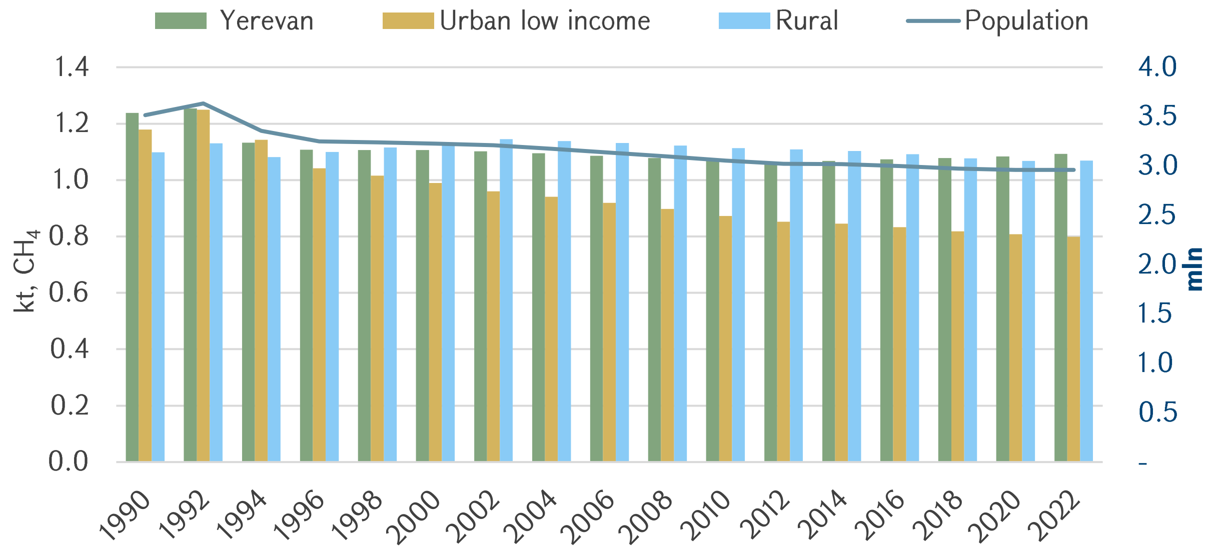

Figure 8.6 Methane emissions from domestic wastewater by population groups, kt

As it comes from the **Figure 8.6**, throughout the entire period, the main sources of methane emissions from domestic wastewater have been the rural population and the city of Yerevan, whose population, according to 2022 data, made up 36.9% of the country's total population and 57.75% of the urban population.

As mentioned before, category-specific recalculations have been done for the entire time series using the newly published data by the RA SC (Ref-1) regarding the share of different population groups (urban, rural, and/or high-, middle-, and low-income groups) with access to sewerage systems, as in the previous inventories the shares of population access to sewer systems and latrines used in the calculation of methane emissions from domestic wastewater were based on expert data. According to the publications of the RA SC, the population’s share with access to the sewer system is higher. As a result, methane emissions from the sewer system have increased, while emissions from latrines have decreased.

Despite this, the total value of methane emissions from domestic wastewater has not changed. This is because an MCF value of 0.1 was used for sewered wastewater disposal, corresponding to the removal of collected but untreated domestic wastewater. Similarly, for latrines, an MCF value of 0.1 was chosen, corresponding to dry climate regions. Numerically, the MCF coefficients are equal, so the total methane emissions from domestic wastewater have not changed although the underlying activity data has.

Uncertainty assessment

Uncertainty assessment of methane emissions from domestic wastewater was performed according to the IPCC 2006 Guidelines (Volume 5, Table 6.7).

According to the Guidelines, the uncertainty range of the human population for calculation of methane emissions from wastewater is considered to be ±5%, BOD per person is ±30%, the uncertainty range of Bo is ±30%, for the sewer access for different groups of people is ±15%.

The shares of different population groups with access to sewerage (Ti,j) were calculated using the logic of the population accounting, which allows the uncertainty of Ti,j to be assumed at ±5%, corresponding to the level of uncertainty in the population count.

The activity data, emissions factor and total uncertainties were calculated according to the 2006 IPCC Guidelines (Volume 1, Equation 3.1), which are as follows:

activity data 36%, emissions factors 58 % and total uncertainty 68.3%.

Category-specific QA / QC and verification

General and category-specific Quality Assurance and Quality Control (QA/QC) was carried out by sector experts in accordance with the Armenian National GHG Inventory QA/QC plan presented in Annex 7.

Category-specific planned improvements

The RA SC conducts a census and household surveys within the established timeframes to improve the quality of the published data.

On the other hand, to switch to a higher calculation method, it is necessary to have national coefficients. The possibilities of their implementation are being considered.

The construction of treatment facilities in Armenia is also of great importance, and work is underway in this direction.

5.D.1 Domestic Wastewater (Nitrous oxide Emissions)

Choice of Method

The 2006 IPCC Guidelines suggest the same approach for the nitrous oxide emissions assessment from the domestic wastewater, both for the developing and developed countries. According to the proposed method, the calculations are based on the country’s total population number and the per capita ‘consumed’ protein. Nitrous oxide emissions from wastewater are estimated based on Equations 6.7 and 6.8 (Volume 5, Chapter 6).

Activity data and emission factors

The following default values were used for the calculations (Volume 5, Chapter 6, Table 6.11):

$EF_{EFFLUENT}$ = 0.005 (kg N_2O-N/kg N) - Nitrous oxide emission factor

F_{NPR} = 1.6(kg N/kg protein) - Fraction of nitrogen in protein

$F_{NON-CON}$ - **Factor to adjust for non-consumed protein**. Taking into account that there is waste and wastewater disposal in Armenia, **$F_{NON-CON}$ = 1.40** value was used in the calculations.

$F_{IND-COM}$ = 1. 25 - Factor to allow for co-discharge of industrial and commercial protein into the sewer.

Nitrogen removed with sludge N_{SLUDGE} = 0 As in the previous two sections related to wastewater, here too, based on the wastewater treatment and discharge practice in the country, nitrogen removal from the sludge generated from wastewater is not considered

Annual per capita protein consumption (kg/person/yr) – For this value the Guidelines recommend to calculate UN FAO protein indicator consumed by a person in the certain country for a certain period of time.

UN FAO updated data on Armenia (Ref-6) were used in this inventory report. These data are presented in **Table 8.7** and served as basis for the calculation for the whole period (1990-2022).

Table 8.7 Consumed protein (g/person/day)

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Consumed protein (g/person/day)	66	66	66	66	66	66	66	66	66	65.3	65.6	67.2	70.5	74.2	77.8	80.2	83.6

Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Consumed protein (g/person/day)	84.8	89.9	94.4	100.1	102.4	104.2	106.7	108.3	108.7	107.7	107.2	107.00	107.90	108.6	109.3	110

The activity data required for the calculations — the total population of the country — were obtained from the data bank of the official website of the RA SC (Ref-2). These data are also published in the annual statistical Yearbooks RA SC.

Time series consistency and recalculations

To ensure time series consistency, the same methodology for estimating nitrogen oxide emissions from wastewater was applied for the whole period.

The time series has been recalculated using updated data for Armenia published by the UN FAO on the amount of protein consumed per person per day.

Time series of the nitrogen oxide emissions from wastewater, depending on protein consumption and population number, are given in the **Figures 8.7** and **8.8.**

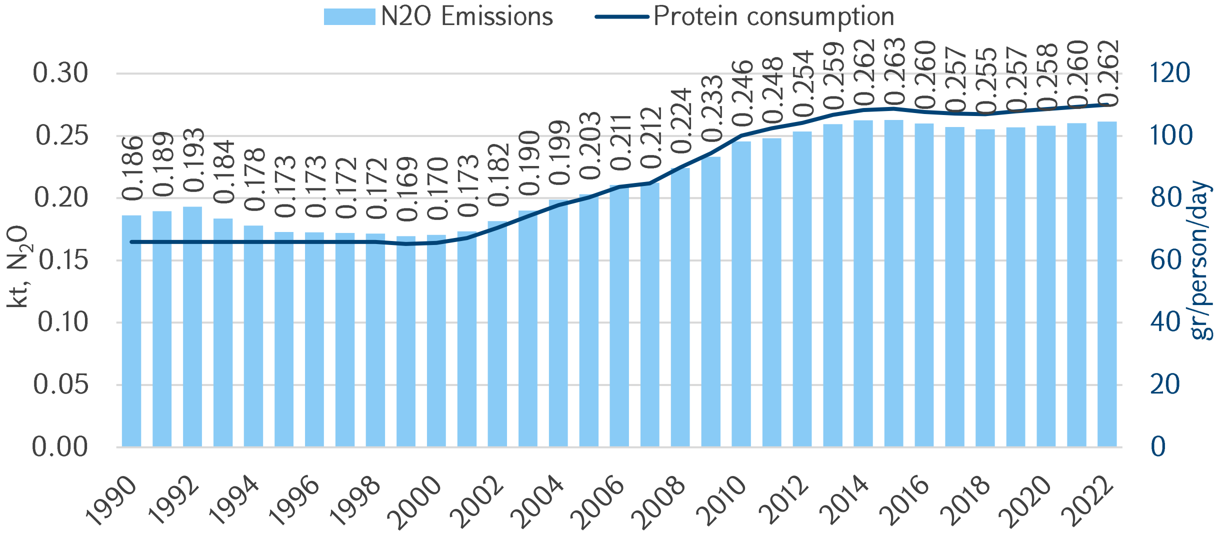

Figure 8.7 Nitrogen oxide emissions from wastewater (kt) and protein consumption

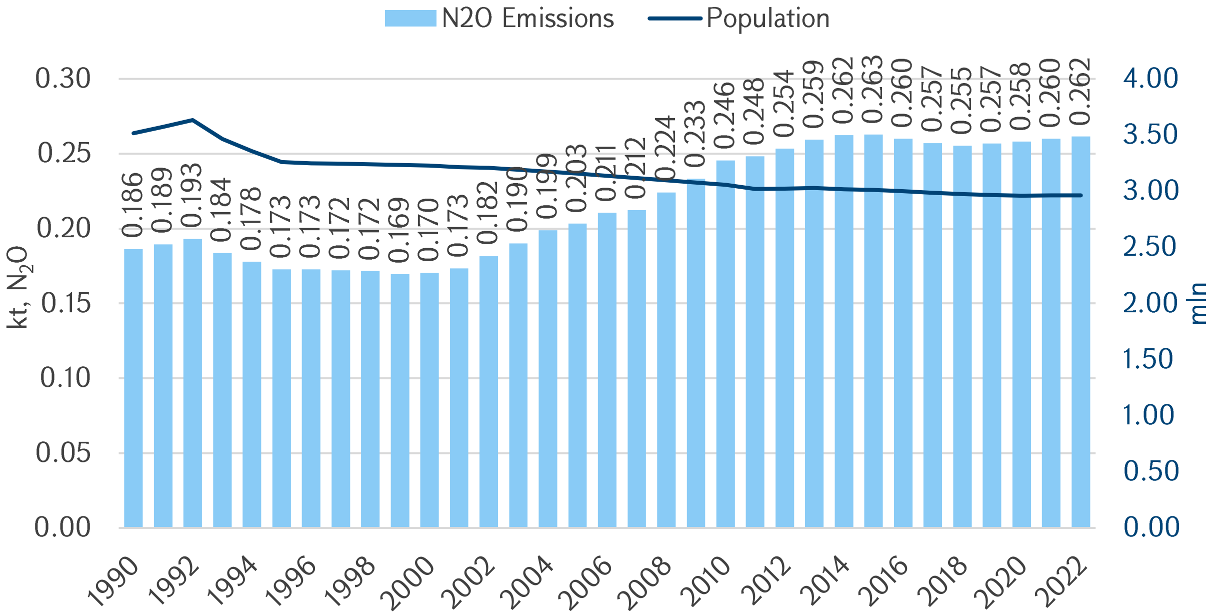

Figure 8.8 Nitrogen oxide emissions from wastewater (kt) and population number

The time series shows that nitrous oxide emissions vary depending on changes in population number and protein consumption.

Category-specific recalculations have been done for the entire time series using updated data for Armenia published by the UN FAO regarding the amount of protein consumed per person per day. As a result of recalculations, there was no change in GHG emissions in1990, whereas GHG emissions increased by 16.8% in 2017 and by 11.7% in 2019.

Uncertainty assessment

Uncertainty assessment of the calculated results of nitrous oxide emissions from domestic wastewater was carried out based on the uncertainties outlined in the 2006 IPCC Guideline (Vol 5, Table 6.11). According to the Guideline, in the calculations of nitrous oxide emissions from wastewater, the population uncertainty can be assumed to be ±5%, the amount of protein consumed per person Protein ±10%, and $EF_{EFFLUENT}$ ±50%.

Category-specific QA / QC and verification

General and category-specific Quality Assurance and Quality Control (QA/QC) was carried out by sector experts in accordance with the Armenian National GHG Inventory QA/QC plan presented in Annex 7.

Category-specific planned improvements (5D1)

No improvements are currently planned.

5.D.2 Industrial Wastewater

Choice of Method

To assess methane emissions from industrial wastewater, the volumes of specific types of production published by the RA SC serve as a reliable and comprehensive source of activity data. However, due to the lack of necessary information for calculating country-specific emission factors, methane emissions from industrial wastewater were estimated using the Tier 1 methodology of the 2006 IPCC Guidelines. According to this methodology, the calculations were performed in three steps, using Equations 6.4, 6.5, and 6.6 from the 2006 IPCC Guidelines (Volume 5).

Activity data

The activity data for this source category is the amount of organically degradable material in the wastewater (TOW). This parameter is a function of industrial output (product) P (tonnes/yr), wastewater generation W (m^3/tonne of product), and degradable organics concentration in the wastewater COD (kg COD/m^3). For determination of TOW, the industrial sectors that generate wastewater with large quantities of organic carbon were identified.

Table 8.8 provides industrial wastewater data relevant to Armenia that were selected from the 2006 IPCC Guidelines (Volume 5, Chapter 6, Table 6.9).

Table 8. 8 Industrial wastewater data

Industry type	Wastewater generation, Wi, m^3/t	COD, kg/m^3
Milk, Dairy Products, including Cheese	7	2.7
Fruits, Vegetables, Preserves, Juices	20	5.0
Alcohol Refining	24	11.0
Paper, Cardboard	162	9.0
Meat, Meat Products, Canned Meat	13	4.1
Beer	6.3	2.9
Wine, Champagne	23	1.5
Plastics	0.6	3.7
Vegetable and Other Oils	3.1	0.5
Soap	1.0	0.5
Fish Processing	8	2.5
Sugar Processing	4	3.2

Table 8.9 presents the quantities of output from which the wastewater was generated, by production type and by year. The required activity data were obtained from RA SC publications (Ref-1) - “Output of Main Commodities in the Industrial Organizations (in Kind), as well as from the RA SC databases under the section “National food balances of the Republic of Armenia by food product groups/types, indicators, and years” (Ref-1).

Table 8.9 Production volumes (thousand t/year) by years, 2000-2022

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Alcohol Refining	12.37	15.64	17.13	18.42	20.22	22.84	22.10	26.92	29.25	25.12	25.77	24.41	28.78	35.95	29.76	29.47	33.77	42.32	39.19	51.20	43.40	19.94	22.44
Beer & Malt	8.14	10.22	7.25	7.49	9.05	11.02	12.93	11.92	10.79	11.10	15.74	15.11	14.01	20.34	24.31	21.20	19.00	20.97	24.16	26.91	24.10	28.89	31.51
Dairy Products	191.0	197.0	207.0	218.0	338.8	594.6	620.0	641.2	661.9	615.7	600.9	601.5	618.2	657.0	700.4	728.6	754.2	758.2	697.7	667.9	654.3	670.7	623.1
Fish Processing	0.00	0.08	0.27	0.23	0.14	0.09	0.01	0.18	0.12	0.03	0.05	0.00	0.00	0.06	0.03	0.34	0.34	0.32	0.27	0.19	0.25	0.50	0.27
Meat & Poultry	41.66	39.47	39.78	42.20	44.45	56.00	66.80	69.70	70.90	70.70	69.50	71.70	73.90	83.40	92.70	100.4	106.1	109.0	108.2	107.3	107.7	110.6	103.7
Plastics & Resins	0.00	0.15	0.23	0.92	2.14	3.10	6.47	9.36	6.69	9.05	10.14	25.31	24.89	24.98	26.95	25.00	27.37	37.97	25.65	27.42	30.04	32.60	35.36
Pulp & Paper (combined)	0.00	0.24	0.65	1.61	1.61	1.81	1.72	1.35	2.00	6.97	8.70	10.10	10.20	11.92	17.68	13.93	14.53	17.63	18.60	24.70	20.75	23.86	34.62
Soap & Detergents	0.00	0.59	0.56	0.49	0.85	3.24	3.57	2.85	2.27	2.38	2.41	2.21	1.97	2.50	1.68	1.57	2.10	4.28	5.82	6.03	6.56	7.39	8.83
Sugar Refining	0.00	0.00	0.00	0.00	0.72	1.89	2.21	3.29	3.83	0.87	32.51	72.16	69.27	69.63	89.19	53.23	54.12	48.63	57.99	59.98	28.77	23.26	66.66
Vegetable Oils	0.00	0.26	1.46	2.18	0.39	0.68	3.38	0.90	2.01	2.20	2.22	1.70	3.26	5.19	5.08	2.44	2.05	1.57	1.45	1.79	1.85	2.15	5.37
Vegetables, Fruits & Juices	20.63	55.31	81.70	53.53	47.97	47.47	53.42	54.54	62.93	52.80	57.71	72.06	71.15	92.25	112.30	108.95	103.62	128.91	146.91	136.63	159.92	183.70	178.53
Wine & Vinegar	4.63	7.44	7.66	3.25	3.34	7.67	4.81	4.72	3.81	4.76	6.47	6.82	6.29	7.22	6.81	6.59	7.53	9.80	9.67	12.75	10.66	12.83	11.90

Emission factors and other parameters

The following default values from the 2006 IPCC Guidelines were used for calculation of methane emissions from industrial wastewater:

- **MCF _ Methane correction factor (fraction)** ***MCF = 0.1*** (for collected and untreated industrial wastewater that are discharged in sea, rivers and lakes) (Volume 5, Chapter 6, Table 6.8).
- **Bo = 0.25 (kg CH_4/kg COD) _ Maximum methane producing capacity** (Volume 5, Chapter 6, Page 6.21].
- **Chemical oxygen demand CODi** (industrial degradable organic component in wastewater), kg COD/m^3) (Volume 5, Chapter 6, Table 6.9).
- **W_i-Wastewater generated (by product), m^3/t product,** (default values, Volume 5, Chapter 6, Table 6.9).

Organic component removed as sludge in inventory year: Si = 0 (default value, (Volume 5, Chapter 6)). Emissions related to sludge are not considered, since based on the information obtained from the conducted surveys, it can be concluded that such activity is absent in Armenia.

Amount of CH_4 recovered in inventory year: Ri = 0 (default value, (Volume 5, Chapter 6)), as methane recovery/capture activity from industrial wastewater is absent Armenia.

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Time series consistency and recalculations

Time series of methane emissions from industrial wastewater are presented below in **Figure 8.9.**

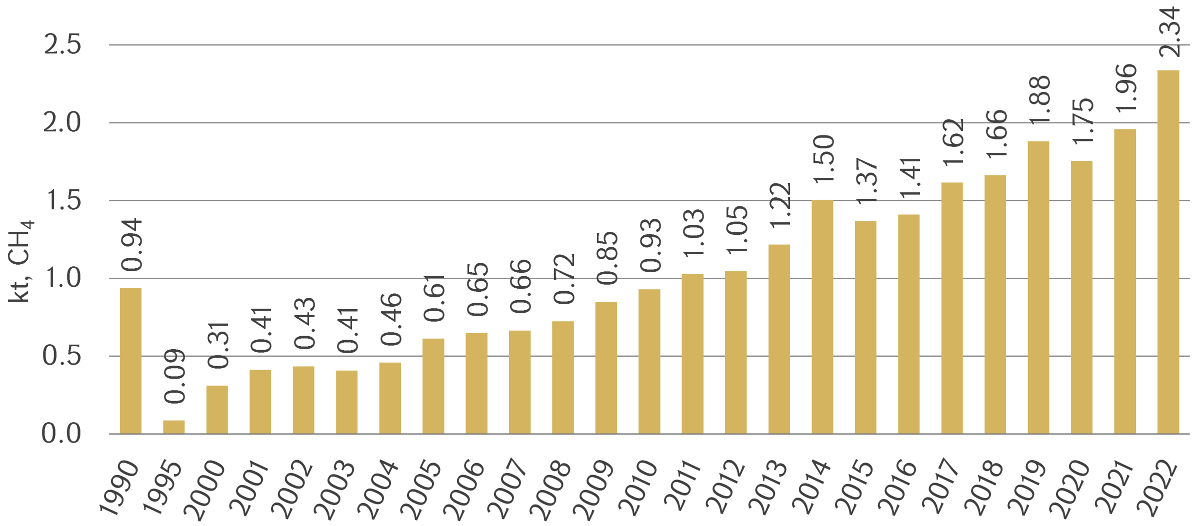

Figure 8.9 Methane emissions from industrial wastewater, kt

The publications of the RA SC for the years 1990–1999 were very incomplete and, therefore, were not included in the inventories of previous years. In recent years, the RA SC has revised and supplemented the time series data, making it possible to perform calculations starting from 1990.

Recalculations have been done for the entire time series using the updated data from RA SC publications (Ref-1) - “Output of Main Commodities in the Industrial Organizations (in Kind), as well as data from the RA SC databases under the section “National food balances of the Republic of Armenia by food product groups/types, indicators, and years”.

As can be seen from Figure 8.9, methane emissions from industrial wastewater have shown a growing trend during the period from 2000 to 2017, except for the years 2003, 2009-2010, and 2015, due to the following reasons:

- In 2003 and 2015 - due to unfavorable agriculture and food safety conditions.
- In 2008-2009 - due to the impact of the global financial crisis.

Methane emissions from industrial wastewater decreased in 2020–2021 and increased again in 2022. This was due to the Covid and the political situation in the country in 2020, which had a negative impact on the national economy as well.

Share of methane emissions from *industrial wastewater* per industry type are illustrated in **Figure 8.10.**

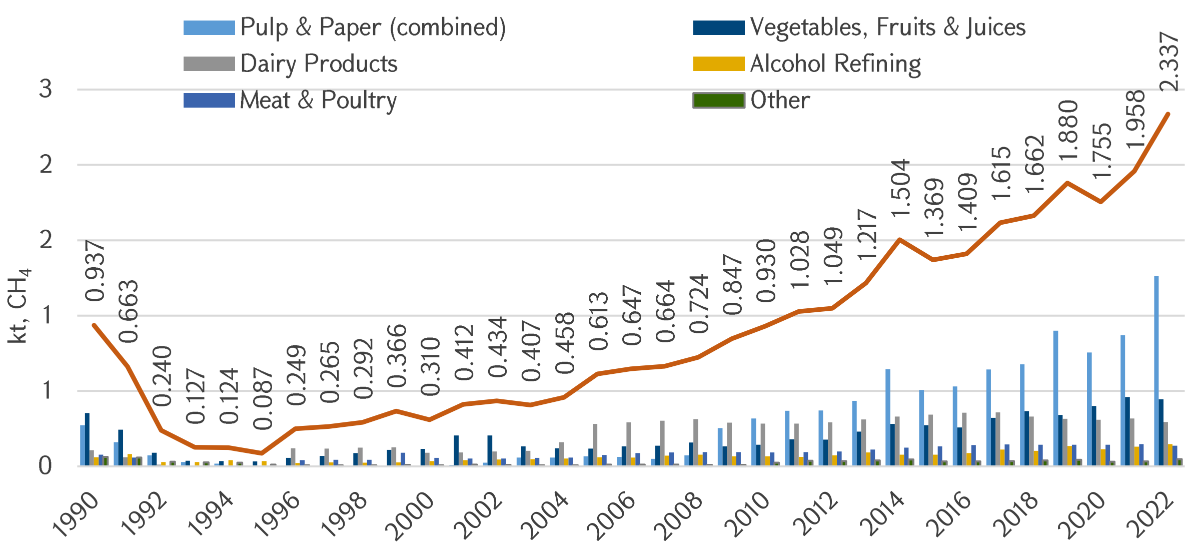

Figure 8.10 Methane emissions from industrial wastewater per industry types, kt

It is obvious from the **Figure 8.10**, that main source of methane emissions from industrial wastewater is “Pulp & Paper” production, the volume of which is increasing.

Category-specific recalculations have been done for the entire time series using the updated data from RA SC publications (Ref-1) - “Output of Main Commodities in the Industrial Organizations (in Kind), as well as data from the RA SC databases under the section “National food balances of the Republic of Armenia by food product groups/types, indicators, and years”.

As a result of recalculations, the GHG emissions decreased by 12.84% in 2017, and by 14.43% in 2019.

Uncertainty assessment

Uncertainty assessment for methane emissions from industrial wastewater was carried out based on the default uncertainty ranges provided in Table 6.10 of the 2006 IPCC Guidelines (Vol 5, Ch. 6).

The uncertainty for maximum CH_4 producing capacity (Bo) is considered 30%, for the methane correction factor (MCF) it ranges from 0 to 1, and for the production volume it is 25%.

The uncertainties of activity data, emission factors, and total uncertainty were calculated using Equation 3.1 (Volume 1). The following values were obtained:

- Activity data: 75.00%
- Emission factors: 58.31%

- Total uncertainty: 95.00%

Category-specific QA / QC and verification

General and category-specific Quality Assurance and Quality Control (QA/QC) was carried out by sector experts in accordance with the Armenian National GHG Inventory QA/QC plan presented in Annex 7.

Category-specific planned improvements

No improvements are currently planned.

9. IMPROVEMENTS IN ARMENIA'S 1990-2022 GHG INVENTORY

The main improvements introduced in the National GHG Inventory for the years 1990–2022 are presented below per IPCC sectors, following the principles of transparency, accuracy, completeness, consistency and comparability (TACCC). These improvements are based on the National GHG Inventory Improvement Plan, which incorporates the recommendations of the team of technical experts who conducted the technical analysis of Armenia’s Third Biennial Update Report, as presented in the Technical Analysis Summary Report (TASR), as well as the improvements proposed based on the outcomes of the expert recommendations.

Energy

- A new sub-category (1A4ci*) Stationary* was considered.
- To ensure the consistency of time series and to calculate GHG emissions from the (1A4ci) *Stationary* subcategory, the time series in the (1A4a) *Commercial/Institutional* and (1A4c) *Agriculture/Forestry/Fishing/Fish Farms* subcategories of the (1A4) *Other Sectors* category have been recalculated.
- The methodology for estimating country-specific fugitive emission factors in the natural gas transmission (including storage) and distribution systems of Armenia has been updated to reflect recent changes in the country's gas supply systems.
- GHG emissions from the Energy sector have been assessed for the years 1991–1994 and 1996–1999, based on data from scientific and technical literature, as well as accompanying research.

IPPU

- A new sub-category (2C1) *Iron and Steel Production* was considered.
- CO_2 emissions from (2D2) *Paraffin Wax Use* have been recalculated for the entire time period due to the adjustment of activity data.
- Emissions of NMVOCs from (2D3) *Solvent Use* have been recalculated for the entire period due to the change in the emission factor.
- The time series of NMVOC emissions from (2D4) *Bitumen/Asphalt Production and Use* has been recalculated for the entire period due to the adjustment for the bitumen content in the asphalt mixture.
- The time series of NMVOC emissions from (2H2) *Food and Beverages* has been recalculated for the entire period due to the change in the methodology applied - EMEP/EEA Manual Tier 2 methodology has been applied
- The time series of HFC emissions from RAC applications has been recalculated for the entire period – emissions were calculated for each sub-application using the appropriate factors provided in the 2006 Guidelines.
- Emissions from closed pressure electrical equipment from 1999 to 2022 have been recalculated based on adjusted activity data from utilities.

Agriculture

- For calculation of emissions from animal husbandry, animal stocks for cattle (both dairy cows and other cattle) and sheep have been divided into sub-divisions used for purposes of Armenia's emissions reporting.
- Time series has been recalculated and consistent time series has been developed for 1990-2022 due to adjustment of data required for assessing emissions from enteric fermentation, as well as due to the subdivision of animal categories.
- Time series on methane and nitrous oxide emissions from manure management has been recalculated for the 1990-2022 period with adjusted activity data.
- Based on the data from the "External Trade of the Republic of Armenia (according to the 8- and 10-digit classification of the Commodity Nomenclature of External Economic Activity)" of the RA SC, the time series of direct and indirect nitrous oxide emissions from managed soils has been recalculated for the entire period.

  Due to data gaps with respect to years 1990-1995, emissions for 1990-1995 were estimated by linear interpolation, assuming a constant annual decrease in emissions throughout the period of 1990-1995.

LULUCF

- The recalculation has been performed for the entire time series for *Cropland Remaining Cropland* subcategory due to the adjusted activity data.
- The recalculation of the time series for *Land converted to settlements* subcategory has been performed for the years 2011-2022 due to the updated data on land-use conversion to Settlements and corrections to it. Data on land-use conversion to Settlements are not available before 2011.
- The recalculation of the time series for 2011-2022 has been performed due to the updated data on land-use conversion to *Other land* and corrections to it. Data on land-use conversion are not available before 2011.
- The recalculation of the time series for the entire period for *Harvested Wood Products* category has been performed due to the adjusted activity data.

Waste

- 2020-2022 emissions from 5.A *Solid Waste Disposal* category have been calculated using waste composition data, while for 1990-2019 emissions were calculated using bulk waste.
- The methodology for calculating total waste has been updated with the new approach, considering the total population of Armenia (both urban and rural), whereas in the previous submissions only urban population was considered.

  Therefore, the methane emissions for 1990-2019 need to be recalculated. This requires additional data collection for previous years, identifying all data gaps and considering various splicing techniques from the 2006 IPCC Guidelines to identify those that are most suitable for recalculation of this category. This improvement is planned for the next inventory cycle.

- Emissions from (5.C.1) *Waste incineration* category have been assessed.
- The recalculation has been performed for the entire time series for methane emissions from *(5.D.1) Domestic Wastewater* category using the newly published data by the RA Statistics Committee, while the values of the population's access to the sewerage system in the previous inventories were based on expert judgment.
- The time series for nitrogen oxide emissions from *(5.D.1) Domestic Wastewater* category has been recalculated using updated data for Armenia published by the UN FAO on the amount of protein consumed per person per day.
- The recalculation has been performed for the entire time series for (5.D.2) *Industrial wastewater treatment and discharge* category (methane emissions), using the updated data from RA SC publications, as well as data from the RA SC databases.

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SF_6

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ANNEX 1. REMOVALS AND EMISSIONS OF GREENHOUSE GASES BY YEAR

Annex 1.1 Greenhouse gas removals and emissions in Armenia, kt, 2020

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Net CO_2 emissions/ removals	CH_4	N_2O	HFCs	PFCs	Unspecified mix of HFCs and PFCs	SF_6	NF_3	NO_x	CO	NMVOC	SO_x	Total GHG emissions/ removals
	(kt)			CO_2 equivalents (kt)			(kt)						$CO_{2\ eq.}$ (kt)
Total national emissions and removals	**6,414.26**	**123.79**	**3.27**	**943.43**	**NO**	**NO**	**0.00**	**NO**	**15.43**	**47.78**	**8.17**	**8.66**	**11,694.76**
1. Energy	**6,377.83**	**50.68**	**0.17**						**15.31**	**43.80**	**4.67**	**0.41**	**7,842.65**
1.A. Fuel combustion	6,377.61	3.68	0.17						15.31	43.80	4.67	0.41	6,526.31
1.A.1. Energy industries	1,437.54	0.03	0.00						2.27	1.00	0.07	0.01	1,438.93
1.A.2. Manufacturing industries and construction	451.23	0.01	0.00						0.82	0.25	0.18	0.03	451.76
1.A.3. Transport	2,273.07	1.99	0.13						10.55	40.31	4.21	0.02	2,362.50
1.A.4. Other sectors	2,215.77	1.66	0.04						1.67	2.25	0.22	0.35	2,273.12
1.A.5. Other	NO	NO	NO						NO	NO	NO	NO	NO
1.B. Fugitive emissions from fuels	0.22	47.00	NO						NO	NO	NO	NO	1,316.35
1.B.1. Solid fuels	NO	NO	NO						NO	NO	NO	NO	NO
1.B.2. Oil and natural gas and other emissions from energy production	0.22	47.00	NO						NO	NO	NO	NO	1,316.35
1.C. CO_2 Transport and storage	NO												NO
2. Industrial processes and product use	**400.16**	**NO**	**NO**	**943.43**	**NO**	**NO**	**0.00**	**NO**	**NO**	**NO**	**3.50**	**8.25**	**1,347.05**
2.A. Mineral industry	391.15	NO	NO						NO	NO	NO	NO	391.15
2.B. Chemical industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.C. Metal industry	3.86	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	8.25	3.86
2.D. Non-energy products from fuels and solvent use	5.15	NO	NO						NO	NO	0.02	NO	5.15
2.E. Electronic industry			NO	NO	NO	NO	NO	NO					NO
2.F. Product uses as substitutes for ODS				943.43	NO	NO							943.43
2.G. Other product manufacture and use	NO	NO	NO		NO	NO	0.00	NO	NO	NO	NO	NO	3.46
2.H. Other	NO	NO	NO		NO	NO	NO	NO	NO	NO	3.48	NO	NO
3. Agriculture	**2.69**	**47.77**	**2.81**						**NO**	**NO**	**NO**	**NO**	**2,084.65**
3.A. Enteric fermentation		45.83											1,283.13
3.B. Manure management		1.83	0.26								NO		119.32
3.C. Rice cultivation		NO									NO		NO
3.D. Agricultural soils		NA	2.55						NO	NO	NO		675.84
3.E. Prescribed burning of savannahs		NO	NO						NO	NO	NO	NO	NO
3.F. Field burning of agricultural residues		0.11	0.003						NO	NO	NO	NO	3.67
3.G. Liming	NO												NO
3.H. Urea application	2.69												2.69

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Net CO_2 emissions/ removals	CH_4	N_2O	HFCs	PFCs	Unspecified mix of HFCs and PFCs	SF_6	NF_3	NO_x	CO	NMVOC	SO_x	Total GHG emissions/ removals
	(kt)			CO_2 equivalents (kt)			(kt)						$CO_{2\ eq.}$ (kt)
3.I. Other carbon-containing fertilizers	NO												NO
3.J. Other	NO	NO	NO						NO	NO	NO	NO	NO
4. Land use, land-use change and forestry	**-397.28**	**0.03**	**0.02**						**0.11**	**3.98**	**NO**	**NO**	**-390.33**
4.A. Forest land	-476.73	0.01	0.00						0.01	0.33	**NO**		-476.12
4.B. Cropland	-6.03	NA	NA						0.10	3.58	NO		-6.03
4.C. Grassland	25.65	0.00	0.01						0.00	0.07	NO		27.83
4.D. Wetlands	18.34	0.02	0.00						NO	NO	NO		18.85
4.E. Settlements	10.90	NA	NA						NO	NO	NO		10.90
4.F. Other land	32.10	NA	0.01						NO	NO	NO		35.74
4.G. Harvested wood products	-1.50												-1.50
4.H. Other	NO	NO	NO						NO	NO	NO	NO	NO
5. Waste	**30.86**	**25.31**	**0.27**						**NO**	**NO**	**NO**	**NO**	**810.75**
5.A. Solid waste disposal		**19.47**							**NO**	**NO**	**NO**		545.09
5.B. Biological treatment of solid waste		NO	NO						NO	NO	NO		NO
5.C. Incineration and open burning of waste	**30.86**	0.85	0.01						NE	NE	NA	NE	57.38
5.D. Wastewater treatment and discharge		5.00	0.26						NA	NA	NE		208.28
5.E. Other	NO	NO	NO						NO	NO	NO	NO	NO
6. Other *(please specify)*	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
Memo items:													
1.D.1. International bunkers	117.40	0.00	0.00						NO	NO	NO	NO	118.30
1.D.1.a. Aviation	117.40	0.00	0.00						NO	NO	NO	NO	118.30
1.D.1.b. Navigation	NO	NO	NO						NO	NO	NO	NO	NO
1.D.2. Multilateral operations	NO	NO	NO						NO	NO	NO	NO	NO
1.D.3. CO_2 emissions from biomass	475.77												475.77
1.D.4. CO_2 captured	NO												NO
5.F.1. Long-term storage of C in waste disposal sites	6,469.62												6,469.62
Indirect N_2O			NO										

Annex 1.2 Greenhouse gas removals and emissions in Armenia, kt, 2021

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Net CO_2 emissions/ removals	CH_4	N_2O	HFCs	PFCs	Unspecified mix of HFCs and PFCs	SF_6	NF_3	NO_x	CO	NMVOC	SO_X	Total GHG emissions/ removals
	(kt)			CO_2 equivalents (kt)			(kt)						$CO_{2\ eq.}$ (kt)
Total national emissions and removals	**7,039.67**	**132.91**	**3.30**	**1,024.56**	**NO**	**NO**	**0.00**	**NO**	**16.61**	**51.47**	**7.31**	**9.48**	**12,663.80**
1. Energy	**6,946.10**	**57.53**	**0.18**						**16.49**	**46.92**	**5.06**	**0.56**	**8,603.70**
1.A. Fuel combustion	6,945.88	3.89	0.18						16.49	46.92	5.06	0.56	7,101.40
1.A.1. Energy industries	1,658.04	0.03	0.00						2.61	1.14	0.08	0.01	1,659.63
1.A.2. Manufacturing industries and construction	531.40	0.01	0.00						1.00	0.29	0.21	0.04	532.04
1.A.3. Transport	2,385.90	2.16	0.13						11.09	42.44	4.47	0.02	2,480.80
1.A.4. Other sectors	2,370.54	1.69	0.04						1.79	3.04	0.30	0.49	2,428.92
1.A.5. Other	NO	NO	NO						NO	NO	NO	NO	NO
1.B. Fugitive emissions from fuels	0.22	53.65	NO						NO	NO	NO	NO	1,502.30
1.B.1. Solid fuels	NO	NO	NO						NO	NO	NO	NO	NO
1.B.2. Oil and natural gas and other emissions from energy production	0.22	53.65	NO						NO	NO	NO	NO	1,502.30
1.C. CO_2 Transport and storage	NO												NO
2. Industrial processes and product use	**449.31**	**NO**	**NO**	**1,024.56**	**NO**	**NO**	**0.00**	**NO**	**NO**	**NO**	**2.25**	**8.92**	**1,477.71**
2.A. Mineral industry	432.94	NO	NO						NO	NO	NO	NO	432.94
2.B. Chemical industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.C. Metal industry	11.02	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	8.92	11.02
2.D. Non-energy products from fuels and solvent use	5.35	NO	NO						NO	NO	0.02	NO	5.35
2.E. Electronic industry			NO	NO	NO	NO	NO	NO					NO
2.F. Product uses as substitutes for ODS				1,024.56	NO	NO							1,024.56
2.G. Other product manufacture and use	NO	NO	NO		NO	NO	0.00	NO	NO	NO	NO	NO	3.84
2.H. Other (4)	NO	NO	NO		NO	NO	NO	NO	NO	NO	2.23	NO	NO
3. Agriculture	**4.90**	**48.13**	**2.83**						**NO**	**NO**	**NO**	**NO**	**2,102.02**
3.A. Enteric fermentation		46.30											1,296.32
3.B. Manure management		1.73	0.27								NO		119.30
3.C. Rice cultivation		NO									NO		NO
3.D. Agricultural soils		NA	2.56						NO	NO	NO		677.73
3.E. Prescribed burning of savannahs		NO	NO						NO	NO	NO	NO	NO
3.F. Field burning of agricultural residues		0.11	0.003						NO	NO	NO	NO	3.77
3.G. Liming	NO												NO
3.H. Urea application	4.90												4.90
3.I. Other carbon-containing fertilizers	NO												NO
3.J. Other	NO	NO	NO						NO	NO	NO	NO	NO
4. Land use, land-use change and forestry	**-391.54**	**0.05**	**0.02**						**0.13**	**4.55**	**NO**	**NO**	**- 383.69**
4.A. Forest land	-471.36	0.04	0.00						0.02	0.85	**NO**		-469.77
4.B. Cropland	-6.02	NO	0.00						0.10	3.68	NO		-6.02

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Net CO_2 emissions/ removals	CH_4	N_2O	HFCs	PFCs	Unspecified mix of HFCs and PFCs	SF_6	NF_3	NO_x	CO	NMVOC	SO_X	Total GHG emissions/ removals
	(kt)			CO_2 equivalents (kt)			(kt)						$CO_{2\ eq.}$ (kt)
4.C. Grassland	25.65	0.00	0.01						0.00	0.02	NO		27.74
4.D. Wetlands	13.29	0.02	0.00						NO	NO	NO		13.80
4.E. Settlements	20.06	NA	NA						NO	NO	NO		20.06
4.F. Other land	32.10	NA	0.01						NO	NO	NO		35.74
4.G. Harvested wood products	-5.25												-5.25
4.H. Other	NO	NO	NO						NO	NO	NO	NO	NO
5. Waste	**30.89**	**27.19**	**0.27**						**NO**	**NO**	**NO**	**NO**	**864.07**
5.A. Solid waste disposal		**21.15**							**NO**	**NO**	**NO**		592.13
5.B. Biological treatment of solid waste		NO	NO						NO	NO	NO		NO
5.C. Incineration and open burning of waste	**30.89**	0.84	0.01						NE	NE	NA	NE	57.33
5.D. Wastewater treatment and discharge		5.20	0.26						NA	NA	NE		214.61
5.E. Other	NO	NO	NO						NO	NO	NO	NO	NO
6. Other *(please specify)*	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
Memo items:													
1.D.1. International bunkers	163.93	0.00	0.00						NO	NO	NO	NO	165.18
1.D.1.a. Aviation	163.93	0.00	0.00						NO	NO	NO	NO	165.18
1.D.1.b. Navigation	NO	NO	NO						NO	NO	NO	NO	NO
1.D.2. Multilateral operations	NO	NO	NO						NO	NO	NO	NO	NO
1.D.3. CO_2 emissions from biomass	470.25												470.25
1.D.4. CO_2 captured	NO												NO
5.F.1. Long-term storage of C in waste disposal sites	6,572.63												6,572.63
Indirect N_2O			NO										

Annex 1.3 Greenhouse gas removals and emissions in Armenia, kt, 2022

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Net CO_2 emissions/ removals	CH_4	N_2O	HFCs	PFCs	Unspecified mix of HFCs and PFCs	SF_6	NF_3	NO_x	CO	NMVOC	SO_X	Total GHG emissions/ removals
	(kt)			CO_2 equivalents (kt)			(kt)						$CO_{2\ eq.}$ (kt)
Total national emissions and removals	**7,231.14**	**134.50**	**3.17**	**1,091.04**	**NO**	**NO**	**0.00**	**NO**	**16.60**	**51.78**	**7.46**	**10.36**	**12,932.20**
1. Energy	**7,072.72**	**61.88**	**0.17**						**16.48**	**47.35**	**5.15**	**0.55**	**8,850.55**
1.A. Fuel combustion	7,072.45	3.86	0.17						16.48	47.35	5.15	0.55	7,225.62
1.A.1. Energy industries	1,680.64	0.03	0.00						2.66	1.17	0.08	0.01	1,682.27
1.A.2. Manufacturing industries and construction	627.92	0.01	0.00						1.11	0.34	0.25	0.04	628.64
1.A.3. Transport	2,337.19	2.14	0.13						10.86	42.76	4.52	0.02	2,430.55
1.A.4. Other sectors	2,426.71	1.67	0.04						1.84	3.08	0.30	0.48	2,484.16
1.A.5. Other	NO	NO	NO						NO	NO	NO	NO	NO
1.B. Fugitive emissions from fuels	0.27	58.02	NO						NO	NO	NO	NO	1,624.93
1.B.1. Solid fuels	NO	NO	NO						NO	NO	NO	NO	NO
1.B.2. Oil and natural gas and other emissions from energy production	0.27	58.02	NO						NO	NO	NO	NO	1,624.93
1.C. CO_2 Transport and storage	NO												NO
2. Industrial processes and product use	**513.81**	**NO**	**NO**	**1,091.04**	**NO**	**NO**	**0.00**	**NO**	**NO**	**NO**	**2.31**	**9.81**	**1,609.00**
2.A. Mineral industry	496.64	NO	NO						NO	NO	NO	NO	496.64
2.B. Chemical industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.C. Metal industry	11.16	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	9.81	11.16
2.D. Non-energy products from fuels and solvent use	6.01	NO	NO						NO	NO	0.02	NO	6.01
2.E. Electronic industry			NO	NO	NO	NO	NO	NO					NO
2.F. Product uses as substitutes for ODS				1,091.04	NO	NO							1,091.04
2.G. Other product manufacture and use	NO	NO	NO		NO	NO	0.00	NO	NO	NO	NO	NO	4.15
2.H. Other (4)	NO	NO	NO		NO	NO	NO	NO	NO	NO	2.29	NO	NO
3. Agriculture	**3.79**	**45.36**	**2.70**						**NO**	**NO**	**NO**	**NO**	**1,989.89**
3.A. Enteric fermentation		43.63											1,221.53
3.B. Manure management		1.64	0.26								NO		114.84
3.C. Rice cultivation		NO									NO		NO
3.D. Agricultural soils		NA	2.44						NO	NO	NO		646.28
3.E. Prescribed burning of savannahs		NO	NO						NO	NO	NO	NO	NO
3.F. Field burning of agricultural residues		0.10	0.003						NO	NO	NO	NO	3.45
3.G. Liming	NO												NO
3.H. Urea application	3.79												3.79
3.I. Other carbon-containing fertilizers	NO												NO
3.J. Other	NO	NO	NO						NO	NO	NO	NO	NO

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Net CO_2 emissions/ removals	CH_4	N_2O	HFCs	PFCs	Unspecified mix of HFCs and PFCs	SF_6	NF_3	NO_x	CO	NMVOC	SO_X	Total GHG emissions/ removals
	(kt)			CO_2 equivalents (kt)			(kt)						$CO_{2\ eq.}$ (kt)
4. Land use, land-use change and forestry	**-390.08**	**0.06**	**0.02**						**0.12**	**4.43**	**NO**	**NO**	**-381.88**
4.A. Forest land	-456.04	0.05	0.00						0.03	1.05	**NO**		-456.04
4.B. Cropland	-6.00	NA	NA						0.09	3.37	NO		-6.00
4.C. Grassland	25.65	0.00	0.01						0.00	0.01	NO		27.73
4.D. Wetlands	21.34	0.02	0.00						NO	NO	NO		21.86
4.E. Settlements	-0.48	NA	NA						NO	NO	NO		-0.48
4.F. Other land	32.10	NA	0.01						NO	NO	NO		35.74
4.G. Harvested wood products	-4.69												-4.69
4.H. Other	NO	NO	NO						NO	NO	NO	NO	NO
5. Waste	**30.90**	**27.20**	**0.27**						**NO**	**NO**	**NO**	**NO**	**864.63**
5.A. Solid waste disposal		**20.78**							**NO**	**NO**	**NO**		581.79
5.B. Biological treatment of solid waste		NO	NO						NO	NO	NO		NO
5.C. Incineration and open burning of waste	**30.90**	0.84	0.01						NO	NO	NO	NO	57.28
5.D. Wastewater treatment and discharge		5.58	0.26						NO	NO	NO		225.55
5.E. Other	NO	NO	NO						NO	NO	NO	NO	NO
6. Other *(please specify)*	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
Memo items:													
1.D.1. International bunkers	309.53	0.00	0.01						NO	NO	NO	NO	311.88
1.D.1.a. Aviation	309.53	0.00	0.01						NO	NO	NO	NO	311.88
1.D.1.b. Navigation	NO	NO	NO						NO	NO	NO	NO	NO
1.D.2. Multilateral operations	NO	NO	NO						NO	NO	NO	NO	NO
1.D.3. CO_2 emissions from biomass	461.38												461.38
1.D.4. CO_2 captured	NO												NO
5.F.1. Long-term storage of C in waste disposal sites	6,675.68												6,675.68
Indirect N_2O			NO										

ANNEX 2. KEY SOURCE ANALYSIS AND UNCERTAINTIES ASSESSMENT

Annex 2.1 Analysis of Key Sources: Level assessment, 2022

A	B	C	D	E	F	G
IPCC Category code	IPCC Category	GHG	2022 Ex,t (kt $CO_{2\ eq.}$)	|Ex,t| (kt $CO_{2\ eq.}$)	Lx,t	Cumulative Total of Column F
1.A.1	**Energy Industries - Gaseous Fuels**	**CO_2**	**1,680.64**	**1,680.64**	**12.12%**	**12.12%**
1.B.2.b	**Fugitive emissions from Natural Gas transportation and distribution**	**CH_4**	**1,624.66**	**1,624.66**	**11.71%**	**23.83%**
1.A.4.b	**Residential- Gaseous Fuels**	**CO_2**	**1,580.20**	**1,580.20**	**11.39%**	**35.22%**
1.A.3.b	**Road Transportation - Liquid Fuels**	**CO_2**	**1,307.23**	**1,307.23**	**9.43%**	**44.65%**
3.A.1	**Enteric Fermentation - Cattle**	**CH_4**	**1,042.54**	**1,042.54**	**7.52%**	**52.17%**
2.F.1	**Refrigeration and Air Conditioning**	**HFCs**	**1,028.08**	**1,028.08**	**7.41%**	**59.58%**
1.A.3.b	**Road Transportation - Gaseous Fuels**	**CO_2**	**982.25**	**982.25**	**7.08%**	**66.66%**
5.A	**Solid Waste Disposal**	**CH_4**	**581.79**	**581.79**	**4.19%**	**70.85%**
1.A.2	**Manufacturing Industries and Construction - Gaseous Fuels**	**CO_2**	**577.33**	**577.33**	**4.16%**	**75.02%**
3.D.1	**Direct N2O Emissions from managed soils**	**N_2O**	**519.76**	**519.76**	**3.75%**	**78.76%**
1.A.4.a	**Commercial/institutional - Gaseous Fuels**	**CO_2**	**504.88**	**504.88**	**3.64%**	**82.40%**
2.A.1	**Cement production**	**CO_2**	**471.59**	**471.59**	**3.40%**	**85.81%**
4.A.1	**Forest land Remaining Forest land**	**CO_2**	**-456.58**	**456.58**	**3.29%**	**89.10%**
3.A.4	**Enteric Fermentation - Other**	**CH_4**	**178.98**	**178.98**	**1.29%**	**90.39%**
1.A.4.c	**Agriculture/Forestry/Fishing/Fish Farms - Gaseous Fuels**	**CO_2**	**170.53**	**170.53**	**1.23%**	**91.62%**
5.D	**Wastewater Treatment and Discharge**	**CH_4**	**156.24**	**156.24**	**1.13%**	**92.74%**
3.D.2	**Indirect N2O Emissions from managed soils**	**N_2O**	**130.23**	**130.23**	**0.94%**	**93.68%**
1.A.4	**Other Sectors - Liquid Fuels**	**CO_2**	**126.71**	**126.71**	**0.91%**	**94.60%**
5.D	**Wastewater Treatment and Discharge**	**N_2O**	**69.32**	**69.32**	**0.50%**	**95.10%**
1.A.2	Manufacturing Industries and Construction - Liquid Fuels	CO_2	50.59	50.59	0.36%	95.46%
3.B	Manure Management	N_2O	49.69	49.69	0.36%	95.82%
2.F.2	Foam Blowing Agents	HFCs	48.41	48.41	0.35%	96.17%
1.A.3.e	Other Transportation - Liquid Fuels	CO_2	47.70	47.70	0.34%	96.51%
3.B	Manure Management	CH_4	45.87	45.87	0.33%	96.84%
1.A.3.b	Road Transportation - Gaseous Fuels	CH_4	44.95	44.95	0.32%	97.17%
1.A.4	Other Sectors - Solid Fuels	CO_2	44.40	44.40	0.32%	97.49%
1.A.4	Other Sectors - Biomass - solid	CH_4	33.00	33.00	0.24%	97.72%
4.F.2	Land Converted to Other land	CO_2	32.10	32.10	0.23%	97.96%
5.C	Incineration and Open Burning of Waste	CO_2	30.90	30.90	0.22%	98.18%
4.C.2	Land Converted to Grassland	CO_2	25.65	25.65	0.18%	98.83%
5.C	Incineration and Open Burning of Waste	CH_4	23.52	23.52	0.17%	98.35%
4.D.1	Peat Extraction remaining Peat Extraction	CO_2	21.34	21.34	0.15%	98.50%
4.B.2	Indirect N2O Emissions from manure management	N_2O	19.28	19.28	0.14%	98.64%
2.A.2	Lime production	CO_2	17.33	17.33	0.12%	98.95%
1.A.3.b	Road Transportation - Liquid Fuels	CH_4	15.00	15.00	0.11%	99.06%
1.A.3.b	Road Transportation - Liquid Fuels	N_2O	14.59	14.59	0.11%	99.16%
1.A.3.b	Road Transportation - Gaseous Fuels	N_2O	13.87	13.87	0.10%	99.26%
2.F.4	Aerosols	HFCs	13.62	13.62	0.10%	99.36%
2.C.1	Iron and Steel Production	CO_2	11.16	11.16	0.08%	99.44%

A	B	C	D	E	F	G
IPCC Category code	IPCC Category	GHG	2022 Ex,t (kt CO_2 eq.)	|Ex,t| (kt CO_2 eq.)	Lx,t	Cumulative Total of Column F
2.A.3	Glass Production	CO_2	7.71	7.71	0.06%	99.50%
4.B.2	Land Converted to Cropland	CO_2	-6.63	6.63	0.05%	99.55%
2.D	Non-Energy Products from Fuels and Solvent Use	CO_2	6.01	6.01	0.04%	99.59%
1.A.4	Other Sectors - Gaseous Fuels	CH_4	5.61	5.61	0.04%	99.63%
1.A.3.e	Other Transportation - Liquid Fuels	N_2O	4.88	4.88	0.04%	99.67%
1.A.4	Other Sectors - Liquid Fuels	N_2O	4.74	4.74	0.03%	99.70%
4.G	Harvested Wood Products	CO_2	-4.69	4.69	0.03%	99.73%
1.A.4	Other Sectors - Biomass - other	CH_4	4.31	4.31	0.03%	99.76%
1.A.4	Other Sectors - Biomass - solid	N_2O	4.16	4.16	0.03%	99.79%
2.G	Other Product Manufacture and Use	SF_6	4.15	4.15	0.03%	99.82%
4(IV)	Burning	CH_4	4.07	4.07	0.03%	99.85%
3.H	Urea application	CO_2	3.79	3.79	0.03%	99.88%
1.A.4	Other Sectors - Solid Fuels	CH_4	3.59	3.59	0.03%	99.91%
4.C	Incineration and Open Burning of Waste	N_2O	2.86	2.86	0.02%	99.93%
3.B.1.b	Land Converted to Forest land	CO_2	-1.42	1.42	0.01%	99.94%
4(IV)	Burning	N_2O	1.37	1.37	0.01%	99.95%
1.A.4	Other Sectors - Gaseous Fuels	N_2O	1.06	1.06	0.01%	99.96%
2.F.3	Fire Protection	HFCs	0.94	0.94	0.01%	99.96%
1.A.1	Energy Industries - Gaseous Fuels	CH_4	0.84	0.84	0.01%	99.97%
1.A.1	Energy Industries - Gaseous Fuels	N_2O	0.79	0.79	0.01%	99.97%
4.B.1	Cropland Remaining Cropland	CO_2	0.63	0.63	0.00%	99.98%
1.A.4	Other Sectors - Biomass - other	N_2O	0.54	0.54	0.00%	99.98%
4.E.2	Land Converted to Settlements	CO_2	-0.48	0.48	0.00%	99.99%
4(II).D.1.a	CH_4 from Drainage Ditches on Organic Soils	CH_4	0.37	0.37	0.00%	99.99%
1.A.2	Manufacturing Industries and Construction - Gaseous Fuels	CH_4	0.29	0.29	0.00%	99.99%
1.B.2.b	Natural Gas	CO_2	0.27	0.27	0.00%	99.99%
1.A.2	Manufacturing Industries and Construction - Gaseous Fuels	N_2O	0.27	0.27	0.00%	99.99%
1.A.4	Other Sectors - Liquid Fuels	CH_4	0.25	0.25	0.00%	100.00%
1.A.4	Other Sectors - Solid Fuels	N_2O	0.19	0.19	0.00%	100.00%
1.A.2	Manufacturing Industries and Construction - Liquid Fuels	N_2O	0.11	0.11	0.00%	100.00%
4(II).D.1.a	CH_4 from Drained Organic Soils	CH_4	0.08	0.08	0.00%	100.00%
1.A.3.e	Other Transportation - Liquid Fuels	CH_4	0.07	0.07	0.00%	100.00%
1.A.2	Manufacturing Industries and Construction - Liquid Fuels	CH_4	0.06	0.06	0.00%	100.00%
Total			**12,932.20**	**13,869.75**	**100%**	

Annex 2.2 Analysis of Key Sources: Trend Assessment, 2022

A	B	C	D	E			F	G	H
IPCC Category code	IPCC Category	GHG	2000 Year Estimate Ex0 (kt $CO_{2\ eq.}$)	2022 Year Estimate Ext (kt $CO_{2\ eq.}$)	2000 Year Estimate (absolute) |Ex0| (kt $CO_{2\ eq.}$)	2022 Year Estimate (absolute) |Ext| (kt $CO_{2\ eq.}$)	Trend Assess ment (Txt)	% Contri-bution to Trend	Cumula-tive Total of Column G
1.A.1	Energy Industries - Gaseous Fuels	CO_2	1696.99	1680.64	1696.99	1680.64	19.083%	15.98%	15.98%
1.A.4.b	Residential- Gaseous Fuels	CO_2	170.43	1580.20	170.43	1580.20	16.754%	14.03%	30.00%
1.B.2.b	Fugitive emissions from Natural Gas transportation and distribution	CH_4	1489.15	1624.66	1489.15	1624.66	14.764%	12.36%	42.36%
2.F.1	Refrigeration and Air Conditioning	HFCs	0.39	1028.08	0.39	1028.08	13.591%	11.38%	53.74%
1.A.3.b	Road Transportation - Gaseous Fuels	CO_2	55.20	982.25	55.20	982.25	11.650%	9.75%	63.49%
3.A.1.a	Enteric Fermentation - Cattle	CH_4	925.63	1042.54	925.63	1042.54	8.745%	7.32%	70.81%
1.A.4.a	Commercial/institutional - Gaseous Fuels	CO_2	42.90	504.88	42.90	504.88	5.634%	4.72%	75.53%
3.B.1.a	Forest land Remaining Forest land	CO_2	-470.82	-456.58	470.82	456.58	5.046%	4.22%	79.75%
5.A	Solid Waste Disposal	CH4	479.17	581.79	479.17	581.79	3.970%	3.32%	83.08%
2.A.1	Cement production	CO_2	138.85	471.59	138.85	471.59	2.858%	2.39%	85.47%
1.A.4.c	Agriculture/Forestry/Fishing/Fish Farms - Gaseous Fuels	CO_2	0.00	170.53	0.00	170.53	2.593%	2.17%	87.64%
1.A.3.b	Road Transportation - Liquid Fuels	CO_2	626.80	1307.23	626.80	1307.23	2.032%	1.70%	89.34%
1.A.2	Manufacturing Industries and Construction - Gaseous Fuels	CO_2	397.25	577.33	397.25	577.33	2.034%	1.70%	91.05%
3.C.4	Direct N2O Emissions from managed soils	N_2O	357.74	519.76	357.74	519.76	1.834%	1.54%	92.58%
3.A.4	Enteric Fermentation - Other	CH_4	145.41	178.98	145.41	178.98	1.173%	0.98%	93.56%
2.F.2	Foam Blowing Agents	HFCs	0.00	48.41	0.00	48.41	0.736%	0.62%	94.18%
1.A.4	Other Sectors - Solid Fuels	CO_2	0.04	44.40	0.04	44.40	0.586%	0.49%	94.67%
5.D	Wastewater Treatment and Discharge	CH_4	107.62	156.24	107.62	156.24	0.553%	0.46%	95.13%
1.A.3.b	Road Transportation	CH_4	2.49	44.95	2.49	44.95	0.534%	0.45%	95.58%
3.C.5	Indirect N2O Emissions from managed soils	N_2O	90.91	130.23	90.91	130.23	0.491%	0.41%	95.99%
4.F.2	Land Converted to Other land	CO_2	0.00	32.10	0.00	32.10	0.488%	0.41%	96.40%
1.A.3.e	Other Transportation	CO_2	10.84	47.70	10.84	47.70	0.367%	0.31%	96.71%
1.A.4	Other Sectors - Biomass	CH_4	32.26	33.00	32.26	33.00	0.349%	0.29%	97.00%
5.C	Incineration and Open Burning of Waste	CO_2	4.47	30.90	4.47	30.90	0.300%	0.25%	97.25%
4.C.2	Land Converted to Grassland	CO_2	0.00	25.65	0.00	25.65	0.390%	0.33%	97.58%
1.A.2	Manufacturing Industries and Construction - Liquid Fuels	CO_2	37.62	50.59	37.62	50.59	0.247%	0.21%	97.78%
3.A.2	Manure Management	N_2O	36.48	49.69	36.48	49.69	0.231%	0.19%	97.98%

A	B	C	D	E			F	G	H
IPCC Category code	IPCC Category	GHG	2000 Year Estimate Ex0 (kt $CO_{2\ eq.}$)	2022 Year Estimate Ext (kt $CO_{2\ eq.}$)	2000 Year Estimate (absolute) |Ex0| (kt $CO_{2\ eq.}$)	2022 Year Estimate (absolute) |Ext| (kt $CO_{2\ eq.}$)	Trend Assess ment (Txt)	% Contri-bution to Trend	Cumula-tive Total of Column G
4.D.1	Wetlands remaining wetlands	CO_2	2.18	21.34	2.18	21.34	0.229%	0.19%	98.17%
5.D	Wastewater Treatment and Discharge	N_2O	45.17	69.32	45.17	69.32	0.183%	0.15%	98.32%
2.C.1	Iron and Steel Production	CO_2	0.00	11.16	0.00	11.16	0.170%	0.14%	98.46%
1.A.3.b	Road Transportation	N_2O	0.77	13.87	0.77	13.87	0.165%	0.14%	98.60%
1.A.1	Energy Industries - Liquid Fuels	CO_2	6.57	0.00	6.57	0.00	0.160%	0.13%	98.74%
1.A.4	Other Sectors - Liquid Fuels	CO_2	62.27	126.71	62.27	126.71	0.160%	0.13%	98.87%
2.A.2	Lime production	CO_2	3.95	17.33	3.95	17.33	0.133%	0.11%	98.98%
5.C	Incineration and Open Burning of Waste	CH_4	18.03	23.52	18.03	23.52	0.128%	0.11%	99.09%
2.F.4	Aerosols	HFCs	3.06	13.62	3.06	13.62	0.106%	0.09%	99.18%
4.B.2	Land Converted to Cropland	CO_2	0.00	-6.63	0.00	6.63	0.101%	0.08%	99.26%
3.B.5	Indirect N2O Emissions from manure management	N_2O	13.34	19.28	13.34	19.28	0.070%	0.06%	99.32%
2.A.3	Glass Production	CO_2	1.50	7.71	1.50	7.71	0.066%	0.05%	99.37%
1.A.4	Other Sectors - Biomass	N_2O	0.00	4.31	0.00	4.31	0.065%	0.05%	99.43%
1.A.4	Other Sectors - Gaseous Fuels	CH_4	0.52	5.61	0.52	5.61	0.061%	0.05%	99.48%
1.A.3.e	Other Transportation	N_2O	0.15	4.88	0.15	4.88	0.061%	0.05%	99.53%
1.A.4	Other Sectors - Liquid Fuels	N_2O	0.08	4.74	0.08	4.74	0.061%	0.05%	99.58%
2.G	Other Product Manufacture and Use	SF_6	0.04	4.15	0.04	4.15	0.054%	0.05%	99.63%
3.C.1	Emissions from biomass burning	CH_4	4.42	4.07	4.42	4.07	0.054%	0.04%	99.67%
3.C.3	Urea application	CO_2	0.00	3.79	0.00	3.79	0.050%	0.04%	99.71%
1.A.4	Other Sectors - Solid Fuels	CH_4	0.00	3.59	0.00	3.59	0.047%	0.04%	99.75%
5.C	Incineration and Open Burning of Waste	N_2O	3.07	2.86	3.07	2.86	0.037%	0.03%	99.78%
1.A.4	Other Sectors - Solid Fuels	N_2O	4.07	4.16	4.07	4.16	0.044%	0.04%	99.82%
2.D	Non-Energy Products from Fuels and Solvent Use	CO_2	4.55	6.01	4.55	6.01	0.031%	0.03%	99.85%
3.A.2	Manure Management	CH_4	25.97	45.87	25.97	45.87	0.025%	0.02%	99.87%
4.A.2	Land Converted to Forest land	CO_2	0.00	-1.42	0.00	1.42	0.022%	0.02%	99.89%
1.A.3.b	Road Transportation - Liquid Fuels	CH_4	7.24	15.00	7.24	15.00	0.022%	0.02%	99.91%
3.D.1	Harvested Wood Products	CO_2	-20.50	-4.69	20.50	4.69	0.019%	0.02%	99.92%
2.F.3	Fire Protection	HFCs	0.00	0.94	0.00	0.94	0.014%	0.01%	99.93%
1.A.4	Other Sectors - Gaseous Fuels	N_2O	0.10	1.06	0.10	1.06	0.012%	0.01%	99.94%
1.A.1	Energy Industries - Gaseous Fuels	N_2O	0.79	0.79	0.79	0.79	0.009%	0.01%	99.95%

A	B	C	D	E			F	G	H
IPCC Category code	IPCC Category	GHG	2000 Year Estimate Ex0 (kt $CO_{2\ eq.}$)	2022 Year Estimate Ext (kt $CO_{2\ eq.}$)	2000 Year Estimate (absolute) |Ex0| (kt $CO_{2\ eq.}$)	2022 Year Estimate (absolute) |Ext| (kt $CO_{2\ eq.}$)	Trend Assess ment (Txt)	% Contri-bution to Trend	Cumula-tive Total of Column G
1.A.1	Energy Industries - Gaseous Fuels	CH_4	0.83	0.84	0.83	0.84	0.009%	0.01%	99.96%
3.C.1	Emissions from biomass burning	N_2O	1.10	1.37	1.10	1.37	0.009%	0.01%	99.97%
1.A.4	Other Sectors - Biomass - other	N_2O	0.00	0.54	0.00	0.54	0.008%	0.01%	99.97%
4.E.2	Land Converted to Settlements	CO_2	0.00	-0.48	0.00	0.48	0.007%	0.01%	99.98%
4.B.1	Cropland Remaining Cropland	CO_2	0.56	0.63	0.56	0.63	0.005%	0.00%	99.98%
1.A.3.b	Road Transportation - Liquid Fuels	N_2O	7.77	14.59	7.77	14.59	0.004%	0.00%	99.99%
4(II).D.1.a.	CH4 from Drainage Ditches on Organic Soils	CH_4	0.37	0.37	0.37	0.37	0.004%	0.00%	99.99%
1.A.2	Manufacturing Industries and Construction - Liquid Fuels	N_2O	0.19	0.11	0.19	0.11	0.003%	0.00%	99.99%
1.A.4	Other Sectors - Solid Fuels	N_2O	0.00	0.19	0.00	0.19	0.002%	0.00%	99.99%
1.A.2	Manufacturing Industries and Construction - Liquid Fuels	CH_4	0.10	0.06	0.10	0.06	0.002%	0.00%	100.00%
1.A.4	Other Sectors - Liquid Fuels	CH_4	0.18	0.25	0.18	0.25	0.001%	0.00%	100.00%
1.B.2.b	Natural Gas Fugitive Emissions	CO_2	0.11	0.27	0.11	0.27	0.001%	0.00%	100.00%
1.A.3.e	Other Transportation - Liquid Fuels	CH_4	0.02	0.07	0.02	0.07	0.001%	0.00%	100.00%
4(II).D.1.a.	CH4 from Drained Organic Soils	CH_4	0.08	0.08	0.08	0.08	0.001%	0.00%	100.00%
1.A.2	Manufacturing Industries and Construction - Gaseous Fuels	CH_4	0.17	0.29	0.17	0.29	0.000%	0.00%	100.00%
1.A.2	Manufacturing Industries and Construction - Gaseous Fuels	N_2O	0.16	0.27	0.16	0.27	0.000%	0.00%	100.00%
1.A.1	Energy Industries - Liquid Fuels	N_2O	0.01	0.00	0.01	0.00	0.000%	0.00%	100.00%
1.A.1	Energy Industries - Liquid Fuels	CH_4	0.01	0.00	0.01	0.00	0.000%	0.00%	100.00%
1.A.2	Manufacturing Industries and Construction - Biomass - solid	CH_4	0.00	0.002	0.00	0.00	0.000%	0.00%	100.00%
1.A.2	Manufacturing Industries and Construction - Biomass - other	N_2O	0.00	0.001	0.00	0.00	0.000%	0.00%	100.00%
1.A.2	Manufacturing Industries and Construction - Biomass - other	CH_4	0.00	0.001	0.00	0.00	0.000%	0.00%	100.00%
1.A.2	Manufacturing Industries and Construction - Biomass - solid	N_2O	0.00	0.0004	0.00	0.00	0.000%	0.00%	100.00%
			6576.81	**12932.20**	**7559.45**	**13869.75**	**1.19**	**100.00%**	

Annex 2.3 Uncertainty Assessment

2006 IPCC Categories	Gas	Base Year emissions or removals (kt CO_2 eq., 2000)	Year T emissions or removals (kt CO_2 eq., 2022)	Activity Data Uncertainty (%)	Emission Factor Uncertainty (%)	Combined Uncertainty (%)	Contribution to Variance by Category in last year (2022)	Type A Sensitivity	Type B 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
1.A.1 - Energy Industries - Gaseous Fuels	CO_2	1696.99	1680.64	3%	3%	4.24%	0.0000304	25.1077%	25.553%	0.7532%	1.0841%	0.0174%
1.A.1 - Energy Industries - Gaseous Fuels	CH_4	0.79	0.79	3%	200%	200.0%	0.0000000	0.0115%	0.012%	0.0230%	0.0005%	0.0000%
1.A.1 - Energy Industries - Gaseous Fuels	N_2O	0.83	0.84	3%	100%	100.0%	0.0000000	0.0121%	0.013%	0.0121%	0.0005%	0.0000%
1.A.1 - Energy Industries - Liquid Fuels	CO_2	6.57	0	5%	3%	5.8%	-	0.1963%	0.000%	0.0059%	0.0000%	0.0000%
1.A.1 - Energy Industries - Liquid Fuels	CH_4	0.01	0	5%	200%	200.1%	-	0.0004%	0.000%	0.0008%	0.0000%	0.0000%
1.A.1 - Energy Industries - Liquid Fuels	N_2O	0.01	0	5%	100%	100.1%	-	0.0002%	0.000%	0.0002%	0.0000%	0.0000%
1.A.2 - Manufacturing Industries and Construction - Gaseous Fuels	CO_2	0	0.0010	100%	500%	509.9%	0.0000000	0.0000%	0.000%	0.0001%	0.0000%	0.0000%
1.A.2 - Manufacturing Industries and Construction - Gaseous Fuels	CH_4	0	0.0008	100%	300%	316.2%	0.0000000	0.0000%	0.000%	0.0000%	0.0000%	0.0000%
1.A.2 - Manufacturing Industries and Construction - Gaseous Fuels	N_2O	0	0.0019	100%	300%	316.2%	0.0000000	0.0000%	0.000%	0.0001%	0.0000%	0.0000%
1.A.2 - Manufacturing Industries and Construction - Liquid Fuels	CO_2	0	0.0004	100%	500%	509.9%	0.0000000	0.0000%	0.000%	0.0000%	0.0000%	0.0000%
1.A.2 - Manufacturing Industries and Construction - Liquid Fuels	CH_4	397.25	577.33	5%	3%	5.8%	0.0000068	3.0945%	8.778%	0.0928%	0.6207%	0.0039%
1.A.2 - Manufacturing Industries and Construction - Liquid Fuels	N_2O	0.18	0.27	5%	200%	200.1%	0.0000000	0.0014%	0.004%	0.0028%	0.0003%	0.0000%
1.A.2 - Manufacturing Industries and Construction - Biomass other	CH_4	0.19	0.29	5%	100%	100.1%	0.0000000	0.0015%	0.004%	0.0015%	0.0003%	0.0000%
1.A.2 - Manufacturing Industries and Construction - Biomass other	N_2O	37.62	50.59	20%	5%	20.6%	0.0000007	0.3552%	0.769%	0.0178%	0.2176%	0.0005%
1.A.2 - Manufacturing Industries and Construction - Biomass solid	CH_4	0.40	0.06	20%	200%	201.0%	0.0000000	0.0110%	0.001%	0.0221%	0.0002%	0.0000%
1.A.2 - Manufacturing Industries and Construction - Biomass solid	N_2O	0.08	0.11	20%	300%	300.7%	0.0000000	0.0008%	0.002%	0.0023%	0.0005%	0.0000%
1.A.3.b - Road Transportation - Liquid Fuels	CO_2	2.49	44.95	5%	1000%	1000.0%	0.0012086	0.6090%	0.683%	6.0902%	0.0483%	0.3709%
1.A.3.b - Road Transportation - Liquid Fuels	CH_4	0.77	13.87	5%	1200%	1200.0%	0.0001658	0.1880%	0.211%	2.2555%	0.0149%	0.0509%
1.A.3.b - Road Transportation - Liquid Fuels	N_2O	55.20	982.25	5%	3%	5.8%	0.0000196	13.2835%	14.935%	0.3985%	1.0560%	0.0127%
1.A.3.b - Road Transportation - Gaseous Fuels	CO_2	626.80	1307.23	20%	5%	20.6%	0.0004344	1.1387%	19.876%	0.0569%	5.6217%	0.3161%
1.A.3.b - Road Transportation - Gaseous Fuels	CH_4	7.77	14.59	20%	1200%	1200.2%	0.0001834	0.0105%	0.222%	0.1255%	0.0627%	0.0002%
1.A.3.b - Road Transportation - Gaseous Fuels	N_2O	7.24	15.00	20%	1000%	1000.2%	0.0001346	0.0118%	0.228%	0.1176%	0.0645%	0.0002%
1.A.3.e - Other Transportation - Liquid Fuels	CO_2	0.15	4.88	20%	1200%	1200.2%	0.0000205	0.0697%	0.074%	0.8360%	0.0210%	0.0070%
1.A.3.e - Other Transportation - Liquid Fuels	CH_4	10.84	47.70	20%	5%	20.6%	0.0000006	0.4013%	0.725%	0.0201%	0.2051%	0.0004%
1.A.3.e - Other Transportation - Liquid Fuels	N_2O	0.02	0.07	20%	1000%	1000.2%	0.0000000	0.0007%	0.001%	0.0066%	0.0003%	0.0000%
1.A.4 - Other Sectors - Liquid Fuels	CO_2	0	4.31	100%	300%	316.2%	0.0000011	0.0655%	0.065%	0.1965%	0.0926%	0.0005%
1.A.4 - Other Sectors - Liquid Fuels	CH_4	0	0.54	100%	500%	509.9%	0.0000000	0.0083%	0.008%	0.0413%	0.0117%	0.0000%
1.A.4 - Other Sectors - Liquid Fuels	N_2O	32.26	33.00	100%	300%	316.2%	0.0000651	0.4627%	0.502%	1.3880%	0.7096%	0.0243%
1.A.4 - Other Sectors - Solid Fuels	CO_2	4.07	4.16	100%	500%	509.9%	0.0000027	0.0585%	0.063%	0.2925%	0.0894%	0.0009%
1.A.4 - Other Sectors - Solid Fuels	CH_4	213.32	2255.61	5%	3%	5.8%	0.0001035	27.9099%	34.296%	0.8373%	2.4251%	0.0658%
1.A.4 - Other Sectors - Solid Fuels	N_2O	0.52	5.61	5%	100%	100.1%	0.0000002	0.0697%	0.085%	0.0697%	0.0060%	0.0000%
1.A.4 - Other Sectors - Gaseous Fuels	CO_2	0.10	1.06	5%	200%	200.1%	0.0000000	0.0132%	0.016%	0.0264%	0.0011%	0.0000%
1.A.4 - Other Sectors - Gaseous Fuels	CH_4	62.27	126.71	20%	5%	20.6%	0.0000041	0.0652%	1.927%	0.0033%	0.5449%	0.0030%

1.A.4 - Other Sectors - Gaseous Fuels	N_2O	0.08	4.74	20%	200%	201.0%	0.0000005	0.0698%	0.072%	0.1395%	0.0204%	0.0002%
1.A.4 - Other Sectors - Biomass - solid	CH_4	0.18	0.25	20%	100%	102.0%	0.0000000	0.0016%	0.004%	0.0016%	0.0011%	0.0000%
1.A.4 - Other Sectors - Biomass - solid	N_2O	0.04	44.40	40%	10%	41.2%	0.0000020	0.6738%	0.675%	0.0674%	0.3819%	0.0015%
1.A.4 - Other Sectors - Biomass - other	CH_4	0.00	3.59	40%	100%	107.7%	0.0000001	0.0545%	0.055%	0.0545%	0.0309%	0.0000%
1.A.4 - Other Sectors - Biomass - other	N_2O	0.00	0.19	40%	200%	204.0%	0.0000000	0.0028%	0.003%	0.0057%	0.0016%	0.0000%
1.B.2.b - Natural Gas	CO_2	1489.15	1624.66	5%	5%	7.1%	0.0000789	19.7664%	24.702%	0.9883%	1.7467%	0.0403%
1.B.2.b - Natural Gas	CH_4	0.11	0.27	5%	5%	7.1%	0.0000000	0.0009%	0.004%	0.0000%	0.0003%	0.0000%
2.A.1 - Cement production	CO_2	138.85	471.59	5%	10%	11.2%	0.0000166	3.0193%	7.170%	0.3019%	0.5070%	0.0035%
2.A.2 - Lime production	CO_2	3.95	17.33	5%	6%	7.8%	0.0000000	0.1454%	0.264%	0.0087%	0.0186%	0.0000%
2.A.3 - Glass Production	CO_2	1.50	7.71	5%	40%	40.3%	0.0000001	0.0725%	0.117%	0.0290%	0.0083%	0.0000%
2.C.1 - Iron and Steel Production	CO_2	0.00	11.16	10%	25%	26.9%	0.0000001	0.1696%	0.170%	0.0424%	0.0240%	0.0000%
2.D - Non-Energy Products from Fuels and Solvent Use	CO_2	4.55	6.01	5%	50%	50.2%	0.0000001	0.0446%	0.091%	0.0223%	0.0065%	0.0000%
2.F.1 - Refrigeration and Air Conditioning	CH_2F_2	0.11	411.64	30%	25%	39.1%	0.0001546	6.2556%	6.259%	1.5639%	2.6554%	0.0950%
2.F.1 - Refrigeration and Air Conditioning	CHF_2CF_3	0.06	304.62	30%	25%	39.1%	0.0000846	4.6297%	4.632%	1.1574%	1.9650%	0.0520%
2.F.1 - Refrigeration and Air Conditioning	CH_2FCF_3	0.20	261.21	30%	25%	39.1%	0.0000622	3.9656%	3.972%	0.9914%	1.6850%	0.0382%
2.F.1 - Refrigeration and Air Conditioning	CH_3CF_3	0.02	50.61	30%	25%	39.1%	0.0000023	0.7690%	0.770%	0.1923%	0.3265%	0.0014%
2.F.2 - Foam Blowing Agents	CH_2FCF_3	0.00	33.87	50%	25%	55.9%	0.0000021	0.5150%	0.515%	0.1288%	0.3642%	0.0015%
2.F.2 - Foam Blowing Agents	CH_3CHF_2	0.00	6.98	50%	25%	39.1%	0.0000000	0.1062%	0.106%	0.0265%	0.0751%	0.0001%
2.F.2 - Foam Blowing Agents	$CHF_2CH_2CF_3$	0.00	5.89	50%	25%	55.9%	0.0000001	0.0895%	0.090%	0.0224%	0.0633%	0.0000%
2.F.2 - Foam Blowing Agents	$CH_3CF_2CH_2CF_3$	0.00	1.66	50%	25%	47.2%	0.0000000	0.0253%	0.025%	0.0063%	0.0179%	0.0000%
2.F.3 - Fire Protection	CF_3CHFCF_3	0.00	0.94	40%	25%	47.2%	0.0000000	0.0143%	0.014%	0.0036%	0.0081%	0.0000%
2.F.4 - Aerosols	CH_2FCF_3	2.93	13.03	30%	25%	39.1%	0.0000002	0.1106%	0.198%	0.0277%	0.0840%	0.0001%
2.F.4 - Aerosols	CH_3CHF_2	0.13	0.59	30%	25%	39.1%	0.0000000	0.0050%	0.009%	0.0013%	0.0038%	0.0000%
2.G - Other Product Manufacture and Use	SF_6	0.04	4.15	5%	30%	30.4%	0.0000000	0.0619%	0.063%	0.0186%	0.0045%	0.0000%
3.A.1 - Enteric Fermentation	CH_4	1071.05	1221.53	10%	20%	22.4%	0.0004462	13.4208%	18.573%	2.6842%	2.6266%	0.1410%
3.A.2 - Manure Management	CH_4	36.48	49.69	25%	30%	39.1%	0.0000023	0.3349%	0.756%	0.1005%	0.2671%	0.0008%
3.A.2 - Manure Management	N_2O	25.97	45.87	25%	30%	39.1%	0.0000019	0.0788%	0.697%	0.0236%	0.2466%	0.0006%
4.A.1- Forest land Remaining Forest land	CO_2	-470.82	-456.58	5%	105%	105.1%	0.0013778	7.1366%	6.942%	7.4935%	0.4909%	0.5639%
4.B.1 - Cropland Remaining Cropland	CO_2	0.00	-1.42	5%	105%	105.1%	0.0000000	0.0216%	0.022%	0.0227%	0.0015%	0.0000%
4.A.2 - Land Converted to Forest land	CO_2	0.56	0.63	5%	105%	105.1%	0.0000000	0.0072%	0.010%	0.0076%	0.0007%	0.0000%
4.B.2 - Land Converted to Cropland	CO_2	0.00	-6.63	5%	50%	50.2%	0.0000001	0.1008%	0.101%	0.0504%	0.0071%	0.0000%
4.C.2 - Land Converted to Grassland	CO_2	0.00	25.65	5%	50%	50.2%	0.0000010	0.3900%	0.390%	0.1950%	0.0276%	0.0004%
4.D.1. - Wetlands remaining wetlands	CO_2	2.18	21.34	5%	50%	50.2%	0.0000007	0.2594%	0.325%	0.1297%	0.0229%	0.0002%
4.E.2 - Land Converted to Settlements	CO_2	0	-0.48	5%	50%	50.2%	0.0000000	0.0073%	0.007%	0.0037%	0.0005%	0.0000%
4.F.2 - Land Converted to Other land	CO_2	0	32.10	5%	50%	50.2%	0.0000016	0.4880%	0.488%	0.2440%	0.0345%	0.0006%
4(IV)- Biomass Burning	CH_4	4.42	4.07	5%	105%	105.1%	0.0000001	0.0701%	0.062%	0.0737%	0.0044%	0.0001%
4(IV)- Biomass Burning	N_2O	1.10	1.37	5%	105%	105.1%	0.0000000	0.0120%	0.021%	0.0126%	0.0015%	0.0000%
3.H - Urea application	CO_2	0	3.79	5%	10%	11.2%	0.0000000	0.0575%	0.058%	0.0057%	0.0041%	0.0000%
3.D.1 - Direct N2O Emissions from managed soils	N_2O	357.68	519.76	20%	150%	151.3%	0.0037003	2.7875%	7.903%	4.1812%	2.2352%	0.2248%
3.D.2 - Indirect N2O Emissions from managed soils	N_2O	90.91	130.23	20%	180%	181.1%	0.0003327	0.7372%	1.980%	1.3269%	0.5600%	0.0207%
3.B.5 - Indirect N2O Emissions from manure management	N_2O	13.34	19.28	25%	30%	39.1%	0.0000003	0.1056%	0.293%	0.0317%	0.1037%	0.0001%
4(II).D.1.a- CH4 from Drained Organic Soils	CH_4	0.08	0.08	25%	30%	39.1%	0.0000000	0.0012%	0.001%	0.0003%	0.0004%	0.0000%
4(II).D.1.a - CH4 from Drainage Ditches on Organic Soils	CH_4	0.37	0.37	25%	30%	39.1%	0.0000000	0.0054%	0.006%	0.0016%	0.0020%	0.0000%
4.G - Harvested Wood Products	CO_2	-20.50	-4.69	50%	50%	70.7%	0.0000001	0.5416%	0.071%	0.2708%	0.0504%	0.0008%
5.A - Solid Waste Disposal	CH_4	479.17	581.79	70%	30%	76.2%	0.0011742	5.4733%	8.846%	1.6420%	8.7570%	0.7938%
5.C - Incineration and Open Burning of Waste	CO_2	4.47	30.90	40%	40%	56.6%	0.0000018	0.3362%	0.470%	0.1345%	0.2658%	0.0009%
5.C - Incineration and Open Burning of Waste	CH_4	18.03	23.52	40%	40%	56.6%	0.0000011	0.1813%	0.358%	0.0725%	0.2023%	0.0005%
5.C - Incineration and Open Burning of Waste	N_2O	3.07	2.86	40%	40%	56.6%	0.0000000	0.0484%	0.043%	0.0193%	0.0246%	0.0000%
5.D - Wastewater Treatment and Discharge	CH_4	45.17	69.32	35%	500%	501.2%	0.0007220	0.2962%	1.054%	1.4810%	0.5217%	0.0247%
5.D - Wastewater Treatment and Discharge	N_2O	107.62	156.24	36%	58%	68.3%	0.0000680	0.8412%	2.375%	0.4879%	1.2094%	0.0170%
Total		**6,576.98**	**12,932.20**				**0.0106190**					**0.0289960**
	Percentage Uncertainty in total inventory:				**10.30%**			**Trend Uncertainty:**		**17.03%**		

ANNEX 3. METHODOLOGY AND DATA PER IPCC SECTORS

Annex 3.1 Energy

Annex 3.1.1 Main indicators of gas supply system in 2020, 2021, 2022 provided by Gazprom Armenia CJSC

Main indicators of gas supply system (mln m^3)

		2020	2021	2022
1	Imported Natural Gas, including:	2,595.4	2,793.8	2,971.4
1.1	From Russian Federation	2,208.6	2,449.2	2,599.6
1.2	From the Islamic Republic of Iran	386.8	344.6	371.8
2	Taken from gas pipelines and Gas Underground Storage Facility (GUSF)	32.0	36.8	45.0
3	Gas for own needs in the transmission system	3.2	3.3	5.5
4	Gas losses in the transmission system. including:	66.5	74.8	82.0
4.1	Technological inevitable losses in gas pipelines	65.4	74.8	81.6
4.2	Accidental losses	0.03	0.03	0.41
5	Injected into gas pipelines and GUSF	39.5	28.6	73.2
6	The volume of gas transmitted	2,519.4	2,723.9	2,855.7
6.1	Other consumers	222.2	386.2	-
6.2	Distribution system	2,297.2	2,337.7	-
7	Gas for own needs in the distribution system	3.2	3.1	2.5
8	Recovered gas	0.9	1.1	0.4
9	Gas losses in the distribution system	31.1	33.1	35.7
10	Natural gas sales in the distribution system. including:	2,262.0	2,300.4	2,817.2
10.1	Residential	724.6	766.3	812.1
10.2	Energy Generation	582.6	503.5	864.9*
10.3	Industry	239.3	254.1	296.7
10.4	Compressed natural gas (CNG) stations	472.8	505.3	504.8
10.5	Budgetary organizations	50.9	56.7	54.7
10.7	Other consumers	191.7	214.5	283.9

* The line “10.2 Energy Generation presents total natural gas consumption (including the sum of supplies from Iran and Russia)

Annex 3.1.2 Energy Balances of the Republic of Armenia, 2020, 2021 and 2022 in the format of the International Energy Agency

Energy Balance of Armenia, IEA format, 2020, ktoe

N	Energy Balance of Armenia, IEA, 2020	Coal	Peat	Oil products	Natural Gas	Nuclear	Hydro	Solar, Wind, Others	Biofuels and waste	Electricity	Heat	Total
1.1	Production	0.0				718.2	152.9	26.2	62.5			959.9
1.2	Imports	7.5	0.1	630.2	2,147.4				13.4	27.5		2,826.2
1. 3	Exports			-1.7					0.0	-114.6		-116.4
1. 4	International aviation bunker			-39.2								-39.2
1.5	Stock changes			-28.8	-6.2							-35.0
1	Total primary energy supply (TPES)	7.5	0.1	560.5	2,141.2	718.2	152.9	26.2	75.9	-87.1		3,595.5
2	Transfers											
3	Statistical differences			0.0						0.0		0.0
4	Transformation processes				-606.2	-718.2	-152.9	-26.2		674.0	15.2	-814.3
4.1	Main activity electricity plants				-603.1	-718.2	-152.9	-2.0		663.0		-813.2
4.2	Auto producer electricity plants							-9.9		9.9		
4.3	Main activity producer CHP plants				-3.2					1.1	0.9	-1.1
4.4	Auto producer CHP plants											
4.5	Main activity producer heat plants											
4.6	Auto producer heat plants							-14.3			14.3	

N	Energy Balance of Armenia, IEA, 2020	Coal	Peat	Oil products	Natural Gas	Nuclear	Hydro	Solar, Wind, Others	Biofuels and waste	Electricity	Heat	Total
4.7	Non specified (transformation)											
5	Energy industry own use				-5.3					-31.8	0.0	-37.1
6	Distribution losses				-80.6					-48.6	-0.7	-129.9
7	Total final consumption	7.5	0.1	560.5	1,449.1		0.0		75.9	506.5	14.5	2,614.1
7.1	Final energy consumption	7.5		497.0	1,449.1				75.5	506.5	14.5	2,549.9
7.1.1	Industry	0.0		13.2	173.3				0.0	141.7		328.2
7.1.1.1	Iron and steel				14.2				0.0	7.3		21.4
7.1.1.2	Chemical and petrochemical			0.1	2.0					1.4		3.5
7.1.1.3	Non-ferrous metals			5.0	0.6					19.5		25.0
7.1.1.4	Non-metallic minerals			0.5	95.9					14.8		111.2
7.1.1.5	Transport equipment				0.0					0.0		0.0
7.1.1.6	Machinery			0.0	0.6				0.0	1.5		2.1
7.1.1.7	Mining and quarrying			6.5	7.5					67.9		81.9
7.1.1.8	Food, beverages and tobacco	0.0		0.0	43.6				0.0	20.0		63.6
7.1.1.9	Paper, pulp and printing				3.5					1.8		5.3
7.1.1.10	Wood and wood products				0.0					0.1		0.1
7.1.1.11	Textiles and leather				0.6				0.0	1.4		2.0
7.1.1.12	Construction			1.1	3.3					2.7		7.1
7.1.1.13	Non-specified (Industry)			0.0	1.5				0.0	3.3		4.9
7.1.2	Transport			456.4	391.2					7.7		855.3
7.1.2.1	Rail, metro, other electric transport									6.0		6.0
7.1.2.2	Road			456.4	391.2							847.6

N	Energy Balance of Armenia, IEA, 2020	Coal	Peat	Oil products	Natural Gas	Nuclear	Hydro	Solar, Wind, Others	Biofuels and waste	Electricity	Heat	Total
7.1.2.3	Aviation									1.1		1.1
7.1.2.4	Non-specified (Transport)									0.6		0.6
7.1.3	Other sectors	7.5		27.3	884.6				75.4	357.1	14.5	1,366.5
7.1.3.1	Households	7.1		2.2	599.5				72.7	173.9	7.3	862.8
7.1.3.2	Agriculture			16.4	65.7					12.4		94.5
7.1.3.3	Services	0.3		8.7	219.4				2.7	170.8	7.2	409.2
7.2	Non-energy use	0.0	0.1	63.6					0.5			64.2
7.2.1	Chemical Industry	0.1		0.1								0.2
7.2.2	Other sectors	-0.1	0.1	63.5					0.5			64.0

Note: In some cases, minor differences between the sum and the result of the components are explained by rounding of data. The 2020 Energy Balance of the Republic of Armenia is prepared by the Ministry of Territorial Administration and Infrastructure. The methodology for compiling the Energy Balance is posted on the website

http://www.minenergy.am/storage/files/pages/pg_8282982648982_2.2EDRC-Explanatory_Notes_on_Energy_Balance_of_Armenia_for_2015_a.docx .

The link to the explanatory notes on the development of the 2020 Energy Balance is posted on the mtad.am website (in Armenian and English)

http://www.mtad.am/u_files/file/energy/1_Armenia%20%20Energy%20Balance%202019_ARM(1).pdf

Energy Balance of Armenia, IEA format, 2021, ktoe

N	Energy Balance of Armenia, IEA, 2021	Coal	Peat	Oil products	Natural Gas	Nuclear	Hydro	Solar, Wind, Others	Biofuels and waste	Electricity	Heat	Total
1.1	Production	0.02				520.7	189.3	40.9	111.4			862.4
1.2	Imports	11.2		671.6	2,333.1				12.4	31.7		3,059.9
1. 3	Exports			-0.4					-0.5	-85.6		-86.4
1. 4	International aviation bunker			-54.8								-54.8
1.5	Stock changes			-19.8	6.8							-12.9
1	Total primary energy supply (TPES)	11.2		596.6	2,339.9	520.7	189.3	40.9	123.4	-53.9		3,768.1
2	Transfers											
3	Statistical differences									0.0		0.0
4	Transformation processes				-692.3	-520.7	-189.3	-40.9		677.5	15.8	-750.0
4.1	Main activity electricity plants				-691.1	-520.7	-189.3	-7.8		659.4		-749.5
4.2	Auto producer electricity plants							-17.6		17.6		
4.3	Main activity producer CHP plants				-1.2					0.5	0.3	-0.4
4.4	Auto producer CHP plants											
4.5	Main activity producer heat plants											
4.6	Auto producer heat plants							-15.5			15.5	
4.7	Non specified (transformation)											
5	Energy industry own use				-5.3					-30.7		-36.1
6	Distribution losses				-91.0					-47.5	-0.2	-138.7
7	Total final consumption	11.2		596.6	1,551.2				123.4	545.4	15.5	2,843.3
7.1	Final energy consumption	11.2		522.9	1,551.2				123.3	545.4	15.5	2,769.5
7.1.1	Industry	0.0		17.5	200.1				0.0	153.0		370.6
7.1.1.1	Iron and steel			0.0	15.8					9.6		25.5
7.1.1.2	Chemical and petrochemical			0.1	1.6				0.0	1.5		3.2
7.1.1.3	Non-ferrous metals			5.4	0.8				0.0	17.7		23.9
7.1.1.4	Non-metallic minerals			0.5	103.0					16.0		119.5
7.1.1.5	Transport equipment											
7.1.1.6	Machinery			0.0	0.9				0.0	1.9		2.8

N	Energy Balance of Armenia, IEA, 2021	Coal	Peat	Oil products	Natural Gas	Nuclear	Hydro	Solar, Wind, Others	Biofuels and waste	Electricity	Heat	Total
7.1.1.7	Mining and quarrying			8.8	7.1				0.0	71.9		87.8
7.1.1.8	Food, beverages and tobacco	0.0		0.0	55.9				0.0	22.8		78.7
7.1.1.9	Paper, pulp and printing				4.4					2.0		6.4
7.1.1.10	Wood and wood products				0.0					0.0		0.1
7.1.1.11	Textiles and leather			0.0	1.0					1.9		2.9
7.1.1.12	Construction			2.7	8.1					2.9		13.7
7.1.1.13	Non-specified (Industry)			0.1	1.5					4.6		6.2
7.1.2	Transport			469.7	422.0					8.1		899.8
7.1.2.1	Rail, metro, other electric transport									6.0		6.0
7.1.2.2	Road			469.7	422.0							891.7
7.1.2.3	Aviation									1.3		1.3
7.1.2.4	Non-specified (Transport)									0.8		0.8
7.1.3	Other sectors	11.2		35.7	929.1				123.3	384.3	15.5	1,499.1
7.1.3.1	Households	10.0		2.2	639.9				121.0	180.7	7.8	961.6
7.1.3.2	Agriculture			15.8	72.9					14.8		103.4
7.1.3.3	Services	1.1		17.7	216.3				2.3	188.9	7.7	434.1
7.2	Non-energy use	0.04		73.7					0.1			73.8
7.2.1	Chemical Industry			0.3								0.3
7.2.2	Other sectors	0.04		73.4					0.1			73.5

Note:

In some cases, minor differences between the sum and the result of the components are explained by rounding of the data. The 2021 Energy Balance of the Republic of Armenia is prepared by the Ministry of Territorial Administration and Infrastructure. The methodology for compiling the energy balance is posted on the website https://ec.europa.eu/eurostat/ramon/statmanuals/files/Energy_statistics_manual_2004_EN.pdf .

The link to the explanatory note on the development of the 2020 energy balance is posted on the mtad.am website: https://api.mtad.am//storage/pages/files/2023/02/pdf/02_16-01-sc431-63dba62c5f22b.pdf

Energy Balance of Armenia, IEA format, 2022, ktoe

N	Energy Balance of Armenia, IEA, 2022	Coal	Oil products	Natural Gas	Nuclear	Hydro	Solar, Wind, Others	Biofuels and waste	Electricity	Heat	Total
1.1	Production	0.0			741.6	166.8	62.0	110.1			1,080.6
1.2	Imports	11.5	727.0	2,450.6				14.2	10.6		3,213.8
1. 3	Exports	0.0	-0.4					-0.4	-135.1		-135.9
1. 4	International aviation bunker		-103.4								-103.4
1.5	Stock changes		-28.5	-23.3							-51.7
1	Total primary energy supply (TPES)	11.5	594.7	2,427.3	741.6	166.8	62.0	123.9	-124.5		4,003.3
2	Transfers										
3	Statistical differences			0.0							0.0
4	Transformation processes			-710.1	-741.6	-166.8	-62.0		790.2	16.8	-873.4
4.1	Main activity electricity plants			-709.2	-741.6	-166.8	-20.9		765.6		-872.8
4.2	Auto producer electricity plants						-24.3		24.3		
4.3	Main activity producer CHP plants			-0.9					0.3		-0.6
4.4	Auto producer CHP plants										
4.5	Main activity producer heat plants										
4.6	Auto producer heat plants						-16.8			16.8	
4.7	Non specified (transformation)										
5	Energy industry own use			-6.6					-35.4		-42.0
6	Distribution losses			-97.4					-52.1		-149.5
7	Total final consumption	11.5	594.7	1,613.2				123.9	578.2	16.8	2,938.4
7.1	Final energy consumption	11.3	524.4	1,613.3				123.3	578.2	16.8	2,867.4
7.1.1	Industry		16.4	244.7				0.0	157.8		418.9
7.1.1.1	Iron and steel			16.4					11.6		28.0
7.1.1.2	Chemical and petrochemical		0.0	1.4				0.0	1.3		2.8

7.1.1.3	Non-ferrous metals		5.3	1.1	0.0	19.0		25.4
7.1.1.4	Non-metallic minerals		0.7	126.2		18.9		145.9
7.1.1.5	Transport equipment					0.0		0.0
7.1.1.6	Machinery			1.0	0.0	2.2		3.1
7.1.1.7	Mining and quarrying		7.8	8.5	0.0	67.4		83.7
7.1.1.8	Food, beverages and tobacco		0.0	74.2	0.0	24.5		98.8
7.1.1.9	Paper, pulp and printing			5.0		2.2		7.2
7.1.1.10	Wood and wood products			0.0		0.0		0.1
7.1.1.11	Textiles and leather			1.5		2.1		3.6
7.1.1.12	Construction		2.5	7.8		3.3		13.7
7.1.1.13	Non-specified (Industry)		0.0	1.5		5.2		6.7
7.1.2	Transport		462.7	416.3		8.5		887.5
7.1.2.1	Rail, metro, other electric transport					6.4		6.4
7.1.2.2	Road		462.7	416.3				879.0
7.1.2.3	Aviation					1.4		1.4
7.1.2.4	Non-specified (Transport)					0.8		0.8
7.1.3	Other sectors	11.3	45.4	952.2	123.3	412.0	16.8	1,561.0
7.1.3.1	Households	10.4	0.7	669.8	120.8	185.7	8.4	995.7
7.1.3.2	Agriculture		14.8	72.3		14.9		102.0
7.1.3.3	Services	0.8	29.9	210.2	2.5	211.3	8.4	463.2
7.2	Non-energy use	0.2	70.3		0.6			71.0
7.2.1	Chemical Industry		0.1					0.1
7.2.2	Other sectors	0.2	70.1		0.6			70.9

Note:

In some cases, minor differences between the sum and the result of the components are explained by rounding of data. The 2022 Energy Balance of the Republic of Armenia was prepared by the Ministry of Territorial Administration and Infrastructure. The methodology for compiling the energy balance is posted on the website https://ec.europa.eu/eurostat/ramon/statmanuals/files/Energy_statistics_manual_2004_EN.pdf .

The link to the explanatory note for the development of the 2022 Energy Balance is posted on the mtad.am website https://api.mtad.am//storage/pages/files/2024/02/pdf/01_12-46-sc431-65bb5a4e98717.pdf

Annex 3.1.3 Main indicators of power system for 2020, 2021, 2022

Main indicators of power system, (million kWh)

Electricity generated and delivered	2020	2021	2022*
1. Electricity generation, including:	7,723.4	7,674.9	8,907.9
1.1 ANPP	2,756.3	1,998.4	2,846.2
1.2 Hrazdan TPP	658.3	1,576.9	890.0
1.3 Gazprom Armenia CJSC Hrazdan-5 TPP	1,083.6	0.0	3.0
1.4 Yerevan CCGT	1,410.4	1,652.7	1,761.7
1.5 International energy corporation HPP	403.1	456.5	390.6
1.6 Contour Global HPP	543.3	940.7	740.1
1.7 “Armpower” CJSC	0.0	148.1	1,220.5
1.8 Combined Heat and Power Production (Cogeneration)	13.3	6.0	3.5
1.9 Power plants using renewable energy resources (up to 30 MW), including	855.2	895.6	1,052.4
1.9.1 Small HPP	832.0	804.6	809.2
1.9.2 Solar PVs	21.3	89.6	241.3
1.9.3 Wind plants	1.9	1.5	1.8
2. Own needs of the generating plants, including:	353.3	357.5	412.1
2.1 ANPP	204.5	145.3	215.3
2.2 Hrazdan TPP	46.5	114.5	62.4
2.3 Gazprom Armenia CJSC Hrazdan-5 TPP	40.8	0.0	0.5
2.4 Yerevan CCGT	45.4	52.0	53.5
2.5 International energy corporation HPP	9.2	10.9	8.5
2.6 Contour Global HPP	5.1	8.3	7.0
2.7 “Armpower” CJSC	0.0	6.6	42.3
2.8 Combined Heat and Power Production (Cogeneration)	0.5	0.5	0.5
2.9 Power plants using renewable energy resources (up to 30 MW)	18.4	19.5	22.0
3. Electricity supply from generation plants, including:	7,388.3	7,391.2	8,618.8
3.1 ANPP	2,551.8	1,853.0	2,630.9
3.2 Hrazdan TPP	611.8	1,462.5	827.6
3.3Gazprom Armenia CJSC Hrazdan-5 TPP	1,042.8	0.0	2.5
3.4 Yerevan CCGT	1,365.0	1,600.7	1,708.1
3.5 International energy corporation HPP	393.9	445.5	382.1
3.6 Contour Global HPP	538.2	932.4	733.0
3.7 “Armpower” CJSC	0.0	141.6	1,178.2
3.8 Combined Heat and Power Production (Cogeneration). including:	12.8	5.5	3.0
3.8.1 Yerevan Medical University CHP plant	4.8	3.6	3.0
3.8.2ArmRosCogeneration CHP plant	8.0	1.9	0.0
3.9 Power plants using renewable energy resources (up to 30 MW). including:	872.0	950.0	1,153.4
3.9.1 Small HPPs	813.9	786.0	790.2
3.9.2 Solar PVs	21.0	88.7	238.5

3.9.3 Autonomous producers, net metering up to 150 kW capacity	35.2	73.9	123.0
3.9.4 Wind plants	1.8	1.4	1.7
4. Import including:	320.3	368.5	126.3
4.1 Artsakh	223.0	16.5	2.5
4.2 The Islamic Republic of Iran	30.9	64.9	22.6
4.3 Georgia	66.4	287.0	101.2
5. Inflow to high voltage network	6,823.8	6,804.2	7,588.7
6. Losses of High Voltage Networks	121.0	106.0	147.0
7. Delivery from High Voltage Networks including:	7,587.5	7,653.7	8,598.1
7.1 Domestic consumption	6,254.4	6,658.5	6,863.3
7.2 Artsakh	36.6	142.6	191.0
7.3 The Islamic Republic of Iran	1,296.5	852.6	1,178.3
7.4. Georgia	0.0	0.0	365.5
8. Total losses in distribution networks including:	444.0	446.0	458.6
9. Electricity supplied by Armenian Electric Networks CJSC (by consumers' groups)	5,810.4	6,212.5	6,404.7
9.1 Residential	1,982.7	2,036.4	2,069.1
9.2 Budgetary organizations	194.5	209.7	219.7
9.3 Industry	1,503.8	1,519.7	1,231.0
9.4 Transport	89.3	93.9	98.8
9.5 Irrigation	144.1	171.5	173.3
9.6 Water supply and sanitation	61.5	61.7	54.1
9.7 Other consumers	1,834.5	2,119.6	2,218.0
9.8 Consumers in the liberalized market sector	0.0	0.0	340.9

*The indicators mentioned in points 1.9 (regarding electricity generation) and 9 (regarding electricity consumption) do not reflect the amounts of electricity produced by autonomous energy producers and consumed on site (not recorded by reverse commercial meters), estimated at 159.2 million kWh. Since the specified amount of electricity is consumed on site at the time of generation, no losses are formed in the distribution network in this regard.

Annex 3.1.4 Data on Natural Gas consumption by Thermal Power Plants in 2020, 2021 and 2022 provided by the Public Services Regulatory Commission

N	Thermal Power Plant	Measurement unit	2020	2021	2022
1	Hrazdan TPP OJSC	thousand m^3	190.960	462.367	263.403
2	Gazprom Armenia CJSC Hrazdan-5 TPP	thousand m^3	253.202	2.156	4.709
3	Yerevan CCGT	thousand m^3	286.832	329.860	356.529
4	Armpower CJSC	thousand m^3	0.0	35.353	238.754
5	Cogeneration plants (Yerevan Medical University CHP plant, ArmRosCogeneration CJSC CHP plant)	thousand m^3	3.095	2.493	1.500

Annex 3.1.5 Calculation of country-specific CO_2 emissions factors for stationary and mobile combustion of natural gas

CO_2 emissions from stationary combustion for electricity and thermal energy generation. were calculated based on natural gas characteristics: composition. density. net calorific value of natural gas (per weight) and carbon content.

Below the sequence of the calculation steps is provided:

1. Carbon (C) content (mol. %) was calculated per natural gas components:

Methane (CH_4) 12/16 = 0.75

Ethane (C_2H_6) 24/30 = 0.8

Propane (C_3H_8) 36/44 = 0.8182

Isobutene (i-C_4H_{10}) 48/58 = 0.8276

N-butane (n-C_4H_{10}) 48/58 =0.8276

Neo-Pentane (C_5H_{12} and C_5+) 60/72 =0.8333

Iso- Pentane (i-C_5H_{12}) 60/72 =0.8333

N-Pentane (i-C_5H_{12}) 60/72 =0.8333

Hexane (C_6H_{14} and others) 72/86 =0.8372

Carbon Dioxide (CO_2) 12/44 =0.2727

2. Carbon (C) content (mol. %) was calculated per components' share:

% of C per Methane share = 0.75 x CH_4 %

% of C per Ethane share = 0.8 x C_2H_6 %

% of C per Propane share = 0.8182 x C_3H_8 %

% of C per Isobutane share = 0.8276x C_4H_{10} %

% of C per N-Butane share= 0.8276 x n-C_4H_{10} %

% of C per Neo-Pentane share = 0.8333 x C_5H_{12} and C_5 + %

% of C per Iso- Pentane share = 0.8333 x i-C_5H_{12} %

% of C per N-Pentane share = 0.8333 x i-C_5H_{12}-ɦ %

% of C per Hexane share = 0.8372 x C_6H_{14}-ɦ %

% of C per Carbon Dioxide share = 0.2727 x CO_2 %

3. Total of Carbon content per components makes the carbon content (%) in 1 m^3 of natural gas.

4. Carbon content value (%) obtained in the point 3 was multiplied by the annual average data on the natural gas density (see **Annex 3.1.6**) to get the weight (g) of carbon content in 1 m^3 of natural gas (g/m^3).

5. Calorific value of the natural gas in $kcal/m^3$ (**Annex 3.1.6**) was recalculated to MJ/m^3 multiplying by 4.1868/1000.

6. To express the carbon content of the natural gas in kg/GJ. the carbon content value in g/m^3 (see point 4) was multiplied by 1,000 and divided on natural gas annual average calorific value in MJ/m^3 (see point 5). This was done to compare it with the reference values provided in the 2006 Guideline.

7. According to 2006 IPCC Guidelines, to get the CO_2 emission factor from natural gas stationary combustion in kg/TJ, the carbon content in kg/GJ given in point 6 should be multiplied by 1000 and 44/12.

CO_2 country-specific emissions factors for natural gas imported from RF, mixture natural gas and natural gas imported from Iran. are presented in the Table below.

Table 3.1.5-1 Carbon content values and country-specific CO_2 emission factors calculated based on the imported natural gas characteristics for 2011-2022

Imported natural gas	Density	Net calorific values (NCV) [Default value: 48 TJ/Gg. confidence intervals limits: 46.5 - 50.4]			Carbon content [Default value: 15.3 kg/GJ; upper and lower intervals limits: 14.8 -15.9]			CO_2 emission factors [Default value: 56100 kg/TJ; 95 % confidence intervals limits: 54300-58300]
	kg/m³	kcal/m³	MJ/m³	TJ/Gg	%	kg/m³	kg/GJ	kg/TJ
2011								
Imported from Russian Federation	0.7231	8245	34.52	47.74	73.9512	0.5347	15.49	56.798.02
Mixture GDS-2	0.7260	8188	34.28	47.22	73.4107	0.5330	15.55	57.004.85
Mixture (weighted average)	0.7258	8190	34.29	47.25	73.4579	0.5331	15.55	57.006.52
Imported from Iran	0.7351	7999	33.49	45.56	71.7326	0.5273	15.75	57.735.59
2012								
Imported from RF	0.7239	8245	34.52	47.68	73.9512	0.5352	15.51	56.851.70
Mixture GDS-2	0.7275	8149	34.12	46.90	73.4107	0.5323	15.60	57.209.21
Mixture (weighted average)	0.7265	8200	34.33	47.25	73.5062	0.5341	15.56	57.041.37
Imported from Iran	0.7374	8020	33.58	45.54	71.7326	0.5293	15.76	57.801.53
2013								
Imported from RF	0.7259	8303	34.76	47.89	74.1141	0.5380	15.48	56.745.52
Mixture GDS-2	0.7305	8256	34.57	47.32	73.5506	0.5373	15.54	56.993.61
Mixture (weighted average)	0.7291	8264	34.60	47.45	73.7167	0.5375	15.53	56.960.17
Imported from Iran	0.7448	8076	33.81	45.40	71.7963	0.5347	15.81	57.987.50
2014								
Imported from RF	0.7278	8337	34.91	47.96	74.1718	0.5398	15.47	56.706.16
Mixture GDS-2	0.7312	8251	34.55	47.24	73.4735	0.5372	15.55	57.022.93
Mixture (weighted average)	0.7296	8287	34.69	47.55	73.7837	0.5383	15.52	56.892.11
Imported from Iran	0.7391	8020	33.58	45.43	71.7284	0.5301	15.79	57.890.73
2015								
Imported from RF	0.7234	8335	34.90	48.24	74.2282	0.5370	15.39	56.419.72
Mixture GDS-2	0.7259	8266	34.61	47.68	73.6668	0.5347	15.45	56.655.00
Mixture (weighted average)	0.7252	8266	34.66	47.79	73.8069	0.5353		56.624.28
Imported from Iran	0.7350	7974	33.39	45.42	71.5373	0.5258	15.75	57.747.46
2016								
Imported from RF	0.7245	8326	34.86	48.11	74.0303	0.5363	15.39	56.415.80
Mixture GDS-2	0.7239	8218	34.41	47.53	73.5192	0.5322	15.47	56.715.56
Mixture (weighted average)	0.7264	8270	34.62	47.66	73.6357	0.5349	15.45	56.646.87
Imported from Iran	0.7360	7987	33.44	45.43	71.6580	0.5274	15.77	57.829.30
2017								
Imported from RF	0.7535	8647	36.20	48.05	74.2943	0.5598	15.46	56.697.39
Mixture GDS-2	0.7460	8469	35.46	47.53	73.8257	0.5507	15.53	56.951.34
Mixture (weighted average)	0.7513	8548	35.79	47.64	73.8852	0.5551	15.51	56.871.87
Imported from Iran	0.7397	8030	33.62	45.45	71.7511	0.5307	15.79	57.883.94

2018								
Imported from RF	0.7186	8,282	34.67	48.25	74.1659	0.5330	15.37	56,356.67
Mixture GDS-2	0.7235	8,186	34.27	47.37	73.3249	0.5305	15.48	56,755.47
Mixture (weighted average)	0.7222	8,227	34.44	47.70	73.6849	0.5321	15.45	56,643.25
Imported from Iran	0.7354	8,025	33.60	45.69	71.9037	0.5288	15.74	57,705.74
2019								
Imported from RF	0.7265	8,383	35.10	48.31	74.2618	0.5395	15.37	56,362.62
Mixture GDS-2	0.7259	8,314	34.81	47.95	73.9255	0.5366	15.42	56,526.24
Mixture (weighted average)	0.7278	8,330	34.88	47.92	73.9040	0.5378	15.42	56,545.70
Imported from Iran	0.7350	8,027	33.61	45.72	71.8555	0.5281	15.71	57,621.33
2020								
Imported from RF	0.7201	8,337	34.91	48.47	74.3043	0.5351	15.33	56,206.45
Mixture GDS-2	0.7208	8,264	34.60	48.00	73.8831	0.5326	15.39	56,436.35
Mixture weighted average)	0.7226	8,294	34.72	48.05	73.9371	0.5343	15.39	56,419.98
Imported from Iran	0.7371	8,045	33.68	45.70	71.8405	0.5295	15.72	57,644.64
2021								
Imported from RF	0.7328	8,432	35.30	48.18	74.2824	0.5443	15.42	56,536.60
Mixture GDS-2	0.7313	8,389	35.12	48.03	74.1280	0.5421	15.48	56,592.22
Mixture (weighted average)	0.7340	8,389	35.12	47.85	73.9865	0.5431	15.46	56,693.89
Imported from Iran	0.7427	8,084	33.85	45.57	71.8840	0.5339	15.77	57,837.40
2022								
Imported from RF	0.7134	8,291	34.71	48.66	74.4003	0.5308	15.29	56,064.77
Mixture GDS-2	0.7144	8,246	34.52	48.33	73.1304	0.5296	15.34	56,244.97
Mixture (weighted average)	0.7166	8,256	34.57	48.24	73.0548	0.5307	15.35	56,290.29
Imported from Iran	0.7390	8,014	33.55	45.40	71.6389	0.5294	15.71	57,853.99

Annex 3.1.6 Natural Gas Composition and Annual Average Characteristics for 2020, 2021 and 2022 provided by Gazprom Armenia CJSC

Natural gas imported from the Russian Federation

Composition. mol % Annual average	2020	2021	2022
Helium, He	0.0216	0.0195	0.0236
Hydrogen, H_2	0.0017	0.0019	0.0049
Oxygen, O_2	0.0058	0.0057	0.0073
Carbon, Dioxide CO_2	0.1996	0.3715	0.1727
Nitrogen, N_2	1.2039	1.2081	1.0210
Ethane, C_2H_6	4.7658	5.2054	3.8631
Propane, C_3H_8	1.0060	1.4083	0.9193
Iso-butene, i-C_4H_{10}	0.0923	0.1567	0.1075
N-butane, n-C_4H_{10}	0.0886	0.1548	0.1058
Neo-Pentane, C_5H_{12} and C_5+	0.0008	0.0011	0.0007
Iso-Pentane, (i-C_5H_{12})	0.0130	0.0227	0.0152
N-Pentane, (i-C_5H_{12})	0.009895	0.018100	0.0104
Hexane, (C_6H_{14} and others)	0.0164	0.0241	0.0103
Methane, CH_4	92.5746	91.4021	93.7380
Density, (kg/m^3)	0.7201	0.7328	0.7134
Characteristics			
Net Calorific Value (average), kcal/m^3 (standard conditions t=20˚C. P=101.325 kPa)	8,337.0	8,432.0	8,291.0
Net Calorific Value (average), MJ/ m^3	34.9054	35.3031	34.7128
Wobbe index MJ/ m^3	49.98	50.11	49.88
Mass concentration of hydrogen sulfide, g/m^3	0.0015	0.0011	0.0014
Mass concentration of mercaptan sulfur, g/m^3	0.0057	0.004	0.0046
Mass concentration of mechanical impurities, g/m^3	0.0	0.0	0.0

Natural gas imported from the Islamic Republic of Iran

Composition. mol % Annual average	2020	2021	2022
Helium, He	0.0545	0.0528	0.0541
Hydrogen, H_2	0.0037	0.0031	0.0033
Oxygen, O_2	0.0119	0.0101	0.0102
Carbon, Dioxide CO_2	0.5808	0.7575	0.7012
Nitrogen, N_2	4.1477	4.0172	4.3443
Ethane, C_2H_6	3.4584	3.6565	3.6010
Propane, C_3H_8	0.9603	1.1908	0.9539
Iso-butene, i-C_4H_{10}	0.1909	0.1951	0.1650
N-butane, n-C_4H_{10}	0.2579	0.2618	0.2244
Neo-Pentane, C_5H_{12} and C_5+	0.0013	0.0014	0.0010
Iso-Pentane, (i-C_5H_{12})	0.0413	0.0448	0.0376

N-Pentane, (i-C_5H_{12})	0.0285	0.0308	0.0258
Hexane, (C_6H_{14} and others)	0.0210	0.0222	0.0211
Methane, CH_4	90.2419	89.7561	89.8571
Density, (kg/m^3)	0.7371	0.7427	0.7390
Characteristics			
Net Calorific Value (average), kcal/m^3 (standard conditions t=20˚C. P=101.325 kPa)	8,045.0	8,084.0	8,014
Net Calorific Value (average), MJ/ m^3	33.6828	33.8461	33.5530
Wobbe index, MJ/ m^3	47.69	47.74	47.45
Mass concentration of hydrogen sulfide, g/m^3	0.001	0.0013	0.0013
Mass concentration of mercaptan sulfur, g/m^3	0.0072	0.0048	0.0061
Mass concentration of mechanical impurities, g/m^3	0.0	0.0	0.0

Natural gas mixture (Yerevan GDS-2)

Composition. mol % Annual average	2020	2021	2022
Helium, He	0.0262	0.0222	0.0265
Hydrogen, H_2	0.002	0.002	0.0050
Oxygen, O_2	0.0082	0.0074	0.0060
Carbon, Dioxide CO_2	0.2627	0.3974	0.2560
Nitrogen, N_2	1.6845	1.3693	1.3110
Ethane, C_2H_6	4.2617	5.0004	3.6296
Propane, C_3H_8	0.9582	1.3039	0.8855
Iso-butene, i-C_4H_{10}	0.1076	0.1542	0.1212
N-butane, n-C_4H_{10}	0.1142	0.1609	0.1184
Neo-Pentane, C_5H_{12} and C_5+	0.0010	0.0007	0.0011
Iso-Pentane, (i-C_5H_{12})	0.0175	0.0251	0.0171
N-Pentane, (i-C_5H_{12})	0.0126	0.0199	0.0119
Hexane, (C_6H_{14} and others)	0.0102	0.0130	0.0107
Methane, CH_4	92.5335	91.5236	93.6001
Density, (kg/m^3)	0.7208	0.7313	0.7144
Characteristics			
Net Calorific Value (average), kcal/m^3 (standard conditions t=20˚C. P=101.325 kPa)	8,264.0	8,389.0	8,246.0
Net Calorific Value (average), MJ/ m^3	34.5997	35.1231	34.5244
Wobbe index, MJ/ m^3	49.54	49.92	49.67
Mass concentration of hydrogen sulfide, g/m^3	0.0013	0.0012	0.0014
Mass concentration of mercaptan sulfur, g/m^3	0.0064	0.004	0.0049
Mass concentration of mechanical impurities, g/m^3	0.0	0.0	0.0

Natural gas mixture (weighted average)

Composition. mol % Annual average	2020	2021	2022
Helium, He	0.0265	0.0236	0.0274
Hydrogen, H_2	0.0020	0.0020	0.0047
Oxygen, O_2	0.0067	0.0062	0.0077
Carbon, Dioxide CO_2	0.2564	0.4191	0.2388
Nitrogen, N_2	1.6426	1.5546	1.4368
Ethane, C_2H_6	4.5710	5.0144	3.8303
Propane, C_3H_8	0.9992	1.3815	0.9236
Iso-butene, i-C_4H_{10}	0.1070	0.1614	0.1147
N-butane, n-C_4H_{10}	0.1138	0.1680	0.1206
Neo-Pentane, C_5H_{12} and C_5+	0.0009	0.0011	0.0007
Iso-Pentane, (i-C_5H_{12})	0.0172	0.0254	0.0180
N-Pentane, (i-C_5H_{12})	0.0127	0.0197	0.0123
Hexane, (C_6H_{14} and others)	0.0171	0.0239	0.0117
Methane, CH_4	92.2270	91.1991	93.2524
Density, (kg/m^3)	0.7226	0.7340	0.7166
Characteristics			
Net Calorific Value (average), kcal/m^3 (standard conditions t=20˚C. P=101.325 kPa)	8,293.5	8,389.1	8,256.3
Net Calorific Value (average), MJ/ m^3	34.7232	35.1234	34.5676
Wobbe index, MJ/ m^3	49.64	49.82	49.58
Mass concentration of hydrogen sulfide, g/m^3	0.0014	0.0011	0.0014
Mass concentration of mercaptan sulfur, g/m^3	0.0059	0.0041	0.0048
Mass concentration of mechanical impurities, g/m^3	0.0	0.0	0.0

Annex 3.1.7 IPCC Reference Approach for Estimating CO_2 Emissions from Fossil Fuel Combustion

Comparison of Reference and Sectoral Approach

The Reference approach and the Sectoral approach often yield different results since the Reference approach is a top-down approach, using a country's energy supply data and has no detailed information on how the specific fuels are used in each sector [Gen-1, Volume 2, Chapter 6].

The IPCC approach to the calculation of emission inventories encourages the use of fuel statistics collected by an officially recognized national body, as this is usually the most comprehensive and accessible source of activity data: the calculations used data from officially published Energy Balances for 2020, 2021 and 2022.

Table 3.1.7-1 and **Figure 3.1.7-1** present a comparison of CO_2 emission volumes in 2011-2022 estimated using Reference and Sectoral approaches. Evidentially, the differences are not essential; specifically, they do not reach 5% for the whole period and amount 3.1%,2.8%, and 3.9% for years 2020, 2021 and 2022 [Gen-1, Volume 2, Chapter 2, Table 2.17].

Table 3.1.7-1 Comparison of CO_2 emissions from fuel combustion estimated with the Reference and Sectoral approaches, kt CO_2

Fuel Combustion Activity (1A)	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Sectoral approach	4,798.8	5,296.5	5,276.[illegible]	5,369.1	5,137.2	4,946.5	5,361.3	5,445.3	5,896.6	6,374.1	6,945.6	7,072.5
Reference approach	4,996.4	5,481.7	5,508.[illegible]	5,598.2	5,381.6	5,199.6	5,616.0	5,640.9	6,078.4	6,578.2	7,143.3	7,358.4

For the purposes of this comparative analysis, CO_2 emissions from fuel combustion are included in the assessment (those covered in other sections of the GHG Inventory, particularly fugitive emissions, are not a part of the estimate).

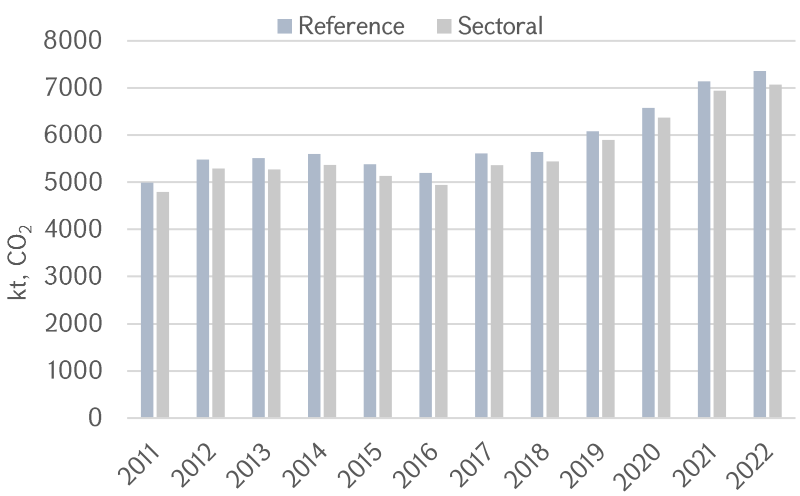

Figure 3.1.7-1 Comparison of the Reference and Sectoral approaches

The emissions obtained using the Reference approach are higher than those yielded from the Sectoral approach. This is legitimate and comes from the 2006 IPCC Guidelines, because natural gas losses are included in the estimation of the Reference approach as a part of consumption. Non-energy use excluded from fuel combustion emissions.

ANNEX 4. AGRICULTURE

4.1 Data Used for Estimating the Number of Livestock

Table 4.1.1 Production of Main Livestock Products[14], 1000 tonne

Indicator	2020	2021	2022
Animals and poultry sold for slaughter (in slaughter weight)	107.7	110.6	103.7
including:			
Veal and beef	68.6	69.4	63.9
Pork	15.7	15.8	14.9
Lamb and goat's meat	10.8	10.8	10.8
Poultry	12.6	14.6	14.1
Milk produced	654.3	670.7	623.1
Wool Produced, tons	1,048	1,083	1,074

Table 4.1.2 Number of Imported High-Breed Cattle, 2014–2022, heads

Code	Unit of measurement	2014	2015	2016	2017	2018	2019	2020	2021	2022
102211000	head	32	321	451	439	164	363	782	773	1,290
102219000	head					846	33	33	-	155
102292100	head					-	134	-	110	84
102292900	head					3,184	-	-	240	30
102294100	head					796	-	-	227	429
102295100	head					55	-	-	40	21
102296100	head					102	-	-	-	-
102297100	head					41	5	-	60	-
102909900	head			6		1,592	0		14	235
Total	head	32	321	457	439	6,780	535	815	1,464	2,573

[14] Statistical Yearbook of Armenia 2020, SC, Yerevan, 2021, p. 365

4.2 Data Used for Calculating National Emission Factors

Table 4.2.1 Activity data used for the calculation of the emission factors

N	Indicator	Unit of measurement	2020	2021	2022
1	Cows average live weight	kg	395	397	398
2	Bulls average live weight	kg	483	486	488
3	Growing cattle average live weight	kg	145	146	147
4	Average daily weight gain of growing cattle	gram	421	426	430
5	Etalon weight of growing cattle	kg	162	164	165
6	Average slaughter weight of cows *	kg	-	-	
7	Average slaughter weight of bulls*	kg	-	-	
8	Average slaughter weight of growing cattle	kg	-	-	
9	Fertility rate of cows	%	88	88	88
10	Feed digestibility of cows	%	61	64	65
11	Feed digestibility of bulls	%	59	60	62
12	Feed digestibility of growing cattle	%	59	59	60
13	Milk fat content of cows	%	3.7	3.7	3.8
14	Average live weight of sheep	kg	42	42	42
15	Feed digestibility coefficient for sheep	%	60	61-61	
16	Livestock regime, including:	day	-	-	
16.1	Nursery	day	210-240	210-240	210-240
16.2	Grazing	day	125-155	125-155	125-155
17	Manure Excretion per one head of cattle	tons/year	5.6	5.6	5.6
18	Cattle manure deposition on Pasture	%	27	27	27
19	Sheep and goats manure deposition on Pasture	%	45	45	45
20	Surface area of artificial reservoirs	ha	-	-	
21	Surface Area of Artificial Ponds Used for Fish Farming (Earthen Artificial Ponds)	ha	1,784	1,788	1,790

ANNEX 5. LAND USE, LAND-USE CHANGE AND FORESTRY

Basic wood density

Tree Species	Factor	Source
Pine-tree	0.415	LUCFref-19
Juniper	0.447	LUCFref-16
Yew	0.474	LUCFref-8
Fir-tree	0.365	LUCFref-19
Oak-tree	0.57	LUCFref-19
Beech	0.538	LUCFref-7
Hornbeam	0.64	LUCFref-19
Ash-tree	0.648	LUCFref-15
Maple	0.557	LUCFref-14
Elm-tree	0.535	LUCFref-15
Lime-tree	0.366	LUCFref-13
Birch-tree	0.459	LUCFref-8
Plane-tree	0.522	LUCFref-18
Walnut tree	0.49	LUCFref-19
Pear tree	0.564	LUCFref-8
Poplar	0.423	LUCFref-17
Willow	0.38	LUCFref-19
Acacia	0.65	LUCFref-19
Hackberry	0.53	LUCFref-9

Average annual biomass growth per 1 ha of forest covered areas

Dominating tree species	Average annual biomass growth (cubic meter/ha year) Revised in 2010 (Ref-8, LUCFref.1, LUCFref.2, LUCFref.10, LUCFref.11, LUCFref.12)
Coniferous trees	
Pine-tree	1.97
Juniper	0.19
Yew	0.48
Broad-leaved trees	
Seed oak-tree	1.18
Stump-sprig oak	0.43
Beech	1.76
Seed hornbeam	1.58
Stump-sprig hornbeam	1.09
Ash-tree	1.4
Maple	0.99
Elm-tree	0.9
Bastard acacia	0.35
Birch tree	0.16
Lime-tree	1.5
Aspen	1.46
Poplar	2.1
Willow	0.25
Oriental beech	0.87
Pear-tree	0.37
Apple tree	0.39
Walnut tree	0.78
Plane-tree	1.1
Almond tree	0.06
Oleaster	0.52
Apricot tree	0.05
Plum tree	0.8
Other species	-
Average (RA forests)	**1.5**

ANNEX 6. TIME SERIES OF NATIONAL EMISSIONS

Annex 6.1 Time series of national emissions, 1990-2022, kt CO_2 eq.

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	1990	1995	2000	2010	2012	2014	2015	2016	2017	2018	2019	2020	2021	2022
Total (net emissions)	**26,013.76**	**7,058.14**	**6,576.68**	**9,017.37**	**10,759.73**	**11,280.21**	**11,064.06**	**11,020.85**	**11,380.87**	**11,001.25**	**11,552.53**	**11,694.76**	**12,663.80**	**12,932.20**
1. Energy	**23,360.92**	**5,208.26**	**4,653.94**	**6,398.59**	**7,542.48**	**7,722.62**	**7,415.44**	**7,298.27**	**7,784.54**	**7,401.82**	**7,677.11**	**7,842.65**	**8,603.70**	**8,850.55**
1.A. Fuel combustion	21,099.13	3,755.74	3,164.68	4,390.27	5,427.34	5,501.92	5,269.40	5,073.73	5,495.77	5,571.21	6,036.58	6,526.31	7,101.40	7,225.62
1.A.1. Energy industries	11,534.10	2,117.31	1,705.19	841.75	1,617.82	1,581.13	1,286.82	1,183.74	1,299.19	1,499.39	1,366.26	1,438.93	1,659.63	1,682.27
1.A.2. Manufacturing industries and construction	2,065.34	455.99	435.37	600.98	685.72	617.77	411.13	440.82	470.45	428.19	437.48	451.76	532.04	628.64
1.A.3. Transport	3,813.68	848.22	711.27	1,561.99	1,598.63	1,736.54	1,743.92	1,661.03	1,797.50	1,894.94	2,160.12	2,362.50	2,480.80	2,430.55
1.A.4. Other sectors	3,686.01	334.22	312.85	1,385.55	1,525.17	1,566.48	1,827.54	1,788.13	1,928.62	1,748.70	2,072.72	2,273.12	2,428.92	2,484.16
1.A.5. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1.B. Fugitive emissions from fuels	2,261.80	1,452.52	1,489.26	2,008.32	2,115.13	2,220.71	2,146.04	2,224.54	2,288.77	1,830.61	1,640.53	1,316.35	1,502.30	1,624.93
1.B.1. Solid fuels	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1.B.2. Oil and natural gas and other emissions from energy production	2,261.80	1,452.52	1,489.26	2,008.32	2,115.13	2,220.71	2,146.04	2,224.54	2,288.77	1,830.61	1,640.53	1,316.35	1,502.30	1,624.93
1.C. CO_2 Transport and storage	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2. Industrial processes and product use	**631.16**	**122.69**	**152.33**	**609.86**	**741.84**	**824.60**	**815.79**	**821.86**	**956.74**	**1,114.16**	**1,179.26**	**1,347.05**	**1,477.71**	**1,609.00**
2.A. Mineral industry	630.33	120.00	144.30	311.14	305.12	253.43	210.74	151.80	258.34	337.04	305.61	391.15	432.94	496.64
2.B. Chemical industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.C. Metal industry	NO	NO	NO	1.10	1.14	1.41	1.54	1.26	1.44	1.40	1.18	3.86	11.02	11.16
2.D. Non-energy products from fuels and solvent use	0.84	2.69	4.55	7.34	7.22	7.12	4.92	4.05	4.20	4.93	5.73	5.15	5.35	6.01
2.E. Electronic industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.F. Product uses as substitutes for ODS	NO	NO	3.44	287.97	425.97	560.08	596.03	662.22	690.21	768.01	863.52	943.43	1,024.56	1,091.04
2.G. Other product manufacture and use	NO	NO	0.04	2.30	2.40	2.55	2.55	2.55	2.55	2.78	3.22	3.46	3.84	4.15
2.H. Other	NO		NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3. Agriculture	**2,210.14**	**1,663.31**	**1,600.89**	**1,816.16**	**2,196.94**	**2,436.67**	**2,506.56**	**2,611.90**	**2,280.86**	**2,142.76**	**2,260.89**	**2,084.64**	**2,102.02**	**1,989.89**
3.A. Enteric fermentation	1,420.86	1,083.41	1,071.05	1,181.58	1,400.12	1,561.66	1,593.40	1,564.50	1,393.32	1,280.62	1,220.58	1,283.13	1,296.32	1,221.53
3.B. Manure management	152.05	73.74	75.79	80.09	100.89	117.56	122.16	123.13	121.52	111.49	114.66	119.32	119.30	114.84
3.C. Rice cultivation	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3.D. Agricultural soils	633.08	503.44	448.59	548.72	690.32	751.19	784.49	917.26	758.62	742.30	916.49	675.84	677.73	646.28
3.E. Prescribed burning of savannahs	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	1990	1995	2000	2010	2012	2014	2015	2016	2017	2018	2019	2020	2021	2022
3.F. Field burning of agricultural residues	4.16	NO	5.46	4.80	5.19	5.59	5.82	5.97	4.68	3.93	3.65	3.67	3.76	3.45
3.G. Liming	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3.H. Urea application	NO	2.72	0.00	0.97	0.43	0.68	0.69	1.03	2.72	4.43	5.51	2.69	4.90	3.79
3.I. Other carbon-containing fertilizers	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3.J. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
4. Land use, land-use change and forestry	**-742.33**	**-515.77**	**-488.01**	**-542.46**	**-475.25**	**-476.97**	**-452.14**	**-495.28**	**-430.65**	**-448.73**	**-345.28**	**-390.33**	**-383.69**	**-381.87**
4.A. Forest land	-739.24	-516.47	-470.77	-551.73	-522.87	-535.39	-534.23	-542.31	-523.70	-519.72	-444.80	-476.12	-469.77	-456.04
4.B. Cropland	0.57	5.83	0.56	0.60	-6.02	-6.05	-6.00	-6.04	-5.96	-6.04	-6.07	-6.03	-6.02	-5.99
4.C. Grassland	NO	NO	0.01	0.03	19.38	27.72	28.31	27.73	28.30	27.89	28.00	27.83	27.75	27.73
4.D. Wetlands	2.69	2.69	2.69	2.69	2.69	6.44	8.37	8.34	19.03	12.27	32.63	18.85	13.80	21.86
4.E. Settlements	NO	NO	NO	NO	4.41	6.83	-0.19	-0.19	-0.19	7.23	2.80	10.90	20.06	-0.48
4.F. Other land	NO	NO	NO	NO	16.06	22.46	53.05	27.75	56.18	35.74	35.74	35.74	35.74	35.74
4.G. Harvested wood products	-6.35	-7.82	-20.50	5.94	11.10	1.01	-1.45	-10.56	-4.32	-6.10	6.41	-1.50	-5.25	-4.69
4.H. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5. Waste	**553.87**	**579.65**	**657.53**	**735.22**	**753.72**	**773.29**	**778.41**	**784.09**	**789.38**	**791.24**	**780.55**	**810.75**	**864.07**	**864.63**
5.A. Solid waste disposal	345.68	406.74	479.17	525.22	539.38	544.17	553.28	559.10	559.97	561.18	544.21	545.09	592.13	581.79
5.B. Biological treatment of solid waste	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5.C. Incineration and open burning of waste	24.83	24.73	25.57	25.22	25.14	24.97	24.85	24.68	24.51	24.69	24.70	57.38	57.33	57.28
5.D. Wastewater treatment and discharge	183.36	148.18	152.79	184.78	189.19	204.15	200.29	200.31	204.90	205.37	211.64	208.28	214.61	225.55
5.E. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
6. Other	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
Memo items:														
1.D.1. International bunkers	412.02	90.61	91.22	137.21	128.59	128.54	96.65	137.68	169.99	196.59	219.16	118.30	165.18	311.88
1.D.1.a. Aviation	412.02	90.61	91.22	137.21	128.59	128.54	96.65	137.68	169.99	196.59	219.16	118.30	165.18	311.88
1.D.1.b. Navigation	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1.D.2. Multilateral operations	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1.D.3. CO_2 emissions from biomass	94.08	392.02	384.10	313.70	363.70	382.70	392.60	382.40	373.19	415.18	473.23	475.77	470.25	461.38
1.D.4. CO_2 captured	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NE	NO	NO	NO
5.F.1. Long-term storage of C in waste disposal sites	2,600.20	3,234.03	3,970.67	5,266.24	5,519.98	5,762.29	5,883.64	6,004.84	6,125.74	6,246.40	6,367.13	6,469.62	6,572.63	6,675.68
Indirect N_2O	NO	NO	NO	NO	NO	NO	NO	NO	NO	NE	NO	NO	NO	NO

Annex 6.2 Time series of national emissions, 1990-2022, kt CO_2

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	1990	1995	2000	2010	2012	2014	2015	2016	2017	2018	2019	2020	2021	2022
1. Energy	**20,930.83**	**3,695.25**	**3,106.99**	**4,298.28**	**5,322.06**	**5,387.49**	**5,153.21**	**4,961.03**	**5,380.02**	**5,445.41**	**5,896.76**	**6,377.83**	**6,946.10**	**7,072.72**
1.A. Fuel combustion	20,930.66	3,695.15	3,106.88	4,298.14	5,321.91	5,387.29	5,153.04	4,960.85	5,379.83	5,445.30	5,896.64	6,377.61	6,945.88	7,072.45
1.A.1. Energy industries	11,507.12	2,114.29	1,703.55	840.94	1,616.28	1,579.61	1,285.58	1,182.60	1,297.95	1,497.94	1,364.95	1,437.54	1,658.04	1,680.64
1.A.2. Manufacturing industries and construction	2,061.69	455.27	434.86	600.26	684.92	617.02	410.73	440.25	469.86	427.70	436.93	451.23	531.40	627.92
1.A.3. Transport	3,726.54	826.99	692.84	1,505.23	1,535.35	1,665.16	1,671.92	1,591.58	1,723.69	1,814.60	2,071.44	2,273.07	2,385.90	2,337.19
1.A.4. Other sectors	3,635.31	298.60	275.63	1,351.70	1,485.36	1,525.51	1,784.81	1,746.42	1,888.33	1,705.06	2,023.33	2,215.77	2,370.54	2,426.71
1.A.5. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1.B. Fugitive emissions from fuels	0.16	0.11	0.11	0.14	0.16	0.20	0.18	0.18	0.19	0.11	0.11	0.22	0.22	0.27
1.B.1. Solid fuels	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1.B.2. Oil and natural gas and other emissions from energy production	0.16	0.11	0.11	0.14	0.16	0.20	0.18	0.18	0.19	0.11	0.11	0.22	0.22	0.27
1.C. CO_2 Transport and storage	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2. Industrial processes and product use	**631.16**	**122.69**	**148.85**	**319.59**	**313.47**	**261.97**	**217.21**	**157.10**	**263.97**	**343.37**	**312.53**	**400.16**	**449.31**	**513.81**
2.A. Mineral industry	630.33	120.00	144.30	311.14	305.12	253.43	210.74	151.80	258.34	337.04	305.61	391.15	432.94	496.64
2.B. Chemical industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.C. Metal industry	NO	NO	NO	1.10	1.14	1.41	1.54	1.26	1.44	1.40	1.18	3.86	11.02	11.16
2.D. Non-energy products from fuels and solvent use	0.84	2.69	4.55	7.34	7.22	7.12	4.92	4.05	4.20	4.93	5.73	5.15	5.35	6.01
2.E. Electronic industry														
2.F. Product uses as substitutes for ODS														
2.G. Other product manufacture and use	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.H. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3. Agriculture	**NO**	**2.72**	**0.00**	**0.97**	**0.43**	**0.68**	**0.69**	**1.03**	**2.72**	**4.43**	**5.51**	**2.69**	**4.90**	**3.79**
3.A. Enteric fermentation														
3.B. Manure management														
3.C. Rice cultivation														
3.D. Agricultural soils														
3.E. Prescribed burning of savannahs														
3.F. Field burning of agricultural residues	NA		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.G. Liming	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3.H. Urea application	NO	2.72	0.00	0.97	0.43	0.68	0.69	1.03	2.72	4.43	5.51	2.69	4.90	3.79

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	1990	1995	2000	2010	2012	2014	2015	2016	2017	2018	2019	2020	2021	2022
3.I. Other carbon-containing fertilizers	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3.J. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
4. Land use, land-use change and forestry	**-742.86**	**-521.82**	**-488.58**	**-544.41**	**-478.94**	**-481.43**	**-458.31**	**-500.77**	**-439.06**	**-455.56**	**-355.15**	**-397.28**	**-391.54**	**-390.08**
4.A. Forest land	-739.26	-516.74	-470.82	-553.13	-523.17	-535.44	-534.39	-542.38	-525.30	-520.14	-448.16	-476.73	-471.36	-458.00
4.B. Cropland	0.57	0.56	0.56	0.60	-6.03	-6.05	-6.00	-6.05	-5.96	-6.05	-6.07	-6.03	-6.02	-6.00
4.C. Grassland	NO	NO	NO	NO	18.15	25.65	25.65	25.65	25.65	25.65	25.65	25.65	25.65	25.65
4.D. Wetlands	2.18	2.18	2.18	2.18	2.18	5.93	7.85	7.83	18.52	11.76	32.12	18.34	13.29	21.34
4.E. Settlements	NO	NO	NO	NO	4.41	6.83	-0.19	-0.19	-0.19	7.23	2.80	10.90	20.06	-0.48
4.F. Other land	NO	NO	NO	NO	14.42	20.64	50.22	24.92	52.53	32.10	32.10	32.10	32.10	32.10
4.G. Harvested wood products	-6.35	-7.82	-20.50	5.94	11.10	1.01	-1.45	-10.56	-4.32	-6.10	6.41	-1.50	-5.25	-4.69
4.H. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5. Waste	**4.34**	**4.32**	**4.47**	**4.41**	**4.39**	**4.36**	**4.34**	**4.31**	**4.28**	**4.60**	**4.71**	**30.86**	**30.89**	**30.90**
5.A. Solid waste disposal														
5.B. Biological treatment of solid waste														
5.C. Incineration and open burning of waste	4.34	4.32	4.47	4.41	4.39	4.36	4.34	4.31	4.28	4.60	4.71	30.86	30.89	30.90
5.D. Wastewater treatment and discharge														
5.E. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
6. Other	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
Memo items:														
1.D.1. International bunkers	408.91	89.93	90.53	136.17	127.62	127.57	95.90	136.61	168.68	195.11	217.50	117.40	163.93	309.53
1.D.1.a. Aviation	408.91	89.93	90.53	136.17	127.62	127.57	95.90	136.61	168.68	195.11	217.50	117.40	163.93	309.53
1.D.1.b. Navigation	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1.D.2. Multilateral operations	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1.D.3. CO_2 emissions from biomass	94.08	392.02	384.10	313.70	363.70	382.70	392.60	382.40	373.19	415.18	473.23	475.77	470.25	461.38
1.D.4. CO_2 captured	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5.F.1. Long-term storage of C in waste disposal sites	2,600.20	3,234.03	3,970.67	5,266.24	5,519.98	5,762.29	5,883.64	6,004.84	6,125.74	6,246.40	6,367.13	6,469.62	6,572.63	6,675.68
Indirect N_2O														

Annex 6.3 Time series of national emissions, 1990-2022, kt CH_4

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	1990	1995	2000	2010	2012	2014	2015	2016	2017	2018	2019	2020	2021	2022
1. Energy	**84.33**	**53.46**	**54.75**	**74.13**	**78.35**	**82.38**	**79.78**	**82.50**	**84.84**	**68.79**	**62.37**	**50.68**	**57.53**	**61.88**
1.A. Fuel combustion	3.56	1.59	1.56	2.41	2.82	3.07	3.14	3.05	3.11	3.41	3.79	3.68	3.89	3.86
1.A.1. Energy industries	0.35	0.05	0.03	0.01	0.03	0.03	0.02	0.02	0.02	0.03	0.02	0.03	0.03	0.03
1.A.2. Manufacturing industries and construction	0.05	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
1.A.3. Transport	1.54	0.40	0.35	1.31	1.52	1.75	1.77	1.72	1.81	2.01	2.20	1.99	2.16	2.14
1.A.4. Other sectors	1.62	1.13	1.18	1.06	1.25	1.29	1.34	1.31	1.26	1.37	1.55	1.66	1.69	1.67
1.A.5. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1.B. Fugitive emissions from fuels	80.77	51.87	53.18	71.72	75.53	79.30	76.64	79.44	81.74	65.37	58.59	47.00	53.65	58.02
1.B.1. Solid fuels	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1.B.2. Oil and natural gas and other emissions from energy production	80.77	51.87	53.18	71.72	75.53	79.30	76.64	79.44	81.74	65.37	58.59	47.00	53.65	58.02
1.C. CO_2 Transport and storage														
2. Industrial processes and product use	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
2.A. Mineral industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.B. Chemical industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.C. Metal industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.D. Non-energy products from fuels and solvent use	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.E. Electronic industry														
2.F. Product uses as substitutes for ODS														
2.G. Other product manufacture and use	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.H. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3. Agriculture	**52.86**	**39.63**	**39.34**	**43.44**	**51.50**	**57.61**	**58.84**	**57.87**	**51.78**	**47.55**	**45.48**	**47.77**	**48.13**	**45.36**
3.A. Enteric fermentation	50.74	38.69	38.25	42.20	50.00	55.77	56.91	55.88	49.76	45.74	43.59	45.83	46.30	43.63
3.B. Manure management	2.00	0.94	0.93	1.10	1.35	1.68	1.77	1.82	1.88	1.70	1.79	1.83	1.73	1.64
3.C. Rice cultivation	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3.D. Agricultural soils	NA	NO	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.E. Prescribed burning of savannahs	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3.F. Field burning of agricultural residues	0.12	NO	0.16	0.14	0.15	0.16	0.17	0.17	0.13	0.11	0.10	0.11	0.11	0.1
3.G. Liming														
3.H. Urea application														
3.I. Other carbon-containing fertilizers														
3.J. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA	NO
4. Land use, land-use change and forestry	**0.02**	**0.17**	**0.02**	**0.05**	**0.02**	**0.02**	**0.03**	**0.02**	**0.07**	**0.03**	**0.10**	**0.03**	**0.05**	**0.06**
4.A. Forest land	0.00	0.01	0.00	0.03	0.01	0.00	0.00	0.00	0.04	0.01	0.08	0.01	0.04	0.05
4.B. Cropland	NA	0.15	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4.C. Grassland	NO	NO	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.00	0.00
4.D. Wetlands	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
4.E. Settlements	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
4.F. Other land	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
4.G. Harvested wood products														

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	1990	1995	2000	2010	2012	2014	2015	2016	2017	2018	2019	2020	2021	2022
4.H. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5. Waste	**17.76**	**18.81**	**21.60**	**23.67**	**24.25**	**24.87**	**25.05**	**25.28**	**25.50**	**25.57**	**25.17**	**25.31**	**27.19**	**27.20**
5.A. Solid waste disposal	12.35	14.53	17.11	18.76	19.26	19.43	19.76	19.97	20.00	20.04	19.44	19.47	21.15	20.78
5.B. Biological treatment of solid waste	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5.C. Incineration and open burning of waste	0.63	0.62	0.64	0.63	0.63	0.63	0.63	0.62	0.62	0.61	0.61	0.85	0.84	0.84
5.D. Wastewater treatment and discharge	4.79	3.66	3.84	4.28	4.36	4.81	4.67	4.69	4.89	4.92	5.13	5.00	5.20	5.58
5.E. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
6. Other	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
Total CH_4 emissions without LULUCF	154.95	111.90	115.69	141.24	154.1	164.86	163.67	165.65	162.12	141.91	133.02	123.76	132.85	134.44
Total CH_4 emissions with LULUCF	154.97	112.07	115.70	141.28	154.13	164.88	163.70	165.67	162.19	141.94	133.13	123.79	132.91	134.50
Memo items:														
1.D.1. International bunkers	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
1.D.1.a. Aviation	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
1.D.1.b. Navigation	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1.D.2. Multilateral operations	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1.D.3. CO_2 emissions from biomass														
1.D.4. CO_2 captured														
5.F.1. Long-term storage of C in waste disposal sites														
Indirect N_2O														

Annex 6.4 Time series of national emissions, 1990-2022, kt N_2O

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	1990	1995	2000	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
1. Energy	**0.26**	**0.06**	**0.05**	**0.09**	**0.09**	**0.10**	**0.10**	**0.11**	**0.11**	**0.10**	**0.11**	**0.11**	**0.13**	**0.17**	**0.18**	**0.17**
1.A. Fuel combustion	0.26	0.06	0.05	0.09	0.09	0.10	0.10	0.11	0.11	0.10	0.11	0.11	0.13	0.17	0.18	0.17
1.A.1. Energy industries	0.06	0.01	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
1.A.2. Manufacturing industries and construction	0.01	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
1.A.3. Transport	0.17	0.04	0.03	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.09	0.09	0.10	0.13	0.13	0.13
1.A.4. Other sectors	0.02	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.04	0.04	0.04
1.A.5. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1.B. Fugitive emissions from fuels	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1.B.1. Solid fuels	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1.B.2. Oil and natural gas and other emissions from energy production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1.C. CO_2 Transport and storage																
2. Industrial processes and product use	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
2.A. Mineral industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.B. Chemical industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.C. Metal industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.D. Non-energy products from fuels and solvent use	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.E. Electronic industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.F. Product uses as substitutes for ODS																
2.G. Other product manufacture and use	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.H. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3. Agriculture	**2.75**	**2.08**	**1.88**	**2.26**	**2.46**	**2.85**	**3.07**	**3.10**	**3.24**	**3.74**	**3.13**	**3.05**	**3.70**	**2.81**	**2.83**	**2.70**
3.A. Enteric fermentation																
3.B. Manure management	0.36	0.18	0.19	0.19	0.21	0.24	0.26	0.27	0.27	0.27	0.26	0.24	0.24	0.26	0.27	0.26
3.C. Rice cultivation																
3.D. Agricultural soils	2.39	1.90	1.69	2.07	2.24	2.60	2.81	2.83	2.96	3.46	2.86	2.80	3.46	2.55	2.56	2.44
3.E. Prescribed burning of savannahs	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3.F. Field burning of agricultural residues	0.0031	NO	0.0041	0.0036	0.0035	0.0039	0.0040	0.0042	0.0044	0.0044	0.0035	0.0029	0.0027	0.0027	0.0021	0.0026
3.G. Liming																
3.H. Urea application																
3.I. Other carbon-containing fertilizers																
3.J. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA	NO

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	1990	1995	2000	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
4. Land use, land-use change and forestry	**0.00**	**0.00**	**0.00**	**0.01**	**0.01**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.03**	**0.03**	**0.03**	**0.02**	**0.02**	**0.02**
4.A. Forest land	0.000	0.00	0.000	0.002	0.001	0.000	0.000	0.000	0.000	0.000	0.002	0.001	0.004	0.001	0.002	0.003
4.B. Cropland	0.003	0.00	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.003	0.003	0.003	0.003	0.003	0.003
4.C. Grassland	NO	NO	0.000	0.000	0.002	0.005	0.006	0.008	0.009	0.008	0.009	0.008	0.008	0.008	0.008	0.008
4.D. Wetlands	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4.E. Settlements	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
4.F. Other land	NO	NO	NO	NO	0.006	0.006	0.006	0.007	0.011	0.011	0.014	0.014	0.014	0.014	0.014	0.014
4.G. Harvested wood products																
4.H. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5. Waste	**0.20**	**0.18**	**0.18**	**0.26**	**0.26**	**0.26**	**0.27**	**0.27**	**0.27**	**0.27**	**0.27**	**0.27**	**0.27**	**0.27**	**0.27**	**0.27**
5.A. Solid waste disposal																
5.B. Biological treatment of solid waste	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5.C. Incineration and open burning of waste	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
5.D. Wastewater treatment and discharge	0.19	0.17	0.17	0.25	0.25	0.25	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26
5.E. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
6. Other	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
Total direct N_2O emissions without LULUCF	**3.21**	**2.32**	**2.12**	**2.61**	**2.81**	**3.21**	**3.44**	**3.48**	**3.62**	**4.11**	**3.50**	**3.42**	**4.10**	**3.25**	**3.27**	**3.14**
Total direct N_2O emissions with LULUCF	**3.21**	**2.33**	**2.12**	**2.61**	**2.82**	**3.22**	**3.45**	**3.50**	**3.64**	**4.13**	**3.53**	**3.45**	**4.13**	**3.27**	**3.30**	**3.17**
Memo items:																
1.D.1. International bunkers	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.01
1.D.1.a. Aviation	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.01
1.D.1.b. Navigation	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1.D.2. Multilateral operations	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1.D.3. CO_2 emissions from biomass																
1.D.4. CO_2 captured																
5.F.1. Long-term storage of C in waste disposal sites																
Indirect N_2O	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NE	NO	NO	NO	NO

Annex 6.5 Time series of national emissions, 1990-2022, HFCs and SF_6

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Emissions of HFCs - CO_2 equivalents (kt)	**3.44**	**7.60**	**10.53**	**16.59**	**26.97**	**46.71**	**79.00**	**123.04**	**197.23**	**226.43**	**287.97**	**355.88**	**425.97**	**493.05**	**560.08**	**596.03**	**662.22**	**690.21**	**768.01**	**863.52**	**943.43**	**1,024.56**	**1,091.04**
HFC-23	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
HFC-32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.03	0.03	0.03	0.04	0.04	0.05	0.06	0.07	0.07
HFC-41	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
HFC-43-10mee	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
HFC-125	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.02	0.03	0.04	0.04	0.05	0.06	0.06	0.07	0.08	0.08	0.10	0.11	0.12	0.13
HFC-134	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
HFC-134a	0.00	0.01	0.01	0.01	0.01	0.02	0.02	0.04	0.05	0.06	0.07	0.09	0.10	0.12	0.13	0.14	0.15	0.16	0.18	0.20	0.22	0.23	0.24
HFC-143	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NA	NO	NO	NO
HFC-143a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.02	0.02	0.03	0.03	0.04	0.04	0.04	0.05	0.05	0.05	0.06	0.06	0.06
HFC-152																							
HFC-152a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02
HFC-161																							

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
HFC-227ea	NO	NO	NO	NO	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	0.00
HFC-236cb																							
HFC-236ea																							
HFC-236fa	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
HFC-245ca	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
HFC-245fa	NO	NO	NO	NO	NO	NO	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	0.01
HFC-365mfc	NO	NO	NO	NO	NO	NO	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	0.01
Emissions of SF_6 - CO_2 equivalents (kt)	**0.04**	**0.04**	**0.12**	**0.48**	**1.20**	**1.23**	**1.50**	**1.50**	**1.50**	**1.81**	**2.30**	**2.31**	**2.40**	**2.49**	**2.55**	**2.55**	**2.55**	**2.55**	**2.78**	**3.22**	**3.46**	**3.84**	**4.15**
SF_6 (kt)	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	0.00	0.00	0.00	0.00	0.00

ANNEX 7. QA/QC PROCEDURES

7.1. Background

The purpose of this annex is to describe the Quality Assurance/Quality Control (QA/QC) procedures that are used throughout the process of creating and compiling the Armenia's Greenhouse Gas Inventory. This includes the evaluation of the quality and relevance of data used as inputs into the Inventory; proper management, incorporation, and aggregation of data; and review of the numbers and estimates to ensure that they are as accurate and transparent as possible. Quality control is applied at every stage of inventory development and document preparation. In addition, quality assurance occurs at three stages - an expert review and a public review in the process of developing the report, followed by an international peer review of the final published report coordinated by the UNFCCC. While all phases contribute to improving the quality of the Inventory, the public review phase is also essential for promoting the openness of the Inventory development process and the transparency of the inventory data and methods. Comments received from these reviews may also result in updates or changes contributing to improved inventory quality.

7.2. Purpose

The *Quality Assurance/Quality Control* guides the process of ensuring the quality of the Inventory. The QA/QC Management Plan describes data and methodology checks and develops processes governing peer review and public comments. The QA/QC Management Plan procedures aim at continual improvement, providing for corrective actions that are designed to improve the inventory estimates over time.

Key attributes of the QA/QC Management Plan include:

- *Procedures and Forms:* to standardize the process of documenting and archiving information, as well as to guide the implementation of QA/QC.

- *Implementation of Procedures:* application of QA/QC procedures throughout the whole Inventory development process from initial data collection, through preparation of the emission estimates, to submission of the Inventory, consistent with the 2006 IPCC Guidelines.

- *Quality Control:* application of General (Tier 1) and Category-specific (Tier 2) quality controls and checks, as recommended by 2006 IPCC Guidelines (IPCC 2006).

  For each greenhouse gas emissions source or sink category included in this *Inventory*, a minimum of general or Tier 1 QC analysis has been undertaken. General inventory quality control checks (2006 IPCC Guidelines, Chapter 6, Table 6.1. General Inventory QC procedures) include routine checks of the integrity and completeness of the data, cross-check of activity data available from the different sources and their underlying assumptions made by the relevant sectoral experts, check for consistency in data between categories, check of time series consistency and finally - documentation and archiving of the inventory data and quality control actions.

  Category-specific QC procedures include technical reviews of the activity data, emission factors and methods applied on a case-by-case basis focusing on key categories and on categories where significant methodological and data revisions have taken place, comparison of estimates to previous estimates. If there are significant changes or departures from expected trends, estimates are rechecked and difference is explained if any. QC procedures for country-specific emission factors include comparison with IPCC default factors and comparison of emission factors between countries.

QC procedures implemented by the sectoral experts precedes to the internal review of GHG National Inventory by the task leader.

- *Quality Assurance:* expert and public reviews for both the Inventory estimates and the report. The expert technical review conducted by the UNFCCC supplements these QA processes, consistent with the QA good practice recommended in the 2006 IPCC Guidelines (IPCC 2006).

- *Record Keeping:* The results of the review (proposals and comments) are summarized in a table, indicating the name of the person who submitted the comment, organization, sector and the comments/proposals.
  The comments/ proposals provided are considered by the implementing body (relevant sectoral experts) for making amendments (if necessary and after appropriate consultations) or clarifications.

- *Interaction and Coordination:* promoting communication within the Ministry of Environment, Hydrometeorology and Monitoring Center SNCO and working group of the Inter-Agency Coordinating Council, across stakeholder state agencies, departments and companies involved in supplying data or preparing estimates for the Inventory.