RA Ministry Of Nature Protection
United Nations Development Programme
Global Environmental Facility

# National Greenhouse Gas Inventory Report of the Republic of Armenia for 2012

*under the United Nations Framework Convention on Climate Change*

Yerevan 2015

*GHG National Inventory Report of the Republic of Armenia is prepared under coordination of the Ministry of Nature Protection of RA, with financial support of Global Environment Facility and under "Armenia's First Biennial Update Report to the UNFCCC" project implemented with the assistance of the United Nations Development Programme.*


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# Abbreviations

| | |
|---|---|
| AFOLU | Agriculture, forestry land other land use |
| BOD | Biochemical oxygen demand |
| CHF | Chlorofluorocarbon |
| CJSC | Closed joint-stock company |
| COD | Chemical oxygen demand |
| CS | Country specific |
| CORINAIR | Core Inventory of Air Emissions |
| D | IPCC default |
| DOC | Degradable organic carbon |
| EMEP | European Monitoring and Evaluation Programme |
| FOD | First order decay |
| GPG | Good Practice Guidance |
| HCA | High clay activity |
| HFC | Hydrofluorocarbon |
| IE | Included elsewhere |
| IPCC | Intergovernmental Panel on Climate Change |
| IPPU | Industrial processes and product use |
| KC | Key Category |
| LCFL | Lands converted to forest lands |
| LLC | Limited Liability Company |
| LULUCF | Land use, land-use change, forestry |
| MCF | Methane correction factor |
| MSW | Municipal solid waste |
| NA | Not applicable |
| NE | Not estimated |
| NI | National Inventory |
| NIR | National Inventory Report |
| NMVOC | Non-methane volatile organic compounds |
| NO | Not occurring |
| NSS | National Statistical Service |
| O | Other |
| ODS | Ozone depleting substances |
| QA | Quality Assurance |
| QC | Quality control |
| RA | Republic of Armenia |
| RAC | Refrigeration and air conditioning |
| RF | Russian Federation |
| SNCO | State non-commercial organization |
| SPAN | Specially protected areas of nature |
| SW | Solid waste |
| SWDS | Solid waste disposal sites |
| TPP | Thermal power plant |

## Measurement Units

| | |
|---|---|
| $^0C$ | degree Celsius |
| BTU | British thermal unit |
| eq. | equivalent |
| Gcal | gigacalorie ($10^9$ calorie) |
| Gg | gigagram ($10^9$ g, or thousand t.) |
| GWh | gigawatt hours ($10^9$ Wh) |
| MW | megawatt |
| PJ | petajoule ($10^{15}$J) |

| | |
|---|---|
| t | tonne |
| t d.m. | tonne of dry material |
| t equivalent fuel | tonne of equivalent fuel (1 t equivalent fuel= 0.7 toe) |
| TJ | terajoule ($10^{12}$J) |
| toe | tonne of oil equivalent (1 toe = 1.43 t equivalent fuel) |

## Chemical Combinations

| | |
|---|---|
| $CO_2$ | Carbon Dioxide |
| $CH_4$ | Methane |
| $N_2O$ | Nitrous oxide |
| HFCs | Hydrofluorocarbons |
| PFCs | Perfluorocarbons |
| $SF_6$ | Sulfur hexafluoride |
| CO | Carbon monoxide |
| NOx | Nitrous oxides |
| $SO_2$ | Sulfur dioxide |
| NMVOC | Non-methane volatile organic compounds |

## Energy units conversion

1 PJ = 277.8 GWh =$23.88 * 10^3$ toe
1 toe = 41. 868 GJ

# Summary

According to the par. 60 (c) of Decision 1/CP.16 adopted by Conference of Parties (COP), the non-Annex I countries, consistent with their capabilities should submit Biennial Update Reports in terms of financial support provided by the Convention financial mechanism.

According to the Decision 2/CP.17 (Annex III) the Parties adopted the Guidelines for preparation of Biennial Update Reports for non-Annex I countries, taking into account their development priorities, objectives, capacity and national circumstances.

The frames of the Biennial Update Reports are defined by the par. 2 of Section 2 of the Guidelines for preparation of BURs, according to which the Reports should update the following information provided in the most recent National Communication:

- National circumstances and institutional arrangements,
- National GHG Inventory,
- Implemented mitigation actions and their effects,
- Constraints and gaps, related financial, technology and capacity building needs and support received
- Domestic Measurement Reporting and Verification

The inventory of greenhouse gases in this Report covers the years 2011 and 2012. It has been compiled in line with the UNFCCC Biennial Update Reporting Guidelines for Parties not included in Annex I to the Convention, COP Decision 17 (2/CP.17, Annex III, Chapter 3).

According to the Key provisions in the BUR Guidelines on reporting information on national GHG inventories in the BUR, Armenia's FBUR:

- provided estimate of anthropogenic emissions of $CO_2$, $CH_4$, and $N_2O$ by sources and removals by sinks, and reported HFCs, CO, NOx, NMVOCs and $SO_2$;
- used the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (2006 Guidelines) and 2006 GHG inventory software
- used the IPCC Good Practice Guidance and Uncertainty Management in GHG Inventories;
- undertook Key Category Analysis (KCA);
- included Inventory sectorial tables according to the 2006 IPCC Guidelines;
- provided a consistent time series for years 2000-2012;

According to the 2006 Guidelines the following sectors were considered:

- Energy
- Industrial Processes and Product Use (IPPU)
- Agriculture, Forestry and Other Land (AFOLU)
- Waste

Within the frames of the first Biennial Update Report the following improvements were made to the GHG inventory:

- Introduction of higher Tier for 11 subsectors;
- Development of Country Specific Emission Factors for the Key Sources (5 country specific EFs);
- Including data for 6 new subsectors in the GHG inventory

Considering that the energy sector is the largest producer of greenhouse gas emissions, the improvements are mostly done to the GHG inventory of this sector.
The table below provides GHG emissions by gases and by sectors for 2012 (in Gg).

**Table. GHG emissions by gases and by sectors for 2012, Gg**

| Sectors | Net $CO_2$ | $CH_4$ | $N_2O$ | HFCs $CO_{2\ eq.}$ | Total $CO_{2\ eq.}$ |
|---|---|---|---|---|---|
| Energy | 5,296.50 | 75.48 | 0.10 | NA | 6,912.78 |
| Industrial Processes and Product Use | 277.90 | NA | NA | 384.58 | 662.48 |
| Agriculture | NA | 54.35 | 1.55 | NA | 1,621.51 |
| Waste | 7.33 | 26.99 | 0.19 | NA | 632.36 |
| **Total GHG Emissions** | **5,581.73** | **156.82** | **1.84** | **384.58** | **9,829.12** |
| Forestry and Other Land Use | **-522.1** | **NA** | **NA** | **NA** | **-522.1** |
| **Net GHG Emissions** | **5,059.66** | **156.82** | **1.84** | **384.58** | **9,307.05** |

Considering that still there is no official decision by UNFCCC COP to use 2006 IPCC Guidelines while preparing the National Inventories, the general table for 2012 is presented per the requirements of 1996 IPCC Revised Guidelines as well.

# 1. Introduction

## *1.1 Basic Information on GHG Inventory*

### *1.1.1 Legal Bases for Preparation of the Inventory*

According to the par. 60 (c) of Decision 1/CP.16 adopted by Conference of Parties (COP), the non-Annex I countries, consistent with their capabilities should submit Biennial Update Reports in terms of financial support provided by the Convention financial mechanism. These reports should include updated national inventories, including the national inventory report, information on mitigation actions as well as on needs and support received.

According to the Decision 2/CP.17 (Annex III) the Parties adopted the Guidelines for preparation of Biennial Update Reports for non-Annex I countries, taking into account their development priorities, objectives, capacity and national circumstances. The frequency of the Binaural Update Reports was also defined: that is one in two years.

### *1.1.2 Baseline years of the GHG National Inventory*

The **first** National Inventory was developed by the Republic of Armenia for 1998, where 1990 was taken as a baseline year.

The **second** National Inventory was developed in 2010, where 2000 was taken as a baseline year.

The **third** National Inventory was developed in 2014, where 2010 was taken as a baseline year.

The RA National Inventory of Biennial Update Report covers the years 2011 and 2012, 2012 is a baseline year.

### *1.1.3. Institutional Mechanisms and Processes for Inventory Development*

The Ministry of Nature Protection (MoNP) as Designated National Authority for coordination of issues relevant to UN Framework Convention on Climate Change (UNFCCC) coordinates the works on development of national communications and biennial update reports in fulfillment of obligations under Convention. The UNFCCC Focal Point provides strategic guidance and support on behalf of the Ministry of Nature Protection. The Inter-Agency Coordinating Council on Implementation of Requirements and Provisions of the UNFCCC ensures high-level support and policy guidance thus giving sustainability to the preparation of the First Biennial Update Report.

UNDP Country Office through the UNDP Climate Change Program Unit supports The Ministry of Nature Protection in fulfillment of obligations under Convention including development of national communications and biennial update reports. With this aim the expert group was formed on competitive basis, with the involvement of experts engaged in preparation of the previous inventories and familiar with 2006 IPCC Guidelines and software. The expert group worked in close cooperation with the Climate change and atmospheric air protection division of the Environmental Protection Policy Department of the Ministry of Nature Protection, National Statistical Service and other relevant stakeholders.

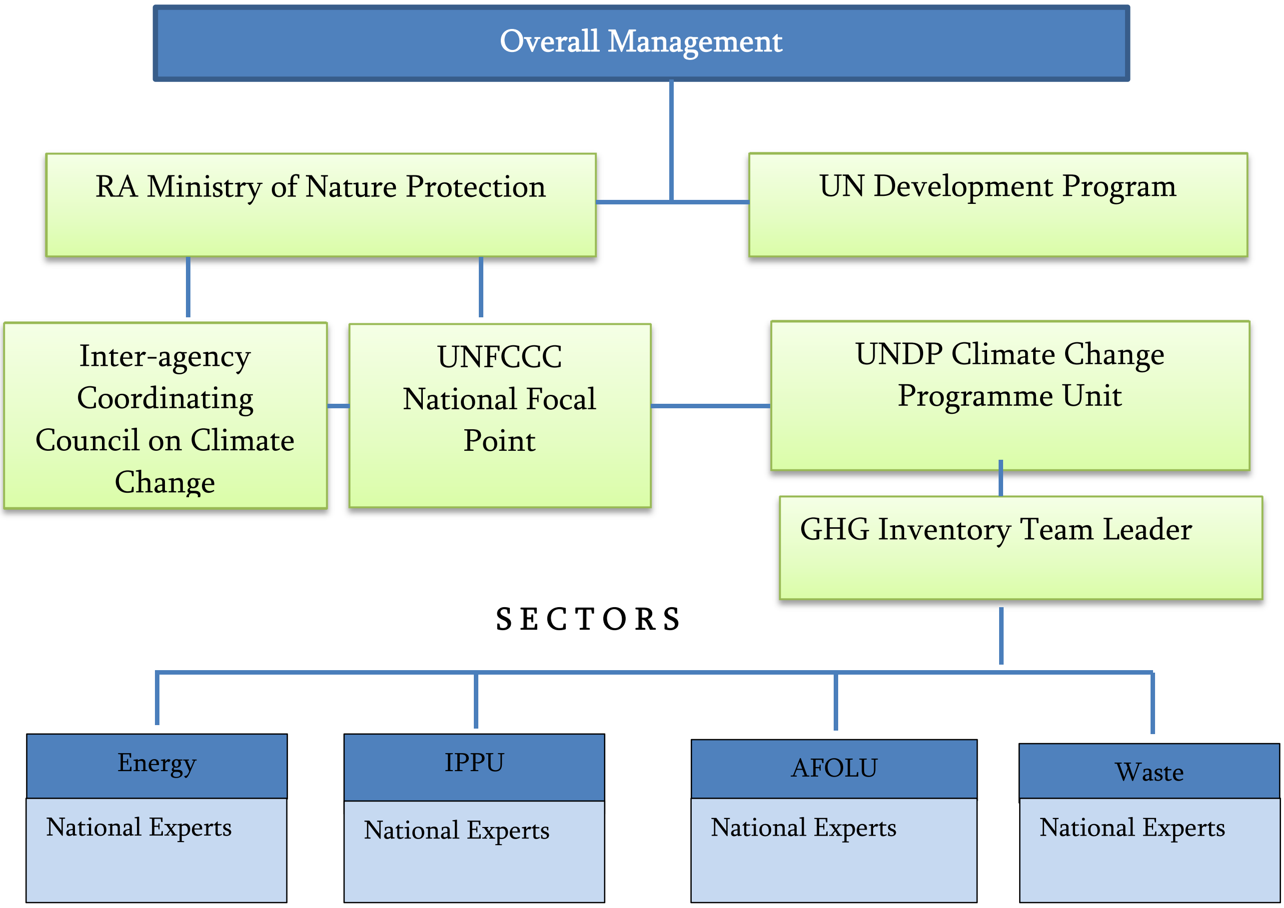


**Figure 1.1 Organization chart of National Inventory**

## *1.2 Overview of Used Methodology and Data Sources*

GHG National Inventory was prepared according to the 2006 IPCC Guidelines for preparation of the GHG national inventories. The IPCC 2006 Inventory Software, developed for these Guidelines, is used for data entry, emission calculation, results analysis and conclusions.

In case of necessity, the approaches and default data of "1996 IPCC Revised Guidelines for preparation of GHG National Inventories" and "Good Practice Guidelines and Uncertainty Management in National GHG Inventories" (IPCC 2000), "Good Practice Guidelines for Land Use, Land Use Change and Forestry" (IPCC 2003) and "Air Pollutant Emission Inventory Guidebook" (EMEP/EEA, 2013) are also used during the preparation of the National Inventory.

In this report, GHG emissions are estimated in units of ton carbon dioxide equivalent ($CO_{2\ eq.}$) using Global Warming Potentials (GWPs) values. 100-year GWPs used in the IPCC's Second Assessment Report was applied (see Table 1.1).

**Table 1.1 Global Warming Potential (GWP) values**

| GHG | GWP |
|---|---|
| $CO_2$ | 1 |
| $CH_4$ | 21 |
| $N_2O$ | 310 |
| HFC-32 | 650 |
| HFC-125 | 2,800 |
| HFC-134a | 1,300 |
| HFC-152a | 140 |
| HFC-143a | 3,800 |
| HFC-227ea | 2,900 |
| HFC-236fa | 6,300 |
| $CF_4$ | 6,500 |

The National Inventory was prepared according to the principles described below:

- Clear observation of the logics and structure of 2006 IPCC Guidelines
- Priority given to the use of national data and indicators
- Utilization of all possible sources of information
- Maximum use of the capacities of national information sources.

During the preparation of the National Inventory the highest priority was given to estimation of emission of gases with direct greenhouse effect, i.e. $CO_2$, $CH_4$ and $N_2O$ from key categories. Estimation was also made for emissions of gases with indirect greenhouse effect, i.e. CO, $NO_x$, NMVOCs and $SO_2$, as well as for emission of Hydrofluorocarbons (HFCs) compounds.

The National Inventory of the First Biennial update Report includes the following sectors as per 2006 IPCC Guidelines:

1. Energy,
2. Industrial Processes and Product Use (including F-gases),
3. Agriculture, Forestry and Land Use,
4. Waste.

National Statistical Service (NSS) has served as main fact sheet source of activity data. Information was also provided by the Ministry of Energy and Natural Resources of RA, Ministry of Finance of RA, Ministry of Agriculture of RA, Ministry of Economy of RA, Public Services Regulatory Commission of RA, State Committee of Real Estate Cadaster, "Gazprom Armenia" CJSC, "ArmForest" SNCO, National Academy of Sciences, municipalities of Yerevan, Gyumri, Vanadzor and other cities of Armenia.

## *1.3 Key Category Analysis*

Key categories were estimated in terms of their contribution to the absolute level of national emissions and removals. According to IPCC Guidelines, key categories are those that, when summed together in descending order of magnitude, add up to 95 percent of the total level.
The level assessment was performed for 2012 (see Table 1.2).

There are 13 key categories for 2012 while there have been some shifts in and no changes of those categories in comparison with 2010. Particularly, 1A1 "Energy Industries - gaseous fuels" from the forth place moved to the first one, and 1B2b "Fugitive emissions of natural gas" category from the sixth place to the second.

The first shift is due to the sharp increase of thermal power generation in 2012 in comparison with 2010-3,398 mln. kWh in 2012 vs 1,443 mln kWh in 2010. Thus power generation by thermal power plants (TPP) has been increased more than twice as a result of fulfilment of the contractual obligations (electricity export to Iran) under Iran-Armenia Electricity-for-Gas Swap Agreement.

1B2b moved to the second place because the higher tier (Tier 2) approach has been applied to the estimation of Fugitive emissions from natural gas networks - National Emission Factors have been developed which are taking into account the structure of the gas supply system in Armenia and the physiochemical parameters of the imported gas.

Enteric fermentation subcategory is the largest producer of greenhouse gases in AFOLU sector where the prevailing part of emissions comes from cattle. According to 2012 inventory dairy cows and other cattle accounted for 86.9% of $CH_4$ emissions derived from enteric fermentation in 2012 and so those species of animals can be identified as "significant" (contributing altogether more than 60% of the emissions of the subcategory).

**Table 1.2 Key Category Analysis (Level assessment), 2012**

| A | B | C | D | E | F |
|---|---|---|---|---|---|
| IPCC category code | IPCC category | GHG | 2012 emission (Gg $CO_2$ eq.) | 2012 emission level from the given category | Total of the column E |
| **1.A.1** | Energy Industries - Gaseous Fuels | **$CO_2$** | **1,616.28** | **0.153** | **0.15** |
| **1.B.2.b** | Fugitive emissions of Natural Gas | **$CH_4$** | **1,505.97** | **0.142** | **0.29** |
| **1.A.4** | Other sectors - gaseous fuels | **$CO_2$** | **1,351.74** | **0.128** | **0.42** |
| **1.A.3.b** | Road transportation | **$CO_2$** | **1,241.73** | **0.117** | **0.54** |
| **3.A.1** | Enteric fermentation | **$CH_4$** | **1,060.01** | **0.100** | **0.64** |
| **3.B.1.a** | Forest land remaining forest land | **$CO_2$** | **-522.14** | **0.070** | **0.71** |
| **1.A.2** | Manufacturing industries and construction - gaseous fuels | **$CO_2$** | **620.14** | **0.059** | **0.77** |
| **1.A.4** | Other sectors - liquid fuels | **$CO_2$** | **456.21** | **0.043** | **0.81** |
| **4.A** | Solid waste disposal | **$CH_4$** | **453.16** | **0.043** | **0.85** |
| **2.F.1** | Refrigeration and air Conditioning | **HFCs** | **372.67** | **0.035** | **0.89** |
| **2.A.1** | Cement production | **$CO_2$** | **277.90** | **0.026** | **0.92** |
| **3.C.4** | Direct $N_2O$ emissions from managed soils | **$N_2O$** | **230.63** | **0.022** | **0.94** |
| **3.C.5** | Indirect $N_2O$ Emissions from managed soils | **$N_2O$** | **117.69** | **0.011** | **0.95** |
| 4.D | Wastewater treatment and discharge | $CH_4$ | 91.41 | 0.009 | 0.96 |
| 3.A.2 | Manure management | $CH_4$ | 81.18 | 0.008 | 0.96 |
| 3.A.2 | Manure management | $N_2O$ | 74.72 | 0.007 | 0.97 |
| 3.C.6 | Indirect $N_2O$ Emissions from manure management | $N_2O$ | 57.13 | 0.005 | 0.98 |
| 4.D | Wastewater treatment and discharge | $N_2O$ | 52.42 | 0.005 | 0.98 |
| 1.A.4 | Other fuel - biomass | $CH_4$ | 43.04 | 0.004 | 0.99 |
| 1.A.3.b | Road transportation | $CH_4$ | 30.93 | 0.003 | 0.99 |
| 4.C | Waste ashing and open burning | $CH_4$ | 22.16 | 0.002 | 0.99 |
| 1.A.3.b | Road transportation | $N_2O$ | 19.53 | 0.002 | 0.99 |
| 3.B.3.a | Grassland remaining grassland | $CO_2$ | 12.59 | 0.001 | 0.99 |

## *1.4 Information on Quality Assurance and Quality Control*

The ultimate aim of the QA/QC process is to ensure the quality of the inventory and to contribute to the improvement of inventory.

General Inventory QC checks included routine checks of the integrity, correctness and completeness of the data, as well as identification of errors. QC was done by the members of the expert group.

Category-specific QC checks including technical reviews of the source categories, activity data, emission factors and methods were applied on a case-by-case basis focusing on key categories and on categories where significant methodological and data revision have taken place. This was done by experts selected for these purposes.

The QA reviews were performed after the implementation of QC procedures concerning the finalized inventory. The draft NIR was submitted to the RA Ministry of Nature Protection for comments and recommendations. Further, the RA Ministry of Nature Protection circulated NIR among the stakeholder ministries and organizations. Received comments and recommendations were taken into account.
The draft NIR was reviewed by the international expert. The review was coordinated by the UNDP-UNEP Global Support Programme (GSP) for National Communications and Biennial Update Reports. Received comments and recommendations were taken into account in the final NIR.

NIR submission to the Climate Change Intergovernmental Working Group for their review is among QA important procedures.

# 2. Main Outcomes of 2012 GHG Inventory

The Table below provides greenhouse gases emissions estimate in Armenia for 2012.

**Table 2.1 GHG Emissions by Sectors and by Gases for 2012, Gg**

| Sectors | Net $CO_2$ | $CH_4$ | $N_2O$ | HFCs $CO_{2\ eq.}$ | Total $CO_{2\ eq.}$ |
|---|---|---|---|---|---|
| Energy | 5,296.50 | 75.48 | 0.10 | NA | 6,912.78 |
| Industrial Processes and Product Use | 277.90 | NA | NA | 384.58 | 662.48 |
| Agriculture | NA | 54.35 | 1.55 | NA | 1,621.51 |
| Waste | 7.33 | 26.99 | 0.19 | NA | 632.36 |
| **Total GHG Emissions** | **5,581.73** | **156.82** | **1.84** | **384.58** | **9,829.12** |
| **Forestry and Other Land Use** | **-522.1** | NA | NA | NA | **-522.1** |
| **Net GHG Emissions** | **5,059.66** | **156.82** | **1.84** | **384.58** | **9,307.05** |

In 2012 total national emissions increased in comparison with 2010. It is mostly due to the increase of emissions in the sectors of “Energy” and “Agriculture, Forestry and Other Land Use”.

The data provided in Table 2.1are summarized in Figure 2.1.

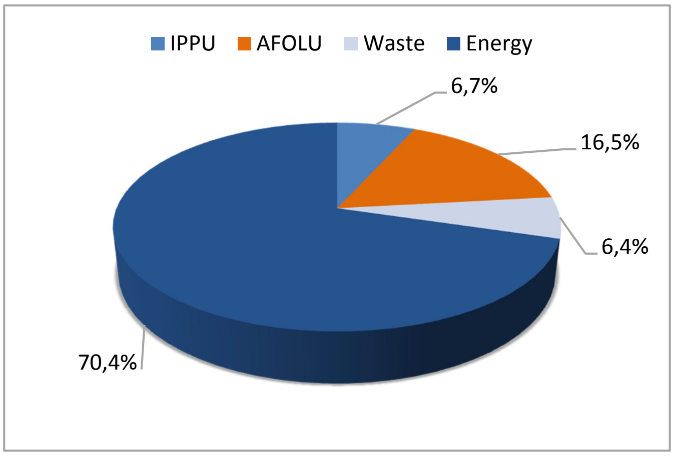


*Figure 2.1 GHG emissions by sectors without forestry and other land use in 2012, $CO_2$ eq.*

The Energy sector is the largest producer of greenhouse gas emissions. In 2012, the Energy sector accounted for 70.3% of Armenia’s total greenhouse gas emissions. The energy sector includes emissions from all use of fuels to generate energy including fuel use in transport, and the fugitive emissions from transmission, storage and distribution of natural gas. The second-largest source of emissions was AFOLU sector (without forestry and other land use) with an emission share of 16.5% followed by IPPU and Waste sectors - 6.7% and 6.4%, correspondingly.

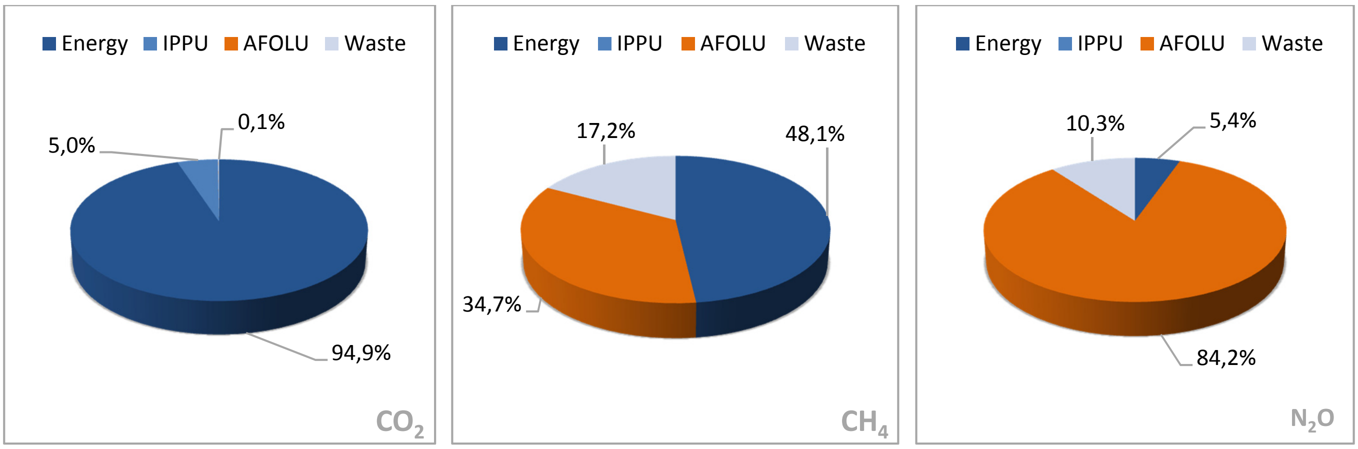


*Figure 2.2 GHG Emissions by Gases for 2012 (without forestry and other land use)*

The most significant greenhouse gas of Armenia's inventory is carbon dioxide ($CO_2$). Its share in 2012 was 54.4%. The Energy sector produced about 95% of all carbon dioxide emissions in 2012 (Fig. 2.2) because of the high emissions volume from thermal power plants, Residential and Road transportation subsectors.

$CO_2$ emissions from IPPU sector are significantly less and make 5% of total emissions.

Methane emissions are also mostly from the "Energy" sector (48.1%), due to the fugitive emissions of the natural gas. The second one is AFOLU sector (34.7%), due to the emissions from enteric fermentation and the "Waste" sector is the third (17.2%).

Most of Nitrous oxide emissions (84.2%) are from the AFOLU sector. Particularly this is due to the direct and indirect $N_2O$ emissions from managed soils.

Summary Report for National GHG Inventories for 2012 is given in Table 2.2.

**Table 2.2 Summary Report for National Greenhouse Gas Inventories for 2012**

| | Emissions (Gg) | | | Emissions $CO_{2\ eq.}$ (Gg) | | | | | Emissions (Gg) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Categories | Net $CO_2$ | $CH_4$ | $N_2O$ | HFCs | PFCs | $SF_6$ | Other halogenated gases with $CO_{2\ eq.}$ conversion factors | Other halogenated gases without $CO_{2\ eq.}$ conversion factors | NOx | CO | NMVOCs | $SO_2$ |
| **Total national emissions and removals** | **5,059.659 `** | **156.820** | **1.837** | **384.58** | **NA, NO** | **NA, NO** | **NA, NO** | **NA, NO** | **19.737** | **46.154** | **17.106** | **36.632** |
| **1 - Energy** | **5,296.501** | **75.484** | **0.100** | **NA** | **NA** | **NA** | **NA** | **NA** | **19.737** | **46.154** | **7.623** | **0.212** |
| **1.A - Fuel combustion activities** | 5,295.567 | 3.771 | 0.100 | NA | NA | NA | NA | NA | 19.737 | 46.154 | 7.623 | 0.212 |
| 1.A.1 - Energy industries | 1,616.277 | 0.028 | 0.003 | NA | NA | NA | NA | NA | 4.306 | 0.574 | 0.144 | NE |
| 1.A.2 - Manufacturing industries and construction | 620.143 | 0.011 | 0.001 | | | | | | 1.342 | 0.267 | 0.045 | NE |
| 1.A.3 - Transport | 1,241.732 | 1.473 | 0.063 | | | | | | 12.293 | 43.971 | 7.281 | 0.058 |
| 1.A.4 - Other sectors | 1,817.414 | 2.259 | 0.033 | | | | | | 1.796 | 1.342 | 0.153 | 0.154 |
| 1.A.5 - Not-specified | NO | NO | NO | | | | | | NO | NO | NO | NO |
| **1.B - Fugitive emissions from fuels** | 0.934 | 71.713 | NA | | | | | | NA | NA | NA | NA |
| 1.B.1 - Solid fuels | NO | NO | NO | | | | | | NO | NO | NO | NO |
| 1.B.2 - Oil and natural gas | 0.934 | 71.7127 | NA | | | | | | NA | NA | NA | NA |
| 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 |
| 1.C.1 - Transportation of $CO_2$ | NO | | | | | | | | NO | NO | NO | NO |
| 1.C.2 - Injection and storage | NO | | | | | | | | NO | NO | NO | NO |
| 1.C.3 - Other | NO | | | | | | | | NO | NO | NO | NO |
| **2 - Industrial processes and product use** | 277.900 | **NA, NO** | **NA, NO** | **384.577** | **NA, NO** | **NA, NO** | **NA, NO** | **NA, NO** | **NA, NO** | **NA, NO** | 9.483 | 36.42 |
| **2.A - Mineral Industry** | 277.900 | | | | | | | | NO | NO | NO | NE,NO |
| 2.A.1 - Cement production | 277.900 | | | | | | | | NA | NA | NA | NA |
| 2.A.2 - Lime production | NO | | | | | | | | NO | NO | NO | NO |
| 2.A.3 - Glass production | NE | | | | | | | | NE | NE | NE | NE |
| 2.A.4 - Other Processes Using Carbonates | NO | | | | | | | | NO | NO | NO | NO |
| 2.A.5 - Other (please specify) | NO | NO | NO | | | | | | NO | NO | NO | NO |
| **2.B - Chemical industries** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2.B.1 - Ammonium production | NO | | | | | | | | NO | NO | NO | NO |
| 2.B.2 - Nitric acid production | | | NO | | | | | | NO | NO | NO | NO |
| 2.B.3 - Adipic acid production | | | NO | | | | | | NO | NO | NO | NO |
| 2.B.4 - Caprolactam, Glyoxal and Glyoxylic Acid Production | | | NO | | | | | | NO | NO | NO | NO |
| 2.B.5 - Carbide production | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 2.B.6 - Titanium dioxide production | NO | | | | | | | | NO | NO | NO | NO |
| 2.B.7 – Calciumized Soda Production | NO | | | | | | | | NO | NO | NO | NO |
| 2.B.8 - Petrochemical and Carbon Ash Production | NO | NO | | | | | | | NO | NO | NO | NO |
| 2.B.9 - Fluorinated chemicals production | | | | | | | | | | | | |
| 2.B.10 - Other(please specify) | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **2.C - Metal industries** | NA,NO | NA,NO | | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | 36.42 |
| 2.C.1 - Iron and Steel Production | NO | NO | | | | | | | NO | NO | NO | NO |
| 2.C.2 - Ferroalloys production | NA | NA | | | | | | | NA | NA | NA | 7.29 |
| 2.C.3 - Aluminum production | NO | | | | NO | | | NO | NO | NO | NO | NO |
| 2.C.4 - Magnesium production | NO | | | | | NO | | NO | NO | NO | NO | NO |
| 2.C.5 - Lead production | NO | | | | | | | | NO | NO | NO | NO |
| 2.C.6 - Zinc production | NO | | | | | | | | NO | NO | NO | NO |
| 2.C.7 - Other (please specify) | NO | | | | | | | | NO | NO | NO | NO |
| **2.D - Non-Energy Products from Fuels and Solvent Use** | NA,NE | NA | NA | | | | | | NO | NO | 8.651 | NA |
| 2.D.1 - Lubricant Use | NE | | | | | | | | NE | NE | NE | NE |
| 2.D.2 - Paraffin Wax Use | NO | | | | | | | | NO | NO | NO | NO |
| 2.D.3 - Solvent Use | NA | NA | NA | | | | | | NA | NA | 3.026 | NA |
| 2.D.4 - Other (please specify) Paint use | NA | NA | NA | | | | | | NA | NA | 5.625 | NA |
| 2.D.4 – Paint Use | NA | NA | NA | | | | | | NA | NA | 3.325 | NA |
| 2.D.4 - Bitumen Use | NA | NA | NA | | | | | | NA | NA | 2.3 | NA |
| **2.E - Electronics industry** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 2.E.1 - Integrated Circuit or Semiconductor | | | | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 2.E.2 - TFT Flat Panel Display | | | | | NO | NO | NO | NO | NO | NO | NO | NO |
| 2.E.3 - Photovoltaic | | | | | NO | NO | NO | NO | NO | NO | NO | NO |
| 2.E.4 - Heat Transfer Fluid | | | | | NO | NO | | | NO | NO | NO | NO |
| 2.E.5 - Other (please specify) | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2.F - Product Uses as Substitutes for Ozone Depleting Substances** | NA | NA | NA | 384.577 | NA | NA | NA | NA | NA | NA | NA | NA |
| 2.F.1 – Refrigeration and Air Conditioning | | | | 372.671 | | | | | NA | NA | NA | NA |
| 2.F.2 - Foam Blowing Agents | | | | 1.134 | | | | | NA | NA | NA | NA |
| 2.F.3 - Fire Protection | | | | 0.497 | | | | | NA | NA | NA | NA |
| 2.F.4 - Aerosols | | | | 10.274 | | | | | NA | NA | NA | NA |
| 2.F.5 - Solvents | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 2.F.6 - Other Applications (please specify) | | | | | | | | | NO | NO | NO | NO |
| **2.G - Other Product Manufacture and Use** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 2.G.1 - Electrical Equipment | | | | | NO | NO | | NO | NO | NO | NO | NO |
| 2.G.2 - SF6 and PFCs from Other Product Uses | | | | | NO | NO | | NO | NO | NO | NO | NO |
| 2.G.3 - N2O from Product Uses | | | NO | | | | | | NO | NO | NO | NO |
| 2.G.4 - Other (please specify) | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **2.H - Other** | NA,NO | NA,NO | NO | | | | | | | | | |
| 2.H.1 - Pulp and Paper Industry | NO | NO | | | | | | | NO | NO | NO | NO |
| 2.H.2 - Food and Beverages Industry | NA | NA | | | | | | | NA | NA | 0.832 | NA |
| 2.H.3 - Other (please specify) | NO | NO | NO | | | | | | | | | |
| **3 - Agriculture, forestry and other land use** | **-521.660** | **54.349** | **1.549** | | | | | | NA | NA | NA | NA |
| **3.A – Veterinary** | NO | 54.342 | 0.241 | | | | | | NA | NA | NA | NA |
| 3.A.1 - Enteric fermentation | | 50.477 | | | | | | | NA | NA | NA | NA |
| 3.A.2 - Manure management | | 3.866 | 0.241 | | | | | | NA | NA | NA | NA |
| **3.B - Land** | -522.068 | NA | NA, NE | | | | | | NA | NA | NA | NA |
| 3.B.1 - Forest lands | -531.401 | | | | | | | | NA | NA | NA | NA |
| 3.B.2 - Croplands | -7.766 | | | | | | | | NA | NA | NA | NA |
| 3.B.3 - Grasslands | 17.215 | | | | | | | | NE | NE | NE | NE |
| 3.B.4 - Wetlands | NE | | NE | | | | | | NA | NA | NA | NA |
| 3.B.5 - Settlements | NE | | | | | | | | NA | NA | NA | NA |
| 3.B.6 - Other lands | NA | | | | | | | | NA | NA | NA | NA |
| **3.C - Aggregate sources and non-$CO_2$ emissions sources on land** | 0.408 | 0.007 | 1.308 | | | | | | NA | NA | NA | NA |
| 3.C.1 - Emissions from biomass | | 0.007 | IE | | | | | | NO | NO | NO | NO |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| burning | | | | | | | | | | | | |
| 3.C.2 - Liming | NO | | | | | | | | NA | NA | NA | NA |
| 3.C.3 - Urea application | 0.408 | | | | | | | | NA | NA | NA | NA |
| 3.C.4 - Direct N2O emissions from managed soils | | | 0.744 | | | | | | NA | NA | NA | NA |
| 3.C.5 - Indirect N2O emissions from manure management | | | 0.38 | | | | | | NA | NA | NA | NA |
| 3.C.6 - Indirect N2O emissions from manure management | | | 0.184 | | | | | | NO | NO | NO | NO |
| 3.C.7 - Rice cultivation | | NO | | | | | | | NO | NO | NO | NO |
| 3.C.8 - Other (please specify) | | NO | | | | | | | NO | NO | NO | NO |
| **3.D - Other** | NA, NO | NA, NO | NA,NO | | | | | | NA, NO | NA, NO | NA, NO | NA, NO |
| 3.D.1 - Harvested Wood Products | NO | | | | | | | | NO | NO | NO | NO |
| 3.D.2 - Other (please specify) | NO | NO | NO | | | | | | NO | NO | NO | NO |
| **4 - Waste** | **7.326** | **26.987** | **0.188** | **NA** | **NA,** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** |
| **4.A - Solid Waste Disposal** | NA | 21.579 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| **4.B - Biological Treatment of Solid Waste** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **4.C - Incineration and Open Burning of Waste** | 7.326 | 1.055 | 0.019 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| **4.D - Wastewater treatment and discharge** | NA | 4.353 | 0.169 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| **4.E - Other (please specify)** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **5 - Other** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **5.A - Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **5.B - Other (please specify)** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Memo Items (5)** | | | | | | | | | | | | |
| **International bunkers** | 127.617 | 0.001 | 0.004 | | | | | | 0.610 | 0.203 | 0.102 | 0.046 |
| 1.A.3.a.i - International Aviation (International Bunkers) | 127.617 | 0.001 | 0.004 | | | | | | 0.610 | 0.203 | 0.102 | 0.046 |
| 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 | NO | NO | NO | NO | NO |

# 3. Trends of GHG Emissions

Figure 3.1. below provides GHG emissions trend by sectors graphically for 2000-2012, Gg $CO_{2eq.}$

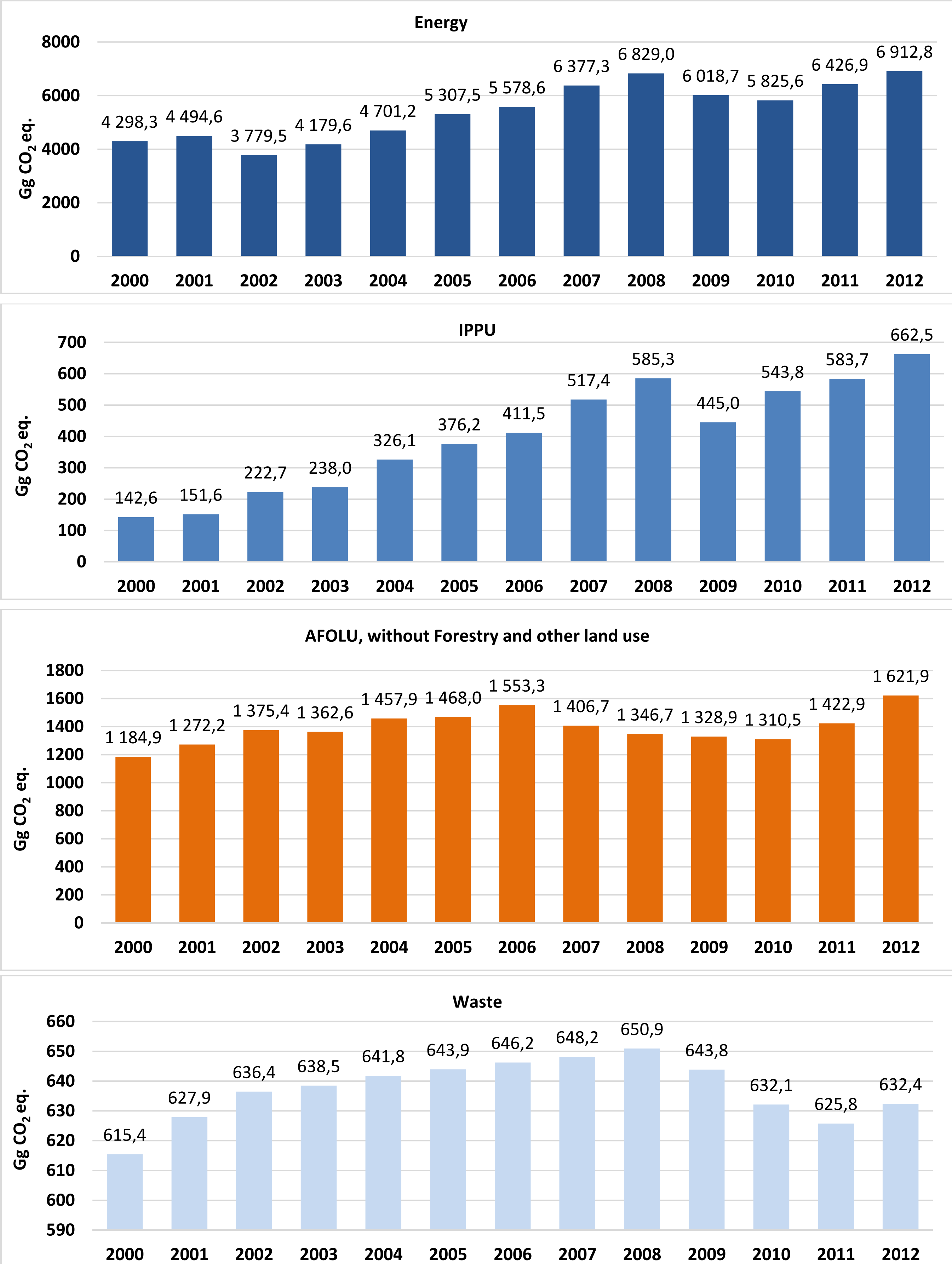


***Figure 3.1 2000-2012 GHG emissions by sectors, Gg $CO_2$ eq.***

The sharp increase of GHG emissions from "Energy" sector in comparison with 2010 is due to increase of thermal power generation in 2012– 3,398 mln. kWh in 2012 vs 1,443 mln. kWh in 2010 or in other words power generation by thermal power plants (TPP) has been increased by 135 % as a result of fulfillment of the contractual obligations (electricity export to Iran) under Iran-Armenia Electricity-for-Gas Swap Agreement. Thus the energy sector emissions show strong annual variation in accordance with the amount of exported electricity.

After the decline of GHG emissions from IPPU sector in 2009 because of the economic crises, which resulted in the decrease of construction volumes and, thus, cement production, in 2010 the construction volumes and cement production increased to a certain degree resulted in the increase of GHG emissions. The increase of GHG emissions in 2011 and 2012 is due to the continuous trend of substituting the ozone layer depleting substances with HFCs, as well as due to using HFC- based foam in construction.
The increase of GHG emissions from AFOLU sector in 2012 is due to the increase of emissions from Enteric Fermentation because of the increase of the number of cattle.

Time series for 2000-2012 GHG emissions by gases in Gg $CO_{2eq.}$ are provided below.

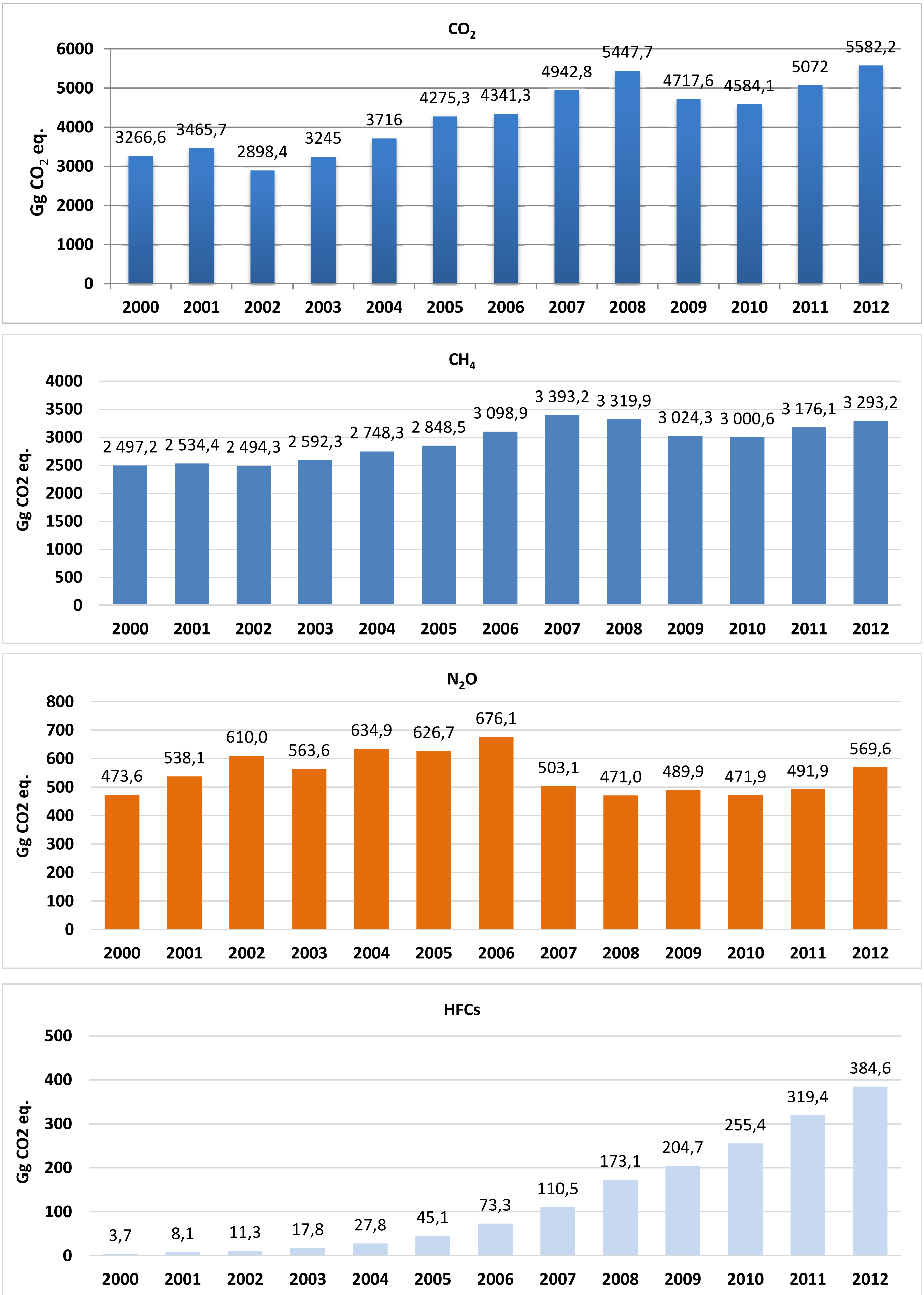


***Figure 3.2 2000-2012 GHG emissions per gases, Gg CO2 eq.***

Increase of $CO_2$ emissions from "Energy" sector in 2011 and 2012 is mainly conditioned by the sharp increase of thermal power generation.

In 2012 the trend of $CH_4$ emissions increasing was kept due to the increased numbers of cattle which in its turn resulted in the increase of the emissions from enteric fermentation.

The increase of $N_2O$ emissions in 2011 and 2012 is the result of the increase of organic and non-organic fertilizers import, taking into account the assumption that the fertilizers were totally used during the reporting year.

F-gases emissions volume has been growing continuously which is conditioned by substituting the ozone layer depletion substances with HFCs, use of foams in construction, and in general by rapid development of this sector since 2008.

# 4. Greenhouse gas emissions by sectors

## *4.1 Energy*

### *4.1.1 Overview of “Energy” Sector Emissions Assessment*

The Energy sector is the largest producer of greenhouse gas emissions. In 2012 the Energy sector accounted for 70.3% of Armenia’s total greenhouse gas emissions.

Energy sector emissions can be divided into emissions resulting from fossil fuel combustion and fugitive emissions from natural gas. The majority of the sector’s emission results from fossil fuel combustion. Within the frames of this inventory, the following improvements were made to the energy sector GHG inventory:

- Higher Tier Methodology was applied for 10 subcategories,
- 4 National Emission Factors were developed for key categories,
- GHG emissions were estimated for 6 new subcategories.

Considering that natural gas is the main fuel consumed in the country and therefore emissions from the energy sector are mainly conditioned by use of natural gas, energy sector inventory improvements have been implemented for assessing emissions from natural gas combustion and from fugitive emissions of natural gas. Emissions assessment was done applying Tier 2 approach by developing National Emission Factors which take into account the country’s gas supply network structure and physiochemical data of imported natural gas.

To ensure time series consistency emissions from energy sector for 2000-2010 have been recalculated applying Tier 2 approach.

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.
Improvements have been made in the method for assessing emissions from manure burning: i.e. part of manure left in pastures was deducted from total mass to calculate the part of manure burned. The time series were recalculated for up to year 2000 with an assumption that part of manure left in pastures has remains unchanged.
The table below provides the summary on methods applied for assessment of greenhouse gases from energy sector.

**Table 4.1.1 Summary on methods applied for assessment of greenhouse gases from energy sector**

| Subcategory | Greenhouse gas | Level Assessment | Method, Approach | Activity Data | Emission Factor |
|---|---|---|---|---|---|
| **1 A FUEL COMBUSTION ACTIVITIES** | | | | | |
| 1 A 1 Energy Industries (gaseous fuels) | $CO_2$ | KC | T2 | CS | CS |
| 1 A 2 Manufacturing Industries and Construction (gaseous fuels) | $CO_2$ | KC | T2 | CS | CS |
| 1 A 3 b Road transportation | $CO_2$ | KC | T1*, T2** | CS | D*; CS** |
| 1 A 4 Other Sectors (gaseous fuels) | $CO_2$ | KC | T2 | CS | CS |
| 1 A 4 Other Sectors (liquid fuels) | $CO_2$ | KC | T1 | CS | D |
| **1 B FUGITIVE EMISSIONS FROM FUELS** | | | | | |
| 1 B 2 b Fugitive emissions of Natural Gas | $CH_4$ | KC | T2 | CS | CS |

* for liquid fuels
** for CNG

### *4.1.2 Description of “Energy” Sector*

As of 2011-2012 the “Energy” sector in Armenia includes the following activities and source categories

**1 A FUEL COMBUSTION ACTIVITIES**

***1 A 1 ENERGY INDUSTRIES***

**1 A 1 a** Electricity and Heat Production

i *Electricity Generation:* Hrazdan TPP with 2 available units of 200 MW capacity each; Hrazdan TPP Unit 5 with 445 MW of installed capacity;

ii *Combined Heat and Power Generation:* Yerevan TPP (Combined Cycle Gas Turbine) of 242 MW of installed electric and 435 GJ/h thermal capacity unit. There are also small Cogeneration Plants in the country, including: “Lous Astgh Sugar” sugar plant, “Armruscogenaration” CJSC and Yerevan State Medical University energy centers;

iii *Thermal Energy Generation (boiler houses):* There are no special enterprises in Yerevan mainly specializing in thermal energy generation and supply.
To avoid double accounting the existing boiler houses providing heat supply in various areas are considered in the respective sectors in order to

All power and heat generation is based on natural gas combustion.

***1 A 2 MANUFACTURING INDUSTRIES AND CONSTRUCTION***

**1A2b** Non-Ferrous Metals

**1A2e** Food Processing, Beverages and Tobacco

**1A2k** Construction

**1A2m** Non-specified Industry: glass production, ferroalloys production and other consumers.

Entire production is based on natural gas combustion.

***1A 3 TRANSPORT***

***1A3a Civil Aviation***

i International Aviation (International Bunkers) is presented by two international airports: “Zvartnots” and “Shirak”.

***1A3b Road transportation:***

i Light passenger cars

ii Light-duty trucks

iii Heavy-duty trucks and buses

***1A3c Railway:*** It is fully electrified in Armenia.

Compressed natural gas and petroleum products are used in road transportation, while the consumption structure is quite specific, i.e. the share of natural gas accounts for 70% (as of 2012 [EnRef-1].

***1 A 4 OTHER SECTORS***

**1A4a** Commercial/institutional

**1A4b** Residential

**1A4c** Agriculture/Forestry/Fishing

1A4C ii Off-road Vehicles and Other Machinery

Natural gas and petroleum products are used as fuel in these sectors.

**1 B FUGITIVE EMISSIONS FROM FUELS**

***Gas supply system***

Armenia imports natural gas from Russia, via Georgia, and from Iran. The gas transmission system includes a main high pressure pipeline and an underground gas storage facility. Total length of gas transmission system is 1841.2 km.

In recent years there was an unprecedented expansion of natural gas distribution system. Currently gasification level is 95%. Gas distribution system operates 3838 km long high- and medium-pressure pipelines and 7508 km long low-pressure lines. There are 2555 gas control points and 6650 individual gas regulating units for operation of the gas distribution system.

Taking into account physiochemical data (official data) of the delivered (mixture of) natural gas, National Emissions Factors were developed for estimation of fugitive emissions in the following subcategories:

1B2biii4 Transmission and storage

1B2biii5 Distribution.

All other sources indicated in 2006 IPCC Guidelines [Gen-1] for Energy sector do not exist in Armenia and are not considered in this Inventory

### *4.1.3 Methodological Approach*

**1 A FUEL COMBUSTION ACTIVITIES**

**SECTORAL APPROACH**

**Stationary Combustion**

This chapter describes the methods and activity data necessary to estimate emissions from Stationary Combustion, and the categories in which these emissions are reported.

***(1A1a) Electricity and Heat Production***

$CO_2$ emissions of greenhouse gases from stationary combustion of natural gas for 1A1ai Electricity Generation and 1A1aii Combined Heat and Power Generation subcategories were estimated using Tier 2 approach by applying country-specific emissions factors. Country-specific $CO_2$ emissions factors were generated based on the carbon content in the natural gas using country-specific net-calorific values (NCV) and density.

Gas supply system of the country has such structure that natural gas used by different consumers varies in physiochemical data. Physiochemical data of natural gas imported from Russian Federation, gas mixture and gas from Iran are described in Annex 1, and the Methodology for calculation of country-specific emissions factors is described in Annex 2.

While data on physiochemical data of natural gas used by large consumers (required for calculations of country-specific emissions factors) such as carbon contents of the natural gas used and gas quality, are available from laboratory tests, for small consumers country-specific emissions factors were calculated based on physiochemical data of natural gas mixture.

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 [Gen-1]. As it comes from the comparison country-specific emission factors are within the 95 percent confidence intervals, given for the default values.

Table 4.1.2 provides $CO_2$ emissions from stationary combustion of natural gas for power generation by power plants calculated applying country-specific emissions factors.

**Table 4.1.2 $CO_2$ emissions by operating power plants**

| Stationary combustion of fuel | Country-Specific Emission Factors | Activity data | | GHG emissions |
|---|---|---|---|---|
| | kg $CO_2$/TJ | TJ | million $m^3$ | Gg $CO_2$ |
| | | **2011** | | |
| **Hrazdan TPP** | 56,798.0 | 6,352.74 | 184.026 | 360.82 |
| **Yerevan TPP** | 57,004.9 | 12,352.12 | 360.318 | 704.13 |
| **Yerevan Medical University** | 57,004.9 | 171.44 | 5.001 | 9.77 |
| **Total** | | **18,876.30** | **549.345** | **1,074.73** |
| | | **2012** | | |
| **Hrazdan TPP** | 56,851.7 | 7,962.90 | 230.683 | 452.70 |
| **Hrazdan Unit 5** | 56,851.7 | 8,126.21 | 235.400 | 461.99 |
| **Yerevan TPP** | 57,209.2 | 12,029.63 | 352.586 | 688.21 |
| **Yerevan Medical University** | 57,209.2 | 107.10 | 3.139 | 6.13 |
| **ArmRuscogeneration** | 57,209.2 | 126.04 | 3.694 | 7.21 |
| **Total** | | **28,351.87** | **825.503** | **1,616.23** |

### *(1A2) Manufacturing Industries and construction*

In Manufacturing Industries and Construction category $CO_2$ emissions from stationary combustion of natural gas were assessed by subcategories applying Tier 2 Approach and based on data on the amount of natural gas combusted in the source subcategory [EnRef-5, EnRef-6, Annex 4] and country-specific emission factors for natural gas mixture (Annex 2
Greenhouse gas emissions from 1A2k subcategory "Construction" were calculated for the first time within the BUR Inventory for 2011, 2012 therefore there is no time series for previous years and emissions from "Non-Ferrous Metals" 1A2b subcategory only includes the years 2010-2012 due to lack of activity data for previous years.

### (1A3) Mobile Combustion

#### *(1A3a) Civil Aviation*

Calculations are made on the basis of an aggregate quantity of fuel consumption data for aviation provided by RA General Department of Civil Aviation RA [EnRef-4] multiplied by default emission factor.
Emissions estimated from this source are not included in national total and are reported as memo item.

#### *(1A3b) Road Transportation*

The vehicles in Armenia operate on wide range of fuels: gasoline, diesel, compressed natural gas (CNG), liquefied petroleum gas (LPG).

Calculations of $CO_2$ emissions from CNG combustion are made applying Tier 2 Approach based on the quantities of compressed natural gas consumed by compressed natural gas feeling stations [EnRef-5, EnRef-6, Annex 4], and country-specific emission factors for natural gas mixture (Annex 2).

$CO_2$ emissions from gasoline, diesel and LPG combustion are calculated applying Tier 1 Approach based on the quantities of fuel sold assuming that the total fuel imported into the country [EnRef-1] in a given year is sold in the same year, and by using default emission factors specified in 2006 IPCC Guideline [Gen-1, 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.

However, $CH_4$ and $N_2O$ emissions from fuel combustion in road transportation are calculated by applying Tier 1 Approach using country's activity data and emission factors from 2006 IPCC Guideline because of lack of the detailed information on this issue.

Estimation of indirect greenhouse gas emissions was done applying Tier 1 Approach using country's activity data and emission factors specified in EMEP/CORINAR, 2007 Guidebook.

***(1A3c) Railway***

It is fully electrified in Armenia therefore emissions from Railways do not occur.

***(1A3d) Water-borne Navigation***

1A3di International Water-Borne Navigation does not exist within the country and in the country do not occur emissions from 1A3dii Domestic Water-Borne Navigation.

***(1A3e) Other Transportation***

Emissions from this sub-category do not occur because there is only Gas Pipeline Transport in the country and the existing compressor stations operate on electricity.

***(1A4) Other Sectors***

***(1A4a) Commercial/Institutional***

Natural gas and LPG are used as fuel in this subcategory.
$CO_2$ emissions from natural gas combustion are assessed applying Tier 2 Approach by using country-specific emission factors. $CO_2$ emissions from combustion of LPG are calculated applying Tier 1 Approach.

***(1A4b) Residential***

The following fuel types used by households in Armenia: natural gas, LPG, firewood, and manure.
$CO_2$ emissions from natural gas combustion are calculated applying Tier 2 Approach based on the quantities of consumed natural gas [EnRef-5, EnRef-6, Annex 4] and country-specific emission factors (Annex 2).

Non-$CO_2$ emissions from fuel combustion are calculated applying Tier 1 Approach.

***(1A4c) Agriculture***

$CO_2$ emissions from combustion of diesel and gasoline are calculated applying Tier 1Approach based on the quantities of fuel consumed and emission factors from 2006 IPCC Guideline.

***(1A4ci) Stationary and (1A4c iii) Fishing (mobile combustion)***

Emissions from (1A4ci) Stationary sub-category do not occur because all stationaries are electricity consuming and emissions from (1A4c iii) Fishing (mobile combustion) are included in 1A4c subcategory.

**1A FUEL COMBUSTION ACTIVITIES**

**REFERENCE APPROACH**

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.

**1B FUGITIVE EMISSIONS FROM FUELS**

***1B2biii4 Transmission and Storage***

***1B2biii5 Distribution***

Given that fugitive emissions from natural gas systems is the key source category in this Report they were assessed applying Tier 2 Approach provided in 2006 IPCC Guidelines [Gen 1].

Country-specific emission factors developed for fugitive emissions from natural gas transportation (including storage) and distribution systems (see Table 4.1.3) were discussed and agreed with "Gasprom Armenia" CJSC.

Calculation of country-specific emission factors and volumes of marketable gas and utility sales delivered via transmission and distribution system was made by using official data from Annual Balances provided by "Gasprom Armenia" CJSC [EnRef-5, EnRef-6, Annex 4] and based on natural gas annual average physiochemical data (gas composition, density, Net Calorific Value ) in gas transmission and distribution systems (Annex 1).

*Calculation of country-specific emission factors for fugitive emissions in gas transmission system* - $F_{trans}$

$$F_{trans} = [(P-T)-k_{trans}*T] * \rho_{trans} * CH_{4tr} / T \ (Gg/mln.m^3)$$

$P_{(Produced\ Gas)}$ = Quantity of imported gas (1[1]) + quantity of gas taken from Gas Underground Storage Facility (2) (million $m^3$)

$T_{(Transmission\ marketable\ gas)}$ = Quantity of transmitted gas (6) + quantity of gas injected in Gas Underground Storage Facility (5) + quantity of gas used for own needs (3) (million $m^3$)

$k_{trans}$ = 0.011 Factor conditioned by transmission system metering devices errors

$\rho_{trans}$ (Density) = Gas density in transmission system (Gg/million $m^3$)

$CH_4$ (Content) = Methane content in transmitted gas

*Calculation of country-specific emission factors for fugitive emissions in gas distribution system* - $F_{dist}$

$$F_{dist} = [(T_{trans}-T_{sales}-D)-k_{dist}*D_{sales}] * \rho_{dist} * CH_{4dis} / D_{sales} \ (Gg/million\ m^3)$$

$T_{trans}$ = Quantity of transmitted gas (6) (million $m^3$)

$T_{sales}$ = Gas sales in transmission system (6.1) (million $m^3$)

D (Distribution marketable gas) = Gas sales in distribution system (10) + Gas consumed for own needs in distribution system (7) + recovered gas (8) (million $m^3$)

$k_{dist}$ =0.003 = Factor conditioned by distribution system metering devices errors

$D_{sales}$ (Distribution utility sales) = Gas sales in distribution system(10) (million $m^3$)

$\rho_{dist}$ (Density) = Gas average density in distribution system (Gg/million $m^3$)

$CH_4$ (Content) = Methane content in distributed gas

Table 4.1.3 below provides country-specific emission factors for methane fugitive emissions, activity data and fugitive emissions in 2011 and 2012

**Table 4.1.3 Country-specific emission factors for methane fugitive emissions, activity data and fugitive emissions in 2011 and 2012**

| Year | Gas supply system | Country-Specific Emission Factors | Activity data | Methane fugitive emissions | | Uncertainty: difference from actual |
|---|---|---|---|---|---|---|
| | | Gg/million $m^3$ | million $m^3$ | Gg | | % |
| 2011 | Transmission system | 0.0230950 | 2054.95 | 47.46 | **71.43** | 25.45% |
| | Distribution system | 0.0156172 | 1534.92 | 23.97 | | |
| 2012 | Transmission system | 0.0198961 | 2443.00 | 48.61 | **71.71** | 29.54% |
| | Distribution system | 0.0143617 | 1608.90 | 23.11 | | |

[1] *The brackets indicate respective row in gas supply balance sheet*

## 4.1.4 "Energy" Sector Activity Data Sources

Main sources of activity data for GHG emissions assessment are the following:

- RA National Statistical Service
- RA Public Services Regulatory Commission
- RA Ministry of Finance (Customs Service)
- RA Ministry of Energy and Natural Resources
- RA Ministry of Transport and Communication
- RR Ministry of Agriculture
- RA Police
- General Department of Civil Aviation under RA Government
- "Gasprom Armenia" CJSC

## 4.1.5 Activity Data

### 4.1.5.1 Fuel and Energy Resources

#### 4.1.5.1.1 General Description

Figure 4.1.1 and Figure 4.1.2 provide fuel consumption structure in Armenia for 2011 and 2012 respectively, by subcategories. As it comes from the figures, Energy Generation, Road Transportation and Residential categories are the biggest consumers both in 2011 and 2012, accounting for 78% of aggregate consumption in 2012.

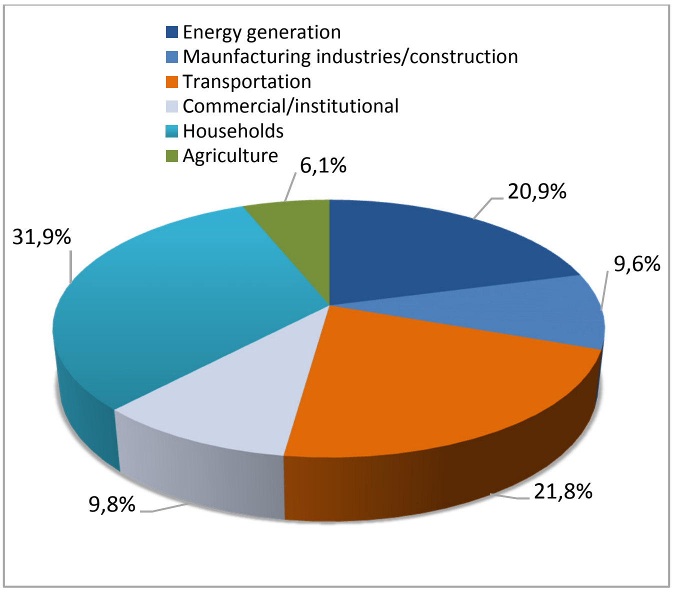


*Figure 4.1.1 2011 fuel consumption structure by categories*

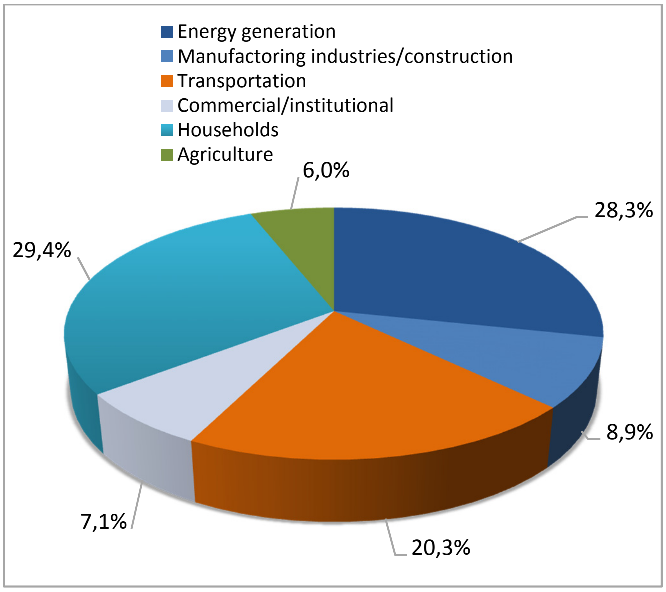


*Figure 4.1.2 2012 fuel consumption structure by categories*

Figure 4.1.3 and Figure 4.1.4 provide 2011 and 2012 fossil fuel consumption structure by types of fuel [EnRef-1]. Natural gas accounts for 81.9% of 2011 total consumption, while together with gasoline and diesel it makes 97%.

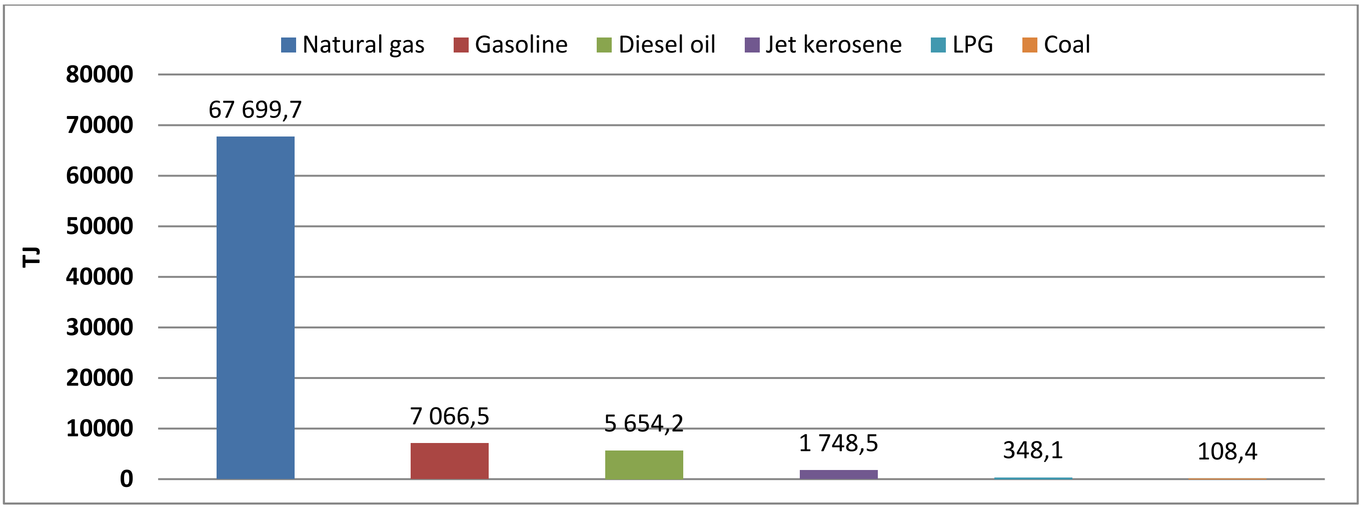


*Figure 4.1.3 2011 Fossil fuel consumption structure by types of fuel in 2011*

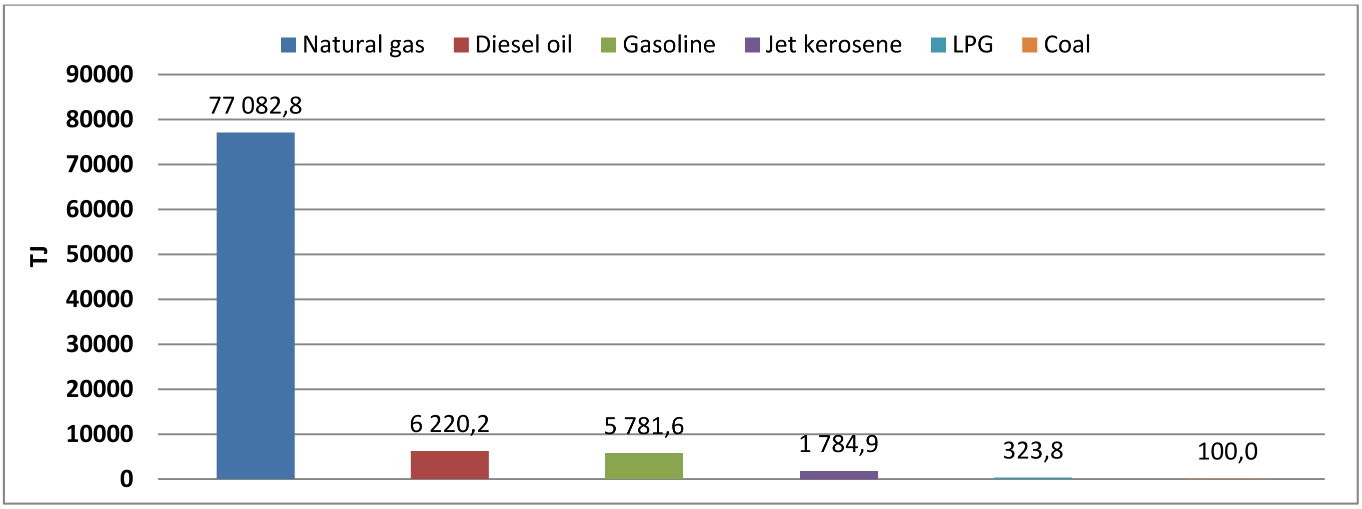


*Figure 4.1.4 2012 Fossil fuel consumption structure by types of fuel in 2012*

Natural gas consumption in 2012 has increased by 13%, however consumption structure has remained almost unchanged.

### *4.1.5.1.2 Natural gas*

Table 4.1.4 provides natural gas balances for 2011 and 2012 [EnRef-5, EnRef-6, Annex 4].

**Table 4.1.4 Natural gas balance for 2011 and 2012, million m$^3$**

| Year | 2011 | 2012 |
|---|---|---|
| *Imports* | 2,069.1 | 2,455.5 |
| **Gas turnover in storage facility** ***(extracted -, injected +)*** | -46.4 | 49.3 |
| **Own needs** | 7.8 | 13.5 |
| **Losses** | 134.05 | 139 |
| **Losses, in %** | 6.5 | 5.7 |
| ***Consumption, including*** | 1,973.6 | 2,253.7 |
| **Energy Generation** | 549.3 | 825.5 |
| **Road Transportation** | 362.4 | 418 |
| **Manufacturing Industries/Construction** | 326.2 | 317.7 |
| **Commercial/Institutional** | 184.9 | 150.5 |
| **Residential** | 550.8 | 542 |

As it comes from Table 4.1.4 Energy Generation category is the largest gas consumer in 2012 which is conditioned by the amount of exported electricity.

Power generation structure is provided below.

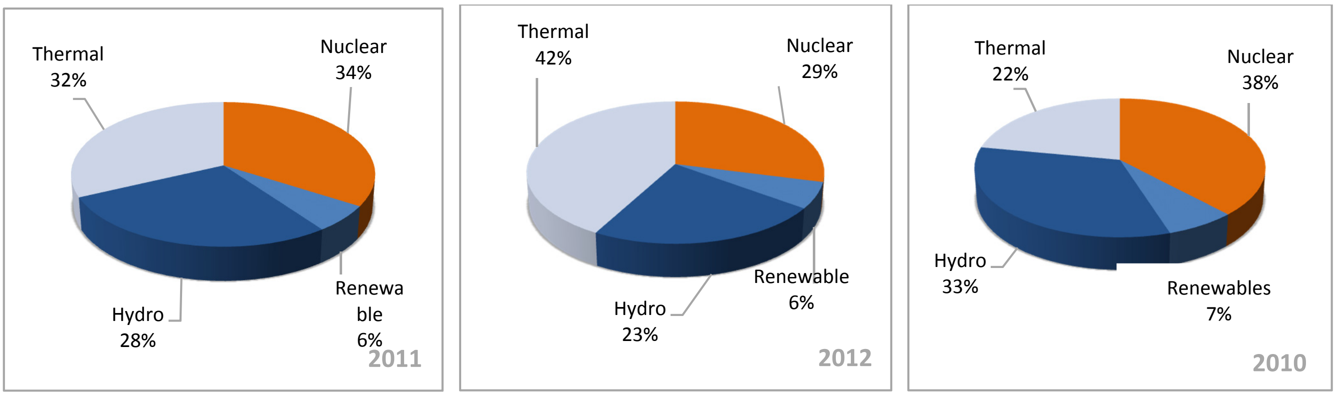


*Figure 4.1.5 Power generation structure*

**Table 4.1.5 Power generation by plant types (million kWh) [EnRef-7, EnRef-8, Annex 5]**

| Power Plant | Year | | |
|---|---|---|---|
| | 2010 | 2011 | 2012 |
| **Nuclear** | 2,490 | 2,548 | 2,311 |
| **Thermal** | 1,443 | 2,395 | 3,398 |
| **Hydro** | 2,143 | 2,033 | 1,814 |
| **Renewables** | 416 | 458 | 513 |
| **Total** | **6,492** | **7,434** | **8,036** |

As it comes from Figure 4.1.5 and Table 4.1.5, in 2012 there is a sharp growth in thermal power plants generation compared with 2010. In 2012 it totaled to 3398 million kWh, or its share was 42%, while in 2010 - 1443 million kWh, or 22% of the total. The growth of power generation by thermal power plants in 2012 vs 2010 reached to 135% because of 1.58 billion kWh electricity exported to Iran.

#### *4.1.5.1.3 Oil Products*

The quantities of oil products imported in Armenia in 2011 and 2012 are summarized in Table 4.1.6. It is assumed that annually imported oil products are fully consumed in the same year because Armenia is lack large storages for liquid fuel.

**Table 4.1.6 Imports of oil products, by years [EnRef-1]**

| Oil products | Import, t | |
|---|---|---|
| | 2011 | 2012 |
| **Gasoline** | 159,515 | 130,332 |
| **Diesel** | 131,588 | 144,683 |
| **Jet kerosene** | 39,648 | 40,473 |
| **LPG** | 7,359 | 6,909 |
| **Total** | **338,110** | **322,397** |

## *4.1.6 Biomass*

### *4.1.6.1 Firewood*

Although Armenia has a high level of gasification - 95% [Gasprom Armenia], population in rural areas of Armenia still continues using firewood due to increase in natural gas tariffs: a sharp increase of firewood consumption was recorded in 2012. The quantity of burned firewood is estimated based on official data on volumes of harvested wood, fallen-wood and illegal logging.

By using average baseline density of wood for Armenia - 0.557 t/m$^3$ [EnRef-2] and firewood calorific value (15.6 TJ/Gg) specified by 2006 IPCC Guidelines [Gen-1] the volumes of burned firewood was calculated in energy units, as summarized in Table 4.1.7.

**Table 4.1.7 Firewood consumption in 2011, 2012 [EnRef-3]:**

| Year | Combusted firewood, m$^3$ | Combusted firewood, TJ |
|---|---|---|
| **2011** | 65,740 | 571.23 |
| **2012** | 85,960 | 746.92 |

The $CO_2$ emissions from wood combustion are not included in the $CO_2$ emissions resulting from combustion.

### *4.1.6.2 Manure*

Manure is largely used as fuel in rural areas of Armenia. Table 4.1.8 summarizes annual quantities of manure burned as fuel calculated based on number of cattle [Ref-1] and RA Ministry of Agriculture's experts assessment on annual manure excretion per animal, manure moisture rate (percent) and the share of manure used as fuel.

According to RA Ministry of Agriculture (Annex 6) in 2011-2012 moist manure annual production per cattle was 8 tons in average. According to RA Ministry of Agriculture's experts' assessment 34.4 - 42.5% of manure is left in pastures, 0.98% of the rest part of moist mass is stored in dry form to be used as fuel or fertilizer. 0.3 part of moist manure after drying is used as organic fertilizer, while 0.7 part is used for preparing fuel (peat), 80 % of which is lost during drying process.

Net Calorific Value of 11.6 TJ/Gg specified in 2006 IPCC Guidelines [Gen-1] for "Other primary solid biomass" was applied to calculate heat.

**Table 4.1.8 Quantity of manure produced, burned and heat received [Annex 6 and Ref-1]**

| Year | 2011 | 2012 |
|---|---|---|
| **Total manure, Gg** | 5,635.1 | 6,211.7 |
| **Total burned manure, Gg** | 475.9 | 524.6 |
| **Heat, TJ** | 5,520.0 | 6,084.9 |

## *4.1.7 Completeness of Input Data*

Currently, there is no complete official data on consumption of certain types of fuel in the country. For example, data on use of oil products is available only in values registered by Customs Service on the country's border points. Data on further consumption in not complete and does not include all necessary direction of activities.

Unlike oil products, there is complete official data on natural gas which has been made publicly available since 2011[EnRef-5,7].

A part of data on biomass (manure and firewood) consumption is derived from indirect calculations and expert's assessment which shows essential deviations in data collected from various sources.

## *4.1.8 Uncertainty of Data*

Data collected on natural gas is based on data officially provided by Public Services Regulatory Commission [EnRef-5,7] and GazProm-Armenia. Uncertainties in the quantities of consumed natural gas are conditioned by errors (1-3%) of metering devices in natural gas transmission and distribution systems.

The approach for uncertainties assessment of oil products consumption is described in details in Third NIR where uncertainties level for oil products consumption does not exceed 10%.

Thus, the estimated total weighted average uncertainty for "Energy" sector is in the range of 4.2-5.8%.

### *4.1.9 Data Quality Assurance*

Quality of input data is ensured by documents from data providing organizations which are used to make reports on financial and economic performance, tax returns, accounting for country's economic development indicators, etc. This basically refers to fossil fuel consumption.

Yet, the quantities of firewood and manure consumption are in part based on assessments made by sector experts. For enhancing their credibility and quality level it is necessary to collect clear indicators on forestry and livestock production by accounting and monitoring activities to be conducted by rural community governments.

### *4.1.10 Calculation Results*

#### *4.1.10.1 Fuel Combustion Activities*

##### *4.1.10.1.1 $CO_2$ Emissions Assessment, Reference Method*

$CO_2$ emissions by fuel type for Fuel Combustion Activities Category (1A) are assessed by Reference Method and summarized in Table 4.1.9 below.

**Table 4.1.9 $CO_2$ emissions from fuel combustion, Reference Method**

| Fuel type | | | Actual emission, Gg $CO_2$ | |
|---|---|---|---|---|
| Year | | | 2011 | 2012 |
| **Liquid fossil** | Secondary fuel | Gasoline | 489.7 | 400.7 |
| | | *Jet kerosene** | *124.9* | *127.6* |
| | | Diesel oil | 418.8 | 460.7 |
| | | Liquefied petroleum gas (LPG) | 21.9 | 20.4 |
| **Total liquid fossil** | | | **930.4** | **881.8** |
| | | Other bitumen coal | 10.2 | 9.5 |
| **Total solid fossil** | | | **10.2** | **9.5** |
| **Gaseous fossil** | | Natural gas | **4,055.7** | **4,590.4** |
| **Total** | | | **4,996.4** | **5,481.7** |

**Note: As jet kerosene is fully consumed in international bunker, such emissions are not included in the country's total emissions.*

As it comes from Table 4.1.9, natural gas is the main fuel component accounting for 81.2% and 83.9% of GHG emissions from fossil fuel combustion in 2011 and 2012, respectively. This is because of high level of gasification – about 95%. It should be noted that natural gas is also largely used in road transportation as it is 2.5 times cheaper than gasoline and there is an expanded network of compressed natural gas feeling stations in the country.

$CO_2$ emissions by fossil fuel types are given in Figures below.

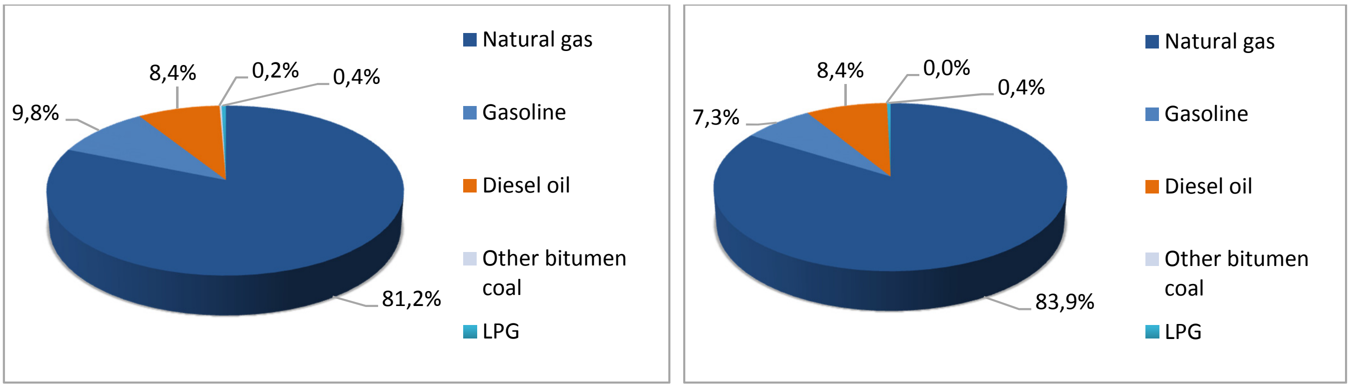


*Figure 4.1.6 2011 and 2012 $CO_2$ emissions by fossil fuel types*

### 4.1.10.1.2 *GHG Emissions Assessment, Sectoral Approach*

Table 4.1.10 provides $CO_2$ emissions from fuel combustion activities by categories and their share for 2011 and 2012. Calculation results are summarized in Figure 4.1.7 below.

**Table 4.1.10 2011, 2012 $CO_2$ emissions in "Energy" sector, by subcategories**

| Code | Subcategory | Measurement Unit | 2011 | 2012 |
|---|---|---|---|---|
| **1.A.1** | Energy Industries | Gg | 1,074.7 | 1616.3 |
| | | % | 22.4 | 30.5 |
| **1.A.2** | Manufacturing Industries and Construction | Gg | 637.4 | 620.1 |
| | | % | 10.3 | 11.7 |
| **1.A.3b** | Road Transportation | Gg | 1,217.2 | 1,241.7 |
| | | % | 25.4 | 23.4 |
| **1.A.4a** | Commercial/Institutional | Gg | 361.4 | 296.1 |
| | | % | 10.6 | 5.6 |
| **1.A.4b** | Residential | Gg | 1,105.1 | 1,082.8 |
| | | % | 23.0 | 20.4 |
| **1.A.4c** | Agriculture | Gg | 403.0 | 438.5 |
| | | % | 8.4 | 8.3 |
| **Total** | | **Gg** | **4,798.8** | **5,296.5** |

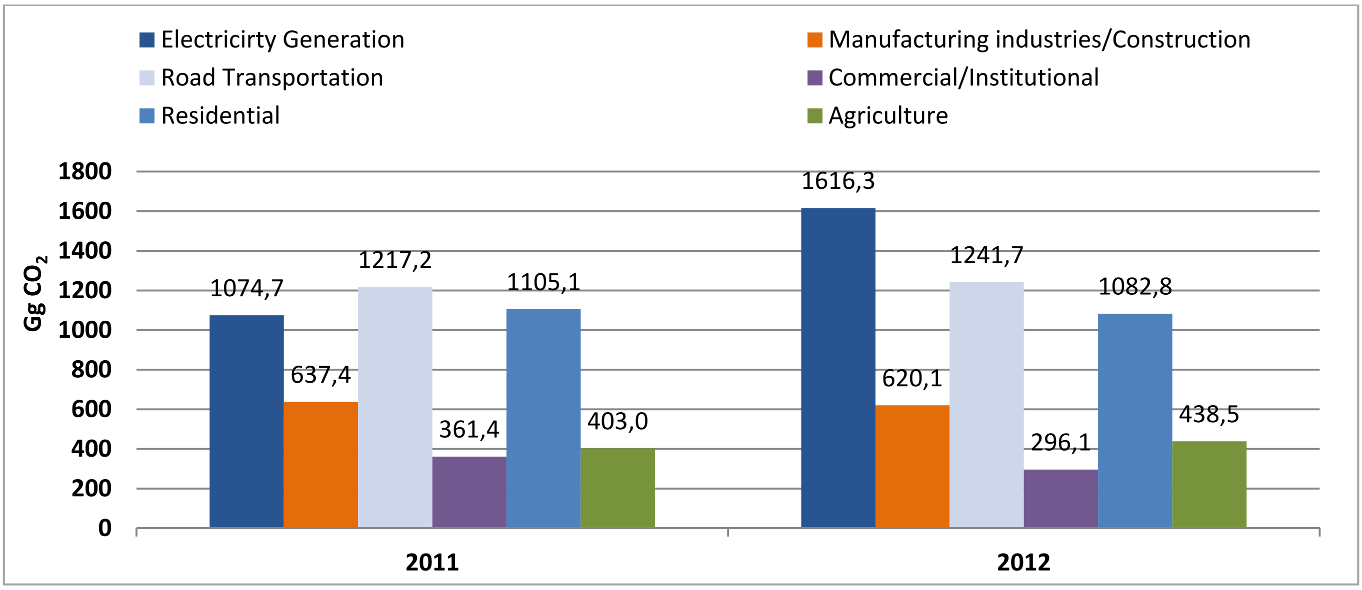


*Figure 4.1.7 2011-2012 "Energy" sector $CO_2$ emissions structure, by subcategories*

The significant increase of $CO_2$ emissions in 2012 from Electricity Generation subcategory is due to sharp increase of thermal power plants generation (see Table 4.1.5).

### *4.1.10.1.3 Comparison between Reference Approach and Sectoral Approach*

The Reference Approach and a Sectoral Approach often have different results because the Reference Approach is a top-down approach using a country's energy supply data and has no detailed information on how the individual fuels are used in each sector.

Figure 4.1.8 presents comparison of 2011 and 2012 $CO_2$ emissions estimated using Reference and Sectoral Approaches.

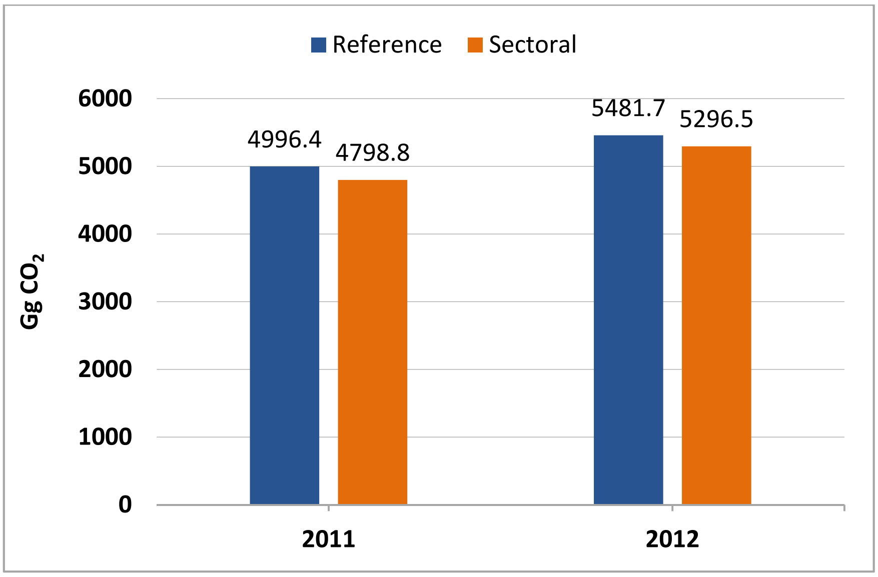


*Figure 4.1.8 Comparison of Reference and Sectoral Approaches*

Emission values derived applying Reference Approach are bigger versus Sectoral Approach which is justified given that according to Guidelines [Gen-1] natural gas leakage from pipelines, emissions from energy transformation, etc. are included in Apparent Consumption in Reference Approach estimate.

Table 4.1.11 describes emissions of greenhouse gases by types and subcategories.

**Table 4.1.11 GHG emissions by subcategories**

| Greenhouse Gas (Gg) / Subcategory | 2011 | 2012 |
|---|---|---|
| **$CO_2$** | **4,798.8** | **5,295.6** |
| **Energy Industries** | 1,074.7 | 1,616.3 |
| **Manufacturing industries/Construction** | 637.4 | 620.1 |
| **Transportation** | 1,217.2 | 1,241.7 |
| **Other Sectors** | 1,869.4 | 1,817.4 |
| **CH4** | **4.9192** | **4.4687** |
| **Energy Industries** | 0.0284 | 0.0189 |
| **Manufacturing industries/Construction** | **0.0112** | **0.0108** |
| **Transportation** | **1.4727** | **1.3515** |
| **Other Sectors** | **3.0770** | **3.3993** |
| **$N_2O$** | **0.1156** | **0.1083** |
| **Energy Industries** | **0.0028** | **0.0019** |
| **Manufacturing industries/Construction** | **0.0011** | **0.0011** |
| **Transportation** | **0.0630** | **0.0612** |
| **Other Sectors** | **0.0442** | **0.0487** |
| **NOx** | **18.2624** | **19.7370** |
| **Energy Industries** | **3.1825** | **4.306** |
| **Manufacturing industries/Construction** | **1.2921** | **1.342** |

| Greenhouse Gas (Gg) / Subcategory | 2011 | 2012 |
|---|---|---|
| **Transportation** | 11.9542 | 12.293 |
| **Other Sectors** | 1.8335 | 1.796 |
| **<u>CO</u>** | **<u>56.8769</u>** | **<u>46.1540</u>** |
| **Energy Industries** | 0.4243 | 0.574 |
| **Manufacturing industries/Construction** | 0.2575 | 0.267 |
| **Transportation** | 54.7769 | 43.971 |
| **Other Sectors** | 1.4181 | 1.342 |
| **<u>NMVOC</u>** | **<u>9.7301</u>** | **<u>7.6220</u>** |
| **Energy Industries** | 0.1061 | 0.144 |
| **Manufacturing industries/Construction** | 0.0430 | 0.045 |
| **Transportation** | 9.4218 | 7.281 |
| **Other Sectors** | 0.1592 | 0.153 |
| **<u>$SO_2$</u>** | **<u>0.2127</u>** | **<u>0.2130</u>** |
| **Energy Industries** | 0.0000 | 0.000 |
| **Manufacturing industries/Construction** | 0.0000 | 0.000 |
| **Transportation** | 0.0584 | 0.058 |
| **Other Sectors** | 0.1543 | 0.154 |

Table 4.1.12 provides total emissions of $CO_2$, $CH_4$ and $N_2O$ as well as their total expressed in $CO_2$ equivalent.

**Table 4.1.12 $CO_2$, $CH_4$ and $N_2O$ emissions and their summary for 2011, 2012, $CO_{2\ eq.}$**

| Greenhouse Gas, Gg | 2011 | 2012 |
|---|---|---|
| **$CO_2$** | 4,798.8 | 5,295.6 |
| **$CH_4$** | 4.92 | 4.47 |
| **$N_2O$** | 0.116 | 0.108 |
| **Total $CO_{2\ eq.}$** | 4,937.9 | 5,423.0 |

### 4.1.10.2 *Emissions from International Bunkers*

According to 2006 IPCC [Gen-1] emissions from international bunkers are not included in total national GHG emissions, however, information on such emissions is reported in National inventory separately as memo item.

Calculations are made on the basis of information on consumed fuel provided by RA General Department of Civil Aviation RA [EnRef-4]. Table 4.1.13 describes GHG emissions form international aviation (bunker) by gases for 2011 and 2012.

**Table 4.1.13 GHG emissions from international bunkers**

| Years | 2011 | 2012 |
|---|---|---|
| ***Consumption, TJ*** | ***1,748.4768*** | ***1,784.8593*** |
| **Emissions, Gg** | | |
| **$CO_2$** | 125.0 | 127.6 |
| **$CH_4$** | 0.001 | 0.001 |
| **$N_2O$** | 0.0035 | 0.0036 |
| ***$CO_{2\ eq.}$*** | **126.11** | **128.74** |
| **NOx** | 0.5691 | 0.6101 |
| **CO** | 0.1897 | 0.2034 |
| **NMVOC** | 0.0948 | 0.1017 |
| **$SO_2$** | 0.0425 | 0.0456 |

International Water-Borne Navigation does not exist within the country.

### 4.1.10.3 *Emissions from Biomass*

According to 2006 IPCC Guidelines [Gen-1], emissions from combustion of biofuels are reported as information items but not included in the sectoral or national totals to avoid double counting. For biomass, only that part of the biomass that is combusted for energy purposes should be estimated for inclusion as an information item in the Energy sector. Table 4.1.14 summarizes fuel wood and manure consumption quantities and $CO_2$ emissions from burning, while Figure 4.1.9 describes the same in graphical form.

**Table 4.1.14 GHG emissions from biomass burning**

| Year | 2011 | 2012 |
|---|---|---|
| | **Biomass consumption, TJ** | |
| **Firewood** | 571.23 | 746.92 |
| **Manure** | 5,520.0 | 6,084.9 |
| **Total** | 6,091.3 | 6,831.8 |
| **$CO_2$ emissions from biomass, Gg** | | |
| **Firewood** | 64.0 | 83.7 |
| **Manure** | 552.0 | 608.5 |
| **Total** | 616.0 | 692.2 |

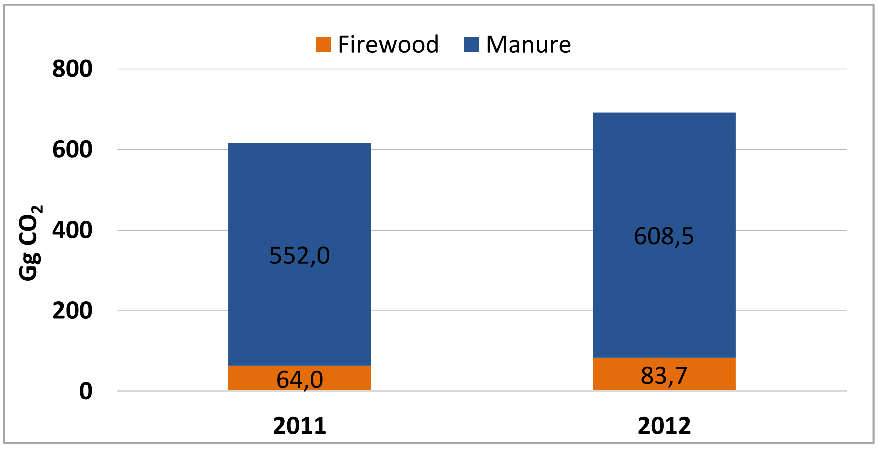


*Figure 4.1.9 $CO_2$ emissions from biomass burning, Gg*

### *4.1.10.4 Fugitive emissions from natural gas system*

Methane fugitive emissions in Armenia occur from operation of natural gas system (accidental leakage, emissions as a result of maintenance works, technological losses). According to official data natural gas losses in transmission and distribution systems accounted for 6.5% and 5.7% in 2011 and 2012 respectively [EnRef-5, EnRef-6, Annex 4].

Fugitive emissions were estimated for:

*1B2biii4 Transmission and Storage* category which includes fugitive emissions related to the transmission and storage of natural gas.

*1 B2b iii 5 Distribution* category which includes fugitive emissions from the distribution of natural gas to end users.

Methane fugitive emissions were estimated by Tier 2 Approach applying country-specific emission factors for fugitive emissions from natural gas transmission (including storage) and distribution system (see Table 4.1.3).

It should be noted that methane fugitive emissions values that have been assessed by using country-specific emission factors are very close to those which are calculated based on the value of losses reported in "Gazprom Armenia" CJSC natural gas balances.

At the mean time methane fugitive emissions values that have been calculated by using country-specific emission factors are very close to those which are obtained using methane emission factors provided for former USSR countries in 1996 IPCC Guidelines (Tier 1 Approach), while they are significantly differ from those that estimated by using methane emission factors specified for developing countries in 2006 IPCC Guidelines [Gen-1].

Table 4.1.15below provides comparison of methane fugitive emissions values.

**Table 4.1.15 Comparison of methane fugitive emissions assessed by using 1996 IPCC Guidelines and country-specific emission factors**

| Year | Gas supply system | Methane fugitive emissions (Gg) | | | | | Uncertainty: difference (%) | |
|---|---|---|---|---|---|---|---|---|
| | | Actual | | By 1996 IPCC Guidelines | By country-specific factors | | Actual | from 1996 IPCC |
| 2011 | Transmission system | 62.56 | 89.61 | 62.84 | 47.46 | 71.43 | 25.5% | 12.0% |
| | Distribution system | 27.05 | | | 23.97 | | | |
| 2012 | Transmission system | 66.57 | 92.90 | 72.01 | 48.61 | 71.71 | 29.5% | 0.4% |
| | Distribution system | 26.33 | | | 23.11 | | | |

The comparison of methane fugitive emission values indicates that emission factors for former USSR countries specified by 1996 IPCC Guidelines are better reflect the real situation of gas supply systems in these countries unlike the factors specified by IPCC 2006 [Gen-1] Guidelines for developing countries.

## *4.1.11 Analysis of Time Series*

### *4.1.11.1 Methane Fugitive Emissions*

To ensure consistency of time series methane fugitive emissions from natural gas systems for 2000-2012 were recalculated by applying country-specific emission factors.

Figure 4.1.10 provides methane fugitive emissions time series for 2000-2012.

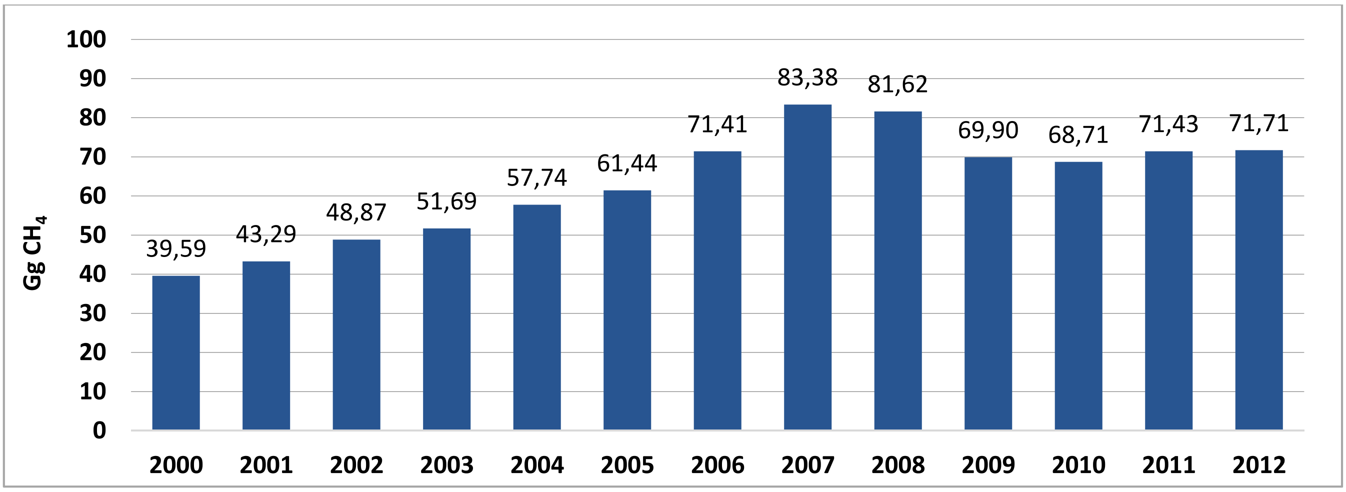


*Figure 4.1.10 $CH_4$ fugitive emissions from natural gas systems for 2000-2012*

Figure 4.1.10 shows that there was a gradual increase in methane fugitive emissions until year 2007 conditioned by the increase of natural gas imports.

The greater values of emissions are reported in 2007 and 2008 because of an unprecedented expansion of gas distribution system in Armenia in these years.

Reduction in gas consumption in 2009-2010 due to global crisis resulted in reduced import of natural gas and in fugitive emissions respectively, while increase in natural gas imports and fugitive emissions respectively in 2011 and 2012 is conditioned by increase of thermal power plants generation.

### *4.1.11.2 $CO_2$ emissions*

For matching data structure of natural gas consumption in "Gazprom Armenia" annual balance sheets with IPCC classification the "Budget funded organization" and "Other consumers" rows in balance sheets are included in Commercial/Institutional subcategory and $CO_2$ emissions time series were afterwards recalculated by applying national emission factors.

**Table 4.1.16 "Energy" sector $CO_2$ emissions time series from fuel combustion for 2000-2012, Gg**

| Subcategory/ Year | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Total** | 3,120.5 | 3,314.8 | 2,679.4 | 3,017.2 | 3,410.1 | 3,936.7 | 3,995.2 | 4,528.9 | 5,028.0 | 4,469.0 | 4,287.1 | 4,798.8 | 5,296.5 |
| **Energy Industries** | 1,703.6 | 1,727.2 | 1,002.6 | 995.0 | 1,036.7 | 1,184.0 | 977.3 | 972.4 | 1,162.3 | 939.9 | 840.9 | 1,074.7 | 1,616.3 |
| **Manufacturing industries/Constr.** | 452.7 | 372.6 | 394.7 | 424.2 | 556.3 | 700.6 | 694.3 | 774.3 | 705.1 | 514.9 | 541.0 | 637.4 | 620.1 |
| **Road Transportation** | 643.0 | 592.4 | 678.2 | 763.8 | 817.3 | 849.2 | 944.8 | 1,071.9 | 1,262.2 | 1,164.4 | 1,213.8 | 1,217.2 | 1,241.7 |
| **Other Sectors, including:** | 321.1 | 622.7 | 604.0 | 834.3 | 999.8 | 1,202.8 | 1,378.8 | 1,709.7 | 1,898.4 | 1,849.8 | 1,691.3 | 1,869.5 | 1,817.4 |
| ***Commercial/ Institutional*** | *40.4* | *92.1* | *86.3* | *143.7* | *154.9* | *172.1* | *204.7* | *270.4* | *324.8* | *348.9* | *311.4* | *361.4* | *296.1* |
| ***Residential*** | *198.9* | *211.7* | *202.2* | *340.9* | *477.6* | *648.0* | *808.9* | *1,053.0* | *1,152.9* | *1,115.2* | *956.1* | *1,105.1* | *1,082.8* |
| ***Agriculture*** | *81.9* | *319.0* | *315.5* | *349.7* | *367.3* | *382.7* | *365.2* | *386.3* | *420.7* | *385.7* | *423.8* | *403.0* | *438.5* |
| **Memo items** | | | | | | | | | | | | | |
| ***International aviation*** | *90.5* | *121* | *117.9* | *94.8* | *110* | *111.7* | *115.8* | *178.1* | *176* | *92.6* | *136.2* | *125* | *127.6* |
| ***Biomass*** | *731,1* | *732,4* | *716,8* | *703,0* | *679,7* | *655,3* | *613,7* | *439,4* | *432,0* | *422,7* | *586,4* | *616,0* | *692,2* |

Figure 4.1.11 provides 2000-2010 time series of total $CO_2$ emissions from fuel combustion and their structure by subcategories. Emissions for Energy Industries are producing by Electricity and Heat Production sub-category and in previous inventories emissions time series were not provided separately for Electricity Generation and Combined Heat and Power Generation sub-categories. However this matter does not affect the emissions data series values reported in the inventories.

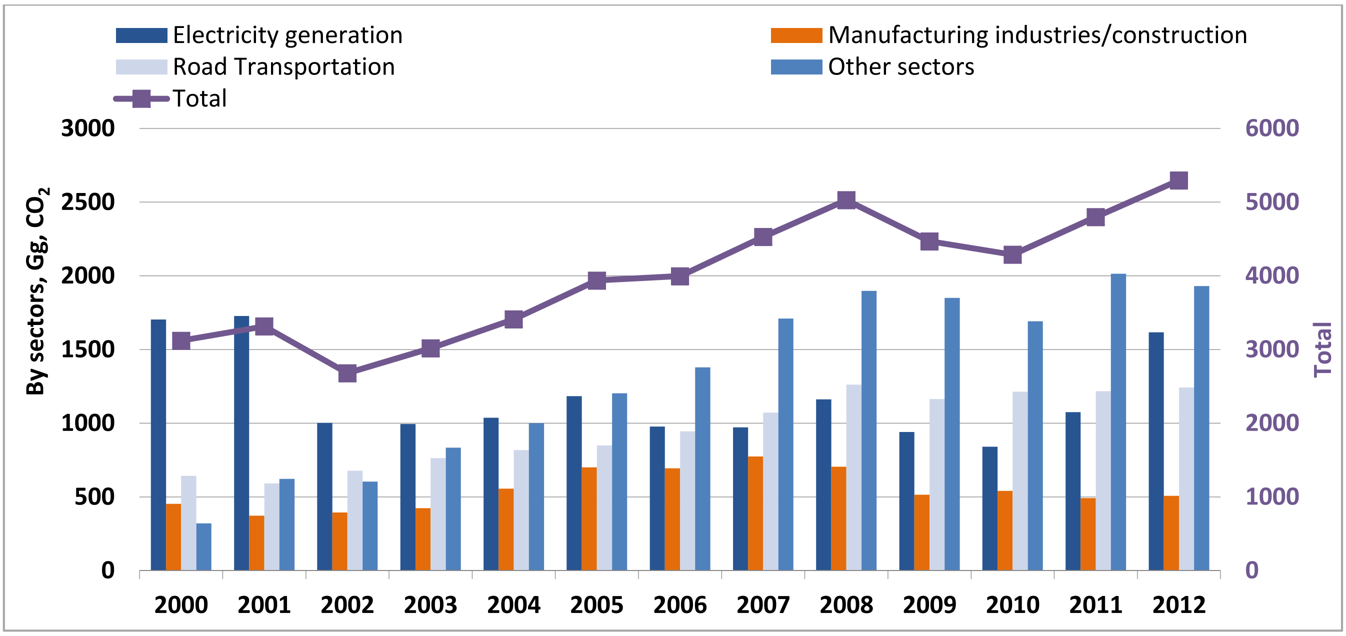


*Figure 4.1.11 $CO_2$ emissions time series*

As it comes from the figure 4.1.11 a significant increase of $CO_2$ emissions was reported in 2007 and 2008 which was mainly due to an unprecedented expansion of gas distribution system in these years resulting in dramatic increase in natural gas consumption particularly by households.

Significant increase in $CO_2$ emissions in 2011 and 2012 compared with 2010 was due to increase in power generation by thermal power plants: it amounted to 3398 million kWh in 2012, while in 2010 it was 1443 million kWh or growth was 135%. Such sharp growth was conditioned by fulfilment of the contractual obligations under Iran-Armenia Electricity-for-Gas Swap Agreement (1.58 billion kWh electricity export to Iran).

### *4.1.12 "Energy" Sector GHG Emissions Consolidated Table*

The consolidated table below provides emissions from "Energy" sector by categories estimated by using "2006 IPCC Software for National Greenhouse Gas Inventories" software.

**Table 4.1.17 Energy sector GHG emissions consolidated table, 2012**

| 2012 | Emissions (Gg) | | | | | | |
|---|---|---|---|---|---|---|---|
| Categories | $CO_2$ | $CH_4$ | $N_2O$ | NOx | CO | NMVOCs | $SO_2$ |
| **1 - Energy** | 5,296.501 | 75.484 | 0.100 | 19.737 | 46.154 | 7.623 | 0.212 |
| **1.A - Fuel Combustion Activities** | 5,295.567 | 3.771 | 0.100 | 19.737 | 46.154 | 7.623 | 0.212 |
| 1.A.1 - Energy Industries | 1,616.277 | 0.028 | 0.003 | 4.306 | 0.574 | 0.144 | NE |
| 1.A.2 - Manufacturing Industries and Construction | 620.143 | 0.011 | 0.001 | 1.342 | 0.267 | 0.045 | NE |
| 1.A.3 - Transportation | 1,241.732 | 1.473 | 0.063 | 12.293 | 43.971 | 7.281 | 0.058 |
| 1.A.4 - Other Sectors | 1,817.414 | 2.259 | 0.033 | 1.796 | 1.342 | 0.153 | 0.154 |
| 1.A.5 - Non-Specified | | | | NO | NO | NO | NO |
| **1.B - Fugitive emissions from fuels** | 0.934 | 71.713 | NA, NO | NA, NO | NA, NO | NA, NO | NA, NO |
| 1.B.1 - Solid Fuels | NO | NO | NO | NO | NO | NO | NO |
| 1.B.2 - Oil and Natural Gas | 0.934 | 71.713 | NA | NA | NA | NA | NA |
| 1.B.3 - Other emissions from Energy Generation | | | | NO | NO | NO | NO |
| **1.C - Carbon dioxide Transport and Storage** | NO | | | NO | NO | NO | NO |
| 1.C.1 - Transport of $CO_2$ | NO | | | NO | NO | NO | NO |
| 1.C.2 - Injection and Storage | NO | | | NO | NO | NO | NO |
| 1.C.3 - Other | NO | | | NO | NO | NO | NO |
| **Memo Items (3)** | | | | | | | |
| International Bunkers | 127.617 | 0.0009 | 0.004 | 0.610 | 0.203 | 0.1017 | 0.046 |
| 1.A.3.a.i - International Aviation (International Bunkers) (1) | 127.617 | 0.0009 | 0.004 | 0.610 | 0.203 | 0.1017 | 0.046 |
| 1.A.3.d.i - International water-borne navigation (International bunkers) (1) | | | | | | | |
| 1.A.5.c - Multilateral Operations (1)(2) | | | | NO | NO | NO | NO |

## 4.2 Industrial Processes and Product Use

### 4.2.1 Description of the Sector

"Industrial Processes and Product Use" (IPPU) sector of the National GHG Inventory of Armenia includes the following emission source subcategories:

- Mineral Industry (2A), which considers:
  - Cement production (2A1),
- Metal Industry (2C), which considers
  - Ferroalloys Production (2C2),
  - Copper Production (2C7),
- Non-energy Products from Fuels and Solvent Use (2D), which considers
  - Solvents Use (2D3) ,
  - Bitumen/asphalt Production and use (2D4),
- Product uses as Substitutes for Ozone Depleting Substances (2F),
- Other (2H), which considers
  - Food and Beverages Industry (2H2).

All other sources indicated in 2006 IPCC Guidelines [Gen-1] for IPPU sector do not exist in Armenia and are not considered in this Inventory with the exception of Glass Production (2A3) and Lubricant Use (2D1) subcategories that exist but not considered due to lack of data.

Greenhouse gases from fuel combustion are not included here either. They are considered in "Energy" sector.

There are no such industries in Armenia where it is difficult to separate emissions from fuel combustion and from technological processes (e.g. iron and steel production).
Emissions from this sector come from:

Mineral Industry (cement production) - 277.9 Gg $CO_2$,
Product uses as Substitutes for Ozone Depleting Substances - 384.58 Gg $CO_{2eq.}$ hydro fluorinated carbons.

In this sector there are also gases with indirect impact, i.e. non-methane volatile organic compounds and sulfurous gas. Their volumes are described in the respective Subsectors.

### 4.2.2 Key Categories

For this sector, cement production (2A1) and refrigeration and air-conditioning (2F1) are key source categories of greenhouse gas (carbon dioxide and HFCs respectively) emissions in Armenia. Emissions of carbon dioxide from cement production account for country's 2.98% of GHG emissions in $CO_{2\ eq.}$, and refrigeration and air-conditioning generate 4.13% of HFCs emissions.

### 4.2.3 Cement Production

Mineral Industry in Armenia is presented by the cement production. In Armenia cement is produced by two plants: "Mika-Cement" CJSC and "Araratcement" CJSC.

#### 4.2.3.1 Choice of Calculation Methodology

Cement production is one of the key source categories of GHG emissions. Given this fact, carbon dioxide emissions from cement production were calculated by applying Tier 3 Approach provided in 2006 IPCC Guidelines [Gen-1] contrary to the Third National Inventory, where the calculations were done by Tier 2 Approach and Tier 3 Approach was applied for cross checking and comparison of results.

Tier 3 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.
Emissions are then calculated using Equation 2.3(Volume 3, Chapter 2) of 2006 IPCC Guidelines [Gen-1]. The Tier 3 approach includes an adjustment to subtract any uncalcined carbonate within cement kiln dust (CKD) not returned to the kiln. If the CKD is fully calcined, or all of it is returned to the kiln, this CKD correction factor becomes zero. Tier 3 is still considered to be good practice in instances where inventory compilers do not have access to data on uncalcined CKD. However, excluding uncalcined CKD may slightly overestimate emissions.

### *4.2.3.2 Calculation of $CO_2$emissions*

Emissions based on carbonate raw material inputs to the kiln(Equation 2.3, Volume 3, Chapter 2 of 2006 IPCC Guidelines):

$$CO_2 = \Sigma(EF_1 \bullet M_1 \bullet F_1) - M_d \bullet C_d \bullet (1 - F_d) \bullet EF_d + \Sigma(M_k \bullet X_k \bullet EF_k)$$

$CO_2$ Emissions = emissions of CO2 from cement production, tons
EFi = emission factor for the particular carbonate *i*, ton CO2/ton carbonate (see Table 2.1 Volume 3, Chapter 2 of [Gen-1])
Mi = weight or mass of carbonate *I* consumed in the kiln, tons
Fi = fraction calcination achieved for carbonate *i*, fraction[2]
Md = weight or mass of CKD not recycled to the kiln (= 'lost' CKD), tons
Cd = weight fraction of original carbonate in the CKD not recycled to the kiln, fraction[3]
Fd = fraction calcination achieved for CKD not recycled to kiln, fraction[(2)]
EFd = emission factor for the uncalcined carbonate in CKD not recycled to the kiln, tons $CO_2$/tons carbonate[(3)]
Mk = weight or mass of organic or other carbon-bearing nonfuel raw material *k*, tons[4]
Xk = fraction of total organic or other carbon in specific nonfuel raw material *k*, fraction[(4)]
EFk = emission factor for kerogen (or other carbon)-bearing nonfuel raw material *k*, tons CO2/tons carbonate[(4)]

### *4.2.3.3 Activity Data*

A questionnaire for entry data has been developed and sent to managers of "Araratcement" CJSC and "Mika-Cement" CJSC. The calculations were done on the data received as response letters.

Data on cement production, quantity and composition of raw materials used by, as well as on emissions from "Araratcement" CJSC and "Mika-Cement" CJSC plants are described below:

**a."Araratcement" CJSC[**IndRef-1**]**

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[2]Calcination fraction: In the absence of actual data, it may be assumed that, at the temperatures and residence times achieved in cement (clinker) kilns, the degree of calcination achieved for all material incorporated in the clinker is 100 percent (i.e., $F_i$ = 1.00) or very close to it. For CKD, a $F_d$ of <1.00 is more likely but the data may show high variability and relatively low reliability. In the absence of reliable data for CKD, an assumption of $F_d$= 1.00 will result in the correction for CKD to equal zero.

[3]Because calcium carbonate is overwhelmingly the dominant carbonate in the raw materials, it may be assumed that it makes up 100 percent of the carbonate remaining in the CKD not recycled to the kiln. It is thus acceptable within *good practice* to set $C_d$ as equal to the calcium carbonate ratio in the raw material feed to the kiln. Likewise, it is acceptable to use the emission factor for calcium carbonate for$EF_d$.

[4]The $CO_2$ emissions from non-carbonate carbon (e.g., carbon in kerogen, carbon in fly ash) in the nonfuel raw materials can be ignored (set $M_k \bullet X_k \bullet EF_k$= 0) if the heat contribution from kerogen or other carbon is < 5 percent of total heat (from fuels).

**Table 4.2.1 Annual Production and Quantity of Main Row Materials, thousand ton**

| Year | Annual production | | Quantity of main raw materials | |
|---|---|---|---|---|
| | Cement | Clinker | Clay | Lime |
| 2011 | 328.63 | 270.36 | 175.60 | 574.28 |
| 2012 | 377.60 | 312.12 | 189.38 | 639.68 |

*Quantity of captured dust in 2011- 83064 t/year, 2012- 95893 t/year, Dust recovery system efficiency -99.7%, Quantity of dust emission (loss) 2011 - 249.2 ton, 2012 - 287.7 ton*

**Table 4.2.2 Chemical composition of main row materials, %**

| Chemical component | Raw material | |
|---|---|---|
| | Clay | Lime |
| $SiO_2$ | 33.9 | 5.3 |
| $Al_2O_3$ | 14.2 | 3.62 |
| $Fe_2O_3$ | 3.4 | 1.75 |
| CaO | 14.81 | 46.95 |
| MgO | 3.1 | 1.29 |
| $SO_3$ | 0.12 | 0.93 |

### d. "Mika-Cement" CJSC [IndRef-2]

**Table 4.2.3 Chemical composition of main row materials, %**

| Chemical component | Lime | Slag, containing iron | Clay | Pearlite |
|---|---|---|---|---|
| CaO | 45.42 | 3.76 | 5.64 | 4.05 |
| $SiO_2$ | 9.54 | 29.87 | 57.32 | 69.8 |
| $Al_2O_3$ | 4.08 | 8.42 | 19.60 | 13.01 |
| $Fe_2O_3$ | 1.01 | 56.1 | 6.68 | 1.90 |
| MgO | 0.81 | 1.23 | 1.51 | 0.30 |
| $SO_3$ | 0.08 | - | 0.52 | 0.12 |

**Table 4.2.4 Annual Production and Quantity of Main Row Materials, thousand ton**

| Year | Annual Production | | Quantity of main row materials | | | |
|---|---|---|---|---|---|---|
| | Cement | Clinker | Clay | Lime | Slag | Pearlite |
| 2011 | 93.6 | 69.6 | 13.4 | 158.6 | 6.38 | 8.57 |
| 2012 | 59.98 | 61.1 | 9.2 | 98.60 | 4.70 | 6.23 |

*Annual average of captured dust in 20110-15636 t/year, in 2012 - 5310 t/year, Dust recovery system efficiency in 2011- 97.4, in 2012 - 97.0 %:, Quantity of emissioned dust (losses) in 2011 - 423.0 ton, in 2012 - 159.0 ton*

### *4.2.3.4 Calculation of carbon dioxide emissions*

The presented data can be directly inserted into the formula, however many of them need recalculation or to be used with some reservation.

As we can see from the formula the quantity of used carbonate will be necessary for calculations. Data presented by plants show CaO (Lime) content in main raw materials.

Given that 80-90% of lime in raw materials is carbonated the calculations are made on carbonate basis.

As data from "Araratcement" CJSC and "Mika-Cement" CJSC plants are presented in generic form, data on calcium oxide content are presented in certain range and the calculations have used averaged indicator.

Conversion is made by the following comparison:

$CaO$ (56) ⟶ $CaCO_3$ (100)

Below is an example of calculation of carbonate for “Araratcement” by using 2011 data:

Clay - 175595.8 ton,

Content of calcium oxide - 46.95 %, or 574237.7 x 0.4695= 269604 ton,

Lime - 574237.7 ton,

Content of calcium oxide –46.95 %, or 574237.7 x 0.4695 = 269604 ton,

Total calcium oxide –26005.7 + 269604 = 295610 t/year,

Calculated carbonate - 295610 x 100/56 = 527875 t/year.

**Table 4.2.5 Calculated carbonate for “Araratcement” CJSC, ton**

| Year | Total carbonate |
|---|---|
| 2011 | 527875 |
| 2012 | 586387 |

For the case of “Mika-Cement” CJSC 4 materials are presented as lime containing raw material. Annual quantity of calcium oxide by years was calculated based on the quantity of said materials and the content of calcium oxide and the results are described in Table 4.2.6.

**Table 4.2.6 Calculated carbonate for “Mika-Cement” CJSC, ton**

| Year | Total carbonate |
|---|---|
| 2011 | 131075.0 |
| 2012 | 81684.0 |

Carbon dioxide emission for 2011 and corresponding activity data are described in Table 4.2.7.

**Table 4.2.7 Activity Data for Calculation of carbon dioxide emissions and Results of Calculation, 2011**

| Indicators | “Araratcement” CJSC | “Mika-Cement” CJSC |
|---|---|---|
| EFi ($tCO_2$/t carbonate) | 0.4397 | 0.4397 |
| Mi (t) | 527,875 | 73,361 |
| Fi (degree) | 1 | 1 |
| $M_d$ (t) | 287.7 | 159.0 |
| $C_d$ (fraction) | 1 | 1 |
| $F_d$ (fraction) | 1 | 1 |
| $EF_d$ (t $CO_2$/t carbonate[2]) | 0.44 | 0.44 |
| $M_κ$ (t) | 0 | 0 |
| $X_κ$ (fraction) | 0 | 0 |
| $EF_k$ (t $C0_2$/t carbonate) | 0 | 0 |
| $CO_2$ (t) | 232,106 | 32,257 |

### *4.2.3.5 Time Series*

$CO_2$ annual emissions from cement production of the both factories are calculated by the Equation provided in 4.2.3.1 subsection. The calculation results are given below in Table 4.2.8.

**Table 4.2.8 Emissions of carbon dioxide from "Araratcement" and "Mika-Cement" CJSC, Gg/year**

| Year | "Araratcement" CJSC | "Mika-Cement" CJSC | Total |
|---|---|---|---|
| 2011 | 232.1 | 32.2 | 264.3 |
| 2012 | 257.8 | 20.1 | 277.9 |

For ensuring the consistency of time series from cement production the results for 2000-2010 were recalculated applying Tier 3 Approach. Activity data for 2006-2010 were taken from the Third National Communication.

Carbon dioxide emissions from cement production for 2000-2012 are given below in Table 4.2.9 and Figure 4.2.1

**Table 4.2.9 Emissions of Carbon Dioxide**

| Year | Carbon dioxide emissions from cement production (Tier III), Gg |
|---|---|
| 2000 | 138.85 |
| 2001 | 143.50 |
| 2002 | 211.36 |
| 2003 | 220.25 |
| 2004 | 298.33 |
| 2005 | 331.11 |
| 2006 | 338.21 |
| 2007 | 406.85 |
| 2008 | 412.21 |
| 2009 | 240.33 |
| 2010 | 288.40 |
| 2011 | 264.30 |
| 2012 | 277.90 |

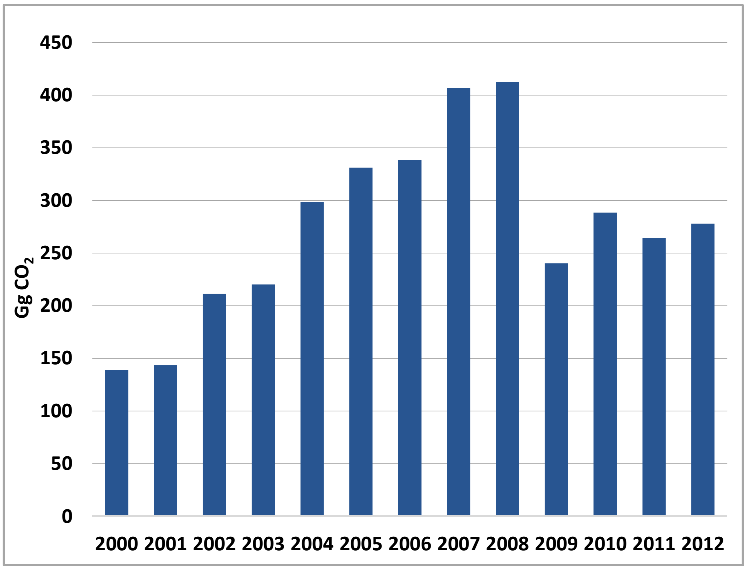



*Figure 4.2.1 Emissions of Carbon Dioxide*

After the decline of $CO_2$emissions from cement production in 2009 because of the economic crises, which resulted in the decrease of construction volumes and, thus, cement production, in 2010 the construction volumes and cement production increased to a certain degree resulted in the increase of $CO_2$ emissions.

### 4.2.4 *Calculation of Sulphur Dioxide Emission Factors for Nonferrous Metallurgy Production*

Main outputs from metal mining in RA are metal concentrates (except gold mining).

A certain part of concentrate is exported. A part of copper concentrate is processed at Alaverdi copper smeltery and molybdenum concentrate is practically fully used in Armenia for ferromolybdenum production.

2006 IPCC Guidelines recommends assessing emissions of gases with indirect greenhouse effect using EMEP/EEA Guidebook, however the Guidebook doesn't provide the methodology for emission calculation from copper and ferromolybdenum production.
Therefore, the calculation of emissions from copper and ferromolybdenum production was done on the basis of production technology and chemical composition of raw materials.
Using the 2006 IPCC Guidelines logics/approaches, calculation methods are equivalent to the Tier 3 Approach.

### *4.2.4.1 Copper Production*

The only manufacturer of primary copper in Armenia is Alaverdi copper smeltery of "Armenia Copper Program" CJSC. The plant uses copper concentrate as a raw material. As a result of thermal treating sulphur content bound in the concentrate is fully transformed into sulphur dioxide. During the process about 4 % of sulphur remains in slag.

Emissions of sulphur dioxide are calculated in following way:

$E_{SO2} = \Sigma [(B_{conc1} \times P_{S1}) + (B_{conc\,2} \times P_{S\,2}) + \dots + (B_{concn} \times P_{sn})] \times 0.96 \times 2$, where:
$E_{SO2}$ - annual emissions of sulphur dioxide, t/year
$Q_{coni}$ - sulphur content in concentrate (analysis), ton
$P_{sul}$ - sulphur content in concentrate, share (%).

Given that the slag retains 4% of sulphur, sulphur dioxide released from the rest of sulphur is emitted and respectively the emission factor is accepted as 0.96x2=1.92, where 2 is the factor of transformation of concentrate sulphur into sulphur dioxide.

Sulphur dioxide emission factor is equal to:
$K_{so_2} = P_{s\,ave} \times 0.96 \times 2$, where

For 2011
$K_{so2} = P_{sul.aver} \times 0.96 \times 2 = 32.29 \times 0.96 \times 2 = 0.62$

For 2012
$K_{so2} = 33.1 \times 0.96 \times 2 = 0.636$
The annual amount of sulphur dioxide is equal to:

$U_{SO2} = Q_{con.annual} \times K_{so2}$where
$Q_{con.annual}$ - is the annual quantity of concentrate used for copper production

The annual quantity of concentrate used for copper production is estimated based on the data on quantity of annual production of copper.
Table 4.2.10 below provides annual quantities of produced copper, copper concentrate used for production and sulphur dioxide emissions for 2011-2012.

**Table 4.2.10 Annual quantities of produced copper, used copper concentrate, and sulphur dioxide emissions**

| Year | Quantity of copper, t[5] | Quantity of copper concentrate, t[6] | Annual emissions of sulphur dioxide, t |
|---|---|---|---|
| 2011 | 8,876 | 46,715.8 | 28,963.8 |
| 2012 | 10,075 | 45,795.5 | 29,125.9 |

Sulphur dioxide emissions are emitted into the atmosphere without cleaning.

It should also be noted that the emissions calculated by the method above does not depend on the availability of cleaning.

### *4.2.4.2 Ferromolybdenum Production*

In Armenia ferromolybdenum is produced by 4 plants:

- "Maqur Yerkat Plant" OJSC
- "Armenian Molybdenum Production" LLC
- "Hoktemberyan Ferroalloy Plant" LLC
- "Alapmet" CJSC

[5] RA NSS
[6] RA NSS

However, the last two factories don’t operate regularly because of the modification and upgrades.

Sulphur dioxide is released from roasting of molybdenum concentrate. Activity data uncertainties are caused by the following reasons:

- The composition of molybdenum concentrate varies in different consignments,
- Technological equipment and technological parameters vary from plant to plant respectively,
- There is significant difference in gas-cleaning levels and effectiveness of these plants.

Based on the analysis of the available data (“Armenian Molybdenum Production” LLC and “Armenian Molybdenum Production” Environmental Assessment Reports) the average sulphur content is 33 – 37%, (in average 0.35).

Oxidization process of molybdenum concentrate is described by the following equation:

$$MoS_2 + 3.5\ O_2 = MoO_3 + 2SO_2 + 228.5\ kcal$$

According to the above mentioned Environmental Assessment Report the residual content of sulphur in ferromolybdenum is 0.1% - which can be ignored, and sulphur in slag is 2-3%, or 2.5% in average. Thus 97.5% of total sulphur is oxygenized.

As the mass of sulphur dioxide is two times more than sulphur mass, hence emission factor will be:

$$K_{so2} = 0.35 \times 0.975 \times 2 = 0.6825$$

As all molybdenum concentrate produced in Armenia is practically used for production of ferromolybdenum, thus sulphur dioxide emissions were calculated using as activity data all quantity of molybdenum concentrate production in the country.

Sulphur dioxide annual emissions are provided in Table 4.2.11.

**Table 4.2.11 Sulphur dioxide emissions, 2011 and 2012**

| Year | Quantity of molybdenum concentrate[7], t | Sulphur dioxide emission, t |
|---|---|---|
| 2011 | 9,455 | 6,455.9 |
| 2012 | 10,677 | 7,290.3 |

Similar to copper case, the quantity of $SO_2$ emissions from ferromolybdenum production depends on the efficiency of gas-cleaning system. The level of cleaning at mentioned plants varies from 72 to 88%. The level of cleaning has no effect on emission factor but it has significant effect on the quantity of final emissions.

### *4.2.5 Non-methane Volatile Organic Compounds (NMVOCs) Calculations*

#### *4.2.5.1 Asphalt Pavement*

##### *4.2.5.1.1 Description of Source Category*

Bitumen is melted for preparation of asphalt mixture which is then shipped to road construction or repair sites and spread on the road surface in hot state. NMVOC emissions occur during these processes.

##### *4.2.5.1.2 Methodological Issues*

Emission factors for NMVOCs are taken from EMEP/EEA Air Pollutant Emission Inventory Guidebook 2013, SNAP 040611[Gen-2].Activity data are taken from RA NSS Yearbooks [Ref-3].

[7] RA NSS

The calculation was made applying Tier 1 Approach considering that it is not key source category as well as insufficient data for applying Tier 2 Approach.

$E_{pollutant} = AP_{production} \times EF_{pollutant}$, where

$E_{pollutant}$ - annual quantity of emitted substance (NMVOC), ton

$AP_{production}$ - the quantity of used bitumen-asphalt mixture, ton

$EF_{pollutant}$- default emission factor for NMVOC, 16 g/ton asphalt ([Gen-2],table 3.1)

#### 4.2.5.1.3 Activity Data Uncertainties

- In most cases asphalt plants in Armenia operate in case of orders. The majority of them do not submit statistical or environmental administrative reports. For that reason all asphalt plants are considered as one source - "Asphalt pavement" and emissions are calculated on the basis of quantity of used asphalt (the area of asphalt cover).
- As there is no accurate information on either composition of asphalt mixture or on bitumen content we have used the design data from "Dorozhnik" LLC and "Sisian Asphalt" plants.
- There are no true data on use of imported bitumen. In general, bitumen can be used for asphalt production or for waterproofing. Given the fact that the quantity of bitumen used in asphalt production significantly exceeds the quantity used for other purposes then calculations were based on the total quantity of the imported bitumen.

#### 4.2.5.1.4 Calculation of NMVOCs Emission during Asphalting Works

Table 4.2.12 provides the quantities of imported bitumen, asphalt mixture made from it and NMVOCs emissions calculated by using the formula from Subsection 4.2.5.1.2. Emission factor for NMVOCs from bitumen is 64 g/t bitumen or 16 g/t asphalt mixture as according to Environmental Assessment report from "Dorozhnik" LLC Plant bitumen content may reach up to 25%.

**Table 4.2.12 NMVOCs Emissions from the Use of Bitumen**

| Year | Quantity of bitumen imported[8], t | Estimated quantity of asphalt mixture, t | NMVOCs emission, t |
|---|---|---|---|
| 2011 | 29,605.7 | 118,422.8 | 1.90 |
| 2012 | 35,130.5 | 14,052.2 | 2.25 |

### 4.2.5.2 Food and Beverages

#### 4.2.5.2.1 Description of Source Category

NMVOCs are emitted from fermentation during cereal and fruit processing, as well as during meat, margarine, pastry production.

#### 4.2.5.2.2 Calculation of NMVOCs Emissions

The emission factors are taken from EMEP/EEA 2013Guidebook [Gen-2, Part B, 2H2, Table 3-1]. Activity data are taken from the Yearbooks of the RA NSS [Ref -3].

NMVOCs emissions from meat, margarine, bread, beer, pastry, wine and cognac production are provided in Table 4.2.13. The emission factors are taken from "Programme for monitoring and evaluation of the long-range transmission of air pollutants in Europe" Guidebook (EMEP/ EEA, 2013) [Gen-2] and makes 2 kg NMVOC for 1 ton product. Activity data are taken from the Yearbooks of the RA NSS.

[8] RA NSS

**Table 4.2.13 NMVOC Emissions from Production of Food and Alcoholic Beverages**

| Year | NMVOC emissions, t |
|---|---|
| 2011 | 817 |
| 2012 | 832 |

### *4.2.5.3 Solvent Use*

NMVOCs emissions also occur during the use of Solvents. At present IPCC Methodology does not offer recommendations on Inventory methods for emissions of gases with indirect greenhouse effect from the use of Solvents. Thus, for emission estimation we have used "Programme for monitoring and evaluation of the long-range transmission of air pollutants in Europe" [Gen-2].

Calculations for NMVOCs emitted from the use of paints are made by using emission factors (200 kg/ton of paint used), from EMEP/EEA Air Pollutant Emission Inventory Guidebook 2013 [Gen-2].

Calculations are based on information on quantity of import and export of paints, provided by the RA NSS [Ref-3]:

**Table 4.2.14 Emission of NMVOCs from Use of Paints**

| Year | Emission of NMVOCs from use of paints, t |
|---|---|
| 2011 | 3,565 |
| 2012 | 3,325 |

Emissions of NMVOCs from use of Solvents by households is calculated by [Gen-2] using the emission factor (1kg per capita) and number of population according to the data of the RA NSS.

**Table 4.2.15 Emissions of NMVOCS from Domestic Use of Solvents**

| Year | Emission of NMVOCS from domestic use of solvents, t |
|---|---|
| 2011 | 3,021 |
| 2012 | 3,026 |

## *4.2.6 Time Series of Industrial Processes and Product Use" Sector Emissions*

### *4.2.6.1 Production of Primary Copper*

**Table 4.2.16 $SO_2$ Emissions, 2006–2012**

| Year | $SO_2$ emissions, Gg |
|---|---|
| 2006 | 26.86 |
| 2007 | 21.25 |
| 2008 | 19.80 |
| 2009 | 20.95 |
| 2010 | 23.35 |
| 2011 | 28.96 |
| 2012 | 29.13 |

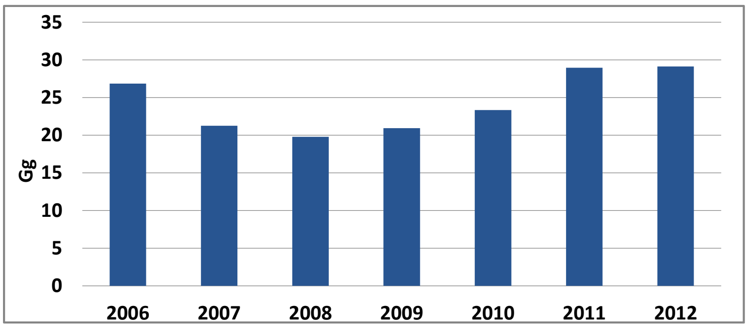



*Figure 4.2.2 Emissions of Sulphur Dioxide*

### *4.2.6.2 Ferromolybdenum production*

**Table 4.2.17 $SO_2$ Emissions, 2006–2012**

| Year | $SO_2$ emissions, Gg |
|---|---|
| 2006 | 5.47 |
| 2007 | 5.75 |
| 2008 | 5.98 |
| 2009 | 5.84 |
| 2010 | 5.86 |
| 2011 | 6.46 |
| 2012 | 7.29 |

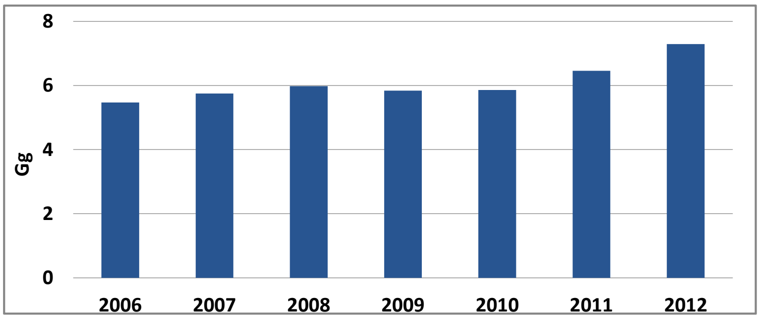



***Figure 4.2.3 Emissions of Sulphur Dioxide***

The changes of $SO_2$ emissions from cooper and ferromolybdenum production are conditioned by the amount of the concentrate available in the market.

### *4.2.6.3 Non-methane Volatile Organic Compounds*

#### *4.2.6.3.1 Asphalt Pavement*

**Table 4.2.18 NMVOC emissions from the use of Bitumen, 2006-2012**

| Year | NMVOC emissions, Gg |
|---|---|
| 2006 | 2.1 |
| 2007 | 3.4 |
| 2008 | 2.6 |
| 2009 | 2.8 |
| 2010 | 2.1 |
| 2011 | 1.9 |
| 2012 | 2.3 |

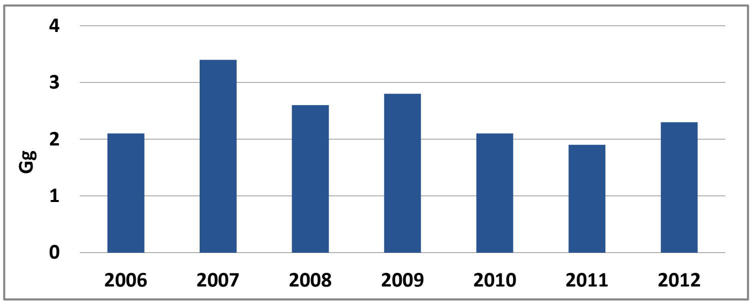



***Figure 4.2.4 NMVOC emissions from the use of Bitumen***

#### *4.2.6.3.2 Food and Beverage*

**Table 4.2.19 NMVOC emissions from food production, 2000-2012**

| Year | Emissions, Gg |
|---|---|
| 2000 | 0.722 |
| 2001 | 0.724 |
| 2002 | 0.706 |
| 2003 | 0.709 |
| 2004 | 0.730 |
| 2005 | 0.744 |
| 2006 | 0.764 |
| 2007 | 0.794 |
| 2008 | 0.775 |
| 2009 | 0.782 |
| 2010 | 0.797 |
| 2011 | 0.817 |
| 2012 | 0.832 |

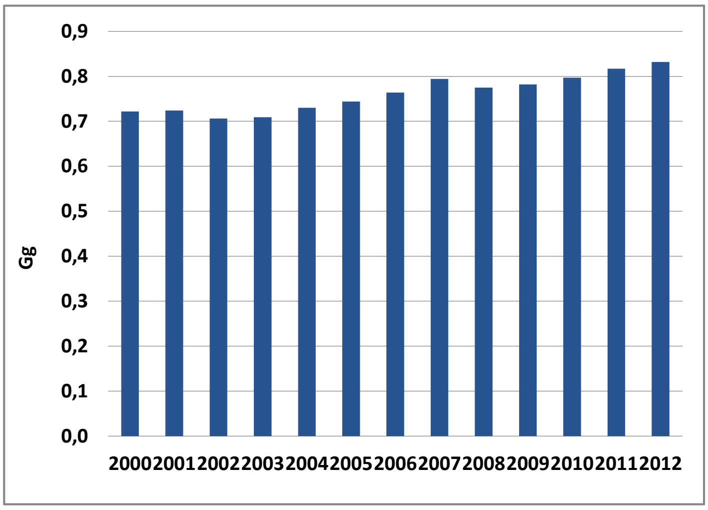



***Figure 4.2.5 NMVOC emissions from food production***

### *4.2.6.3.3 Paints use*

**Table 4.2.20 NMVOC emissions from paints use, 2000-2012**

| Year | Emissions, Gg |
|---|---|
| 2000 | 0.61 |
| 2001 | 0.875 |
| 2002 | 1.034 |
| 2003 | 1.35 |
| 2004 | 1.955 |
| 2005 | 2.547 |
| 2006 | 2.843 |
| 2007 | 2.9 |
| 2008 | 3.004 |
| 2009 | 3.13 |
| 2010 | 3.319 |
| 2011 | 3.565 |
| 2012 | 3.325 |

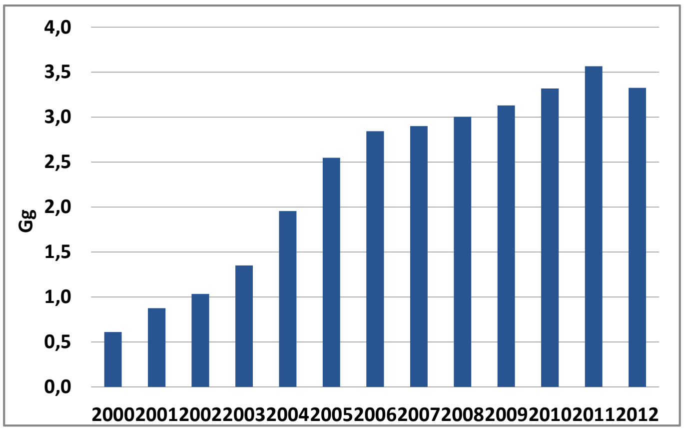



*Figure 4.2.6 NMVOC emissions from paints use*

### *4.2.6.3.4 Solvent domestic use*

**Table 4.2.21 NMVOC emissions from solvent domestic use, 2000-2012**

| Year | Emissions, Gg |
|---|---|
| 2000 | 3.227 |
| 2001 | 3.213 |
| 2002 | 3.213 |
| 2003 | 3.210 |
| 2004 | 3.212 |
| 2005 | 3.216 |
| 2006 | 3.219 |
| 2007 | 3.222 |
| 2008 | 3.230 |
| 2009 | 3.238 |
| 2010 | 3.249 |
| 2011 | 3.021 |
| 2012 | 3.026 |

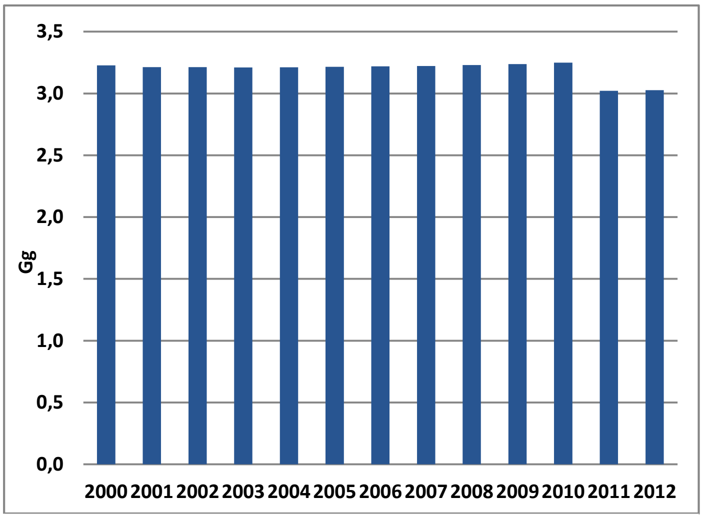



*Figure 4.2.7 NMVOC emissions from solvent domestic use*

## *4.2.7 Assessment of emissions of substitutes (F gases) for Ozone Depleting Substances (ODSs)*

### *4.2.7.1 Introduction*

The need for assessing emissions of substitutes (F gases) for ozone depleting substances is due to their high global warming potential (GWP) and long atmospheric residence times.

Emissions are estimated according to Chapter 7 “Emissions of Fluorinated Substitutes for Ozone Depleting Substances” of Volume 3 - “Industrial Processes and Product Use” of “2006 IPCC Guidelines for National Greenhouse Gas Inventories” [Gen-1].

From F gases Armenia largely uses Hydrofluorocarbons (HFCs). Perfluorocarbons (PFCs) are not used in the country. In Armenia, as well as globally, F gases are serving as alternatives to ozone depleting substances (ODS) which are being phased out under the Montreal Protocol. Armenia undertook commitments for ODS phase-out by having ratified the *Vienna Convention for the Protection of the Ozone Layer*, and the *Montreal Protocol on Substances that Deplete the Ozone Layer*.

Armenia has no domestic production of HFCs. The country imports them as chemicals from UAE, sometimes from Iran and Turkey, while they come contained in products or equipment type (sub-application) from a great number of other countries.

In general, Armenia started importing products or equipment containing HCFCs and HFCs after 2005 when the country launched its first country program for CFCs phase-out. In particular: Armenia adopted the Law on Substances that Deplete the Ozone Layer and secondary legislation for ensuring enforcement of the Law; later, Armenia limited CFC import and completely banned it in 2010. In parallel, the country has launched HCFCs phase-out program. All these measures resulted in sharp increase of HFCs import since 2010.

#### *4.2.7.2 Use of Fluoride containing substitutes (F gases)*

HFCs applications include:

- ***Refrigeration and Air Conditioning (RAC)*** (2F1) is the main application area in Armenia. HFCs are used here as refrigerants and their emissions in 2012 accounted for 96.6% of total $CO_{2eq.}$emissions in "Product Uses as Substitutes for Ozone Depleting Substances" category.

The following subcategories were considered: stationary (2F1a) and mobile (2F1b).
Stationary subcategory includes: domestic refrigerators, autonomous commercial refrigerators, small- and medium-size commercial and industrial refrigeration equipment, air-conditioners.

Mobile subcategory includes: transport refrigeration including equipment and systems used in refrigerated trucks and containers, mobile air-conditioning systems used in passenger cars.
HFCs mostly used here include: HFC-134a and HFC mixtures - HFC-404A (HFC-125-44% / HFC-143a-52% / HFC-134a-4%), HFC-407C (HFC-32-23% / HFC-125-25% / HFC-134a-52%), HFC-410A (HFC-32-50% / HFC-125-50%).
HFCs generally replace CFC-12 formerly used in RAC devices, while currently they substitute the phased out HCFC-22.

- ***Aerosols*** (2F4), where HFCs are used as propellant or solvent. This application is the second in HFCs emissions. Aerosols account for 3.1% in 2011 and 2012 of $CO_{2eq.}$ total emissions. They include: MDIs used in medicine for patients with asthma; items for personal care (e.g. hair care items, deodorants); home care items (e.g. air-fresheners, stove and fabric cleaners), aerosol paints.

The study mainly covers the use of HFCs exclusively as a propellant in aerosols and not as a solvent. Propellants used in aerosols imported by Armenia include: HFC -134a, HFC227ea, and HFC-152a. They generally substitute not only CFC -12 formerly used in this sector but also CFC -11, and sometimes CFC -114.

- ***Fire protection*** (2F3), this application is the third accounting for 0.78% (both in 2011 and 2012) of $CO_{2eq.}$ HFCs total emissions. HFCs are used in fire extinguishers and other fire protection systems both as propellants and as active agents.

From HFCs only HFC-227ea is used in Armenia. It is used only in automatic fire-extinguishing systems. In this sector HFCs come to substitute Halons formerly used in fire-extinguishing systems: Halon-1211 - in mobile fire extinguishers, and Halon-1301- in stationary systems.

- ***Foam production*** (2F2), accounts for 0.23% (both in 2011 and 2012) of $CO_{2eq.}$ HFCs total emissions. HFCs are used in foam production as foam blowing agents.

Activities conducted under GHG National Inventory enabled to obtain data only on HFC-134a used in solid foam production. Here, HFC-134a mainly substitutes the formerly used CFC-11 and HCFC-141b currently used in imported pre-blended polyol in foam production.

- ***Solvents (non-aerosol)*** (2F5). HFCs use in solvents is not found In Armenia.

Probably there is minor use of HFCs in many other sectors but they are not included in this report because of their insignificant quantities.
Sectors in Armenia using HFCs along with substances used in the said sectors are described in the Table below.

**Table 4.2.22 HFCs used in Armenia, by applications**

| 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 | | x |
| HFC-152a | | x | | |

### *4.2.7.3 Data collection sources*

Baseline data sources for HFCs emission volumes include:

- RA Ministry of Finance [IndFRef-1],
- Rescue Service under RA Munistry of Emergency Situations [IndFRef-2],
- RA National Statistical Service [Ref-3],
- Armenian Drugs and Medical Technology Center [Ref-4],
- Data and assessments from a number of companies and specialists/experts. Also a partial research is conducted in the local market.

### *4.2.7.4 Methodological issues*

In order to have a good understanding of HFCs use and their quantities the National HCFCs Phase-out Management Plan for Armenia 2011-2014 was studied [IndFRef-3].

The next step was to study the Commodity List of Foreign Economic Activities of the Commonwealth of Independent States (CL FEA), fifth edition [Ref-3], and the Customs and Enforcement Officers Information Note jointly published by UNEP and WCO in 2012. Data collection and calculations are based on Inventory Reports made by other countries, a number of IPCC Communications and Reports relevant to the sector, as well as on several sources and materials from the internet [Gen-2; Gen-3; Gen-4; Gen-6; Gen-7; Ref-2].

Assessment of F gas emissions is implemented according to Chapter 7 "Product Uses as Substitutes for Ozone Depleting Substances (F gases) emissions", Volume 3 "Industrial processes and product use" of 2006 IPCC Guidelines [Gen-1].

According to 2006 IPCC Guidelines [Gen-1] data collection and emissions assessment can be done by applying the methods and approaches described below.

**Table 4.2.23 Overview of Data Requirements for Different Tiers and Approaches**

| Overview of Data Requirements for Different Tiers and Approaches | | |
|---|---|---|
| | **Approach A (emission-factor approach)** | **Approach B (mass-balance approach)** |
| Tier 2 (emission estimation at a disaggregated level) | • Data on chemical sales and usage pattern by sub-application [country-specific or globally/regionally derived]<br>• Emission factors by sub-application [country-specific or default] | • Data on chemical sales by sub-application [country-specific or globally/regionally derived]<br>• Data on historic and current equipment sales adjusted for import/export by sub-application [country-specific or globally/regionally derived] |
| Tier 1 (emission estimation at an aggregated level) | • Data on chemical sales by application [country-specific or globally/regionally derived]<br>• Emission factors by application [country-specific or (composite) default] | • Data on chemical sales by application [country-specific or globally/regionally derived]<br>• Data on historic and current equipment sales adjusted for import/export by application [country-specific or globally/regionally derived] |

The inventory of HFC emissions in Armenia for all uses except RAC was implemented by applying Method 1A. In particular, such an inventory of emissions for Aerosols is considered to be preferable as emissions from all Aerosols have the same character no matter what they are used for - medical, cosmetic or domestic purposes: almost 100% of their propellant content is emitted during the first 2 years of use.

It would have been reasonable to apply Method 2A or Method 2B to inventories for Foam Production and Fire Protection as in this case emissions have different characters. However, taking into consideration the availability of generic information on applicability (without dividing by subsectors) again Method 1A was selected for data collection and calculation.

In respect of refrigerators and air-conditioners, Method 2A was applied for emissions inventory as it is the key one in terms of applicability, and there were data available in each sublevel.

### *4.2.7.5 Emission Calculation Equations and Choice of Emission Factors*

Due to unavailability of accurate measurements for estimating emission factors for applications and sub-applications all calculations were made by using 2006 IPCC Guidelines [Gen-1] default factors which, prior to using, were compared with estimates made by experts in order to avoid incorrectness.

In all **RAC** subcategories emissions were calculated according to equations 7.10, 7.11, 7.12, 7.13, 7.14 described in Chapter 7 "Product Uses as Substitutes for Ozone Depleting Substances (F gases) emissions", Volume 3 "Industrial processes and product use" of 2006 IPCC Guidelines [Gen-1] and the factors described in Table 7.4 in the same source.

Selection of a factor from the said range is related to peculiarities of each sub-application in the country.

Although the quantities of F gases in general and HFCs in particular used in **Aerosols** were calculated by sub-application it should be noted that calculation of emissions was made by applying Method 1A as the default emission factor for the entire application is one and is equal to 0.5.

HFC emissions from Aerosols were calculated according to formula 7.6 of the Guidelines [Gen-1].

For **Foam Production** application area emissions from solid foam production were calculated according to formula 7.7 of the Guidelines [Gen-1]. Two emission factors are used in calculation: according to the Guidelines emission factor of the first year loss ($EF_{AL}$) is 0.1, while the annual emission factor ($EF_{AL}$) caused by loss is 0.045 [Gen-1, Table 7.7]:

For **Fire Protection** application area emissions were calculated according to formula 7.17 of the Guidelines [Gen-1]. Only one factor is used for calculations - EF annual emissions from systems (except gas removal from the system for destruction or other purposes), which is equal to 0.04 according to the Guidelines [Gen-1].

The quantity of annual losses of the agent during extraction and recharge of agent from system to system ($RRL_t$) is 0 for Armenia due to the fact that are few such systems in the country and no data is available on extraction or recycling.

Estimated emissions (t) were entered into the Software for deriving final data in $CO_2$ equivalent.

For **Refrigeration and Air Conditioning** application area the Software allows to enter data only for 2 individual sub-applications. Therefore, generic factors of annual average emissions for individual substances were estimated for these 2 sub-applications (however, with regard to importance of this sector, for ensuring credibility of estimates data collection and calculation were made for 6 sub-applications separately and generic factors are slightly different from factors estimated by the Software).

They are:

For **Refrigeration and Stationary Air Conditioning** (2F1a):

| Substance | Annual average emissions factor |
|---|---|
| HFC-134a | 0.21 |
| HFC-32 | 0.22 |
| HFC-125 | 0.28 |
| HFC-143a | 0.36 |

For **Mobile Air Conditioning** (2F1b):

| Substance | Annual average emissions factor |
|---|---|
| HFC-134a | 0.27 |

### *4.2.7.6 Emissions Assessment, Time Series*

Table 4.2.24 describes HFC emissions in $CO_2$ equivalent by uses.

As indicated in the Table, in Armenia as well as in many other countries RAC is the leader in emissions of HFCs used as substitutes for ozone depleting substances. RAC accounts for 96.91% of total HFC emissions (2011 and 2012), Aerosols account for 2.67%, and Foam production and Fire Fighting account for only 0.29% and 0.13% respectively (Figure 4.2.8).

There is a sustainable annual average growth for all uses, however the growth dynamics differs for each individual use. While 2012 indicator of HFC emissions from RAC use is about 1.5 times more than 2010 indicator, it is only 1.1 times more than Aerosols, about 2.9 times more than Foam Blowing Agents, and about 2 times more than Fire Fighting.

Such increase in RAC emissions is due to the fact that in Armenia as well as globally, in developing countries in particular, disregarding active campaign for using natural refrigerants (mainly ammonia, carbon dioxide, and carbon) as ODS alternative substances, HFCs are still considered as main substitutes for CFCs and HCFCs regulated under the Montreal Protocol.

**Table 4.2.24 HFC emissions by application areas (Gg $CO_{2eq.}$), 2010-2012**

| Year | Refrigeration and Air Conditioning | Aerosols | Foam Blowing Agents | Fire protection | Total |
|---|---|---|---|---|---|
| 2010 | 245.54 | 9.09 | 0.40 | 0.354 | **255.38** |
| 2011 | 308.21 | 10.13 | 0.67 | 0.426 | **319.44** |
| 2012 | 372.67 | 10.27 | 1.13 | 0.497 | **384.58** |

The situation is quite different with regard to Aerosols. HFCs substitute only 2% of the formerly used CFC-12, CFC-11 and sometimes CFC-114. The remaining 98% of demand is met by hydrocarbons, dimethyl ether, carbon dioxide, nitric propellants and alternative non-synthetic substances. Global trends show that in this subcategory natural refrigerants would gradually come to replace HFCs as substitutes.

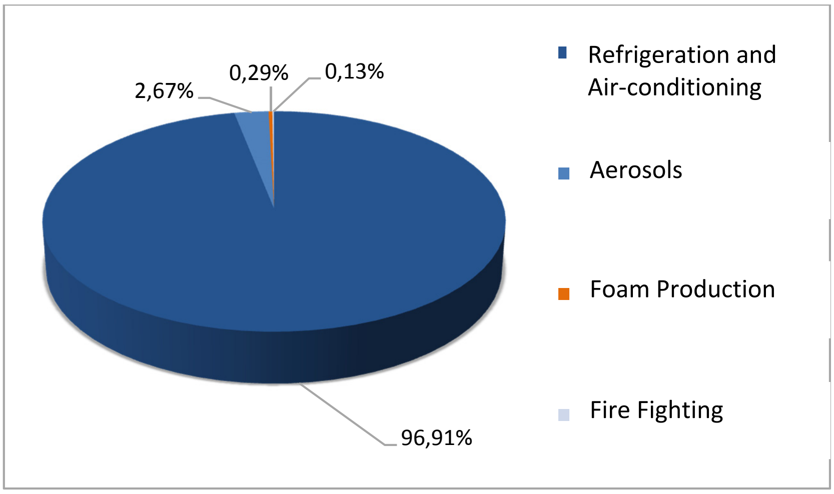



***Figure 4.2.8 Breakdown of HFC total emissions by application areas (Gg $CO_{2eq.}$), for 2012***
(in 2011 situation was the same)

The situation is similar with regard to Fire Protection and Foam Production applications. Not only did imports of HFCs in these application areas start relatively late - in 2004 and 2006 respectively, but they are also not the only ODS substitutes. Natural substances such as hydrocarbons and carbon dioxide are also used as substitutes in Foam Production, and nitrous oxide, carbon dioxide and pressurized air are used in Fire Protection.

Figure 4.2.9 describes time series of HFCs emissions by gas types, for 2000-2012.

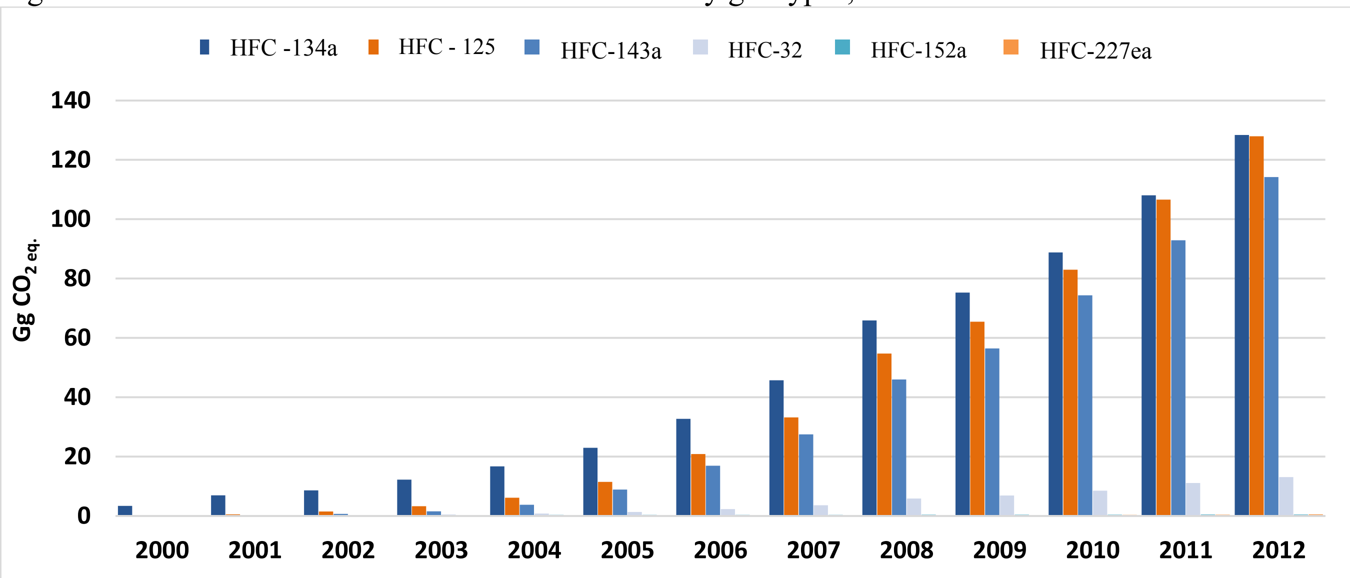



***Figure 4.2.9 Emissions of HFCs by gas types, 2000-2012***

The 33.39% share of HFC-134a is due to multifunctional use of this substance. It is widely used as both a pure substance and a mixture (R-404A, R-410A, R-407C) component in all sub-applications of RAC which is the country's HFC key application area. HFC-134a is also used in aerosols as a Propellant and as a Foam Blowing Agent in foam production.

The significant share of HFC-125, HFC-143a and HFC-32 is also due to wide use of these substances in mixtures in various sub-applications of RAC.

Insignificant share of HFC-152a and HFC-227ea is due to the use of the former in Aerosols only, and the latter – only in Fire Protection.

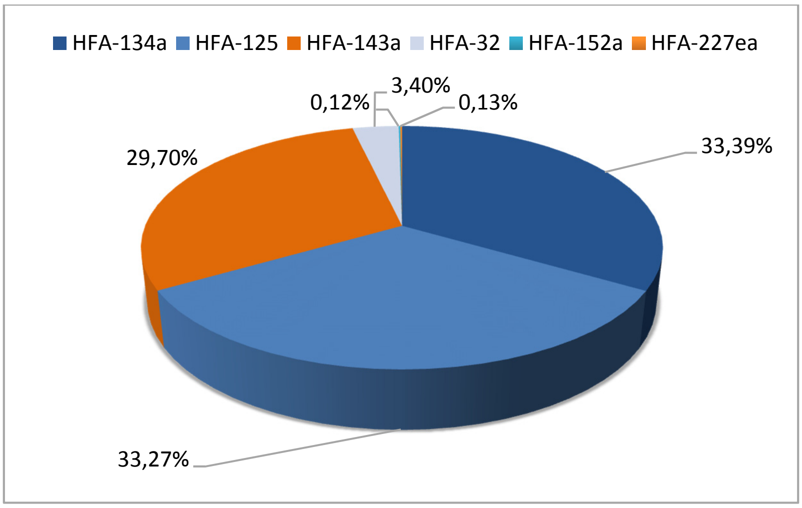



**Figure 4.2.10.** *Breakdown of total HFC emissions by* **gas types (Gg $CO_2$ eq.), 2012**

### *4.2.7.7 Completeness of Data*

During data collection process by applying Method 2A almost 70% of RAC uses were successfully captured. This was due to availability of relevant database and experience obtained in years. Data collection by using experts' assessment covered 60% of Aerosols uses, including: DIs, aerosol items for personal care and domestic detergents, and aerosol paints.

Data for Foam production is fairly poor. These data was mostly collected from country's large foam producers which according to expert assessment account for only 40% of solid foam market of the country. Therefore, completeness of data for this use is equals to 40%.

Calculation for Fire Protection uses was made by applying statistical data and according to experts' assessment. Completeness of data here is equal to 40%.

During the reporting period the number of disposed non-transport refrigeration equipment and stationary air-conditioners containing HFCs as well as the number of disposed fire-fighting equipment containing HFCs is insignificant in Armenia and cannot be accounted. According to findings of research made by experts during the reporting period no refrigerant was destructed as a result of disposal of mobile refrigeration equipment and air-conditioners containing HFCs while the quantities of refrigerant emissions are accounted in estimates of annual average emissions generic factors for given subsector.

### *4.2.7.8 Uncertainty Assessment*

In general, uncertainty of estimated data for RAC and Aerosol uses is 30%; for Foam Production - 50-60%; for Fire Protection - 40%.

### *4.2.7.9 Quality Control and Quality Assurance (QC/QA)*

All necessary quality control procedures for all subcategories was implemented in compliance with Chapter 6 "Quality Control/Quality Assurance and Verification", Volume 1 "General Instructions and Reporting" of 2006 IPCC Guidelines.

The quality assurance procedure was also implemented in due diligence. Calculations for emissions assessment were revised by experts. The revision was made in two phases: firstly - revision of interim versions of emissions calculation sets, and then revision of calculations and the NIR text.

### *4.2.7.10 Improvements foreseen*

Improvements are foreseen in data collection particularly for RAC subcategory, as well as for Foam Production and Fire Protection uses.

There is also an intention to develop a country specific methodology for data collection on Solvents uses which in future will enable to make inventory for such uses also.

It is also planned to eliminate data collection shortcomings for all other uses by adjusting data completeness and uncertainties.

## 4.3 "Agriculture, Forestry and other Land Use" Sector

### 4.3.1 Sector description and main categories of emissions

Pursuant to 2006 IPCC "Guidelines for Inventories of Greenhouse Gases" [Gen-1] "Agriculture, Forestry and Other Land Use" sector in Armenia includes the following categories and subcategories:

**(3A) Livestock:** methane and nitrous oxide emissions including:

- (3A1) Enteric Fermentation (CH4 emissions)
    - 3A1a Cattle
        - *3A1ai From Dairy Cows*
        - *3A1aii Other Cattle*
- (3A2) Manure management ($CH_4$ and $N_2O$ emissions)

**(3B) Lands:** following subcategories of GHG emissions and removals are considered in "Land" category:

- (3B1) Forest Land:
    - (3B1a) Forest Land remaining Forest Land,
    - (3B1b) Land concerted to Forest Land,
- (3B2) Cropland,
- (3B2a) Cropland remaining Cropland,
- (3B2b) Land converted to Cropland,
- (3B3) Grassland,
- (3B3a) Grassland remaining Grassland,
- (3B3b) Land converted to Grassland,
- (3B4) Wetland,
- (3B5) Settlement,
- (3B6) Other Land,

**(3C) Aggregate sources on land, and non-$CO_2$ emissions**

(3C1) Biomass burning,
(3C3) Urea application,
(3C4) Direct $N_2O$ emissions from managed soils,
(3C5) Indirect $N_2O$ emissions from managed soils,
(3C6) Indirect $N_2O$ emissions from manure management.

### 4.3.2 Calculation Methodology, Choice of Emission Factors and Activity Data

#### 4.3.2.1 Livestock

##### 4.3.2.1.1 (3A1) Enteric Fermentation

According to previous Inventories, Enteric Fermentation subcategory is the largest producer of greenhouse gases in "Agriculture, Forestry and Other Land Use" sector where the prevailing part of emissions comes from cattle. Therefore, GHG emissions from cattle enteric fermentation was estimated according to 2006 IPCC Guidelines [Gen-1, Volume 4] Tier 2 Approach by applying national emission factors. Methane emissions from enteric fermentation of other animals were estimated according to Tier 1 Approach by applying emission factor for developing countries provided in 2006 IPCC Guidelines.

The number of livestock (see Table 4.3.1) is the key indicator for estimating GHG emissions from Enteric Fermentation. It was calculated by using available statistical information as well data provided by official authorized entities (Annex 1). The methodology for estimating average annual number of livestock was described in details in Third NIR [Ref-6].

**Table 4.3.1 Annual average number of livestock, heads**

| | 2011 | 2012 |
|---|---|---|
| **Cattle, of which** | 704,386 | 776,462 |
| **cows** | 295,100 | 311,908 |
| **bulls** | 20,846 | 24,728 |
| **Young animals (calves and heifers)** | 388,441 | 439,826 |
| **Buffalos** | 465 | 502 |
| **Sheep** | 766,688 | 876,476 |
| **Goats** | 40,555 | 41,179 |
| **Horses** | 10,167 | 10,345 |
| **Mules and donkeys** | 3,984 | 3,957 |
| **Pigs** | 198,209 | 211,955 |
| **Poultry** | 4,844,272 | 4,876,201 |

*Source: Estimated by experts based on date from RA NSS and RA Ministry of Agriculture*

The rest of baseline data necessary for estimating national emission factors by using Tier 2 Approach is provided in Annex 2 including, in particular: animal weight, milk yield rate, fat in milk, gross energy use, digestion energy, methane conversion factors, raising regimes, etc.

Comparison of emission factors provided in Guideline [Gen-1, Volume 4, Table 10,11] with country-specific factors (see Table 4.3.2) shows that country-specific factors for cows are greater by 16-18%, for bulls - by 32-34%, because the values of activity data used for calculation of country-specific emission factors (weight, lactation etc.) are larger than those provided in the Guideline ,while country-specific factors for young animals is smaller by 13-9% due to the difference between the value of activity data.

**Table 4.3.2 Emission Factors provided in Guideline and Estimated Country-Specific Emission Factors (kg/head/year)**

| | Cows | | Bulls | | Young animals | |
|---|---|---|---|---|---|---|
| | Guideline | National | Guideline | National | Guideline | National |
| 2011 | 68 | 79 | 47 | 62 | 47 | 41 |
| 2012 | 68 | 80 | 47 | 63 | 47 | 43 |

### *4.3.2.1.2 (3A2) Manure Management*

Methane emissions from Manure Management was calculated by using Tier 1 Approach. Emission factors were selected in the following way:

- Factors intended for Asian Continent [Gen-1, Volume 4] were used for cattle, buffalos and pigs as animal raising practices of that region is the closest to Armenian conditions;
- Factors intended for developing countries [Gen-1, Volume 4] were used for other animal categories

considering that annual average temperature in Armenia is below 10° C [Ref-6] classifying it as a country with cold climate.

Nitrous oxide emissions from Manure Management was estimated by using Tier 1 Approach and emission factors provided for Asian Continent [Gen-1, Volume 4].

The following AWMS used in Armenia have been considered in the estimation:

1. Pasture /Range/Paddock, 2. Daily spread, 3. Solid storage, 4. Liquid / Slurry, 5. Poultry manure with litter, 6. Poultry manure without litter:

### *4.3.2.1.3 Emissions from livestock category*

The Table below provides methane and nitrous oxide emissions from Livestock enteric fermentation and manure management.

**Table 4.3.3 Methane and Nitrous oxide emissions from Livestock enteric fermentation and manure management, Gg**

| | 2011 | | 2012 | |
|---|---|---|---|---|
| (Gg) | $CH_4$ | $N_2O$ | $CH_4$ | $N_2O$ |
| **3.A Livestock** | **48.6345** | **0.2162** | **54.3422** | **0.2410** |
| **3.A.1 Enteric fermentation** | **45.0143** | **IE** | **50.4766** | IE |
| 3.A.1.a Cattle | 40.5314 | IE | 45.4230 | IE |
| 3.A.1.a.i Cows | 23.3129 | | 24.9526 | |
| 3.A.1.a.ii Other Cattle | 17.2185 | | 20.4704 | |
| 3.A.1.b Buffalos | 0.0256 | | 0.0276 | |
| 3.A.1.c Sheep | 3.8334 | | 4.3824 | |
| 3.A.1.d Goats | 0.2028 | | 0.2059 | |
| 3.A.1.f Horses | 0.1830 | | 0.1862 | |
| 3.A.1.g Donkeys and mules | 0.0398 | | 0.0396 | |
| 3.A.1.h Pigs | 0.1982 | | 0.2120 | |
| **3.A.2 Manure management** | **3.6203** | **0.2162** | **3.8655** | **0.2410** |
| 3.A.2.a Cattle | 3.0652 | 0.1571 | 3.2717 | 0.1756 |
| 3.A.2.a.i Cows | 2.6559 | 0.1060 | 2.8072 | 0.1147 |
| 3.A.2.a.ii Other Cattle | 0.4093 | 0.0510 | 0.4646 | 0.0610 |
| 3.A.2.b Buffalos | 0.0005 | 0.0001 | 0.0005 | 0.0001 |
| 3.A.2.c Sheep | 0.0767 | 0.0374 | 0.0876 | 0.0428 |
| 3.A.2.d Goats | 0.0045 | 0.0018 | 0.0045 | 0.0019 |
| 3.A.2.f Horses | 0.0111 | 0.0019 | 0.0113 | 0.0020 |
| 3.A.2.g Donkeys and mules | 0.0024 | 0.0005 | 0.0024 | 0.0005 |
| 3.A.2.h Pigs | 0.3964 | 0.0119 | 0.4239 | 0.0128 |
| 3.A.2.a Cattle | 0.0636 | 0.0054 | 0.0635 | 0.0054 |
| 3.A.2.i Poultry | 0.0111 | 0.0019 | 0.0113 | 0.0020 |

Figure 4.3.1 provides methane emissions volumes by livestock categories.

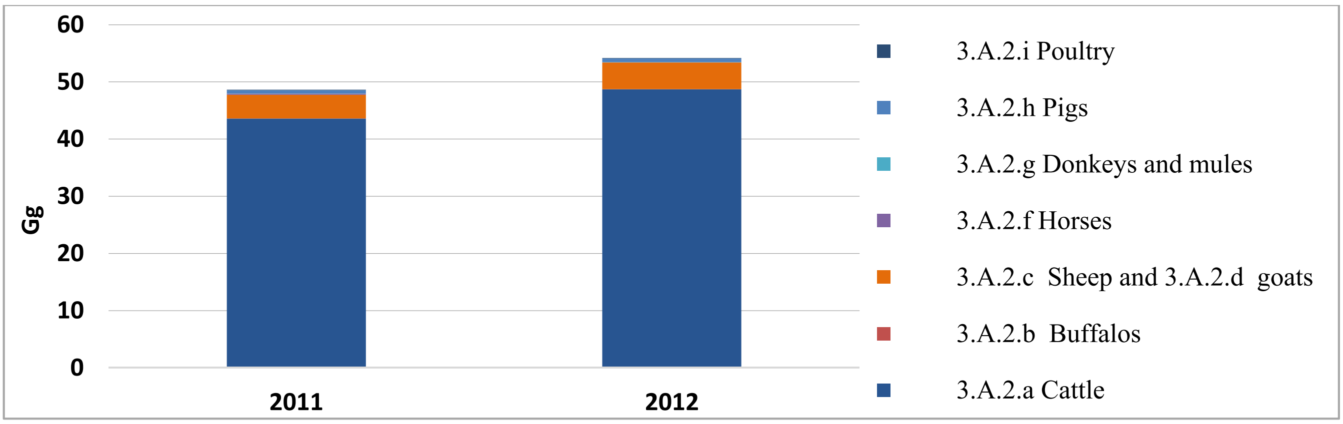



*Figure 4.3.1 Methane emissions from Livestock enteric fermentation and manure management, by years, Gg*

The increase in methane emissions is due to changes in livestock milk yield rate and cattle weight which according to data from RA NSS and RA Ministry of Agriculture have shown a growing trend.

Emissions were estimated according to Tier 2 Approach by applying national emission factors. Such approach decreased uncertainty of the results (Chapter 4.3.5 and 4.3.6).

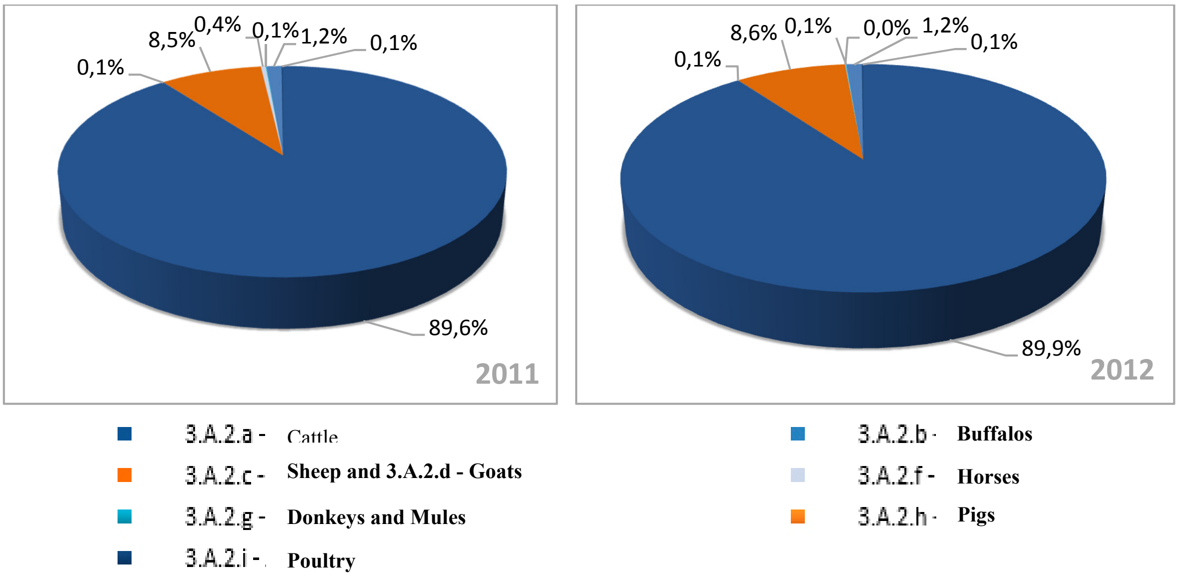



*Figure 4.3.2 Structure of methane emissions from livestock enteric fermentation and manure management, %*

**Table 4.3.4 Methane emissions from livestock enteric fermentation and manure management, Gg**

| | $CH_4$ (Gg) | |
|---|---|---|
| **Year** | **2011** | **2012** |
| **3.A Livestock** | **48.635** | **54.342** |
| 3.A.1 Enteric fermentation | **45.014** | **50.477** |
| 3.A.1.a Cattle | **40.531** | **45.423** |
| 3.A.1.a.i Cows | 23.313 | 24.953 |
| 3.A.1.a.ii Other Cattle | 17.219 | 20.470 |
| 3.A.1.b Buffalos | 0.026 | 0.028 |
| 3.A.1.c Sheep | 3.833 | 4.382 |
| 3.A.1.d Goats | 0.203 | 0.206 |
| 3.A.1.f Horses | 0.183 | 0.186 |
| 3.A.1.g Donkeys and mules | 0.040 | 0.040 |
| 3.A.1.h Pigs | 0.198 | 0.212 |
| 3. A.2 **Manure management** | **3.620** | **3.866** |
| 3.A.2.a Cattle | **3.065** | **3.272** |
| 3.A.2.a.i Cows | 2.656 | 2.807 |
| 3.A.2.a.ii Other Cattle | 0.409 | 0.465 |
| 3.A.2.b Buffalos | IE | 0.001 |
| 3.A.2.c Sheep | 0.077 | 0.088 |
| 3.A.2.d Goats | 0.004 | 0.005 |
| 3.A.2.f Horses | 0.011 | 0.011 |
| 3.A.2.g Donkeys and mules | 0.002 | 0.002 |
| 3.A.2.h Pigs | 0.396 | 0.424 |
| 3.A.2.i Poultry | 0.064 | 0.064 |

2000-2012 time series of methane emission from livestock enteric fermentation and manure management, Gg $CO_{2\ eq.}$ are provided below.

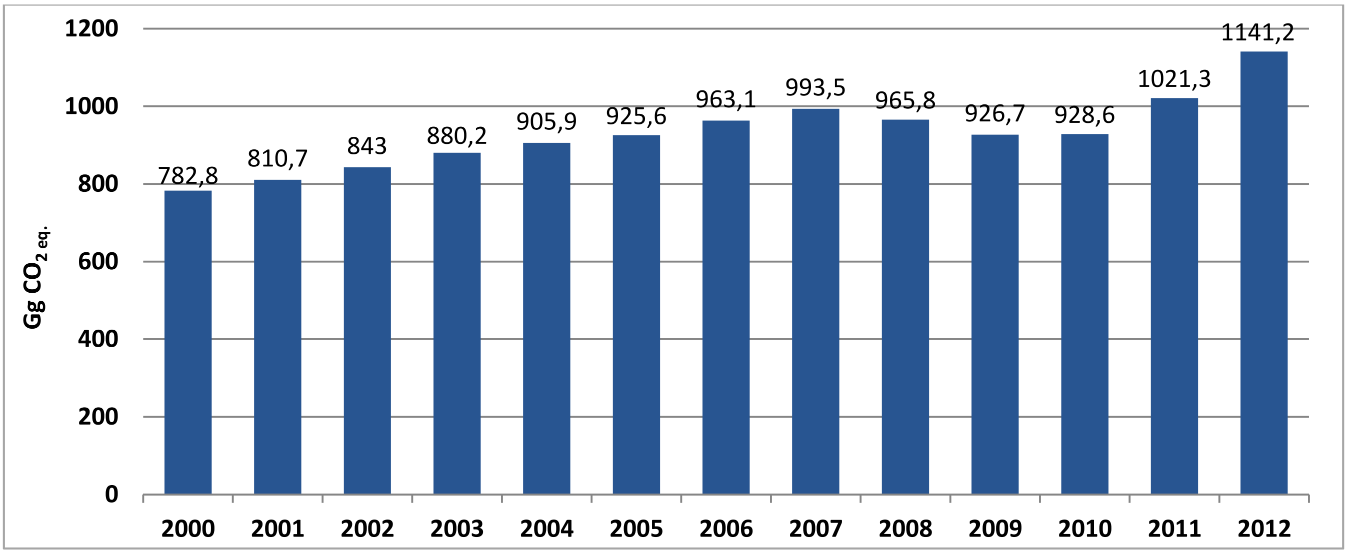



*Figure 4.3.3 Methane emissions from livestock enteric fermentation and manure management, 2000-2012, Gg CO2 eq.*

**Table 4.3.5 Nitrous oxide ($N_2O$) emissions from manure management for 2011-2012, Gg**

| | $N_2O$ ( Gg ) | |
|---|---|---|
| Year | 2011 | 2012 |
| 3. A.2 Manure management | 0.2162 | 0.2410 |
| 3.A.2.a Cattle | 0.1571 | 0.1756 |
| 3.A.2.a.i Cows | 0.1060 | 0.1147 |
| 3.A.2.a.ii Other Cattle | 0.0510 | 0.0610 |
| 3.A.2.b Buffalos | 0.0001 | 0.0001 |
| 3.A.2.c Sheep | 0.0374 | 0.0428 |
| 3.A.2.d Goats | 0.0018 | 0.0019 |
| 3.A.2.f Horses | 0.0019 | 0.0020 |
| 3.A.2.g Donkeys and mules | 0.0005 | 0.0005 |
| 3.A.2.h Pigs | 0.0119 | 0.0128 |
| 3.A.2.i Poultry | 0.0054 | 0.0054 |

**Table 4.3.6 Summary on emissions from livestock category**

| IPCC Category Code | IPCC Categories | Greenhouse Gas | 2011 Ex,t (Gg $CO_{2\ eq.}$) | 2012 Ex,t (Gg $CO_{2\ eq.}$) |
|---|---|---|---|---|
| 3.A.1 | Enteric fermentation | Methane ($CH_4$) | 945.30 | 1,060.01 |
| 3.A.2 | Manure management | Methane ($CH_4$) | 76.03 | 81.18 |
| 3.A.2 | Manure management | Nitrous oxide ($N_2O$) | 67.03 | 74.72 |
| **Total** | | | **1,088.36** | **1,215.91** |

### *4.3.2.2 (3B) Land*

While developing GHG Inventory it is very important to match national classification for lands with categories defined by IPCC Guidelines.

To this aim, an essentially comparison of main categories of Land provided in Guideline with Land Stock classification defined in RA Land Balance was done.

According to Land Code of the Republic of Armenia the country’s land stock is classified by purpose of use (by categories and subcategories) as follows:

1) agricultural lands
2) settlements
3) industry, mining and other industrial purpose lands
4) energy, transport, communication, public utilities infrastructures lands
5) specially protected areas
6) lands for special purpose
7) forest
8) wetlands
9) reserve lands

According to 2006 IPCC Guideline the following 6 sub-categories of Land have been considered:

3B1 Forestland
3B2 Cropland
3B3 Grassland
3B4 Wetland
3B5 Settlement, and
3B6 Other land

which were formed on the basis of the existing in Armenia national classification.

To this end the following steps were undertaken:

- a certain part of agricultural lands as well arable lands and perennial plants from forest land were included in Cropland;
- hay-lands and pastures from agricultural lands and forest as well as non-forested, non-water covered areas from specially protected areas were included in Grassland;
- no changes in Wetland category;
- settlement lands excluding 50% of homestead lands and gardens, industry, mining and other production facilities lands excluding mining lands, lands for energy, communication, transport, public utilities infrastructure facilities; lands for health, recreation, and historical and cultural lands from specially protected areas were included in Settlement;
- the rest of agricultural and forest lands, mining and special purpose lands were included in Other Land.

**Table 4.3.7 Classification of Land categories pursuant to Land Balances provided by RA Land Code and State Committee of Real Estate Cadaster under RA Government, and by Guideline**

| By Land Balance | By Guideline |
|---|---|
| 1) Agricultural lands | 3B1 Forest land |
| 2) Settlements | 3B2 Cropland |
| 3) Industry, mining and other industrial lands | 3B3 Grassland |
| 4) Lands for energy, transport, communication, public utilities infrastructure facilities | 3B4 Wetland |
| 5) Specially protected areas | 3B5 Settlement |
| 6) Lands for special purpose | 3B6 Other land |
| 7) Forest | |
| 8) Wetland | |
| 9) Reserve lands | |

**Table 4.3.8 Country's land matrix by categories of GHG Inventory Guideline and respective conversions according to RA Land Balance, 2011, ha [AFOLURef-8]**

| Initial / Final | Forest land | Cropland | Grassland | Wetland | Settlement | Other land | Total Final |
|---|---|---|---|---|---|---|---|
| Forest land (forested) | **349,017** | | | 117 | 4 | 209 | **349,347** |
| Cropland | 634 | **529,844.2** | | | 135.6 | | **530,613.8** |
| Grassland | | 1,448 | **1,225,263.4** | 458 | 1,618.1 | 33,456.3 | **1,262,243.8** |
| Wetland | | | 394.8 | **152811.8** | | 1.4 | **153,208** |
| Settlement | | 30 | | | **190631** | | **190,661** |
| Other land | | 5.5 | | | | **488,180** | **488,185.5** |
| Total initial | **349,651** | **531,327.7** | **1,225,658.2** | **153,386.8** | **192,388.7** | **521,846.7** | **2,974,259.1** |
| Total Changes | -304 | -713.9 | 36,585.6 | -178.8 | -1,727.7 | -33,661.2 | 0 |

** This and next matrixes are made in format provided in Guidelines [Gen-6]*

**Table 4.3.9 Country's land matrix by Guideline categories and respective conversions according to RA Land Balance, 2012, ha [AFOLURef-9]**

| Initial / Final | Forest land | Cropland | Grassland | Wetland | Settlement | Other land | Total Final |
|---|---|---|---|---|---|---|---|
| Forest land (forested) | **349,141** | | | 136 | | | **349277** |
| Cropland | 700 | **528,600.4** | 110.8 | | 271.4 | 277.3 | **529,959.9** |
| Grassland | | 700 | **1,230,389.6** | 55 | | 15,894.5 | **1,247,039.1** |
| Wetland | | | | **15,3396.8** | 0.9 | | **15,3397.7** |
| Settlement | | 5.6 | | | **189,296** | 813.4 | **190,115** |
| Other land | | | | | | **505,170.7** | **505,170.7** |
| Total initial | **349,841** | **529,306** | **1,230,500.4** | **153,587.8** | **189,568.3** | **522,155.9** | **2,974,959.4** |
| Total Changes | -564 | 653.9 | 16,538.7 | -190.1 | 546.7 | -16,985.2 | 0 |

Greenhouse gas emissions resulting from land convertion were estimated for the first time within Biennial Update Report inventory for 2011, 2012 and therefore there are no time series for previous years.

***3B1 Forest land***

According to 2006 IPCC Guideline, GHG emissions/removals were estimated for two subcategories: Forest Land Remaining Forest Land - according to RA Forest Stock lands, and Land Converted to Forest Land (Annex 4, Table 1).

Because of lack of complete information on Forest sector in Armenia GHG emissions and removals in *3B1a Forest Land Remaining Forest Land subcategory* were estimated only for carbon stock changes in biomass (above-ground and below-ground), while in *3B1b Land Converted to Forest land subcategory* GHG emissions estimate involves estimation of changes from dead organic matter as well.

GHG emissions/removals in 3B1a *Forest land remaining Forest land subcategory* were estimated using Gain-Loss Method where the annual increase in carbon stocks due to biomass growth and annual decrease in carbon stocks due to biomass losses are estimated. The estimate was done by Tier 2 Method given that prevailing part of activity data are country-specific estimates (wood annual average growth, wood baseline density, etc.). These data were calculated based on findings from studies conducted in Armenia (Annex 4, Tables 2-4).

Below-ground biomass to above-ground biomass ratios (R) is taken from 2006 IPCC Guideline [Gen-1, Volume 4, Chapter 4, Table 4.4] which is chosen according to climatic zones – moderate, and ecological zone – moderate zone for mountain systems given that above-ground biomass in forests of Armenia varies in the range of 75-150 tons per 1 hectare [AFOLURef-29]:

***Activity Data***

For collecting data on areas of RA Forest Stock (Annex 4, Table 1) by soils (forest covered areas, non-adherent forest cultures, rare forests, burned areas, haylands, pastures, etc.), as well as on areas (ha) of forests covered by tree species, accumulated stock (cubic m), age, completeness and other necessary forest assessment data, forests and forest land allocation under "Armforest" SNCO according to the existing Forest Management Plans of "Forestry" branches [AFOLURef -10, AFOLURef -30] and Specially Protected Areas of Nature (SPAN) Management Plans [AFOLURef -11, AFOLURef -24] were studied. Former forest management plans [AFOLURef -19, AFOLURef -20, AFOLURef -21] served as data sources for those «Forestry" branches and SPANs that do not yet have new (approved) Management Plans.

*3B1a Forest Land Remaining Forest land*

"Forest land Remaining Forest land" subcategory accounts for 99.82% and 99.78% of the annual increase in biomass carbon stock in 2011 and 2012 respectively.

**Table 4.3.10 Annual increase in biomass carbon stock**

| Calculation Data | 2011 | 2012 |
|---|---|---|
| Covered area, ha [9] | 348,713 | 348,577 |
| Biomass annual average growth per 1 ha, cubic meters[10] | 1.5 | 1.5 |
| Carbon annual gains, C t/year | 171,910 | 171,843 |
| Annual volume of harvested fuelwood, cubic m /including fallen wood/ [11] | 65,740 | 85,960 |
| Annual volume of timber harvested (commercial fellings), cubic m[12] | 3,385 | 3,565 |
| Burned areas /ha [12] | 419.7 | 167.9 |
| Loss of wood due to fires, cubic m* | - | - |
| Annual carbon loss, C t/year | 22,732 | 29,440 |

** Volumes of wood loss caused by wild fires are included in the volumes of harvested fuelwood and* volume of commercial fellings.

As it comes from Table 4.3.10, there is a decrease in forest areas in 2012 which is caused by forest clearing activities in "Sevan" National Park lakeside forest covered areas, and by mining operations in "Teghut" area. Increased volume of harvested fuelwood in 2012 was mainly due to RA Government decision adopted in 2011 on free provision to population of fallen-wood as fuel.

Trees (not growing) damaged in 2011-2012 by wild fires in forest covered areas are officially harvested for commercial fellings and for fuelwood: these data were included in respective rows in Table 4.3.10.

Wood actually harvested by "Armforest" SNCO ("Forestry" branches) and SPANs ("Sevan", "Dilijan", and "Arevik" national parks), as well as illegal harvest discovered by various state institutions ("FSMC" SNCO, "Armforest" SNCO, "NPI" under the Ministry of Nature Protection) as a result of annual inspections [AFOLU-29,30,31] are studied for estimating volumes of wood removed from forest in 2011-2012.

[9] [Annex 4, Table 1]
[10] [AFOLURef-10, AFOLURef -11, AFOLURef -15, AFOLURef -19, AFOLURef -20, AFOLURef -21, AFOLURef -29, AFOLURef -31]
[11] [AFOLURef -29, 30,213]

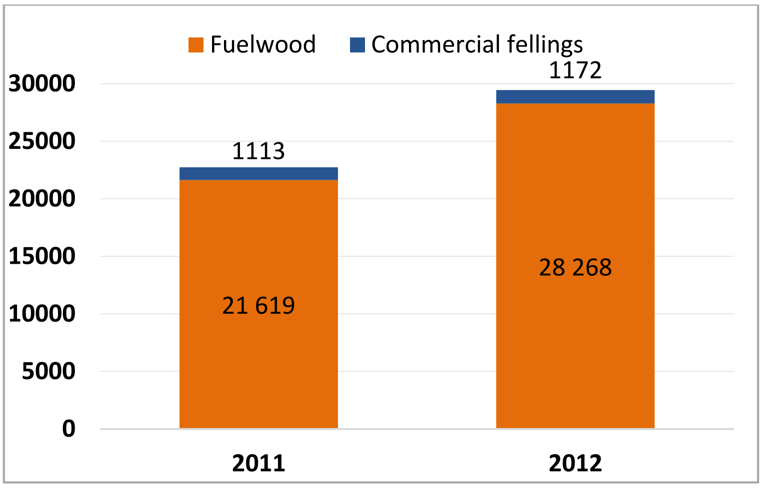



*Figure 4.3.4 Carbon loss (ton) caused by harvested fuelwood and commercial fellings*

In 2011, about 95% of carbon loss is due to harvested fuelwood, 5% - commercial fellings, while in 2012 it was 96% and 4% respectively.

Thus, in 2012 (Table 4.3.10) was an increase in carbon annual losses causing reduction in carbon dioxide removals: 547Gg in 2011 vs 522Gg in 2012.

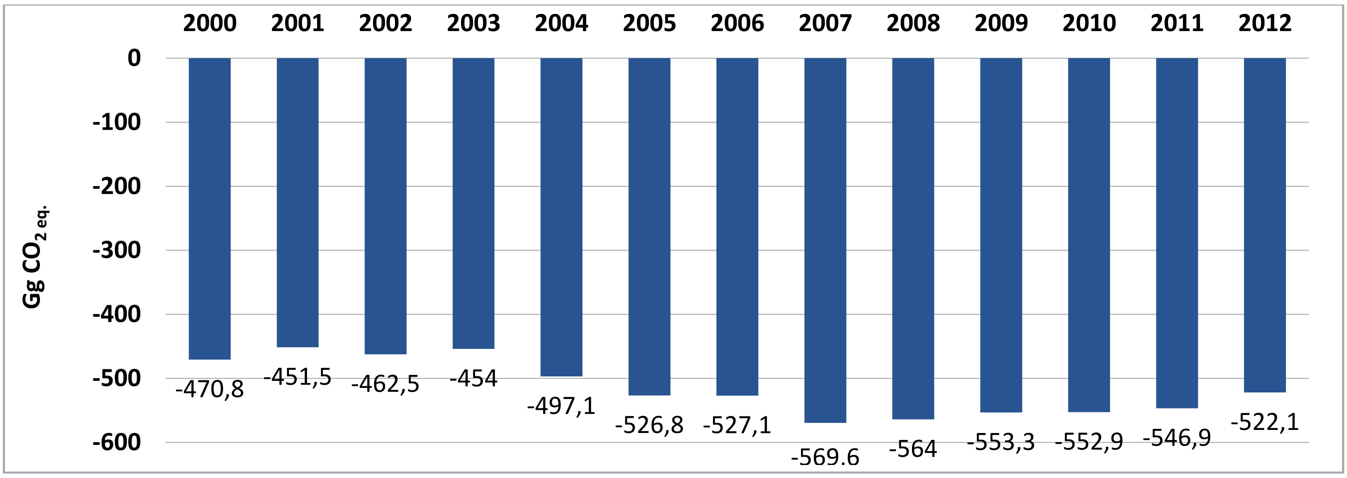



*Figure 4.3.5 Carbon dioxide removals in Forest land Remaining Forest land subcategory in 2000-2012, Gg CO2 eq.*

### *3B1b Land Converted to Forest land*

Lands Converted to Forest land (LCFL) subcategory in 2010 GHG NIR totaled to 598.9ha. In 2011 it increased by about 35ha, while in 2012 - by another 66ha, about 101 ha in total [AFOLURef-29].
Pine plantations account for dominating part of LCFL covered areas and accumulated biomass stock: as of 2011, pine plantations account for 394 ha of 634 ha of covered areas, while in 2012 – 460 h a of 700 ha [AFOLURef - 29]. Hence, the country-specific factors for estimating the annual change in carbon stock in biomass derived as weighted average values basically match the pines.

The 20-year interval is taken as a default length of transition period for carbon stock changes following land-use change (Gen-1). Therefore, estimates for this subcategory are made for biomass carbon gains as well as for carbon stock change in dead organic matter. Carbon gains in biomass account for about 0.2% of yearly growth in total forest covered areas.

**Table 4.3.11 LCFL annual carbon stock gain in biomass**

| Inventory Year | 2011 | 2012 |
|---|---|---|
| Covered area, ha | 634 | 700 |
| Biomass annual average growth per 1 ha, cubic m | 1.5 | 1.5 |
| Carbon annual gains, C t/year | 312 | 345 |
| Carbon stock change in dead organic matter, C t/year | 887.6 | 1,867.6 |

***3B2-3B6 Cropland, Grassland, Wetland, Settlement and Other Land***

For Armenia, Land Use categories and changes therein are described in complex approach including the Land Use and character of conversion, areas, cultivated crops, and biophysical criteria (e.g. climatic zonation). This approach not only enables to have a clear picture of each conversion in land use but also to follow further changes in such conversions.

Land change by years is made based on land balances and land change data provided by State Committee of Real Estate Cadaster under RA Government.
$CO_2$ emissions and removals are estimated based on carbon stock change in biomass and in dead organic matter, and in soil types - based on organic carbon stock change by using gain/loss method.

**3B2 Cropland**

Estimates for “Cropland” category in Land Use are made for 3B2a “Cropland Remaining Cropland” and 3B2b “Land Converted to Cropland” subcategories.

*3B2a Cropland remaining Cropland*

The inventory is made for all lands that have not undergone essential changes in terms of land use during recent 20 years by matching local and international classifications of lands with local soil types. Lands are subdivided according to three international climatic zones available in Armenia: warm moderate dry, cold moderate arid, and cold moderate humid. Then, annual crops were classified according to Armenian agricultural practices. $CO_2$ emissions and removals are estimated based on change of carbon stock in biomass, and organic carbon stock change in mineral soils.
Carbon stock change in biomass is estimated based on carbon gain/loss by using Tier 2 Methodology given that land use type, area, cultivated crops, and climatic zonal distribution are taken into consideration.

*3B2b Land converted to Cropland*

2011-2012 Inventories has reported on conversion of other land categories to Cropland (in 2011 - 770 ha, in 2012 - 1359 ha). $CO_2$ emissions and removals are estimated based on changes of carbon stock in biomass and in dead organic matter, and organic carbon stock change in mineral soils.

**3B3 Grassland**

The area of lands in “Grassland” category of Land Use has increased in 2011-2012 as a result of conversion of “Arable Land” and “Other Land” subcategories (in 2011 – 3147 ha, in 2012 – 656 ha [AFOLURef-8 և AFOLURef -9].

Main source of Greenhouse Gas emissions and removals from “Grassland” category is carbon stock change in biomass and soil (organic substance) which is generally due to Grassland management and changes in management practices.

Emissions and removal from “Grassland” category are estimated for 3B3a “Grassland Remaining Grassland” and 3B3b “Land Converted to Grassland” subcategories.

GHG emissions and removals for 3B3a “Grassland Remaining Grassland” subcategory are estimated by using Tier 1 Method. The assumption offered by Guidelines on stability of biomass and absence of any change in it is taken as a basis given the fact that: firstly there are no data in Armenia on grassland management practices and intensity of use, and secondly this category is not a main source for GHG emissions. Emissions and removal in this subcategory are estimated based on carbon stock change in mineral and organic soils.

Spatial inclusion of soil areas of this category are estimated by using three approaches recommended by the Guidelines according to which soils are divided and included in the Inventory according to three climatic zones and soil types. Such division of soils for estimating emissions by using Tier 2 methodology is the first required condition which, however, is not sufficient as there is lack of information on grassland types, impact and management regimes and on other factors that make essential effect on both biomass and carbon stock gain/loss in it.

$CO_2$ emissions and removals in 3B3b “Land Converted to Grassland” subcategory are estimated based on carbon stock change in biomass and in dead organic matter as well as on carbon stock change in mineral and organic coils.

**3B6 Other Land**

This category of Land Use includes unusable reserve lands, rocks, ice lands, and other unmanageable lands that are not included in former five categories. Availability of data will enable to check and correct land total areas and match them in for the entire area of the country.

### *4.3.2.3 (3C) Aggregate sources and non-$CO_2$ emissions sources on land*

This category covers all land types impacted by human or cultivated by human including managed forestlands. Calculations of direct and indirect nitrous oxide emissions as a result of fertilization of soil by organic and inorganic fertilizers as well as carbon dioxide emissions from biomass burning were done by using Tier 1 Method. Carbon dioxide emissions were calculated for 3C1A Forest land subcategory.

Emissions from “3 C 3 Urea application” subcategory were calculated with activity data on the use of inorganic fertilizers and the factors provided by the Guidelines.

Emissions from “3 C 4 - Direct $N_2O$ emissions from managed soils” subcategory were calculated using country- specific assessments on the use of manure as a fuel and as a fertilizer (share of the total mass of the manure) and the factors provided by the Guidelines.

## *4.3.3 Emissions from “Land” and “Aggregate sources and non-CO2 emissions sources on land” Categories*

Calculations of $CO_2$ emissions and removals, non-$CO_2$ emissions from land use change, as well as direct and indirect nitrous oxide emissions from agricultural lands and manure management were estimated in these categories.

### *4.3.3.1 Emissions from Land Category*

Assessment of 2011 and 2012 GHG emissions/removals from Land category in $CO_{2\ eq}$. is provided below.

**Table 4.3.12 Emissions/removals estimate from AFOLU “Land” category, 2011 and 1012**

| Categories | 2011 (Gg) | | | 2012 (Gg) | | |
|---|---|---|---|---|---|---|
| | Net $CO_2$ emission/ removal | Emissions | | Net $CO_2$ emission/ removal | Emissions | |
| | | $CH_4$ | $N_2O$ | | $CH_4$ | $N_2O$ |
| **3.B Land** | -536.97 | IE | IE | -522,07 | IE | IE |
| **3.B.1 Forest land** | -551.39 | IE | IE | -531.40 | IE | IE |
| 3.B.1.a Forest land remaining Forest land | -546.99 | | | -522.14 | | |
| 3.B.1.b Land converted to Forest land | -4.40 | | | -9.26 | | |
| 3.B.1.b.i Cropland converted to Forest land | -4.40 | | | -9.26 | | |
| **3.B.2 Cropland** | -2.37 | IE | IE | -7,77 | IE | IE |
| 3.B.2.a Cropland Remaining Cropland | 0.67 | | | 0.67 | | |
| 3.B.2.b Land Converted to Cropland | -3.04 | IE | IE | -8.44 | IE | IE |
| 3.B.2.b.i Forest land converted to Cropland | 0.22 | | | 0.22 | | |
| 3.B.2.b.ii Grassland converted to Cropland | -3.27 | | | -8,66 | | |
| 3.B.2.b.v Other lands converted to Cropland | IE | | | IE | IE | IE |
| **3.B.3 Grassland** | 16.79 | IE | IE | 17.21 | IE | IE |
| 3.B.3.a Grassland remaining Grassland | 12.72 | | | 12.59 | | |
| 3.B.3.b Land converted to Grassland | 4.08 | IE | IE | 4.63 | IE | IE |
| 3.B.3.b.ii Cropland converted to Grassland | 0.27 | | | 0.82 | | |
| 3.B.3.b.iv Settlement Converted to Grassland | 0.01 | | | 0.01 | | |
| 3.B.3.b.v Other lands converted to Grassland | 3.80 | | | 3.80 | | |
| **3.B.4 Wetland** | NE | NE | NE | NE | NE | NE |
| **3.B.5 Settlement** | NE | NE | NE | NE | NE | NE |
| **3.B.6 Other land** | IE | IE | IE | IE | IE | IE |

### *4.3.3.2 Emissions from “Aggregate sources and non-CO2 emissions sources on land” Category*

Assessment of 2011 and 2012 GHG emissions from “Aggregate sources and non-CO2 emissions sources on land” Category in $CO_{2\ eq}$. is provided below.

**Table 4.3.13 Emissions/removals estimate from AFOLU “Aggregate sources and non-$CO_2$ emissions sources on land” category, 2011 and 1012**

| Categories | 2011 (Gg) | | | 2012 (Gg) | | |
|---|---|---|---|---|---|---|
| | Net $CO_2$ emission/ removal | Emissions | | Net $CO_2$ emission/ removal | Emissions | |
| | | $CH_4$ | $N_2O$ | | $CH_4$ | $N_2O$ |
| 3.C Aggregate sources and non-$CO_2$ emissions sources on land | 1.05 | IE | 1.07 | 0.41 | IE | 1.31 |
| 3.C.1 Emissions from biomass burning | IE | 0.02 | IE | IE | 0.01 | IE |
| 3.C.3 Urea application | 1.05 | | | 0.41 | | |
| 3.C.4 Direct $N_2O$ emissions from managed soils | | | 0.60 | | | 0.74 |
| 3.C.5 Indirect $N_2O$ emissions from managed soils | | | 0.31 | | | 0.38 |
| 3.C.6 Indirect $N_2O$ emissions from manure management | | | 0.17 | | | 0.18 |

### 4.3.4 Emissions/removals estimate for "Agriculture, Forestry and Other Land Use" Sector

**Table 4.3.14 GHG emissions/removals (in key source category classification format) from "Agriculture, Forestry and Other Land Use" sector, $CO_{2\ eq.}$**

| IPCC category codes | IPCC categories | Greenhouse Gas | 2011 Ex,t (Gg $CO_{2\ eq.}$) | 2012 Ex,t (Gg $CO_{2\ eq.}$) |
|---|---|---|---|---|
| 3.A.1 | Enteric fermentation | $CH_4$ | **945.30** | **1,060.01** |
| 3.B.1.a | Forest land Remaining Forestland | $CO_2$ | **-546.99** | **-522.14** |
| 3.C.4 | Direct $N_2O$ emissions from managed soils | $N_2O$ | **184.45** | **230.63** |
| 3.C.5 | Indirect $N_2O$ emissions from managed soils | $N_2O$ | **96.83** | **117.69** |
| 3.A.2 | Manure management | $CH_4$ | **76.03** | **81.18** |
| 3.A.2 | Manure management | $N_2O$ | 67.03 | 74.72 |
| 3.C.6 | Indirect $N_2O$ emissions from manure management | $N_2O$ | 51.87 | 57.13 |
| 3.B.3.a | Grassland Remaining Grassland | $CO_2$ | 12.72 | 12.59 |
| 3.B.1b | Land converted to Forestland | $CO_2$ | -4.40 | -9.26 |
| 3.B.3.b | Land converted to Grassland | $CO_2$ | 4.08 | 4.63 |
| 3.B.2.b | Land converted to Cropland | $CO_2$ | -3.04 | -8,44 |
| 3.B.2.a | Cropland Remaining Cropland | $CO_2$ | 0.67 | 0.67 |
| 3.C.3 | Urea application | $CO_2$ | 1.05 | 0.41 |

**Table 4.3.15 Detailed Information on GHG emissions from "Agriculture, Forestry and Other Land Use" sector for 2011-2012**

| Categories | 2011 (Gg) | | | 2012 (Gg) | | |
|---|---|---|---|---|---|---|
| | Net $CO_2$ emission/ removal | Emissions | | Net $CO_2$ emission/ removal | Emissions | |
| | | $CH_4$ | N2O | | $CH_4$ | N2O |
| **3 - Agriculture, Forestry and Other Land Use** | -545.729 | 48.652 | 1.291 | -521,660 | 54.349 | 1.549 |
| **3.A Livestock** | IE | 48.635 | 0.216 | IE | 54.342 | 0.241 |
| 3.A.1 Enteric fermentation | IE | 45.014 | IE | IE | 50.477 | IE |
| 3.A.1.a Cattle | IE | 40.531 | IE | IE | 45.423 | IE |
| 3.A.1.a.i Cows | | 23.313 | | | 24.953 | |
| 3.A.1.a.ii Other Cattle | | 17.219 | | | 20.470 | |
| 3.A.1.b Buffalos | | 0.026 | | | 0.028 | |
| 3.A.1.c Sheep | | 3.833 | | | 4.382 | |
| 3.A.1.d Goats | | 0.203 | | | 0.206 | |
| 3.A.1.f Horses | | 0.183 | | | 0.186 | |
| 3.A.1.g Donkeys and Mules | | 0.040 | | | 0.040 | |
| 3.A.1.h Pigs | | 0.198 | | | 0.212 | |
| 3. **Manure management** (1) | IE | 3.620 | 0.216 | IE | 3.866 | 0.241 |
| 3.A.2.a Cattle | IE | 3.065 | 0.157 | IE | 3.272 | 0.176 |
| 3.A.2.a.i Cows | | 2.656 | 0.106 | | 2.807 | 0.115 |
| 3.A.2.a.ii Other Cattle | | 0.409 | 0.051 | | 0.465 | 0.061 |
| 3.A.2.b Buffalos | | IE | IE | | 0.001 | IE |
| 3.A.2.c Sheep | | 0.077 | 0.037 | | 0.088 | 0.043 |
| 3.A.2.d Goats | | 0.004 | 0.002 | | 0.005 | 0.002 |
| 3.A.2.f Horses | | 0.011 | 0.002 | | 0.011 | 0.002 |
| 3.A.2.g Donkeys and Mules | | 0.002 | IE | | 0.002 | IE |
| 3.A.2.h Pigs | | 0.396 | 0.012 | | 0.424 | 0.013 |
| 3.A.2.i Poultry | | 0.064 | 0.005 | | 0.064 | 0.005 |
| **3.B Land** | -536.965 | IE | IE | -522.068 | IE | IE |
| 3.B.1 **Forest land** | -551.386 | IE | IE | -531.401 | IE | IE |

| Categories | 2011 (Gg) | | | 2012 (Gg) | | |
|---|---|---|---|---|---|---|
| | Net $CO_2$ emission/ removal | Emissions | | Net $CO_2$ emission/ removal | Emissions | |
| | | $CH_4$ | N2O | | $CH_4$ | N2O |
| 3.B.1.a Forest land Remaining Forest land | -546.986 | IE | IE | -522.142 | | |
| 3.B.1.b Land Converted to Forest land | -4.401 | IE | IE | -9.259 | IE | IE |
| 3.B.1.b.i Cropland converted to Forest land | -4.401 | | | -9.259 | | |
| 3.B.1.b.ii Grassland converted to Forest land | IE | | | IE | | |
| 3.B.1.b.iii Wetland converted to Forest land | IE | | | IE | | |
| 3.B.1.b.iv Settlement converted to Forest land | IE | | | IE | | |
| 3.B.1.b.v Other land converted to Forest land | IE | | | IE | | |
| 3.B.2 **Cropland** | -2.374 | IE | IE | -7.766 | IE | IE |
| 3.B.2.a Cropland remaining Cropland | 0.670 | | | 0.670 | | |
| 3.B.2.b Land converted to Cropland | -3.044 | IE | IE | -8.436 | IE | IE |
| 3.B.2.b.i Forest land converted to Cropland | 0.223 | | | 0.223 | | |
| 3.B.2.b.ii Grassland converted to Cropland | -3.267 | | | -8.660 | | |
| 3.B.2.b.iii Wetland converted to Cropland | IE | | | IE | | |
| 3.B.2.b.iv Settlement converted to Cropland | IE | | | IE | | |
| 3.B.2.b.v Other land converted to Cropland | IE | | | IE | | |
| 3.B.3 **Grassland** | 16.795 | IE | IE | 17.215 | IE | IE |
| 3.B.3.a Grassland remaining Grassland | 12.718 | | | 12.588 | | |
| 3.B.3.b Land converted to Grassland | 4.077 | IE | IE | 4.627 | IE | IE |
| 3.B.3.b.i Forest land converted to Grassland | IE | | | IE | | |
| 3.B.3.b.ii Cropland converted to Grassland | 0.272 | | | 0.817 | | |
| 3.B.3.b.iii Wetland converted to Grassland | IE | | | IE | | |
| 3.B.3.b.iv Settlement converted to Grassland | 0.005 | | | 0.011 | | |
| 3.B.3.b.v Other Land converted to Grassland | 3.799 | | | 3.799 | | |
| 3.B.4 **Wetland** | NE | NE | NE | NE | NE | NE |
| 3.B.4.a Wetland remaining Wetland | NE | NE | NE | NE | NE | NE |
| 3.B.4.b Land converted to Wetland | NE | NE | NE | NE | NE | NE |
| 3.B.5 **Settlement** | NE | NE | NE | NE | NE | NE |
| 3.B.5.a Settlement remaining Settlement | NE | NE | NE | NE | NE | NE |
| 3.B.5.b Land converted to Settlement | NE | NE | NE | NE | NE | NE |
| 3.B.6 **Other land** | IE | IE | IE | -0.115 | IE | IE |
| 3.B.6.a Other land remaining other land | | | | | | |
| 3.B.6.b Land converted to other land | IE | IE | IE | -0.115 | IE | IE |
| **3.C Aggregate sources and non-CO2 emissions sources on land (2)** | 1.053 | 0.018 | 1.075 | 0.408 | 0.007 | 1.308 |
| 3.C.1 Emissions from biomass burning | 0.00 | 0.018 | IE | IE | 0.007 | IE |
| 3.C.3 Urea application | 1.05 | | | 0.408 | | |
| 3.C.4 Direct $N_2O$ emissions from managed soils | | | 0.595 | | | 0.744 |
| 3.C.5 Indirect $N_2O$ emissions from managed soils | | | 0.312 | | | 0.380 |
| 3.C.6 Indirect $N_2O$ emissions from manure management | | | 0.167 | | | 0.184 |

### *4.3.5 Quality Control/Quality Assurance*

Use of various methodologies for estimating emissions and comparison of results are important measures for quality control and quality assurance. As Cattle Enteric Fermentation and Manure Management are key sources of GHG emissions in Agriculture emissions in Livestock subcategory are estimated by using Tier 1 and Tier 2 methodologies. Besides, baseline data and emission factors are recalculated through livestock population recalculated data and other indicators (animal weight, milk yield rate, weight increase rate, etc.) for estimating uncertainties deviation.

Quality assurance in Land category is mostly due to uncertainty level of baseline data. Estimates are based on Land Balances approved for each year by RA Government.

As a quality assurance measure the Report was reviewed by an expert not directly involved in developing and drafting the Inventory.

### *4.3.6 Completeness of Data and Uncertainties Analysis*

*Livestock*

There was an increase in methane emission volumes form livestock enteric fermentation in 2011 and 2012. This was due to increase in livestock population, milk yield rate, and cattle weight change which, according to RA NSS and RA Ministry of Agriculture data. Emissions were estimated by applying country-specific emission factors and Tier 2 Method. Such approach somehow reduces uncertainties range of results. There are significant differences between activity data and factors for Cattle offered by Tier 1 Method (Gen-1) and activity data for livestock in Armenia. In particular, Tire 1 Method provides for Cows: emissions factor - 68kg head/year, milk yield rate - 1650kg head/year or 4.5kg head/day, while for Armenia according to data from RA NSS activity data for cows are: 2035kg head/year and 2036kg head/year or about 5.6kg head/day for 2011 and 2012 respectively. Tier 1 Method provides 350kg of average living weight for dairy cows, while for Armenia according to data from RA Ministry of Agriculture, average weight of cows is 430-440kg. The difference is much greater for bulls and young animals, which ended up in a greater deviation in estimates made by using Tier 1 and Tier 2 Methods [Gen-1, Chapter 10, Volume 4]. In calculations, the uncertainties of activity data conditioned by the following main reasons were minimized:

1. Limitations in official data collection process which affects data completeness and credibility.

2. Lack of expertise with regard to some indicators estimated by professional institutions, use of Soviet period professional reference books particularly for milk yield rates, digestion, forage resources, animal raising practices, weight increase, cattle breeds, manure quantities, manure use per directions, and other indicators.

To ensure data completeness and reduce uncertainties the following actions were done:

- Along with available official data a certain activity data were clarified: annual average number of livestock was clarified based on calculations using data on monthly sales of animals for meat/to butcheries. Such approach enabled to have a more realistic view for livestock population as consideration was given to data on seasonality of calving, import – export data, data on slaughter and losses. Deviations between data on slaughter derived by calculations and respective official data equal to 4.2%. At the same time, according to monitoring conducted by Agriculture department of RA NSS, during livestock population census deviation on population data equals up to 3% as of January 1.

As a result, about 7-7.5% of emissions uncertainty is due to existing deviations in data on livestock population.

- Country-specific emission factors estimated for cow differ from those provided in Guidelines, i.e. 79kg/head/year (2011) and 80kg/head/year (2012) instead of 68 kg/head/year default factor (Gen-1). This approach reduces uncertainties of emissions to some extent.

- In estimating emissions from Poultry the number of broilers is separated from the number of laying hens, which resulted in reducing uncertainties of emissions from Poultry although increasing emissions.

*Land*

Uncertainties in Forestry is related to lack of complete and accurate information on changes in forest covered areas which is the most serious issue for GHG inventory. Lack of mechanism for forest inventory is the main obstacle for forest management planning as well as on comprehensive reflection of current qualitative and quantitative changes (in particular, on forest logging, afforestation, forest rehabilitation, burned forests, area exposed to infection and pests, etc.)

Uncertainties in Other Land Use are related to uncertainties in land areas; they are also due to the fact that the Government is publishing RA Land Balances as of July 1 of each year leaving some changes out of the balance of a given Inventory year. Besides, materials for cadaster mapping implemented in the country and data published by NSS serve as primary sources for data included in Land Balances approved by the Government. However, as it is proven in practice, often there are differences in said data which also caused uncertainties in data.

Other sources of uncertainties could be errors made during cadaster mapping process, changes made but not yet registered in Land Use.

## 4.4 Waste

### 4.4.1 Description of the Sector

"Waste" sector of National Inventory of Greenhouse Gases of Armenia includes the following categories:

- "Solid waste disposal" (4A), where methane emissions from solid waste was considered;
- "Incineration and open burning of waste" (4C), where carbon dioxide, methane, and nitrous oxide emissions from open burning was considered (4C2);
- "Wastewater treatment and discharge" (4D) where the following subcategories were considered:
    - "Domestic wastewater treatment and discharge" (4D1),
    - "Industrial wastewater treatment and discharge" (4D2),

Methane emissions from domestic and industrial wastewater and nitrous oxide emissions from domestic wastewater were considered in "Wastewater treatment and discharge" category.

Other sources provided in 2006 IPCC Guidelines do not exist in Armenia.

GHG emissions were estimated by using 2006 IPCC Software.

GHG emissions from "Waste" sector are provided below in Table 4.4.1.

**Table 4.4.1 Emissions from "Waste" sector**

| Sources of Emissions | Emissions, Gg | | | | | |
|---|---|---|---|---|---|---|
| | 2011 | | | 2012 | | |
| | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2$ | $CH_4$ | $N_2O$ |
| 4 –Waste | 6.910 | 26.700 | 0.188 | 7.326 | 26.987 | 0.188 |
| 4A – Solid waste disposal | NA | 21.397 | NA | NA | 21.579 | NA |
| 4C –Incineration and open burning of waste | 6.910 | 0.995 | 0.018 | 7.326 | 1.055 | 0.019 |
| 4C2 – Open burning of waste | 6.910 | 0.995 | 0.018 | 7.326 | 1.055 | 0.019 |
| 4D – Wastewater treatment and discharge | NA | 4.307 | 0.170 | NA | 4.353 | 0.169 |
| 4D1 – Domestic wastewater treatment and discharge | NA | 3.306 | 0.170 | NA | 3.308 | 0.169 |
| 4D2 – Industrial wastewater treatment and discharge | NA | 1.002 | NA | NA | 1.044 | NA |

### 4.4.2 Main Sources of Emissions

Emission main sources for "Waste" sector include: "Solid Waste Disposal" (methane emissions) accounting for 4.8% (in 2011) and 4.5% (in 2012), and "Wastewater treatment and discharge" (methane emissions) accounting for 2.08% (in 2011) and 1.02% (in 2012).

### 4.4.3 Solid waste

### 4.4.3.1 Methane emissions from municipal solid waste (MSW)

#### 4.4.3.1.1 Choice of Methodology

The IPCC methodology for estimating CH4 emissions from SWDS is based on the First Order Decay (FOD) method. This method assumes that the degradable organic component (degradable organic carbon, DOC) in waste decays slowly throughout a few decades, during which $CH_4$ and $CO_2$ are formed. If conditions are constant, the rate of CH4 production depends solely on the amount of carbon remaining in the waste. As a result emissions of CH4 from waste deposited in a disposal site are highest in the first few years after deposition, then gradually decline as the degradable carbon in the waste is consumed by the bacteria responsible for the decay.

Half-lives for different types of waste vary from a few years to several decades or longer. The FOD method requires data to be collected or estimated for historical disposals of waste over a time period of 3 to 5 half-lives in order to achieve an acceptably accurate result. It is therefore good practice to use disposal data for at least 50years as this time frame provides an acceptably accurate result for most typical disposal practices and conditions.

In Armenia lack of activity data does not allow making such accurate assessments for the Soviet period (up to 90s). FOD calculation is based on 3.1, 3.2, 3.4-3.7 equations provided in Chapter 5,Volume 5 of 2006 IPCC Guidelines [Gen-1].

Pursuant to such conditions the following approach was chosen. Calculations were made in two options. In one option calculations started from year 1990. In this case methane emissions value can be underestimated as of present, but in the course of time methane emissions values will be corrected in parallel with availability of more and more data.

For the other option calculations started from year 1950 while expert assessment data was filled in for missing data. As a result methane emissions were not underestimated but uncertainty level was high. Table 4.4.1 summarizes these figures for 2011,2012.

#### 4.4.3.1.2 Choice of emissions factors and parameters

The calculation is based on Tier 1 Method given that mainly factors provided in2006 IPCC Guidelines [Gen-1] were used.

The following default values were chosen for calculations:

The value of 0.34 t/person/year [Gen-1, Vol.5, Table 2A.1] recommended for Russian Federation was chosen for per capita MSW generation factor. This value was multiplied by 0.71 [[Gen-1, Vol.5, Table 2A.1]] factor which is the fraction of MSW disposed into dumpsites and burned (based on the expert assessment it is the share of waste burned). As a result, the factor equals to 0.2414 t/person/year or 0.661 kg/capita/day.

Local reliable information on MSW morphology should be considered in order to define the amount of degradable organic carbon (DOC) in MSW mass disposed into dumpsites (GgC/GgMSW) in a specific year.

Increase in fraction of degradable carbon in MSW (food waste, paper, cardboard) generated in the country was observed in recent decades. According to available data [WRef-1] the value of this factor is equal to 0.17 which is very close to default value 0.18 provided in the Guidelines [Gen-1, MSW Section].

Fraction of degradable organic carbon in waste ($DOC_f$) was selected 0.5[Gen-1, Vol.5, Chp.3, 3.2.3., page 3.13], fraction of methane in generated landfill gas (F)` 0.5[Gen-1, h .5, Chap.3, Table 3.1].

The default value 0.05 year$^{-1}$ of 2006 IPCC Guidelines was selected for decomposition reaction factor k [Gen-1, Vol.5, Chap.3, Table 3.3]. It complies with SW half-life decay 13.86 year period [Gen-1, Vol.5, Chap.3, Table 3.3].

2006 IPCC Guidelines default value 6.0 month is selected for decomposition delay time factor (t) [Gen-1, Vol. 5, Chap.3, Delay time, Page 3.19].

#### *4.4.3.1.3 Activity Data*

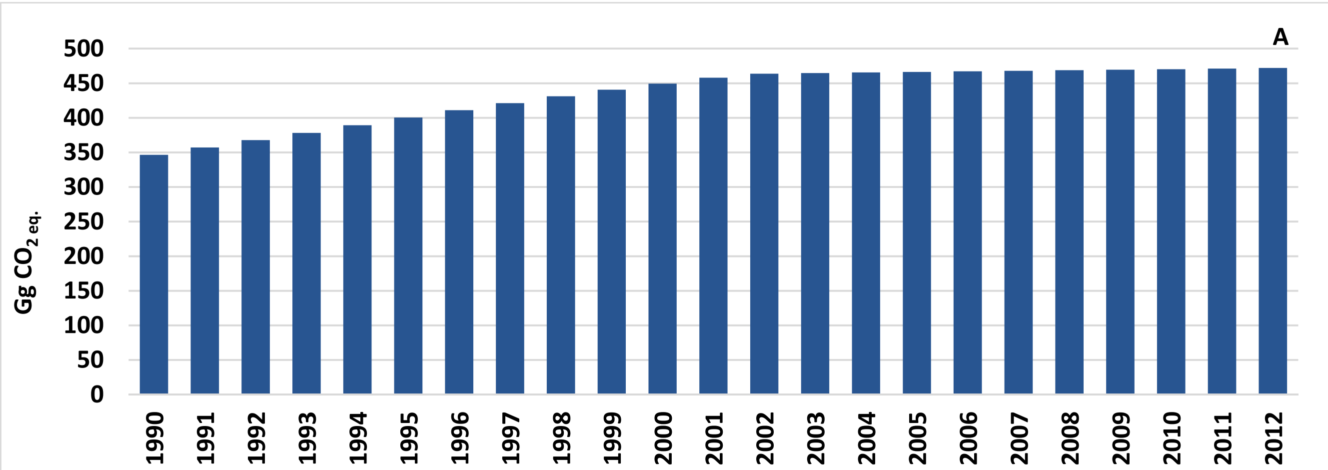
The number of urban population was taken from official statistical sources [Ref-1, Ref-5].

For assessing methane emissions from SWDs they were classified by cities of RA, by using default values [Gen-1, Table 3.1]:

- Capital City of Yerevan – managed SW disposal sites with anaerobe SW degradation ("Nubarashen" SWDS is the largest in RA), MCF = 1.0.
- Gyumri and Vanadzor cities – unmanaged SWDSs with deep SW layer[12], MCF = 0.8.
- Other 45 cities and towns of the country – unmanaged SWDSswith not-deep SW layer[13], MCF = 0.4.

According to monitoring reports implemented in "Nubarashen" under the framework of the UNDP Programme in 2011 1.04 Gg $CH_4$ gas was captured, or 21.8 Gg $CO_{2eq.}$ under a UNDP Project. In 2012 the values totaled to 0.9 Gg methane and 19.1 Gg $CO_{2eq.}$ respectively [WRef-2].

Figure 4.4.1 below provides time series for methane emissions from SWDSs, estimated by using both approaches.




[12] 5 meters and deeper

[13] Up to 5 meters deep

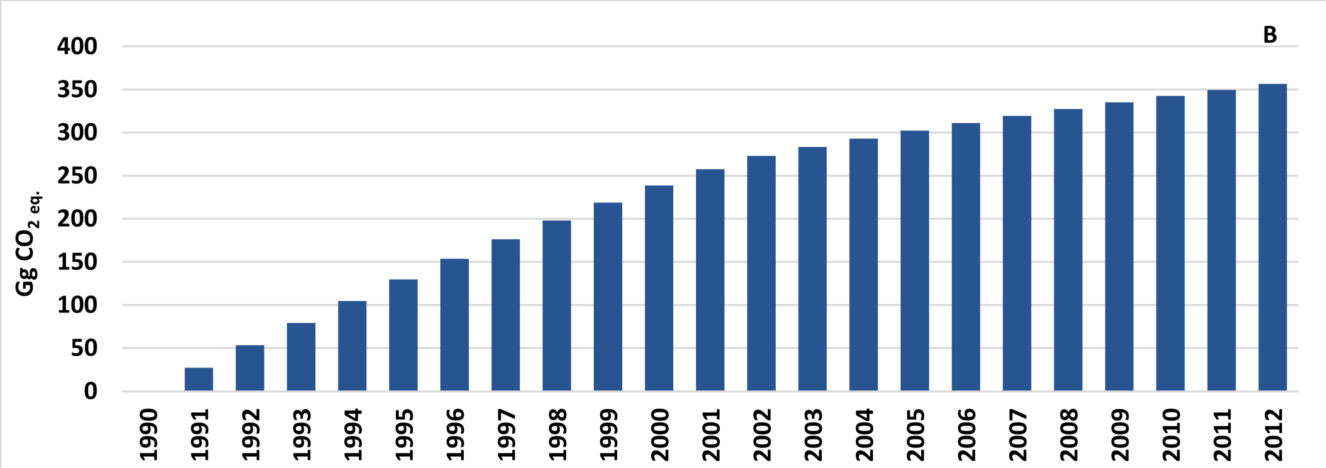



*Figure 4.4.1 Methane emissions from SWDSs, calculated since 1950 (A), and since 1990 (B), (without $CH_4$ gas capture)*

As it was expected, figures calculated since 1990 are underestimated.

#### 4.4.3.2 Open burning of waste

There are no data on amounts and emission factors of waste exposed to open burning in Armenia. Calculations were made according to [equations 5.4, 5.5, 5.7, Chapter 5.,Vol.5, Gen-1]. The amount of waste exposed to open burning was calculated based on the number of rural population which totaled to 1174 thousand and 1178 thousand in 2011 and 2012 respectively [Ref-1].

Similar to the case of MSW disposal, the value of 0.34 t/person/year [Gen-1, Vol.5, Table 2A.1] recommended for Russian Federation was chosen (for rural population as well) for per capita MSW generation factor. This value was multiplied by 0.71 [[Gen-1, Vol.5, Table 2A.1]] factor which is the fraction of MSW disposed into dumpsites and burned (based on the expert assessment it is the share of waste burned). As a result, the factor equaled to 0.2414 t/person/year or 0.661 kg/capita/day [Gen-1]. Default values were applied for waste parameters (dry matter content, carbon content and other input parameters).

Fraction of the waste amount that is burned relative to the total amount of waste treated ($B_{frac}$) is equal to 0.6 [Gen-1, Vol.5., Chap. 5, Box 5.1, Page 5.17].

Dry matter content in MSWs ($dm_i$) is equal to 0.78 [Gen-1, Vol.5., Chap. 5, Page 5.17].

Carbon content in MSWs ($CF_i$) is equal to 0.34 [Gen-1, Vol.5., Chap. 5, Page 5.17-18].

Fraction of fossil carbon ($FCF_i$) in MSW is equal to 0.08 [Gen-1, Vol.5.,Chap. 5, Page 5.19-20].

Oxidation factor ($OF_i$) is equal to 0.58 (Gen-1, Vol.5.,Chap. 5, Box 5.2, Page 5.18).

Gases produced from open burning include: carbon dioxide, methane and nitrous oxide. The results are described in Table 4.4.1.

### 4.4.4 Wastewater Treatment and Discharge

### 4.4.4.1 Domestic Wastewater Treatment and Discharge

Methane emissions from domestic wastewater were calculated based on formula 6.1, 6.2, 6.3 in Chapter 6, Vol.5, [Gen-1].

#### 4.4.4.1.1 Choice of Emission Factor

Tier 1 Method was applied and the following factors provided in 2006 IPCC Guidelines were used for estimation of emission factor:

Bo -Maximum methane producing capacity: Bo= 0.6 kg$CH_4$/kg BOD (default value, [Gen-1]- Vol.5., Chap.6, Table 6.2).

MCFj - methane correction factor (fraction). The MCF indicates the extent to which the CH4 producing capacity (Bo) is realized in each type of treatment and discharge pathway and system. Thus, it is an indication of the degree to which the systemic anaerobic. In the case of latrines the value of 0.1 was selected for $MCF_J$ factor which complies with areas with dry climate, ground water table lower than latrine, small family (3-5 persons)([Gen-1]- Vol.5., Chap.6, Table 6.3.)

BOD - country-specific per capita BOD in inventory year, g/person/day. The value of 18250 kg/1000persons/year (50g/person/day) recommended in [Gen-8, Page 6.23] for former USSR countries was used as the most appropriate for Armenia. The same value was also used in calculations made for all former GHG National Inventories for Armenia.

I - correction factor for additional industrial BOD discharged into sewers: I = 1.00 for uncollected domestic wastewater (default value, [Gen-1]-ի Vol.5., Chap.6, Page 6.14). This default value was used based on the information from industries and establishments.

#### *4.4.4.1.2 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 and BOD generation per person. It is expressed in terms of biochemical oxygen demand (kg BOD/year).

TOW - total organics in wastewater in inventory year, kg BOD/yr

P -country population in inventory year, (person)[Ref-1],which is classified by the size of income 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, and rural population - as low-income population group([Gen-1], Vol.5., Chap..6).

Tj - degree of utilization of treatment/discharge pathway or system.

Sewer for large cities (Yerevan, Gyumri, Vanadzor) accounts for 0.95, public and other toilets - 0.05. Sewage for other cities accounts for 0.5, public and other toilets - 0.05, while for rural areas it is 0.05 and 0.95 respectively (expert assessment, Ref-6, WRef-4).

### *4.4.4.2 Industrial Wastewater*

#### $CH_4$ emissions

Methane emissions from industrial wastewater were calculated based on formula 6.4, 6.5, 6.6 in Chapter 6, Vol.5, [Gen-1].

#### *4.4.4.2.1 Choice of Factors*

There are significant differences in the $CH_4$ emitting potential of different types of industrial wastewater. To the extent possible, data should be collected to determine the maximum CH4 producing capacity (Bo) in each industry.

Methane emissions from industrial wastewater were calculated by using the fallowing default values for factors:

Si -organic component removed as sludge in inventory year, kg COD/yr. Si = 0(default value,[Gen-1], Vol.5., Chap.6). No emissions from sludge are considered.

Ri - amount of CH4 recovered in inventory year, kg CH4/yr$R_i$= 0 (default value, [Gen-1], Vol.5., Chap.6). Activities for methane capture/removal from industrial wastewater are missing.

MCF - Methane correction factor: MCF= 0.1 (the value complies untreated systems with sea, river and lake discharge[Gen-1], Vol.5., Chap. 6, Table 6.8).

Bo- maximum CH4 producing capacity, kg $CH_4$/kg COD Bo = 0.25. As no country-specific data are available, it is good Practice[Gen-1] to use the IPCC COD-default factor for Bo.

### *4.4.4.2.2 Activity Data and Emissions Estimate*

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 (tons/yr), wastewater generation W (m3/ton of product), and degradable organics concentration in the wastewater COD (kg COD/m3).

For determination of TOW the industrial sectors that generate wastewater with large quantities of organic carbon were identified. Industrial production data were obtained from national statistics.

For each selected sector total organically degradable carbon (TOW) was estimated using the following data:

Pi -total industrial product for industrial sector i, t/yr

Wi -wastewater generated, $m^3$/t product

CODi - chemical oxygen demand (industrial degradable organic component in wastewater), kg COD/$m^3$,default values were used ([Gen-1] Vol.5, Chap.6 Table 6.9).

Table 4.4.2 provides time series of production volumes by sectors of industry from which wastewater was generated.

**Table 4.4.2 Production volumes (thousand/t/year) by years [WRef-3, WRef-4]**

| Industry sector | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 |
| Beer and malt | 7.94 | 9.97 | 7.08 | 7.31 | 8.83 | 10.75 | 12.62 | 11.63 | 10.53 | 10.83 | 15.35 | 14.74 | 13.80 |
| Dairy products | 196.04 | 202.63 | 212.79 | 226.03 | 354.75 | 315.91 | 328.91 | 370.41 | 388.24 | 359.09 | 374.58 | 355.40 | 359.94 |
| Fish processing | 0.00 | 0.08 | 0.27 | 0.23 | 0.14 | 0.09 | 0.01 | 0.18 | 0.12 | 0.03 | 0.05 | 7.10 | 9.35 |
| Meat and poultry | 41.66 | 39.47 | 39.78 | 42.78 | 44.98 | 48.27 | 55.30 | 60.85 | 63.87 | 63.03 | 59.46 | 66.14 | 71.85 |
| Plastics and 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 |
| Pulp and paper | 0.00 | 0.24 | 0.65 | 1.61 | 1.61 | 1.81 | 1.72 | 1.35 | 2.00 | 2.14 | 3.37 | 10.48 | 10.66 |
| Soap and detergents | 0.00 | 0.00 | 0.00 | 0.05 | 0.20 | 0.06 | 0.02 | 0.06 | 0.01 | 0.05 | 0.08 | 0.09 | 0.09 |
| Starch production | 0.00 | 0.59 | 0.56 | 0.44 | 0.65 | 3.18 | 3.55 | 2.80 | 2.27 | 2.33 | 2.33 | 2.11 | 1.89 |
| 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 |
| Vegetable, fruit and 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 |
| Wine and vinegar | 4.09 | 6.92 | 7.10 | 2.65 | 2.83 | 7.21 | 4.32 | 4.19 | 3.76 | 4.84 | 6.37 | 6.75 | 6.24 |

### Nitrous oxide emissions

Nitrous oxide ($N_2O$) emissions were estimated based on equations 6.7 and 6.8 in [Gen-1], Vol.5, Chap.6., using default values of factors and activity data ([Gen-1],Vol.5.,Chap.6,Table 6.11). The default value for non-consumed protein corresponding to developed countries using garbage disposal ($F_{NON-CON}$ =1.4) was used instead of the value recommended for developing countries because Armenia uses garbage disposal.

The value of per capita amount of protein consumption (kg/person/year)in Armenia of 70g/person/year was taken from data published by UN Food and Agriculture Organization (UN FAO) [WRef-5].

Methane and nitrous oxide emissions from wastewater in 2011 and 2012 are provided in Table 4.4.1.

Time series of methane emissions from wastewater are provided in Figure 4.4.2.

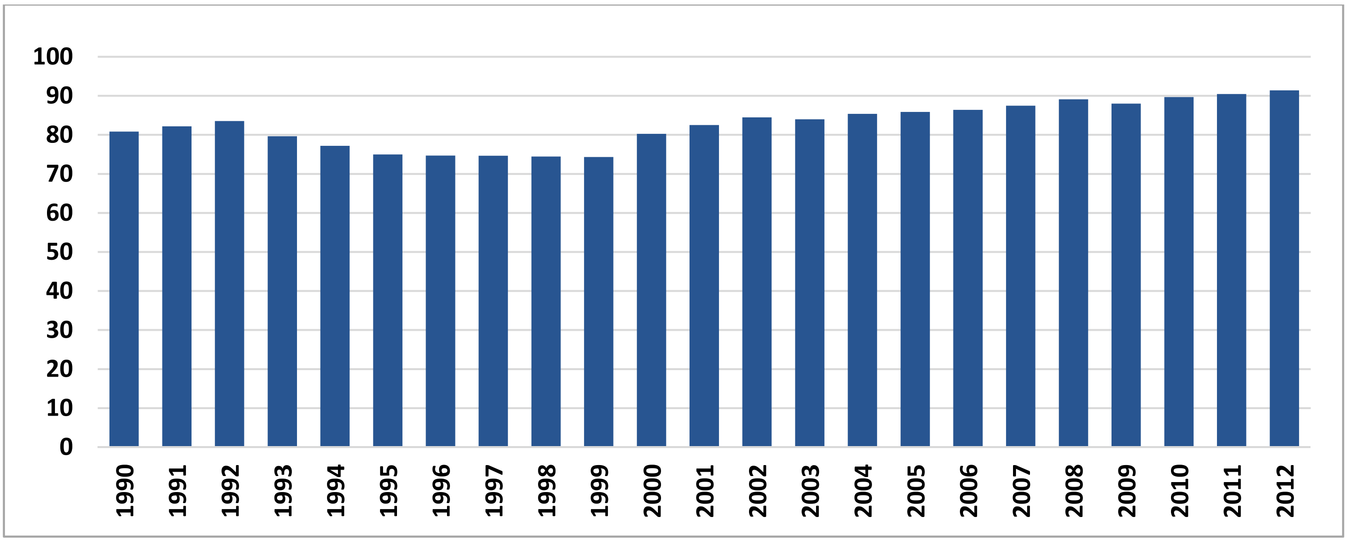



*Figure 4.4.2 Methane emissions from wastewater (Gg), 1990-2012.*

## 4.4.5 Uncertainty Analysis

Uncertainties in "Waste" section are related to uncertainties in the amount of generated and disposed waste, their composition, and properties. According to [Gen-1] uncertainties in activity data for solid waste can be: for total amount of SW - ±30%; for WS disposed in dumpsites - 30%; for degradable organic carbon –±20%; for uncertainty in organic carbon which actually degrades - ±20%; for fraction of methane in biogas - ±5%.

In the case of solid waste open burning the waste moisture indicators and oxidization factor is added to existing uncertainties. Composition of emitted gases also depends on it.

In the case of methane emissions from liquid waste the uncertainty in the number of population can be accepted as 5%, uncertainty in per capita BOD is ±30%. Uncertainty in default factor on maximum methane producing capacity ($B_o$) is ±30%:

In calculating industrial wastewater the uncertainty in the effluent/product-unit ratio is extremely great. This is due to various approaches in wastewater management practices in various plants. The uncertainty in COD $^x$ Waste could be less and it can be accepted as 50 %, +100% [Gen-1]:

## 4.4.6 Prospects for Improving the Inventory

For increasing inventory credibility there is a need to develop country-specific emission factors. This is rather complicated issue as there are no clear waste management mechanisms resulted in lack of complete and reliable activity data. Since 2015, internationally recognized organizations like "Sanitec" company started to get involved in waste collection sector.

Is important also to consider the impact of the updated correct data on number of population, including urban population, on the sector's GHG emissions.

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# ANNEXES

## *Energy*

**Annex 1. Information on natural gas average physiochemical parameters, 2011-2012**

«ԳԱԶՊՐՈՄ» ԲԲԸ

**«ԳԱԶՊՐՈՄ ԱՐՄԵՆԻԱ» ՓԱԿ ԲԱԺՆԵՏԻՐԱԿԱՆ ԸՆԿԵՐՈՒԹՅՈՒՆ**

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«18» 02 2015թ. № 02-24/664

Հայաստանի Հանրապետության
բնապահպանության նախարարի
առաջին տեղակալ
պարոն Ս. Պապյանին

Հարգելի պարոն Պապյան

Ի պատասխան ՀՀ բնապահպանության նախարարության 09.02.2015թ. թիվ 2/07/2003 գրության՝ Ձեզ է տրամադրվում 2011թ. եւ 2012թ. բնական գազի միջին տարեկան ֆիզիկաքիմիական ցուցանիշներ վերաբերյալ տեղեկատվությունը:

Առդիր՝ 2 թերթ:

Հ. Թադեւոսյան

Ս.Գրիգորյան
29-49-59

ՀՀ բնապահպանության
Նախարարության աշխատակազմի
Քարտուղարության ընդհանուր
բաժին
Մուտք № 3263
«20» 02 2015թ.

**The natural gas physicochemical data in the transformation and distribution systems of the Republic of Armenia.**

The average physiochemical parameters of the natural gas imported from the Russian Federation in 2011

| # | Components, mol % | Annual average |
|---|---|---|
| 1. | Methane $CH_4$ | 92,7119 |
| 2. | Ethane $C_2H_6$ | 4,0839 |
| 3. | Propane $C_3H_8$ | 0,9040 |
| 4. | Isobuthane i-$C_4H_{10}$ | 0,0890 |
| 5. | N-buthane n-C4H10 | 0,1186 |
| 6. | Pentane $C_5H_{12}$ and $C_5$+ | 0,0671 |
| 7. | Oxygen $O_2$ | 0,0078 |
| 8. | Nitrogen $N_2$ | 1,3475 |
| 9. | Carbon Dioxide $CO_2$ | 0,6702 |
| Density (kg/m$^3$) | | 0,7231 |
| Net Calorific Value (kcal/m$^3$) | | 8245 |

The physiochemical data of the natural gas (mixture) supplied from Yerevan Gas Distribution Station# 2 in 2011

| # | Components, mol % | Annual average |
|---|---|---|
| 1. | Methane $CH_4$ | 92,0770 |
| 2. | Ethane $C_2H_6$ | 3,9535 |
| 3. | Propane $C_3H_8$ | 0,9257 |
| 4. | Isobuthane i-$C_4H_{10}$ | 0,1011 |
| 5. | N-buthane n-C4H10 | 0,1364 |
| 6. | Pentane $C_5H_{12}$ and $C_5$+ | 0,0755 |
| 7. | Oxygen $O_2$ | 0,0103 |
| 8. | Nitrogen $N_2$ | 2,0853 |
| 9. | Carbon Dioxide $CO_2$ | 0,6351 |
| Density (kg/m$^3$) | | 0,7260 |
| Net Calorific Value (kcal/m$^3$) | | 8188 |

The physiochemical data of the natural gas imported from Islamic Republic of Iran in 2011

| # | Components, mol % | Annual average |
|---|---|---|
| 1. | Methane $CH_4$ | 90,4026 |
| 2. | Ethane $C_2H_6$ | 3,3283 |
| 3. | Propane $C_3H_8$ | 0,9105 |
| 4. | Isobuthane i-$C_4H_{10}$ | 0,1386 |
| 5. | N-buthane n-C4H10 | 0,1921 |
| 6. | Pentane $C_5H_{12}$ and $C_5$+ | 0,1128 |
| 7. | Oxygen $O_2$ | 0,0122 |
| 8. | Nitrogen $N_2$ | 4,3331 |
| 9. | Carbon Dioxide $CO_2$ | 0,5699 |
| Density (kg/m$^3$) | | 0,7379 |
| Net Calorific Value (kcal/m$^3$) | | 7999 |

The physiochemical data of the natural gas imported from the Russian Federation in 2012

| # | Components, mol % | Annual average |
|---|---|---|
| 1. | Methane $CH_4$ | 92,7119 |
| 2. | Ethane $C_2H_6$ | 4,0839 |
| 3. | Propane $C_3H_8$ | 0,9040 |
| 4. | Isobuthane i-$C_4H_{10}$ | 0,0890 |
| 5. | N-buthane n-C4H10 | 0,1186 |
| 6. | Pentane $C_5H_{12}$ and $C_5$+ | 0,0671 |
| 7. | Oxygen $O_2$ | 0,0078 |
| 8. | Nitrogen $N_2$ | 1,3475 |
| 9. | Carbon Dioxide $CO_2$ | 0,6702 |
| Density (kg/m$^3$) | | 0,7231 |
| Net Calorific Value (kcal/m$^3$) | | 8245 |

The average physiochemical data of the natural gas (mixture) supplied from Yerevan Gas Distribution Station # 2in 2012

| # | Components, mol % | Annual average |
|---|---|---|
| 1. | Methane $CH_4$ | 91,8675 |
| 2. | Ethane $C_2H_6$ | 3,8531 |
| 3. | Propane $C_3H_8$ | 0,8746 |
| 4. | Isobuthane i-$C_4H_{10}$ | 0,1091 |
| 5. | N-buthane n-C4H10 | 0,1434 |
| 6. | Pentane $C_5H_{12}$ and $C_5$+ | 0,0770 |
| 7. | Oxygen $O_2$ | 0,0106 |
| 8. | Nitrogen $N_2$ | 2,3286 |
| 9. | Carbon Dioxide $CO_2$ | 0,7363 |
| Density (kg/m$^3$) | | 0,7275 |
| Net Calorific Value (kcal/m$^3$) | | 8149 |

The physiochemical data of the natural gas imported from Islamic Republic of Iran in 2012

| # | Components, mol % | Annual average |
|---|---|---|
| 1. | Methane $CH_4$ | 90,2225 |
| 2. | Ethane $C_2H_6$ | 3,4826 |
| 3. | Propane $C_3H_8$ | 0,9674 |
| 4. | Isobuthane i-$C_4H_{10}$ | 0,1483 |
| 5. | N-buthane n-C4H10 | 0,2029 |
| 6. | Pentane $C_5H_{12}$ and $C_5$+ | 0,1017 |
| 7. | Oxygen $O_2$ | 0,0133 |
| 8. | Nitrogen $N_2$ | 4,2494 |
| 9. | Carbon Dioxide $CO_2$ | 0,6119 |
| Density (kg/m$^3$) | | 0,7392 |
| Net Calorific Value (kcal/m$^3$) | | 8020 |

## Annex 2. Calculation of country-specific $CO_2$ emission factor for stationary combustion of natural gas in the Energy Industries

$CO_2$ emissions from stationary combustion for electricity and thermal energy generation were calculated based on natural gas physicochemical data: 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
Pentane ($C_5H_{12}$ and $C_5$+) 60/72 =0.8333
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 per N-Butane share= 0.8276 x n-$C_4H_{10}$ %
% of C per Pentane share = 0.8333 x $C_5H_{12}$ and $C_5$ + %
% of C per Carbon Dioxide share = 0.2727 x $CO_2$ %

3. The total of Carbon content per components makes the carbon content (%) in 1 $m^3$ of natural gas.

4. The carbon content value (%) obtained in the point 3 was multiplied by the annual average data on the natural gas density (see Annex 1) to get the weight (g) of carbon content in 1 $m^3$ of natural gas ($g/m^3$).

5. The calorific value of the natural gas in $kcal/m^3$ (Annex 1) 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 1000 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 Guideline, 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 emission factors for natural gas imported from RF, mixture natural gas and natural gas imported from Iran are given in the Table below.

The carbon content values and country-specific $CO_2$ emission factors

| Imported natural gas | Dencity | 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 RF | 0.7231 | 8245 | 34.52 | 47.74 | 73.95 | 0.5347 | 15.49 | 56,798.02 |
| Mixture | 0.7260 | 8188 | 34.28 | 47.22 | 73.41 | 0.5330 | 15.55 | 57,004.85 |
| Imported from Iran | 0.7351 | 7999 | 33.49 | 45.56 | 71.73 | 0.5273 | 15.75 | 57,735.59 |
| | | | | 2012 | | | | |
| Imported from RF | 0.7239 | 8245 | 34.52 | 47.68 | 73.95 | 0.5352 | 15.51 | 56,851.70 |
| Mixture | 0.7275 | 8149 | 34.12 | 46.90 | 73.41 | 0.5323 | 15.60 | 57,209.21 |
| Imported from Iran | 0.7374 | 8020 | 33.58 | 45.54 | 71.73 | 0.5293 | 15.76 | 57,801.53 |

Annex 3. Information about the electrical system indicators for 2011 and 2012.

ՀԱՅԱՍՏԱՆԻ ՀԱՆՐԱՊԵՏՈՒԹՅԱՆ
ՀԱՆՐԱՅԻՆ ԾԱՌԱՅՈՒԹՅՈՒՆՆԵՐԸ ԿԱՐԳԱՎՈՐՈՂ ՀԱՆՁՆԱԺՈՂՈՎ
ՆԱԽԱԳԱՀԻ ՏԵՂԱԿԱԼ

ՀՀ, ԵՐԵՎԱՆ, ՍԱՐՅԱՆ 22, ՀԵՌ.(374-10) 566471, ՖԱՔՍ (374-10) 525563

« ______ » ______________ 2013թ.

№______________

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Ի պատասխան Ձեր 31.10.2013թ.
N2/07/2213-13 գրության

Հարգելի պարոն Պապյան,

Ձեզ է ուղարկվում էլեկտրաէներգետիկական համակարգի վերաբերյալ Ձեր կողմից պահանջվող տեղեկատվությունը:

Ռ.Վ.

????? ??????????
Nov 7 2013 5:49 PM

Կատարող՝ Ս. Պապոյան ☎ 56-49-27(316)

**Տ Ե Ղ Ե Կ Ա Ն Ք**

*էլեկտրաէներգետիկական համակարգի ցուցանիշների վերաբերյալ*

| | | Չափման միավորը | Մեծությունը |
|---|---|---|---|
| 1 | 2011թ. ՀՀ էներգահամակարգ մուտք գործած վերջին 15 էլեկտրակայանների դրվածքային հզորությունները | | |
| 1.1 | «Հ.Ա.Գ. ԵՌՅԱԿ» ՍՊԸ-ի «ՈՍԿԵՊԱՐ» ՓՀԷԿ | կՎտ | 150 |
| 1.2 | «Ժ ԵՎ Կ ՀԷԿ» ՍՊԸ-ի «ԱՆԳԵՂԱԿՈԹ» ՓՀԷԿ | կՎտ | 150 |
| 1.3 | «ՄԿՇԳ ԷՆԵՐԳԻԱ» ՍՊԸ-ի «ՄԱՐՏՈՒՆԻ» ՓՀԷԿ | կՎտ | 1800 |
| 1.4 | «ԷԼԲԻՍՏ» ՍՊԸ-ի «ՄԱՐՄԱՇԵՆ» ՓՀԷԿ | կՎտ | 2150 |
| 1.5 | «ԿԱՐԲԻ ՋՐՀՈՍ» ՀԷԿ» ՍՊԸ-ի «ԿԱՐԲԻ ՋՐՀՈՍ» ՓՀԷԿ | կՎտ | 1000 |
| 1.6 | «ՄԱՍՖԻՇ» ՍՊԸ-ի «ՎԱՐԴԱՆԱՆՑ» ՓՀԷԿ | կՎտ | 1050 |
| 1.7 | «ՍԻՐԱՐՓԻ ԱՀ» ՍՊԸ-ի «ՍԻՐԱՐՓԻ» | կՎտ | 697 |
| 1.8 | «ԱՖԱՄԻԱ» ՍՊԸ-ի «Դարբաս ՓՀԷԿ-2» | կՎտ | 904 |
| 1.9 | «ՖԻՐՄԱ Գ.Ա.Խ» ՍՊԸ-ի «Սարավան» | կՎտ | 2470 |
| 1.10 | «ԳՐԻԱՐ» ՓԲԸ-ի («ԱՐԻՅՈ ԷՆԵՐՋԻ» ՍՊԸ) «Գետիկ-1» | կՎտ | 5600 |
| 1.11 | «Ջերմուկի Հիդրոտեխ» ՍՊԸ-ի «Ջերմուկ ՀԷԿ-2» | կՎտ | 2350 |
| 1.12 | «ՄԻՆԱ-ՄԱՅԱ» ՍՊԸ-ի «Եղեգնաձոր ՓՀԷԿ-1» | կՎտ | 1060 |
| 1.13 | «ԽՈՒՄ» ՍՊԸ-ի «Խում» | կՎտ | 290 |
| 1.14 | «ԱՐԳԻՇՏԻ-1» ՍՊԸ-ի «Մարցիգետ ՓՀԷԿ-2» | կՎտ | 5134 |
| 1.15 | «ՀայՌուսգազարդ» ՓԲԸ -ի շոգեգազային ցիկլով էլեկտրական էներգիա արտադրող «Հրազդան-5» կայան | կՎտ | 467000 |
| 2 | 2011թ. ջերմային էլեկտրակայանների կողմից սպառված վառելիքի տարեկան ծախսը և այրման ջերմատվությունը | | |
| 2.1 | «Հրազդանի ՋԷԿ» ԲԲԸ | | |
| | *բնական գազ* | հազ. խմ | 184026 |
| | | կկալ/խմ | 8271 |
| 2.2 | «Երևանի ՋԷԿ» ՓԲԸ [1] | | |
| 2.3 | «Երևանի ՋԷԿ» ՓԲԸ-ի համակցված շոգեգազային ցիկլով աշխատող էներգաբլոկ | | |
| | *բնական գազ* | հազ. խմ | 360318 |
| | | կկալ/խմ | 8190 |
| 2.4 | Երևանի Մխիթար Հերացու անվան պետական բժշկական համալսարանի կոգեներացիոն էլեկտրակայան [2] | | |
| | *բնական գազ* | հազ. խմ | 5001 |
| 2.5 | «Երֆրեզ» ԲԲԸ | | |
| | *բնական գազ* | հազ. խմ | 0 |
| 2.6 | «Լուս Աստղ Շուգար» ՍՊԸ [2] | հազ. խմ | - |
| 2.7 | «Լուսակերտ Բիոգազ Փլանթ» ՓԲԸ [3] | հազ. խմ | - |
| 2.8 | «ՀայՌուսկոգեներացիա» ՓԲԸ [4] | հազ. խմ | - |

1) «Երևանի ՋԷԿ» ՓԲԸ -ի հին էներգատեղակայանքներում 2011 թվականին էլեկտրական և ջերմային էներգիա չի արտադրվել:

2) Երևանի Մխիթար Հերացու անվան պետական բժշկական համալսարանի և «Լուս Աստղ Շուգար» ՍՊԸ-ի կողմից հանձնաժողով ներկայացվող հաշվետվությունները չեն պարունակում տեղեկատվություն ծախսված բնական գազի ջերմատվության վերաբերյալ:

3) «Լուսակերտ Բիոգազ Փլանթ» ՓԲԸ-ի համար հանձնաժողովի կողմից սահմանված հանձնաժողով ներկայացվող հաշվետվությունների ձևերը չեն պարունակում տեղեկատվություն ծախսված բնական գազի և դրա ջերմատվության վերաբերյալ:

4) «ՀայՌուսկոգեներացիա» ՓԲԸ-ի էլեկտրական և ջերմային էներգիայի համակցված արտադրության կայանից առաքվող էլեկտրական (ջերմային) էներգիայի սակագները սահմանվել են 2011 թվականի դեկտեմբերի 21-ին, իսկ ուժի մեջ են մտել 2012 թվականի հունվարի 21-ին, ուստի արտադրված էլեկտրական էներգիայի և դրա համար ծախսված վառելիքի քանակի վերաբերյալ տեղեկատվություն հանձնաժողով չի ներկայացվել:

**Տ Ե Ղ Ե Կ Ա Ն Ք**

*էլեկտրաէներգետիկական համակարգի ցուցանիշների վերաբերյալ*

| N | Անվանումներ | Չափման միավորը | Մեծությունը |
|---|---|---|---|
| 1 | 2012թ. ՀՀ էներգահամակարգ մուտք գործած վերջին 15 էլեկտրակայանների դրվածքային հզորությունները | | |
| 1.1 | «ԱՐՋԱՁՈՐ ՀԷԿ» ՍՊԸ-ի «Արջաձոր» ՓՀԷԿ | կՎտ | 738.0 |
| 1.2 | «ՀՈՎ-ԽԱՉ» ՍՊԸ-ի «Յոթաղբյուր-3» ՓՀԷԿ | կՎտ | 605.0 |
| 1.3 | «ԱՅՈՒԴԱ-ԼՈՍ» ՍՊԸ-ի «Պոզիտրոն» ՓՀԷԿ | կՎտ | 1,630.0 |
| 1.4 | «ՀՈՎ-ԽԱՉ» ՍՊԸ-ի «Յոթաղբյուր-2» ՓՀԷԿ | կՎտ | 573.0 |
| 1.5 | «ԷՐԻԿ» ՓՀԷԿ» ՍՊԸ-ի «Վահան» ՓՀԷԿ | կՎտ | 1,300.0 |
| 1.6 | «ԱՐԻՅՈ-ԷՆԵՐՋԻ» ՍՊԸ-ի «Գետիկ-1» ՓՀԷԿ | կՎտ | 5,600.0 |
| 1.7 | «Վարդահովիտ» ՍՊԸ-ի «Վարդահովիտ» ՓՀԷԿ | կՎտ | 4,250.0 |
| 1.8 | «ՎՈՒ ԴԻՆ» ՍՊԸ-ի «Կեչուտ» ՓՀԷԿ | կՎտ | 3,360.0 |
| 1.9 | «ՎԱՆՇԱՅՆ» ՍՊԸ-ի «Կաթնառատ» ՓՀԷԿ | կՎտ | 2,075.0 |
| 1.10 | «ԼԱՅԹԷԿՈ» ՍՊԸ-ի «Փարոս» ՓՀԷԿ | կՎտ | 2,383.0 |
| 1.11 | «ՀՈՎ-ԽԱՉ» ՍՊԸ-ի «Յոթաղբյուր-1» ՓՀԷԿ | կՎտ | 547.0 |
| 1.12 | «ԵՂՎԱՐԴ ԱՐՏԱԴՐԱԿԱՆ ԲԱԶԱ» ՍՊԸ-ի «Օշէներգո» ՓՀԷԿ | կՎտ | 289.0 |
| 1.13 | «ՍԱՐ-ՌՈՒԲ» ՍՊԸ-ի «Նժդեհ» ՓՀԷԿ | կՎտ | 1,732.0 |
| 1.14 | «Ամբերդ ՀԷԿ» ՍՊԸ-ի «Ամբերդ ՓՀԷԿ-2» | կՎտ | 6,290.0 |
| 1.15 | «Վ.Ա.Լ ԷՆԵՐԳՈ» ՍՊԸ -ի «Վ.Ա.Լ.» ՓՀԷԿ | կՎտ | 200.0 |
| 2 | 2012թ. ջերմային էլեկտրակայանների կողմից սպառված վառելիքի տարեկան ծախսը և այրման ջերմատվությունը | | |
| 2.1 | «Հրազդանի ՋԷԿ» ԲԲԸ | | |
| | *բնական գազ* | հազ. խմ | 230,683.1 |
| | | կկալ/խմ | 8,359.8 |
| 2.2 | «ՀայՌուսգազարդ» ՓԲԸ-ի շոգեգազային ցիկլով էլեկտրական էներգիա արտադրող «Հրազդան-5» կայան | | |
| | *բնական գազ* | հազ. խմ | 235,400.0 |
| | | կկալ/խմ | 8,382.7 |
| 2.3 | «Երևանի ՋԷԿ» ՓԲԸ-ի համակցված շոգեգազային ցիկլով աշխատող էներգաբլոկ | | |
| | *բնական գազ* | հազ. խմ | 352,586.4 |
| | | կկալ/խմ | 8,141.0 |
| 2.4 | «Երևանի Մխիթար Հերացու անվան պետական բժշկական համալսարան» ՊՈԱԿ-ի կոգեներացիոն կայան 1) | | |
| | *բնական գազ* | հազ. խմ | 3,139.0 |
| 2.5 | «ՀայՌուսկոգեներացիա» ՓԲԸ 1) | | |
| | *բնական գազ* | հազ. խմ | 3,694.2 |
| 2.6 | «Երֆրեզ» ԲԲԸ 2) | | |
| | *բնական գազ* | հազ. խմ | 0 |
| 2.7 | «Լուս Աստղ Շուգար» ՍՊԸ 2) | հազ. խմ | 0 |
| 2.8 | «Լուսակերտ Բիոգազ Փլանթ» ՓԲԸ 3) | հազ. խմ | - |

1) «Երևանի Մխիթար Հերացու անվան պետական բժշկական համալսարան» ՊՈԱԿ-ի և «ՀայՌուսկոգեներացիա» ՓԲԸ-ի կողմից հանձնաժողով ներկայացվող հաշվետվությունները չեն պարունակում տեղեկատվություն ծախսված բնական գազի ջերմատվության վերաբերյալ:

2) «Երֆրեզ» ԲԲԸ-ի և «Լուս Աստղ Շուգար» ՍՊԸ-ի կողմից հանձնաժողով ներկայացված հաշվետվությունների համաձայն՝ վերջիններիս կայաններից 2012 թվականին էլեկտրական էներգիա չի առաքվել:

3) «Լուսակերտ Բիոգազ Փլանթ» ՓԲԸ-ի համար հանձնաժողովի կողմից սահմանված հանձնաժողով ներկայացվող հաշվետվությունների ձևերը չեն պարունակում տեղեկատվություն ծախսված բնական գազի և դրա ջերմատվության վերաբերյալ:

# Annex 4. Main indicators of the gas supply system for 2011 and 2012.

մլն նխմ

| | | հոկտեմբեր | նոյեմբեր | դեկտեմբեր | IV եռամսյակ | 2011 թվական |
|---|---|---|---|---|---|---|
| **1** | **Ներկրված գազի քանակը, այդ թվում`** | **196,12** | **225,47** | **252,74** | **674,33** | **2069,10** |
| 1.1 | Ռուսաստանի Դաշնությունից | 158,69 | 186,54 | 200,02 | 545,25 | 1609,06 |
| 1.2 | ԻԻՀ-ից | 37,43 | 38,93 | 52,72 | 129,08 | 460,03 |
| **2** | **Վերցվել է գազապարներից և գազի ստորգետնյա պահեստ-կայանից (ԳՍՊԿ -ից)** | **1,70** | **1,98** | **53,52** | **57,20** | **79,45** |
| **3** | **Գազի ծախսը սեփական կարիքների համար փոխադրման համակարգում** | **0,88** | **0,14** | **0,38** | **1,41** | **3,23** |
| **4** | **Գազի կորուստները փոխադրման համակարգում, որից`** | **7,52** | **7,92** | **9,30** | **24,74** | **93,59** |
| 4.1 | տեխնոլոգիական անխուսափելի կորուստներ գազապարներում | 7,47 | 7,92 | 9,28 | 24,68 | 92,90 |
| 4.2 | վթարային կորուստներ | 0,05 | 0,00 | 0,01 | 0,06 | 0,69 |
| **5** | **Մղվել է գազապարներ և գազի ստորգետնյա պահեստ-կայան (ԳՍՊԿ)** | **15,01** | **0,00** | **3,71** | **18,71** | **33,06** |
| **6** | **Փոխադրված գազի ծավալը** | **174,41** | **219,39** | **292,88** | **686,67** | **2018,66** |
| 6.1 | Այլ սպառողներ | 41,78 | 42,41 | 56,13 | 140,31 | 438,70 |
| 6.2 | Բաշխման համակարգ | 132,63 | 177,0 | 236,75 | 546,36 | 1579,96 |
| **7** | **Գազի ծախսը սեփական կարիքների համար բաշխման համակարգում** | **0,08** | **0,17** | **0,64** | **0,89** | **2,896** |
| **8** | **Վերականգնված գազ** | **0,20** | **0,22** | **0,17** | **0,59** | **1,68** |
| **9** | **Գազի կորուստները բաշխման համակարգում, որից`** | **2,84** | **4,15** | **5,30** | **12,29** | **40,46** |
| 9.1 | տեխնոլոգիական անխուսափելի կորուստներ | 4,23 | 5,39 | 7,34 | 16,97 | 54,07 |
| 9.2 | վթարային կորուստներ | 0,01 | 0,02 | 0,01 | 0,04 | 0,38 |
| 9.3 | գերնորմատիվային կորուստներ | -1,40 | -1,27 | -2,05 | -4,72 | -13,99 |
| **10** | **Բաշխման համակարգում իրացված գազի ծավալը, որից** | **129,51** | **172,43** | **230,64** | **532,58** | **1534,92** |
| 10.1 | Բնակչություն | 27,66 | 72,32 | 97,38 | 197,35 | 550,75 |
| 10.2 | Էներգետիկա | 32,89 | 14,96 | 46,20 | 94,06 | 184,91 |
| 10.3 | Արդյունաբերություն | 28,30 | 26,93 | 21,03 | 76,27 | 252,04 |
| 10.4 | Ավտոգազալիցքավորման ճնշակայաններ (ԱԳԼՃԿ) | 35,43 | 32,54 | 33,96 | 101,93 | 362,36 |
| 10.5 | Բյուջետային կազմակերպություններ | 0,73 | 8,26 | 11,34 | 20,32 | 51,45 |
| 10.6 | Ջեռուցում իրականացնող ընկերություններ | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| 10.7 | Այլ սպառողներ | 4,50 | 17,43 | 20,73 | 42,66 | 133,42 |
| **11** | **Բնական գազի միջին ջերմարարությունը (կկալ/խմ)** | **8152** | **8177** | **8264** | | |

*մլն խմ*

| | | հոկտեմբեր | նոյեմբեր | դեկտեմբեր | IV եռամսյակ | 2012 թվական |
|---|---|---|---|---|---|---|
| 1 | **Ներկրված գազի քանակը, այդ թվում՝** | **225,8** | **247,0** | **298,6** | **771,5** | **2455,5** |
| 1.1 | Ռուսաստանի Դաշնությունից | 182,4 | 206,0 | 256,3 | 644,7 | 1967,2 |
| 1.2 | ԻԻՀ-ից | 43,4 | 41,0 | 42,3 | 126,8 | 488,3 |
| 2 | **Վերցվել է գազապարներից և գազի ստորգետնյա պահեստ-կայանից (ԳՍՊԿ -ից)** | **11,7** | **1,2** | **2,7** | **15,6** | **87,1** |
| 3 | **Գազի ծախսը սեփական կարիքների համար փոխադրման համակարգում** | **0,9** | **0,4** | **0,3** | **1,5** | **8,2** |
| 4 | **Գազի կորուստները փոխադրման համակարգում, որից՝** | **8,4** | **8,3** | **9,4** | **26,2** | **99,6** |
| 4.1 | տեխնոլոգիական անխուսափելի կորուստներ գազապարներում | 8,4 | 8,3 | 9,4 | 26,1 | 99,5 |
| 4.2 | վթարային կորուստներ | 0,0 | 0,0 | 0,0 | 0,0 | 0,1 |
| 5 | **Մղվել է գազապարներ և գազի ստորգետնյա պահեստ-կայան (ԳՍՊԿ)** | **11,3** | **3,6** | **2,0** | **16,8** | **136,4** |
| 6 | **Փոխադրված գազի ծավալը** | **216,9** | **236,0** | **289,7** | **742,6** | **2298,4** |
| 6.1 | Այլ սպառողներ | 73,6 | 80,4 | 96,0 | 250,0 | 644,8 |
| 6.2 | Բաշխման համակարգ | 143,3 | 155,6 | 193,7 | 492,6 | 1653,6 |
| 7 | **Գազի ծախսը սեփական կարիքների համար բաշխման համակարգում** | **0,0** | **0,1** | **0,6** | **0,7** | **3,2** |
| 8 | **Վերականգնված գազ** | **0,2** | **0,2** | **0,3** | **0,7** | **2,1** |
| 9 | **Գազի կորուստները բաշխման համակարգում, որից՝** | **2,5** | **3,1** | **4,8** | **10,4** | **39,4** |
| 9.1 | տեխնոլոգիական անխուսափելի կորուստներ | 4,3 | 4,6 | 6,3 | 15,1 | 55,6 |
| 9.2 | վթարային կորուստներ | 0,1 | 0,0 | 0,0 | 0,2 | 0,6 |
| 9.3 | գերնորմատիվային կորուստներ | -1,8 | -1,5 | -1,5 | -4,9 | -16,8 |
| 10 | **Բաշխման համակարգում իրացված գազի ծավալը, որից** | **140,5** | **152,3** | **188,0** | **480,8** | **1608,9** |
| 10.1 | Բնակչություն | 22,0 | 39,5 | 84,3 | 145,8 | 542,0 |
| 10.2 | Էներգետիկա | 54,0 | 38,7 | 6,6 | 99,4 | 231,9 |
| 10.3 | Արդյունաբերություն | 21,8 | 24,8 | 29,1 | 75,7 | 259,9 |
| 10.4 | Ավտոգազալիցքավորման ճնշակայաններ (ԱԳԼՃԿ) | 38,7 | 36,7 | 38,3 | 113,7 | 418,0 |
| 10.5 | Բյուջետային կազմակերպություններ | 0,4 | 4,1 | 10,6 | 15,1 | 48,4 |
| 10.6 | Ջեռուցում իրականացնող ընկերություններ | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 |
| 10.7 | Այլ սպառողներ | 3,6 | 8,5 | 19,0 | 31,1 | 108,7 |
| 11 | **Բնական գազի միջին ջերմարարությունը (կկալ/խմ)** | **8376** | **8240** | **8193** | | |

## Annex 5. Excerpts on provided electricity from electrical system statements for 2011 and 2012.

**ՏԵՂԵԿԱՆՔ**
**ԷԼԵԿՏՐԱԷՆԵՐԳԵՏԻԿԱԿԱՆ ՀԱՄԱԿԱՐԳԻ 2011Թ. ԱՌԱՔՎԱԾ ԷԼԵԿՏՐԱԿԱՆ ԷՆԵՐԳԻԱՅԻ (ՀԶՈՐՈՒԹՅԱՆ) ՎԵՐԱԲԵՐՅԱԼ**

| | | | 2011 | | | |
|---|---|---|---|---|---|---|
| | | | Քանակ<br>**մլն կՎտժ**<br>**ՄՎտ** | Սակագնի դրույք<br>**դրամ/կՎտժ**<br>**դրամ/կվտ** | Ապրանքային առաքում<br>**մլն դրամ**<br>**(ԱԱՀ-ով)** | Ընդամենը գումար<br>**մլն դրամ**<br>**(ԱԱՀ-ով)** |
| 1 | 2 | | 15 | 16 | 17 | 18 |
| 1 | Առաքված էլեկտրական էներգիա (հզորություն), ընդամենը | | 6019,1 | | | 70865,2 |
| | այդ թվում՝ | | | | | |
| 1.1 | «Հայկական ԱԷԿ» ՓԲԸ | էլ. էներգիա | 2356,8 | 4,93 | 11615,3 | 23729,0 |
| | | հզորություն | 3866,3 | 3133,16 | 12113,7 | |
| 1,2 | «Հրազ ՋԷԿ» ԲԲԸ (Հայէլցանց) | էլ. էներգիա | 584,8 | 30,114 | 17612,0 | 21927,8 |
| | | հզորություն | 4574,4 | 943,46 | 4315,8 | |
| 1,3 | Երևանի ՋԷԿ (շոգեգազ. ցիկլով աշխ. էներգաբլոկ) | էլ. էներգիա | 523,2 | 6,69 | 3500,6 | 6136,4 |
| | | հզորություն | 2426,5 | 1086,27 | 2635,8 | |
| 1,4 | «Միջազգային էներգետիկ կորպորացիա» ՓԲԸ | էլ. էներգիա | 641,7 | 0,90 | 575,1 | 2811,4 |
| | | հզորություն | 4319,2 | 517,73 | 2236,2 | |
| 1,5 | «Որոտանի ՀԷԿՀ» ՓԲԸ | էլ. էներգիա | 1352,5 | 3,68 | 4981,7 | 5961,6 |
| | | հզորություն | 4559,7 | 214,90 | 979,9 | |
| 1,6 | «Ջրագետ Հիդրո» ՍՊԸ | | 90,0 | 12,60 | 1133,4 | 1133,4 |
| 1,7 | Լուս ասպդ շուգր | | 0,0033 | 11,12 | 0,04 | 0,04 |
| 1,8 | «Լոռի-1» հողմային էլ.կայան | | 2,8 | 40,51 | 112,3 | 112,3 |
| 1,9 | Եր. Մ.Հ. անվ. Պետ. բժշկ. համալսարան | | 18,5 | 32,32 | 597,2 | 597,2 |
| 1,10 | Լուս. Բիոգազ Փլանտ | | 2,6 | 44,31 | 114,4 | 114,4 |
| 1,11 | Երֆրեզ | | 0,0 | 36,87 | 0,0 | 0,0 |
| 1,12 | ՀայՌուսկոգեներացիա | | 4,9 | 43,64 | 215,3 | 215,3 |
| 1,13 | Փոքր ՀԷԿ-եր | | 441,4 | 18,41 | 8126,4 | 8126,4 |

**ՏԵՂԵԿԱՆՔ**
**2012 թվականի ընթացքում էլեկտրաէներգետիկական համակարգի ընկերությունների կողմից առաքված քլեկտրական էներգիայի (հզորության) վերաբերյալ**
**(ներքին սպառման մասով)**

| Հ/հ | Ընկերության անվանումը | | 2012 | | | |
|---|---|---|---|---|---|---|
| | | | Քանակ<br>**<u>մլն կՎտժ</u>**<br>**ՄՎտ** | Սակագնի դրույք<br>**<u>դրամ/կվտժ</u>**<br>**դրամ/կվտ** | Ապրանքային առաքում<br>**մլն դրամ**<br>**(ԱԱՀ-ով)** | Ընդամենը գումար<br>**մլն դրամ**<br>**(ԱԱՀ-ով)** |
| 1 | 2 | | 15 | 16 | 17 | 18 |
| 1 | Առաքված էլեկտրական էներգիա (հզորություն), ընդամենը | | 6270.5 | | | 93587.4 |
| | այդ թվում՝ | | | | | |
| 1.1 | «Հայկական ԱէԿ» ՓԲԸ | էլ. էներգիա | 2123.5 | 5.54 | 11774.6 | 23346.5 |
| | | հզորություն | 3330.6 | 3474.39 | 11571.9 | |
| 1.2 | «Հրազ ՋէԿ» ԲԲԸ (Հայէլցանց) | էլ. էներգիա | 745.5 | 29.931 | 22314.9 | 26566.7 |
| | | հզորություն | 4636.6 | 917.02 | 4251.8 | |
| 1.3 | «ՀայՌուսգազարդ» ՓԲԸ-ի շոգեգազային ցիկլով էլեկտրական էներգիա արտադրող "Հրազդան-5" կայան | էլ. էներգիա | 618.0 | 25.98 | 16056.8 | 16056.8 |
| 1.4 | Երևանի ՋէԿ (շոգեգազ. ցիկլով աշխ. էներգաբլոկ) | էլ. էներգիա | 507.4 | 2.47 | 1252.7 | 6183.3 |
| | | հզորություն | 2480.6 | 1987.68 | 4930.6 | |
| 1.5 | «Միջազգային էներգետիկ կորպորացիա» ՓԲԸ | էլ. էներգիա | 621.5 | 0.92 | 573.7 | 3006.4 |
| | | հզորություն | 4545.6 | 535.16 | 2432.6 | |
| 1.6 | «Որոտանի ՀէԿՀ» ՓԲԸ | էլ. էներգիա | 1067.1 | 4.78 | 5103.3 | 6078.6 |
| | | հզորություն | 4342.3 | 224.59 | 975.2 | |
| 1.7 | «Ձորագետ Հիդրո» ՍՊԸ | | 60.9 | 23.46 | 1429.5 | 1429.5 |
| 1.8 | Լուս ասպղ շուգր | | 0.023 | 11.1 | 0.3 | 0.3 |
| 1.9 | Եր. Մ.Հ. անվ. Պետ. բժշկ. համալսարան | | 11.9 | 32.31 | 384.4 | 384.4 |
| 1,10 | Երֆրեզ | | 0.0 | 0.00 | 0.0 | 0.0 |
| 1,11 | ՀայՌուսկոգեներացիա | | 13.2 | 43.64 | 575.7 | 575.7 |
| 1,12 | «Լոռի-1» հողմային էլ.կայան | | 2.0 | 42.41 | 85.2 | 85.2 |
| 1,13 | Լուս. Բիոգազ Փլանտ | | 2.0 | 44.94 | 90.1 | 90.1 |
| 1,14 | Փոքր ՀէԿ-եր | | 497.3 | 19.67 | 9784.0 | 9784.0 |

# Annex 6. Statement on cattle breeding indicators for 2011 and 2012.

**ՀԱՅԱՍՏԱՆԻ ՀԱՆՐԱՊԵՏՈՒԹՅԱՆ ԳՅՈՒՂԱՏՆՏԵՍՈՒԹՅԱՆ**
**ՆԱԽԱՐԱՐԻ ԱՌԱՋԻՆ ՏԵՂԱԿԱԼ**

« »__________ 20 թ. N__________

ՀԱՅԱՍՏԱՆԻ ՀԱՆՐԱՊԵՏՈՒԹՅԱՆ
ԲՆԱՊԱՀՊԱՆՈՒԹՅԱՆ ՆԱԽԱՐԱՐԻ
ԱՌԱՋԻՆ ՏԵՂԱԿԱԼ
ՊԱՐՈՆ ՍԻՄՈՆ ՊԱՊՅԱՆԻՆ

Ի պատասխան Ձեր 2014 թվականի
օգոստոսի 21-ի N 2/07/2169-14 գրության

Հարգելի պարոն Պապյան,

ՄԱԶԾ-ԳԷՖ ծրագրի շրջանակներում ջերմոցային գազերի ազգային կադաստրը կազմելու նպատակով՝ սահմանված ձևաչափին համապատասխան, ներկայացվում է տեղեկատվություն 2010-2012 թվականների անասնաբուծության ցուցանիշների վերաբերյալ:

Առդիր՝ 1 էջ:

ՀԱՐԳԱՆՔՈՎ՝

ԳՐԻՇԱ ԲԱՂԻՅԱՆ

Կատ. Անասնաբուծության և
անասնաբուժության վարչության պետ
Ա. Հովհաննիսյան
հեռ. 52 93 33

0010, ք. Երևան, Կառավարական տուն 3 հեռ. (374 10) 52 48 34, ֆաքս. (374 10) 52 46 10
էլ. փոստ agro@minagro.am

Տեղեկատվություն

2010-2012 թվականների անասնաբուծության ցուցանիշների վերաբերյալ

| **Ցուցանիշի անվանումը** | **Չափի միավորը** | **2010 թ.** | **2011 թ.** | **2012 թ.** |
|---|---|---|---|---|
| Խոշոր եղջերավոր անասուններ, որից | | - | - | - |
| կովերի միջին կենդանի քաշը | կգ | 430 | 430 | 440 |
| ցուլերի միջին կենդանի քաշը | կգ | 500 | 510 | 520 |
| մատղաշի միջին կենդանի քաշը (մեկ տարեկան) | կգ | 180 | 190 | 200 |
| մատղաշի միջին օրական քաշաճ | գրամ | 420 | 450 | 465 |
| կովերի մարսելիության էներգիան (կերերի մարսելիության գործակիցը) | % | 61 | 61 | 61 |
| ցուլերի մարսելիության էներգիան (կերերի մարսելիության գործակիցը) | % | 57 | 57 | 57 |
| մատղաշի մարսելիության էներգիան (կերերի մարսելիության գործակիցը) | % | 59 | 59 | 59 |
| կաթի յուղայնությունը | % | 3.7 | 3.7 | 3.7 |
| Խոշոր եղջերավոր անասունների պահվածքի եղանակները. | x | x | x | x |
| մսուրային | օր | 210-240 | 210-240 | 210-240 |
| արոտային | օր | 125-155 | 125-155 | 125-155 |
| Գոմաղբի արտաթորանքը 1 խոշոր եղջերավոր կենդանու հաշվով (տարում) | տոննա | 8 | 8 | 8 |
| Գոմաղբի չափաբաժինը արոտա-վայրում | % | 34.4-42.5 | 34.4-42.5 | 34.4-42.5 |

## *IPPU*

Calculation tables *(data for 2010 are given for comparison)*

Table 1. HFCs emissions per gas types (t), 2010-2012

| Year | HFCs - 134a | HFCs -125 | HFCs - 143a | HFCs --32 | HFCs - 152a | HFCs - 227ea | Total |
|---|---|---|---|---|---|---|---|
| 2010 | 68.78 | 29.76 | 19.46 | 13.05 | 2.87 | 0.06 | **133.98** |
| 2011 | 83.66 | 37.76 | 24.13 | 17.02 | 3.19 | 0.08 | **165.84** |
| 2012 | 98.19 | 44.96 | 29.01 | 20.03 | 3.24 | 0.1 | **195.53** |

Table 2.HFCs annual emissions in refrigeration and air conditioning application for 2010-2012

| Name | Emissions (t) | | |
|---|---|---|---|
| | 2010 | 2011 | 2012 |
| HFC- 134a | 61.87 | 75.69 | 89.76 |
| HFC --32 | 13.05 | 17.02 | 20.03 |
| HFC -125 | 27.76 | 37.76 | 44.96 |
| HFC -143a | 19.46 | 24.3 | 29.01 |

Table 3. HFCs annual emissions in aerosols application for 2010-2012

| Name | Emissions (t) | | |
|---|---|---|---|
| | 2010 | 2011 | 2012 |
| HFC-134a | 6.69 | 7.45 | 7.56 |
| HFC-152a | 2.87 | 3.19 | 3.24 |

Table4. HFCs-134a annual emissions in foam production application for 2010-2012

| Name | Emissions (t) | | |
|---|---|---|---|
| | 2010 | 2011 | 2012 |
| HFC-134a | 0.31 | 0.52 | 0.87 |

Table5. HFCs-227ea annual emissions in fire-extinguishing application for 2010-2012

| Name | Emissions (t) | | |
|---|---|---|---|
| | 2010 | 2011 | 2012 |
| HFC-227ea | 0.06 | 0.08 | 0.1 |

Table6. HFCs emissions per gas types (Գգ $CO_{2\ eq.}$) for 2010-2012

| Year | HFC-134a | HFC-125 | HFC-143a | HFC-32 | HFC-152a | HFC-227ea | Total |
|---|---|---|---|---|---|---|---|
| 2010 | 88.78 | 82.99 | 74.37 | 8.48 | 0.40 | 0.35 | **255.4** |
| 2011 | 108.03 | 106.57 | 92.9 | 11.07 | 0.45 | 0.43 | **319.44** |
| 2012 | 128.4 | 127.95 | 114.21 | 13.06 | 0.45 | 0.5 | **384.58** |

*AFOLU*

## Annex 1

**Table 1.1 Livestock Population in all Economies, as of January 1 (heads) (AFOLURef - 3, AFOLURef - 6)**

| Categories of livestock | 2011 | 2012 | 2013 |
|---|---|---|---|
| Cattle, including | 571357 | 599243 | 661003 |
| cows | 272572 | 283349 | 303277 |
| bulls | 18516 | 23173 | 26282 |
| young animals | 280269 | 292721 | 331444 |
| Buffalos | 460 | 472 | 531 |
| Pigs | 114777 | 108088 | 145044 |
| Sheep and goats, of which | 532515 | 590214 | 674731 |
| Sheep | 503624 | 561634 | 645711 |
| Goats | 28891 | 28580 | 29020 |
| Horses | 10042 | 9912 | 10777 |
| Donkeys and mules | 3999 | 3968 | 3945 |
| Poultry, of which | 3462529 | 4023482 | 4050001 |
| Laying hens | 2305410 | 2509157 | 2689025 |

### Table 1.2 Main Livestock Products [AFOLURef-3, AFOLURef-6]

| | 2011 | 2012 |
|---|---|---|
| Animals and poultry sold for slaughter (in living weight), thousand ton | 127.9 | 130.3 |
| Animals and poultry sold for slaughter (in slaughter weight), thousand ton | 71.7 | 73.9 |
| Of which - veal and beef | 48.2 | 47.6 |
| Pork | 8.4 | 8.5 |
| Lamb and goat’s meat | 9.4 | 9.5 |
| Poultry meat | 5.7 | 8.3 |
| Milk, thousand ton | 601.5 | 618.2 |

### Table 1.3 Slaughter and loss data for livestock, 2011-2012*

| Categories of livestock | Measurement Unit | 2011 | 2012 |
|---|---|---|---|
| Slaughter | | | |
| Cattle, of which | head | 282895 | 279035 |
| cows | head | 42435 | 41855 |
| young animals | head | 240460 | 237180 |
| Sheep and goats | head | 483000 | 489200 |
| Pigs | head | 240660 | 243330 |
| Poultry | thousand heads | 7400000 | 7266000 |
| Loss | | | |
| Cattle, | head | 11980 | 13220 |
| Sheep and goats | head | 17700 | 20240 |
| Pigs | head | 5405 | 7250 |
| Poultry | head | 281640 | 283880 |

* Source: RA Ministry of Agriculture (data received form the RA Ministry of Agriculture in response to the letter (dated 09.09.2014, N 2/07/2188-14 ) of the RA Ministry of Nature Protection

### Table 1.4 Export and import data of alive animals, 2011-2012 [AFOLURef - 7]

| Categories of livestock | Import | | Expert | |
|---|---|---|---|---|
| | 2011 | 2012 | 2011 | 2012 |
| Cattle | 43 | 74 | 0 | 0 |
| Pedigree bulls | 349 | 90 | 0 | 0 |
| Young animals | 297 | 230 | 0 | 0 |
| Sheep | 160 | 0 | 2825 | 31169 |
| Horses | 27 | 0 | 0 | 0 |
| Pigs | 187 | 3088 | 0 | 0 |
| Poultry | 1431518 | 2768709 | 124000 | 169600 |

### Table 1.5 Baseline Data for Calculation of GHG Emission Factors from livestock *

| Indicator | Measurement Unit | 2010 | 2011 | 2012 |
|---|---|---|---|---|
| Cattle, of which | | - | - | - |
| Average living weight of cows | kg | 430 | 430 | 440 |
| Average living weight of bulls | kg | 500 | 510 | 520 |
| Average living weight of young animals (1 year of age) | kg | 180 | 190 | 200 |
| Daily average weight increase rate for young animals | gram | 420 | 450 | 465 |
| Digestion energy of cows (fodder digestion rate) | % | 61 | 61 | 61 |
| digestion energy of bulls (fodder digestion rate) | % | 57 | 57 | 57 |
| digestion energy of young animals (fodder digestion rate) | % | 59 | 59 | 59 |
| fat in milk | % | 3.7 | 3.7 | 3.7 |
| Raising regime of cattle | x | x | x | x |
| nursery | day | 210-240 | 210-240 | 210-240 |
| grazing | day | 125-155 | 125-155 | 125-155 |
| Manure excrement for one cattle (year) | ton | 8 | 8 | 8 |
| Manure portion in pasture | % | 34.4-42.5 | 34.4-42.5 | 34.4-42.5 |

* Source: RA Ministry of Agriculture (data received form the RA Ministry of Agriculture in response to the letter (dated 21.08.2014, N 2/07/2169-14) of the RA Ministry of Nature Protection

Annex 2.

Table 2.1 Baseline Data for Calculation of GHG Emission Factors from Cows

| | Indicator | 2011 | 2012 | Source |
|---|---|---|---|---|
| 1. | Animal population, head | 295100 | 311908 | Expert assessment |
| 2. | Average living weight, kg | 430 | 440 | Ministry of Agriculture od RA |
| 3. | Fat in milk, % | 3.7 | 3.7 | Ministry of Agriculture od RA |
| 4. | Lactation, kg milk/head/year | 2035 | 2036 | RA Statistical Yearbook [AFOLURef-3] |
| 5. | Digestion energy, % DE | 61 | 61 | Ministry of Agriculture od RA |
| 6. | Raising regime, of which in nursery regime, day | 210 | 210 | Ministry of Agriculture od RA |
| 7. | Grazing regime, day | 155 | 155 | Ministry of Agriculture od RA |
| 8. | Cows used for work | X | X | Cows are not used for work |
| 9. | Weight loss kg/day | 0 | 0 | 2006 National Inventories, Fundamental Principles of Greenhouse Gas Inventories, IPCC Guidelines, [Gen-1, Volume 4, Gen-8] |
| 10. | Methane generation factor for cows ($Y_m$) confinement regime | 0.07 | 0.07 | 2006 National Inventories, Fundamental Principles of Greenhouse Gas Inventories, IPCC Guidelines, [Gen-8, table 4.8] |
| 11. | Methane generation factor for cows ($Y_m$) grazing regime | 0.06 | 0.06 | 2006 National Inventories, Fundamental Principles of Greenhouse Gas Inventories, IPCC Guidelines, [Gen-8, table 4.8] |
| 12. | Emission factor (EF) | 79 | 80 | Expert assessment |

Table 2.2 Baseline Data for Calculation of GHG Emission Factors from Bulls

| | Indicator | 2011 | 2012 | Source |
|---|---|---|---|---|
| 1. | Animal population, head | 20846 | 24728 | Expert assessment |
| 2. | Average living weight, kg | 510 | 520 | Ministry of Agriculture od RA |
| 3. | Digestion energy, % DE | 57 | 57 | Ministry of Agriculture od RA |
| 4. | Raising regime, of which in nursery, day | 210 | 210 | Ministry of Agriculture od RA |
| 5. | Grazing regime, day | 155 | 155 | Ministry of Agriculture od RA |
| 6. | Bulls used for work | X | X | Bulls are not used for work |
| 7. | Weight loss kg/day | 0 | 0 | 2006 National Inventories, Fundamental Principles of Greenhouse Gas Inventories, IPCC Guidelines, [Gen-1, Volume 4, Gen-8] |
| 8. | Methane generation factor for bull ($Y_m$) nursery regime | 0.07 | 0.07 | 2006 National Inventories, Fundamental Principles of Greenhouse Gas Inventories, IPCC Guidelines, [Gen-8, table 4.8] |
| 9. | Methane generation factor for bull ($Y_m$) grazing regime | 0.06 | 0.06 | 2006 National Inventories, Fundamental Principles of Greenhouse Gas Inventories, IPCC Guidelines, [Gen-8, table 4.8] |
| 10. | Emission Factor (EF) | 62 | 63 | Expert assessment |

Table 2.3 Baseline Data for Calculation of GHG Emission Factors from Young Animals

| | Indicator | 2011 | 2012 | Source |
|---|---|---|---|---|
| 1. | Animal population, head | 388441 | 439826 | Expert assessment |
| 2. | Average living weight, kg | 190 | 200 | Ministry of Agriculture od RA |
| 3. | Mature (reference) weight, kg | 350 | 350 | Ministry of Agriculture od RA |
| 4. | Average weight increase kg/head | 0.45 | 0.47 | Ministry of Agriculture od RA |

| | | | | |
|---|---|---|---|---|
| 5. | Digestion energy, % DE | 59 | 59 | Ministry of Agriculture od RA |
| 6. | Raising regime, of which in nursery, day | 210 | 210 | Ministry of Agriculture od RA |
| 7. | Grazing regime, day | 155 | 155 | Ministry of Agriculture od RA |
| 8. | Methane generation factor for young animals ($Y_m$) confinement regime | 0.07 | 0.07 | 2006 National Inventories, Fundamental Principles of Greenhouse Gas Inventories, IPCC Guidelines, [Gen-8, table 4.8] |
| 9. | Methane generation factor for young animals l ($Y_m$) grazing regime | 0.06 | 0.06 | 2006 National Inventories, Fundamental Principles of Greenhouse Gas Inventories, IPCC Guidelines, [Gen-8, table 4.8] |
| 10. | Emission Factor (EF) | 62 | 63 | Expert assessment |

## Annex 3.

### Baseline data for Calculation of GHG Emission Factors from Fermentation

| Cows | 2011 | |
|---|---|---|
| **Baseline data** | | |
| Living weight | | 430 kg |
| DE | | 61,0000 |
| Fat in milk | | 0,0370 |
| Lactation | | 5,58 |
| **Regime** | | |
| $NE_m$ (MJ/day) =$Cf_i$ x $(Weight)^{0.75}$ | NEm=0.335 x $430^{0.75}$=31.63 | 31,6334 |
| **Activity** | | |
| $NE_a$(MJ/day) = $C_a$ x $NE_m$ | $NE_a$= 0 x 31.63=0 nursery regime | 0,0000 |
| | $NE_a$= 0.36 x 31.63=11.39 grazing regime | 11,3880 |
| **Lactation** | | |
| $NE_l$(MJ/day) =kg milk/day x (1.47+0.4 x Fat) | $NE_l$=5,58x (1.47+0.4x3.70)=16,46 | 16,4610 |
| **Pregnancy** | | |
| $NE_p$ (MJ/day)=$C_{pregnancy}$ x $NE_m$ | $NE_p$=0.1 x 31.63=3.16 | 3,1633 |
| **NEm/DE** | | |
| $NE_m$/DE=1.123-(4.092 x $10^{-3}$x DE) + [1.126 x $10^{-5}$ x $(DE)^2$]-25.4/DE) | $NE_m$/DE=1.123-(4.092 x 0.001 x 61) + (1.126 x 0.00001 x 61 x 61) – (25.4/61) = 0.4989 | 0,4989 |
| **Whole energy** | | |
| GE = [($NE_m$+ $NE_a$+$NE_l$+$NE_p$)$NE_{ma}$/DE]/(DE/100) | GE=[(31.63+0+ 16,46+3.16+0)/0,4989]/0,61= 168,4311ՄՋ/head/day nursery regime | 168,4311 |
| | GE=[(31.63+11.39 + 16,46 +3,16 +0) /0,4989] / 0,61= 205.85ՄՋ/head/day grazing regime | 205,8518 |
| **Emission Factor** | | |
| EF=GE x $Y_m$ x 365 days/year)/ (55.65 MJ/kg $CH_4$) | EF=[(168.43 x 0.07 x 210 + 205.85 x 0.06 x 155)/55.65]=78,89 kg methane/head/year | **79** |

| Cows | 2012 | |
|---|---|---|
| **Baseline data** | | |
| Living weight | | 440 kg |
| DE | | 61,0000 |
| Fat in milk | | 0,0370 |
| Lactation | | 5,5800 |
| **Regime** | | |
| $NE_m$ (MJ/day) =$Cf_i$ x $(Weight)^{0.75}$ | NEm=0.335 x $440^{0.75}$=32.18 | 32,1836 |
| **Activity** | | |
| $NE_a$(MJ/day) = $C_a$ x $NE_m$ | $NE_a$= 0 x 31.63=0 nursery regime | 0,0000 |

| | | |
|---|---|---|
| | $NE_a$= 0.36 x 31.63=11.39 grazing regime | 11,5861 |
| Lactation | | |
| $NE_l$(MJ/day) =kg milk/day x (1.47+0.4 x Fat) | $NE_l$=5,58x (1.47+0.4x3.70)=16,46 | 16,4610 |
| Pregnancy | | |
| $NE_p$ (MJ/day)=$C_{pregnancy}$ x $NE_m$ | $NE_p$=0.1 x 31.63=3.16 | 3,2184 |
| **NEm/DE** | | |
| $NE_m$/DE=1.123-(4.092 x $10^{-3}$x DE) + [1.126 x $10^{-5}$ x $(DE)^2$]-25.4/DE) | $NE_m$/DE=1.123-(4.092 x 0.001 x 61) + (1.126 x 0.00001 x 61 x 61) – (25.4/61) = 0.4989 | 0,4989 |
| Whole energy | | |
| GE = [($NE_m$+ $NE_a$+$NE_l$+$NE_p$)$NE_{ma}$/DE]/(DE/100) | GE=[(31.63+0+ 6,46+3.16+0)/0,4989]/0,61= 168,4311ՄՋ head/day nursery regime | 170,4197 |
| | GE=[(31.63+11.39+ 16,46 + 3.16 + 0 ) / 0,4989 ] /0,61= 205.85ՄՋ/head/day grazing regime | 208,4912 |
| Emission Factor | | |
| EF=GE x $Y_m$ x 365 days/year)/ (55.65 MJ/kg $CH_4$) | EF=[(168.43 x 0.07 x 210 + 205.85 x 0.06 x 155)/55.65]=78,89 kg methane/head/year | **80** |

| Bulls | 2011 | |
|---|---|---|
| Baseline data | | |
| Weight | | 510 |
| DE | | 57 |
| Regime | | |
| **$NE_m$ (MJ/day) =Cfi x (Weight)$^{0.75}$** | $NE_m$= 0.322 x $510^{0.75}$=34.56 | 34,5568 |
| Activity | Activity | |
| $NE_a$(MJ/day) = $C_a$ x $NE_m$ | $NE_m$= 0 x 34.05=0 nursery regime | |
| | $NE_m$= 0.36 x 34,55=12.44 grazing regime | 12,4404 |
| **NEm/DE** | | |
| $NE_{ma}$/DE=1.123-(4.092 x $10^{-3}$x DE) + [1.126 x $10^{-5}$ x $(DE)^2$]-25.4/DE) | $NE_m$/DE=1.123-(4.092 x 0.001 x57.0) + (1.126 x 0.00001 x 57.0 x57.0) – (25.4/57.0) = 0.4807 | 0,4807 |
| Whole energy | | |
| GE = [($NE_m$+ $NE_a$)$NE_{ma}$/DE]/(DE/100) | GE=[(34,55+0)/0,48]/0,570= 124.25 nursery regime | 126,1134 |
| | GE=[(34,55+12.26)/0,48]/0,57=168.98 grazing regime | 171,5143 |
| Emission factor | | |
| EF=GE x $Y_m$ x 365 days/year)/ (55.65 MJ/kg $CH_4$) | EF=[(124,25 x 0.07 x 210 + 168.98 x 0.06 x 155)/55.65]=61,06 MJ/kg $CH_4$ | **62** |

| Bulls | 2012 | |
|---|---|---|
| Baseline data | | |
| Weight | | 520 |
| DE | | 57 |
| Regime | | |
| **$NE_m$ (MJ/day) =Cfi x (Weight)$^{0.75}$** | $NE_m$= 0.322 x $520^{0.75}$=35.06 | 35,0638 |
| Activity | Activity | |
| $NE_a$(MJ/day) = $C_a$ x $NE_m$ | $NE_m$= 0 x 35.06=0 nursery regime | |
| | $NE_m$= 0.36 x 35,06=12.62 grazing regime | 12,6230 |
| **NEm/DE** | | |
| $NE_{ma}$/DE=1.123-(4.092 x $10^{-3}$x DE) + [1.126 x $10^{-5}$ x $(DE)^2$]-25.4/DE) | $NE_m$/DE=1.123-(4.092 x 0.001 x57.0) + (1.126 x 0.00001 x 57.0 x57.0) – (25.4/57.0) = 0.4807 | 0,4807 |

| | | |
|---|---|---|
| **Whole energy** | | |
| GE = [($NE_m$+ $NE_a$)$NE_{ma}$/DE]/(DE/100) | GE=[(35,06+0)/0,48]/0,570= 124.25 nursery regime | 127,9635 |
| | GE=[(35,06+12.26)/0,48]/0,57=168.98 grazing regime | 174,0304 |
| **Emission factor** | | |
| EF=GE x $Y_m$ x 365 days/year)/ (55.65 MJ/kg $CH_4$) | EF=[(124,25 x 0.07 x 210 + 168.98 x 0.06 x 155)/55.65]=61,06 MJ/kg $CH_4$ | **63** |

| Young animals | 2011 | |
|---|---|---|
| **Baseline data** | | |
| Weight | | 190 |
| Mature weight | | 350 |
| Average weight increase | | 0,45 |
| DE | | 59 |
| **Regime** | | |
| **$NE_m$ (MJ/day) =$Cf_i$ x (Weight)$^{0.75}$** | $NE_m$=0.322 x $190^{0.75}$=16,48 | 16,4786 |
| **Activity** | | |
| $NE_a$(MJ/day) = $C_a$ x $NE_m$ | $NE_m$= 0 x 15,82=0 nursery regime | 0,0000 |
| | $NE_m$= 0.45 x 16,48=7,4154 grazing regime | 7,4154 |
| **Growth** | | |
| $NE_g$(MJ/day) =4.18 x {0.0635 x [0.891 x (BW x 0.96) x (478/(C x MW))]$^{0.75}$ x (WG x 0.92)$^{1.097}$} | $NE_g$(MJ/day) =4.18 x {0.0635 x [0.891 x (170 x 0.96) x (478/(1,2 x 350)]$^{0.75}$ x (0,42 x 0.92)$^{1.097}$}=4,65 | 4,6546 |
| **$NE_{ma}$/DE** | | |
| $NE_{ma}$/DE=1.123-(4.092 x $10^{-3}$x DE) + [1.126 x $10^{-5}$ x (DE)$^2$]-25.4/DE) | $NE_{ma}$/DE=1.123-(4.092 x 0.001 x 59) + (1.126 x 0.00001 x 59 x 59) – (25.4/59) = 0.49 | 0,4903 |
| **NEg/DE** | | |
| $NE_g$/DE=1.164-(5.160 x $10^{-3}$x DE) + [1.308 x $10^{-5}$ x (DE)$^2$]-37.4/DE) | NEg/DE=1.1624-(5,160 x 0.001 x 59) + (1.308 x 0.00001 x 59 x 59) – (37,4/59) = 0.27 | 0,2712 |
| **Whole energy** | | |
| GE = [($NE_m$+$NE_a$)/($NE_{ma}$/DE)+$NE_g$/($NE_g$/DE)]/(DE/100)] | GE=[(16.48+0)/0,59+4,31/0,29]/0,59= 86,06 nursery regime | 86,0601 |
| | GE=[(16,48+5,45)/0,99+4,31/0,27]/0,59=111,70 grazing regime | 111,6964 |
| **Emission factor** | | |
| EF=GE x $Y_m$ x 365 days/year)/ (55.65 MJ/kg $CH_4$) | EF=[(86,06 x 0.07 x 233+ 111,70 x 0.06 x 132)/55.65]=41,12 | **41** |

| Young animals | 2012 | |
|---|---|---|
| **Baseline data** | | |
| Weight | | 200 |
| Mature weight | | 350 |
| Average weight increase | | 0,47 |
| DE | | 59 |
| **Regime** | | |
| NEm (MJ/day) =Cfi x (Weight)0.75 | NEm=0.322 x 2000.75=17,12 | 17,1249 |
| Activity | | |
| NEa(MJ/day) = Ca x NEm | NEm= 0 x 17,12=0 nursery regime | 0,0000 |
| | NEm= 0.47 x 17,12=6,1650 grazing regime | 8,0487 |
| Growth | | |
| NEg(MJ/day) =4.18 x {0.0635 x [0.891 x (BW x 0.96) x (478/(C x MW))]0.75 x (WG x 0.92)1.097} | NEg(MJ/day) =4.18 x {0.0635 x [0.891 x (170 x 0.96) x (478/(1,2 x 350)]0.75 x (0,42 x 0.92)1.097}=4,88 | 4,8820 |

| Young animals | 2012 | |
|---|---|---|
| NEma/DE | | |
| NEma/DE=1.123-(4.092 x 10-3x DE) + [1.126 x 10-5 x (DE)2]-25.4/DE) | NEma/DE=1.123-(4.092 x 0.001 x 59) + (1.126 x 0.00001 x 59 x 59) – (25.4/59) = 0.49 | 0,4903 |
| NEg/DE | | |
| NEg/DE=1.164-(5.160 x 10-3x DE) + [1.308 x 10-5 x (DE)2]-37.4/DE) | NEg/DE=1.1624-(5,160 x 0.001 x 59) + (1.308 x 0.00001 x 59 x 59) – (37,4/59) = 0.27 | 0,2712 |
| Whole energy | | |
| GE = [(NEm+NEa)/(NEma/DE)+NEg/(NEg/DE)]/(DE/100)] | GE=[(17,12+0)/0,59+4,88/0,29]/0,59= 89,72 nursery regime | 89,7157 |
| | GE=[(17,12+5,45)/0,99+4,31/0,27]/0,59= 117,54 grazing regime | 117,5415 |
| Emission factor | | |
| EF=GE x Ym x 365 days/year)/ (55.65 MJ/kg CH4) | EF=[(89,72 x 0.07 x 233+ 117,54 x 0.06 x 132)/55.65]=38,36 | **43** |

Annex 4.

Table 1. General Description of the Lands of the Forest Resources in RA [AFOLURef-10, AFOLURef-30, AFOLURef-11, AFOLURef-31, AFOLURef-19, AFOLURef-20, AFOLURef-21]

| Per year | Forest land, ha | | | | | | | | | | | Not Forest land, ha | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Forest covered | | | Non-adherent forest cultures | Nurseries | Forest covered | | | | | Non-adherent forest cultures | Hay-land | Pasture | Orchard | Arable land | Other land | Total non-forest land | |
| | | | | | | | | | Rare forests | | | | | | | | | |
| | Natural | Artificial | Total | | | Fired areas | Totally logged areas | Forest gaps | Anthropogenic | Biological | | | | | | | | |
| 2011 | 315646.1 | 33701.1 | 349347.2 | 3684.7 | 135 | 319.4 | 1397.8 | 24382.7 | 5777.5 | 17476 | 402520.3 | 1943.1 | 11649.1 | 483.9 | 537.9 | 40065.4 | 54679.4 | 457199,7 |
| 2012 | 315596.8 | 33680.1 | 349276.9 | 3618,7 | 135 | 319.4 | 1397.8 | 24382.7 | 5777.5 | 17476 | 402384 | 1943.1 | 11649.1 | 483.9 | 537.9 | 40065.4 | 54679.4 | 457063,4 |

**Table 2. Baseline Density Factors for Wood**

| Tree Species | Baseline density factor for wood (ton d.m./ cubic meter moist) | | | |
|---|---|---|---|---|
| | Previous | Revised 2000 | Revised | |
| | | | 2010 | Reference |
| Pine-tree | 0,525 | 0,42 | 0.415 | AFOLURef-28. |
| Juniper | 0,524 | 0,425 | 0.447 | AFOLURef -25. |
| Yew | 0,584 | 0,465 | 0.474 | AFOLURef -17. |
| Fir-tree | - | - | 0.365 | AFOLURef -28. |
| Oak-tree | 0,729 | 0,58 | 0.57 | AFOLURef -28. |
| Beech | 0,665 | 0,58 | 0.538 | AFOLURef -16. |
| Hornbeam | 0,760 | 0,63 | 0.64 | AFOLURef -28. |
| Ash-tree | 0,743 | 0,57 | 0.648 | AFOLURef -24. |
| Maple | 0,703 | 0,52 | 0.557 | AFOLURef -23. |
| Elm-tree | 0,673 | 0,52 | 0.535 | AFOLURef -24. |
| Lime-tree | 0,495 | 0,43 | 0.366 | AFOLURef -22. |
| Birch-tree | 0,616 | 0,51 | 0.459 | AFOLURef -17. |
| Plane-tree | - | - | 0.522 | AFOLURef -27. |
| Walnut tree | 0,594 | 0,53 | 0.49 | AFOLURef -28. |
| Pear tree | 0,710 | 0,552 | 0.564 | AFOLURef -17. |
| Poplar | 0,459 | 0,35 | 0.423 | AFOLURef -26. |
| Willow | 0,416 | 0,45 | 0.38 | AFOLURef -28. |
| Acacia | 0,824 | 0,672 | 0.65 | AFOLURef -28. |
| Hackberry | - | - | 0.53 | AFOLURef -18. |

**Table 3. Mean Value of Wood Density of Tree Species, t/cubic meter**

| Tree species | $P_{15}$ | $P_{12}$ | $P_0$ | Baseline density factor for wood $m_0$/Vmoist (t/cubic meter) |
|---|---|---|---|---|
| Pine-tree | 0.511 | 0.505 | 0.48 | 0.415 |
| Juniper | 0.55 | 0.543 | 0.514 | 0.447 |
| Yew | 0.59 | 0.584 | 0.559 | 0.474 |
| Fir-tree | 0.45 | 0.445 | 0.42 | 0.365 |
| Oak-tree | 0.7 | 0.69 | 0.655 | 0.57 |
| Beech | 0.67 | 0.663 | 0.635 | 0.538 |
| Hornbeam | 0.803 | 0.795 | 0.76 | 0.64 |
| Ash-tree | 0.807 | 0.799 | 0.765 | 0.648 |
| Maple | 0.685 | 0.677 | 0.64 | 0.557 |
| Elm-tree | 0.656 | 0.65 | 0.62 | 0.535 |
| Lime-tree | 0.45 | 0.445 | 0.421 | 0.366 |
| Birch-tree | 0.572 | 0.566 | 0.542 | 0.459 |
| Plane-tree | 0.65 | 0.644 | 0.616 | 0.522 |
| Walnut tree | 0.596 | 0.59 | 0.56 | 0.49 |
| Pear tree | 0.702 | 0.695 | 0.665 | 0.564 |
| Poplar | 0.52 | 0.514 | 0.486 | 0.423 |
| Willow | 0.46 | 0.455 | 0.425 | 0.38 |
| Bastard Acacia | 0.808 | 0.8 | 0.77 | 0.65 |
| Hackberry | 0.66 | 0.653 | 0.625 | 0.53 |

## Table 4. Annual Average Growth of Wood

| Dominating tree species | Annual average growth of wood (cubic meter/ha year) | | |
|---|---|---|---|
| | First National Inventory [AFOLURef- 11] | Revised 2000 [AFOLURef- 12, AFOLURef-13] | Revised 2010 [AFOLURef-10, AFOLURef -11, AFOLURef -15, AFOLURef -19, AFOLURef -20, AFOLURef -21, AFOLURef -29, AFOLURef -31] |
| **Coniferous trees** | | | |
| Pine-tree | 2.29 | 4,30 | 1.97 |
| Juniper | 0.83 | 0,49 | 0.19 |
| Yew | - | 0,62 | 0.48 |
| **Broad-leaved trees** | | | |
| Seed oak-tree | 1.04 | 1,33 | 1.18 |
| Stump-sprig oak | 1.04 | 1,44 | 0.43 |
| Beech | 1.84 | 1,91 | 1.76 |
| Seed hornbeam | 1.61 | 2,14 | 1.58 |
| Stump-sprig hornbeam | - | - | 1.09 |
| Ash-tree | 1.52 | 1,54 | 1.4 |
| Maple | 1.6 | 1,56 | 0.99 |
| Elm-tree | 1.47 | 1,92 | 0.9 |
| Bastard acacia | 1.6 | 1,28 | 0.35 |
| Birch tree | 0.89 | 1,27 | 0.16 |
| Lime-tree | 1.71 | 2,76 | 1.5 |
| Aspen | - | - | 1.46 |
| Poplar | 2.52 | 5,19 | 2.1 |
| Willow | 2.46 | 2,34 | 0.25 |
| Oriental beech | - | 1,44 | 0.87 |
| Pear-tree | - | 0,79 | 0.37 |
| Apple tree | - | - | 0.39 |
| Walnut tree | - | 2,27 | 0.78 |
| Plane-tree | - | - | 1.1 |
| Almond tree | - | - | 0.06 |
| Oleaster | - | - | 0.52 |
| Apricot tree | - | - | 0.05 |
| Plum tree | - | - | 0.8 |
| Other species | 1.2 | 1.33 | - |
| **Average (RA forests )** | **1.44** | **1,86** | **1.5** |

GHG emissions/removals recalculated data for 2012, per 1996 IPCC Guideline

| Greenhouse gas source and sink categories | $CO_2$ emissions (Gg) | $CO_2$ removals (Gg) | $CH_4$ (Gg) | $N_2O$ (Gg) | $NO_x$ (Gg) | CO (Gg) | NMVOCs (Gg) | $SO_x$ (Gg) |
|---|---|---|---|---|---|---|---|---|
| **Total national emissions and removals** | **5,581.727** | **-522.068** | **156.820** | **1.837** | **19.737** | **46.154** | **17.106** | **36.632** |
| **1. Energy** | **5,296.501** | | **75.484** | **0.100** | **19.737** | **46.154** | **7.623** | **0.212** |
| **A.** Fuel combustion (sectorial approach) | **5,295.567** | | **3.771** | **0.100** | **19.737** | **46.154** | **7.623** | **0.212** |
| 1. Energy Industries | 1,616.277 | | 0.028 | 0.003 | 4.306 | 0.574 | 0.144 | 0.000 |
| 2. Manufacturing industries and construction | 620.143 | | 0.011 | 0.001 | 1.342 | 0.267 | 0.045 | 0.000 |
| 3. Transport | 1,241.732 | | 1.473 | 0.063 | 12.293 | 43.971 | 7.281 | 0.058 |
| 4. Other sectors | 1,817.414 | | 2.259 | 0.033 | 1.796 | 1.342 | 0.153 | 0.154 |
| 5. Other | NO | | NO | NO | NO | NO | NO | NO |
| **B. Fugitive emissions from fuels** | **0.934** | | **71.713** | | **NO** | **NO** | **NO** | **NO** |
| 1. Solid fuels | | | NO | | NO | NO | NO | NO |
| 2. Oil and natural gas | 0.934 | | 71.713 | | NO | NO | NO | NO |
| **2. Industrial processes** | **277.900** | | | | **NO** | **NO** | **6.457** | **36.420** |
| A. Mineral products | 227.900 | | | | NO | NO | 0.000 | 0.000 |
| B. Chemical industry | NO | | NO | NO | NO | NO | NO | NO |
| C. Metal production | NO | | NO | NO | NO | NO | NO | 36.420 |
| D. Other production | NO | | NO | NO | NO | NO | 5.625 | NO |
| E. Production of halocarbons and sulphur hexafluoride | | | | | | | | |
| F. Consumption of halocarbons and sulphur hexafluoride | | | | | | | | |
| G. Other | NO | | NO | NO | NO | NO | 0.832 | NO |
| **3. Solvent and other product use** | **NO** | | | **NO** | | | **3.026** | |
| **4. Agriculture** | | | **54.349** | **1.549** | **IE** | **IE** | **NO** | |
| A. Enteric fermentation | | | 50.477 | | | | | |
| B. Manure management | | | 3.866 | 0.241 | | | NO | |
| C. Rice cultivation | | | NE | | | | NO | |
| D. Agricultural soils | | | | 1.308 | | | NO | |
| E. Prescribed burning of savannahs | | | NO | NO | NO | NO | NO | |
| F. Field burning of agricultural residues | | | 0.007 | 0.005 | 0.159 | 4.327 | NO | |
| G. Other | | | NO | NO | NO | NO | NO | |
| **5. Land-use change and forestry** | | **-522.068** | **NE,NO** | **NO** | **NO** | **NO** | | |
| A. Changes in forest and other woody biomass stocks | NE | NE | | | | | | |
| B. Forest and grassland conversion | | 18.108 | NO | NO | NO | NO | | |
| C. Abandonment of managed lands | | NA | | | | | | |
| D. $CO_2$ emissions and removals from soil | | -540.176 | | | | | | |
| E. Other | NE | NE | NE | NO | NO | NO | | |
| **6. Waste** | **7.326** | | **26.987** | **0.188** | **NO,NE** | **NO** | **NO,NE** | **NO** |
| A. Solid waste disposal on land | | | 21.579 | | NE | | NE | |
| B. Waste-water handling | | | 4.353 | 0.169 | NO | NO | NO | |
| C. Waste incineration | 7.326 | | 1.055 | 0.019 | NO | NO | NO | NO |
| D. Other | | | | | NO | NO | NO | NO |
| **7. Other** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** |
| **Memo items** | | | | | | | | |
| **International bunkers** | **127.617** | | **0.001** | **0.004** | **0.610** | **0.203** | **0.102** | **0.046** |
| Aviation | 127.617 | | 0.001 | 0.004 | 0.610 | 0.203 | 0.102 | 0.046 |
| Marine | **NO** | | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** |