"Armenia's Third Biennial Update Report to the UNFCCC"
UNDP-GEF Project

Development of the National Greenhouse Gas Inventory of the "Energy" sector of Armenia

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EMISSIONS FROM THE "ENERGY" SECTOR (1)

- The energy sector is the largest source of GHG emissions in the world, typically accounting for more than 90% of carbon dioxide emissions in developed countries and about 75% of total GHG emissions.

- Emissions of carbon dioxide in the energy sector in Armenia make up 95% of carbon dioxide emissions in the country (according to the 2017 National GHG Inventory), and greenhouse gas emissions reach 70% of the country's total emissions (66.7% in 2017).
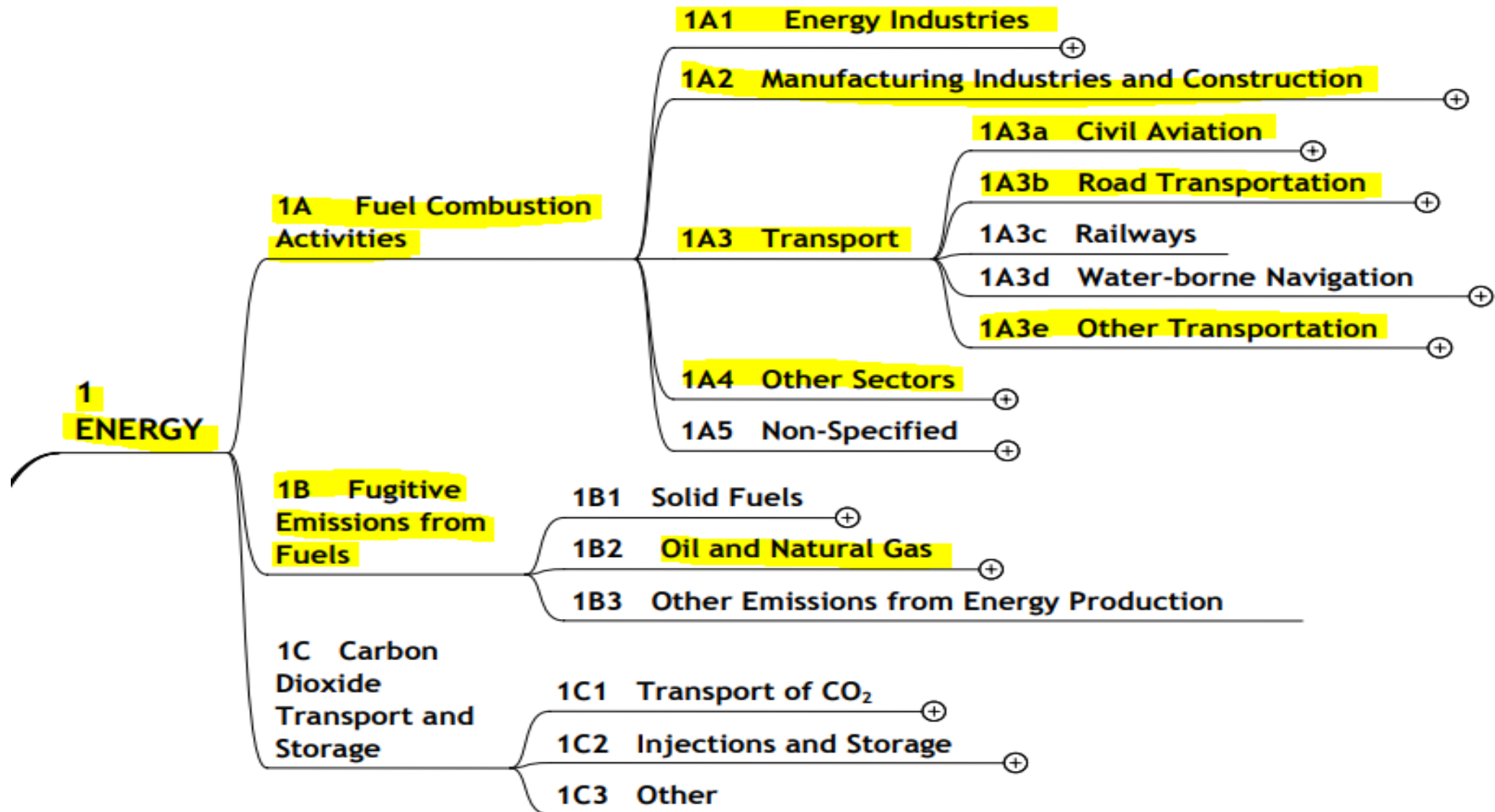
EMISSIONS FROM THE "ENERGY" SECTOR (2)

- The "energy" sector includes all emissions from the combustion of energy fuels, including fuel used in transport, as well as fugitive emissions from the transportation, storage and distribution of natural gas.

Petroleum 6.4%
Jet Fuel 2.4%
Coal 0.05%
Diesel 5.8%
Liquid gas 0.3%
Natural Gas 85.0%
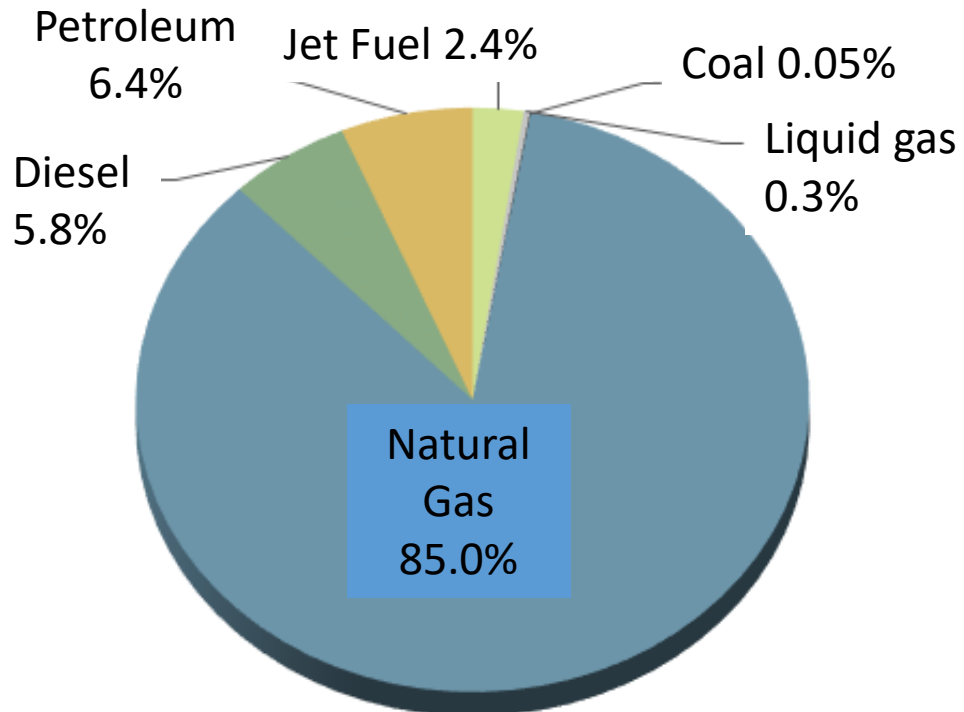
- Natural gas is the main fuel consumed in Armenia. As of 2017 natural gas accounts for about 61% of primary energy, 85% of fossil fuel consumption, and more than 83% of CO_2 emissions from fossil fuel combustion.

- Sectoral emissions in 2017 amounted to **7,087.4 Gg** CO_2 - only 31.2% of 1990 emissions, an increase by 7% compared to 2016.

GHG EMISSION SOURCES OF THE "ENERGY" SECTOR IN ARMENIA ACCORDING TO 2006 IPCC GUIDELINE

1 ENERGY

- **1A Fuel Combustion Activities**
  - **1A1 Energy Industries** ⊕
  - **1A2 Manufacturing Industries and Construction** ⊕
  - **1A3 Transport**
    - **1A3a Civil Aviation** ⊕
    - **1A3b Road Transportation** ⊕
    - 1A3c Railways
    - 1A3d Water-borne Navigation ⊕
    - **1A3e Other Transportation** ⊕
  - **1A4 Other Sectors** ⊕
  - 1A5 Non-Specified ⊕
- **1B Fugitive Emissions from Fuels**
  - 1B1 Solid Fuels ⊕
  - 1B2 **Oil and Natural Gas** ⊕
  - 1B3 Other Emissions from Energy Production
- 1C Carbon Dioxide Transport and Storage
  - 1C1 Transport of CO_2 ⊕
  - 1C2 Injections and Storage ⊕
  - 1C3 Other

GHG EMISSION SOURCES OF THE "ENERGY" SECTOR IN ARMENIA (2)

1 A Fuel Combustion Activities

1 A 1 - Energy Industries

1 A 1 a ii Combined production of electric and thermal energy

1 A 2 - Manufacturing Industries and Construction

1 A 2 a Iron and Steel

1 A 2 b Non-Ferrous Metals

1 A 2 c Chemicals

1 A 2 d Pulp, Paper and Print

1 A 2 e Food Processing, Beverages and Tobacco

1 A 2 f Non-Metallic Minerals

1 A 2 g - Transport Equipment

1 A 2 h Machinery

1 A 2 i Mining (excluding fuels) and Quarrying

1 A 2 j Wood and wood products

1 A 2 k Construction

1 A 2 l Textile and Leather

1 A 2 m Non-specified Industry

GHG EMISSION SOURCES OF THE "ENERGY" SECTOR IN ARMENIA (3)

1 A 3 TRANSPORT

1 A 3 a Civil aviation

1 A 3 b Road transport

1 A 3 e ii Off-road transport

1 A 4 OTHER SECTORS

1 A 4 a Commercial / institutional

1 A 4 b Household

1 A 4 c ii Off-road vehicles and other vehicles

1 B FUGITIVE EMISSIONS FROM FUELS

1 B 2 b iii Natural gas transportation and storage

1 B 2 b iii Natural gas distribution

FUEL COMBUSTION ACTIVITIES

Calculation formulas

GHG Emissions$_{fuel\ 1}$= Burnt fuel$_{fuel\ 1}$ x Emission factor$_{fuel\ 1}$

$$\textbf{GHG Emissions}_{\textbf{total}} = \sum \textbf{GHG Emissions}_{\textbf{fuel 1,2…}}$$

Fuel combustion is estimated from Stationary and Mobile Combustion Activities

Stationary combustion: electricity generation, industry and construction and other sectors: households, commercial / institutional organizations.

Mobile combustion: road transport, off-road transport.

Emissions from international bunkers are not included in total emissions and are presented as information only.

ACTIVITY DATA SOURCES

ACTIVITY DATA ACCORDING TO AVAILABILITY

Published data:

➢ Main data of the RA gas supply system for the given year: Public Services Regulatory Commission (PSRC) website

➢ RA Energy Balance: Statistical Committee website

➢ Main data of the energy system for the given year: PSRC website

Unpublished data:

➢ Actual volumes of natural gas consumed in the RA energy system according to thermal power plants: PSRC

➢ Average annual physicochemical indicators of natural gas transmitted by gas transmission and distribution systems of the Republic of Armenia from Russia and supplied from gas distribution station 2 of Yerevan (mixed natural gas) and from Iran: "Gazprom Armenia" CJSC

STATISTICAL COMMITTEE (1)

- *Energy balance is the main source of activity data for the development of the GHG inventory of the "Energy" sector and extremely important in terms of improving transparency, accuracy, completeness, comparability and consistency of the GHG inventory (TACCC)*

- *In order to maximize the above (TACCC) principles, activity data were collected from primary sources and cross-checked with the Energy Balance data to ensure the compatibility of the National GHG Inventory Activity and Energy Balance data.*

- *Existing discrepancy: volumes of burnt firewood*

STATISTICAL COMMITTEE (2)

➢ *Industry and Construction Sector*

Actual volumes of fuel consumed by sectors (subcategories):

- natural gas
- coal
- diesel fuel (for transport and energy purposes)
- gasoline
- liquefied petroleum gas (LPG)
- fuelwood
- manure
- other biofuel

STATISTICAL COMMITTEE (3)

➢ **Road Transport** Sector

According to the "Energy Balance", actual volumes of consumed fuel are:

- – compressed natural gas
- – diesel fuel
- – gasoline
- – liquefied petroleum gas (LPG)

The amount of fuel consumed according to the type of vehicle is also required for the development of the GHG.

Such information is provided by the Statistical Committee according to the following types of vehicles:

- – trucks (including pickups, scooters)
- – buses (including minibuses)
- – light passenger cars (taxis and service cars)
- – special cars

Existing problems: the information is incomplete and does not meet the classification required by the IPCC Guideline.

COMPARISON OF ROAD TRANSPORT SUB-GROUP CLASSIFICATION ACCORDING TO IPCC GUIDELINES AND GOVERNMENT DECISION OF ARMENIA N 965-N OF 22.07.2006

According to IPCC Guidelines	According to Government Decision
Light passenger cars, vehicles with a capacity of up to 12 passengers	M1 - light passenger vehicles intended for transportation of passengers, which, in addition to the driver's seat, have no more than 8 seats. M2 - vehicles for transportation of passengers (buses with internal combustion engines), which, in addition to the driver's seat, have more than 8 seats, the maximum weight of which does not exceed 5 tons.
Light trucks with an estimated load capacity of 3,500-3,900 kg	N1 - vehicles for cargo transportation, the maximum weight of which does not exceed 3.5 tons.

According to IPCC Guidelines	According to Government Decision
Heavy trucks over 3,900 kg and buses with a capacity of more than 12 passengers	M3 - vehicles for transportation of passengers (buses with internal combustion engines), which, in addition to the driver's seat, have more than 8 seats, with a maximum weight exceeding 5 tons; N2 - vehicles intended for cargo transportation, with a weight of more than 3.5 tons but not exceeding 12 tons; N3 - vehicles for cargo transportation, with a maximum weight of more than 12 tons.
	T - newly released or overhauled tractors and self-propelled agricultural diesel vehicles, agricultural, production, forestry and forest production diesel tractors ...

STATISTICAL COMMITTEE (4)

➤ *Commercial / Institutional category*
- – Actual volumes of consumed fuel [natural gas, coal, diesel fuel (for transport and energy purposes), gasoline, LPG, fuelwood, manure and other biofuel, etc.].

Existing Issues: fuel costs provided by the Statistical Committee for the "Services" category does not meet the IPCC classification

➤ *"Housing sector" category*
- – Actual volumes of fuel consumed by the population [natural gas, coal, diesel fuel (for transport and energy purposes), gasoline, LPG, fuelwood, manure and other biofuel, etc.].

Existing problems: inconsistency of burned firewood volumes with official data.

DATA DIFFERENCE ON THE VOLUME OF BURNT FIREWOOD

Volume of Burnt Firewood				
Year	According to official data		According to Energy Balance (household study)	
	m3	kt n.h.	m3	kt n.h.
2011	65,740	13.6	2,167,803	222.7*
2012	85,960	17.8	2,020,817	207.6*
2014	65,621	13.6	557,040	55.5*
2015	76,600	15.9	1,654,128	171.8**
2016	70,246	14.6	678,119	67.6**
2017	82,743	17.2	665,828	66.4**
2018	***	***	475,984	53.2**
2019	***	***	439,936	49.3**
2020	***	***	472,072	50.8***

* USAID-supported pilot balances

** according to Officially Published Energy Balances

*** according to the Draft Energy Balances (not officially published)

STATISTICAL COMMITTEE (5)

➢ *"Agriculture / Forestry / Fish Farming" category*

   – Actual volumes of consumed fuel [natural gas, coal, diesel fuel (for transport and energy purposes), gasoline, LPG, fuelwood, manure and other biofuel, etc.].

Existing problems: The Statistical Committee provides only the cost of diesel fuel; other fuel costs, such as natural gas, are missing.

OTHER SOURCES OF ACTIVITY DATA

- **PSRC:** Actual volumes of natural gas consumed in the energy system of Armenia according to thermal power plants.

  ➢ Used to calculate CO_2 emissions from natural gas combustion in thermal power plants by the 3rd class methodology.

- *"Gazprom Armenia" CJSC: Average annual physicochemical indicators of natural gas transmitted by gas transmission and distribution systems of Armenia from Russia and supplied from gas distribution station 2 of Yerevan (mixed natural gas) and the ingredients, density calorific value of the natural gas imported from Iran.*

  ➢ Used for the calculation of natural gas fugitive emissions by the 2nd class methodology.

METHODOLOGICAL APPROACHES

IPCC 2006 National GHG Inventory Guidelines presents three methodologies for calculating emissions from fossil fuel combustion: 1st (Tier 1), 2nd (Tier 2), 3rd (Tier 3).

1st Class Methodology (Tier 1)

Tier 1 method is based on activity data (fuel quantities burned) and emission reference ratios provided by the IPCC 2006 Guideline according to greenhouse gases.

2nd Class Methodology (Tier 2)

Tier 2 method is based on activity data (quantities of fuel burned) and national emission ratios.

3rd Class Methodology (Tier 3)

Tier 3 method is based on fuel consumption data at the level of emission sources (thermal stations).

- Emissions in the energy sector were calculated using the 2nd and 3rd class methodologies based on national energy statistics and national emission factors, **with the exception of emissions from liquid fuel combustion, which were calculated using the 1st class methodology due to lack of data.**

- Indirect GHG emissions from fuel combustion were calculated using the first level sectoral methodology approach (Tier 1) using country performance data and the coefficients set out in the EMEP / EEA 2016 Guideline.

| Subcategory	GHG	Methodology	Data	Emission Ratio
1A Fuel Combustion Activities				
Energy products (gas fuel)	CO_2	Tier 3	National	National
Industry and construction (gas fuel)	CO_2	Tier 2	National	National
Industry and construction (liquid fuel)	CO_2	Tier 1	National	IPCC Value
Road Transport (gas fuel)	CO_2	Tier 2	National	National
Road Transport (liquid fuel)	CO_2	Tier 1	National	IPCC Value
Commercial / Institutional (gas fuel)	CO_2	Tier 2	National	National
Housing (gas fuel)	CO_2	Tier 2	National	National
Other areas (liquid fuel)	CO_2	Tier 1	National	IPCC Value
1B Fuel Fugitive Emissions				
Natural gas fugitive emissions	CH_4	Tier 2	National	National

ELECTRICITY AND THERMAL ENERGY PRODUCTION
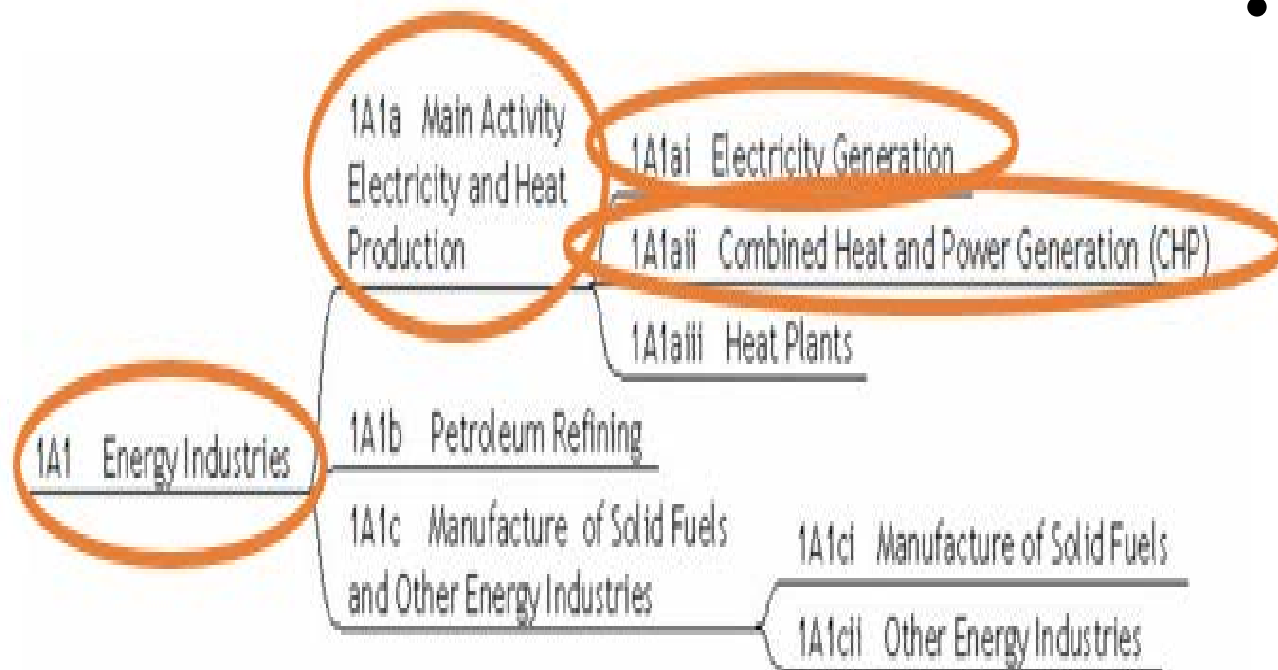
- This category includes thermal power plants generated emissions as a result of natural gas combustion: Hrazdan TPP, Hrazdan-5 and Yerevan Thermal Power Plant CJSC (steam-gas cycle power unit), as well as small power cogeneration plants - "Armruskogeneratsia"CJSC and State Medical University energy center.

- The national emission factors were calculated on the basis of physicochemical parameters of a mixture of natural gas imported from Russia (Yerevan Gas Distribution Station 2) and Iran (reference issued by Gazprom Armenia CJSC).

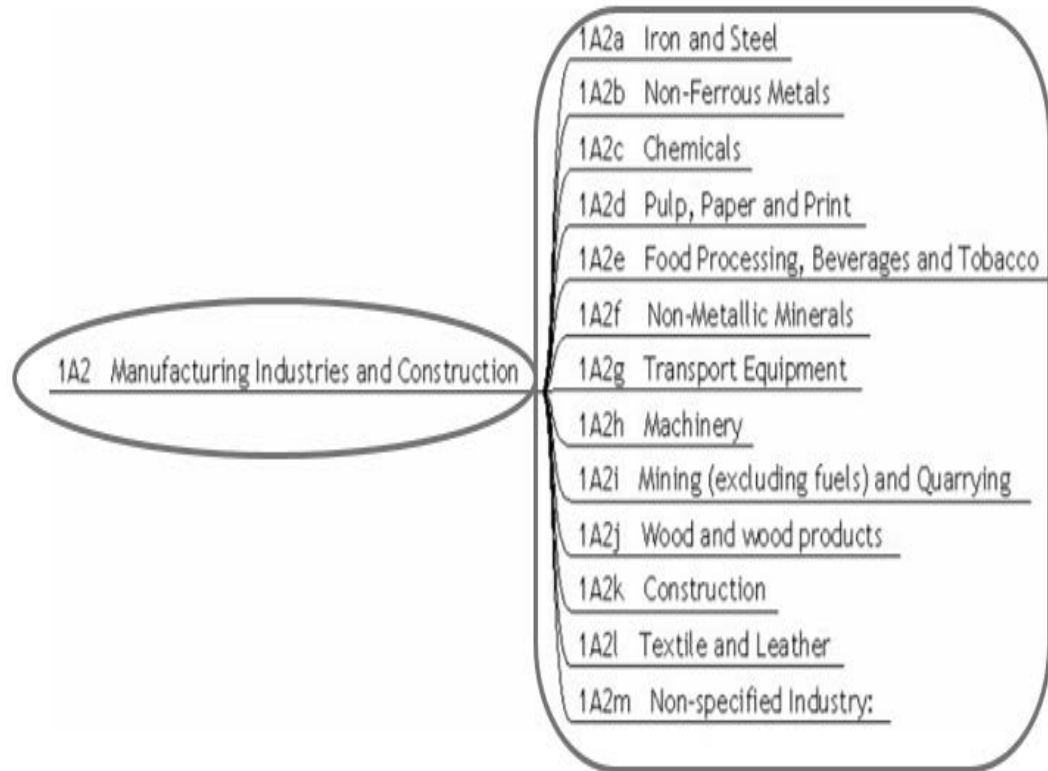# TIME SERIES OF GHG EMISSIONS OF SUBCATEGORY "ELECTRICITY AND THERMAL POWER GENERATION"
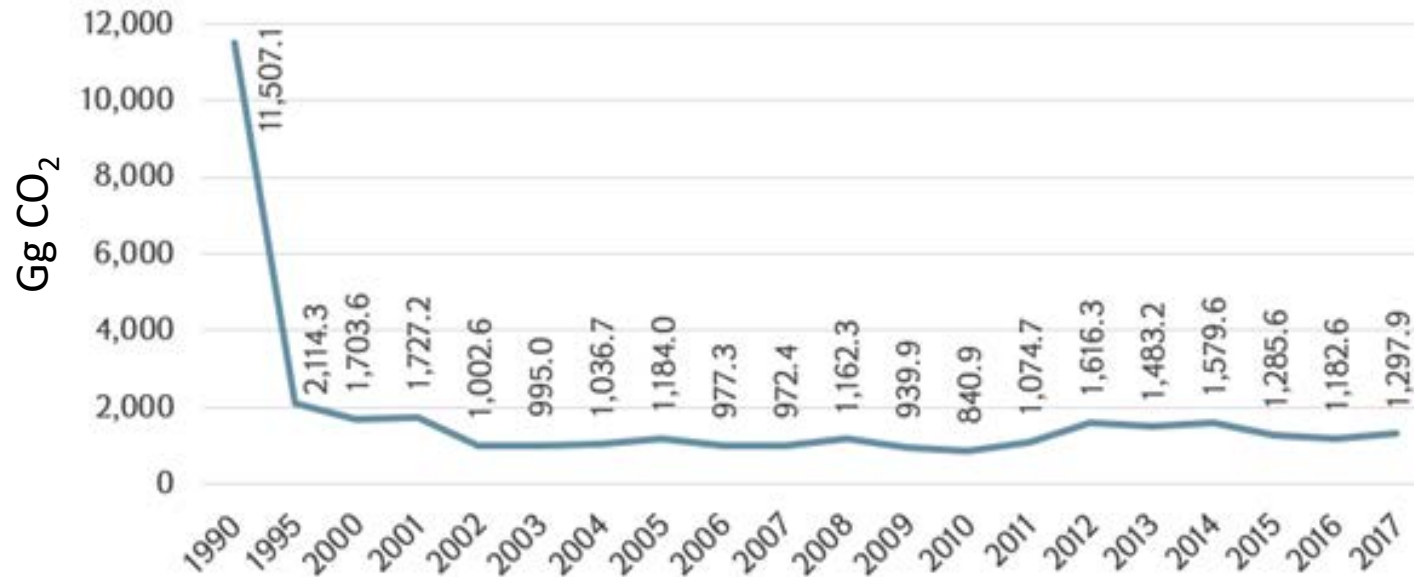
- Emissions from the "Electricity and thermal power generation" subcategory show annual fluctuations, mainly due to changes in electricity exports.

- The volume of emissions each year is also affected by the economic situation of the country's energy sector, weather conditions and the volume of production of hydropower plants.

INDUSTRY AND CONSTRUCTION

1A2a	Iron and Steel
1A2b	Non-Ferrous Metals
1A2c	Chemicals
1A2d	Pulp, Paper and Print
1A2e	Food Processing, Beverages and Tobacco
1A2f	Non-Metallic Minerals
1A2g	Transport Equipment
1A2h	Machinery
1A2i	Mining (excluding fuels) and Quarrying
1A2j	Wood and wood products
1A2k	Construction
1A2l	Textile and Leather
1A2m	Non-specified Industry:

1A2   Manufacturing Industries and Construction

This category includes emissions resulting from the combustion of fuel for the production of thermal energy in industry for its own use, as well as from the operation of off-road equipment and other machinery. The energy used by vehicles in industry was not included, it was reviewed in the Transport category.

TRANSPORT

- In Armenia, the sources of emissions in the Transport category are: International Aviation (International Bunker), Road Transport and Off-Road Transport.

- Emissions from international bunkers are not included in total emissions and are presented for information only.

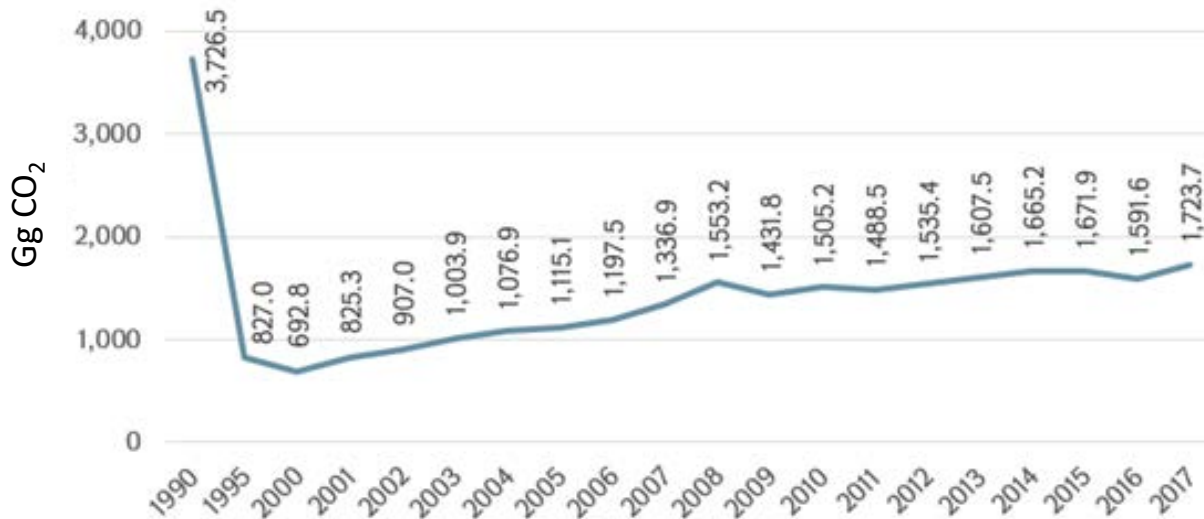# STRUCTURE OF FUEL CONSUMPTION IN ROAD TRANSPORT
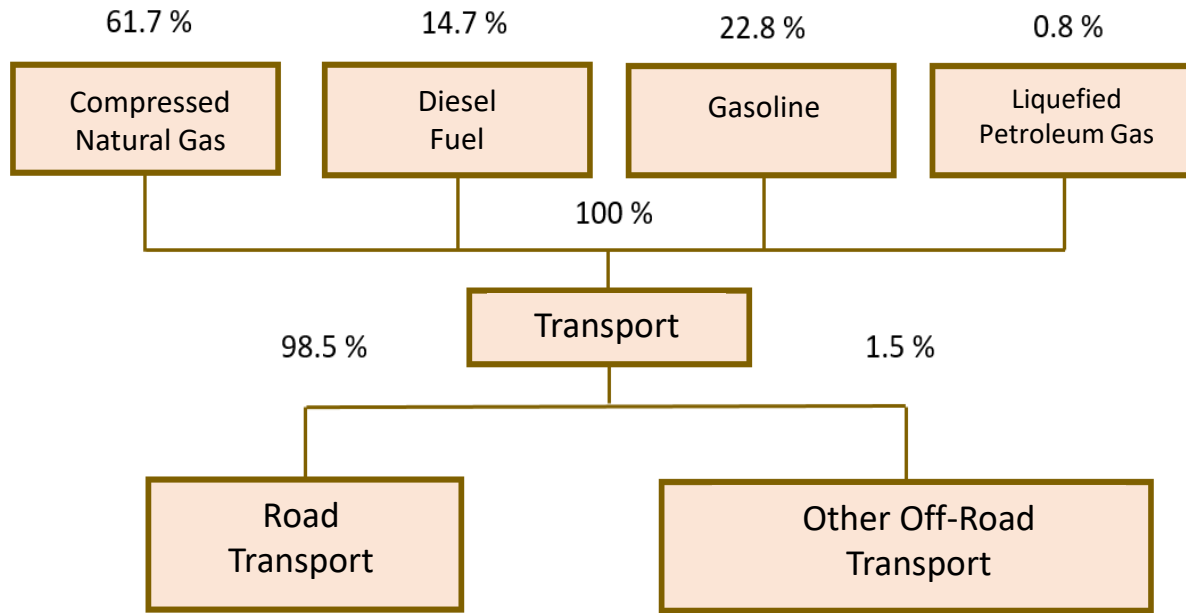
The structure of fuel consumption in road transport is quite unique: Compressed Natural Gas consumption in 2017 accounted for about 62% of the fuel consumed in transport.

The vehicles also use gasoline, diesel fuel, liquefied petroleum gas (LPG).

More than 98% of emissions of Transport category in 2017 come from road transport.

During 2000-2017 emissions from transport increased by more than 150%.

OTHER SECTORS


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1A4a
Commercial/Institutional

1A4b  Residential

1A4c  Agriculture/Forestry/       1A4ci   Stationary
      Fishing/Fish Farms          1A4cii  Off-road Vehicles and Other Machinery
                                  1A4ciii Fishing (mobile combustion)

1A4   Other Sectors
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- This category includes *Commercial / Institutional, Housing and Off-Road Equipment and Other Equipment* subcategories of Agriculture.

- *The Housing and Commercial / Institutional subcategories* are the main source of GHG emissions [gaseous fuels, greenhouse gases (carbon dioxide (CO_2)] in terms of both levels and trends.
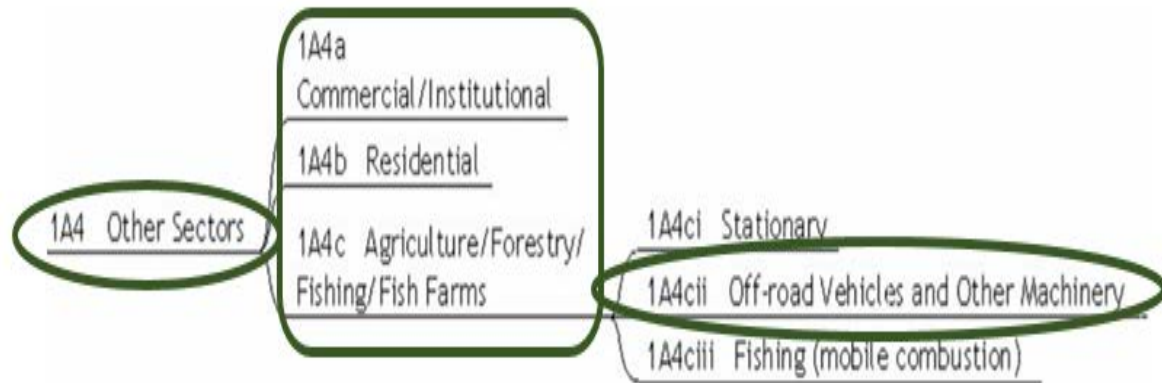
HOUSEHOLDS

- The main portion of fuel used in households in Armenia is natural gas - 85.8%, biofuel being next - 14.1%.

- GHG emissions from biomass combustion include emissions from firewood, manure, coupon and other solid residues and coal combustion.

- According to 2006 IPCC Guideline, CO_2 **emissions from biomass are not included in the national GHG emissions and are presented in a separate section as a note, whereas methane (CH_4) and nitrous oxide (N_2O) emissions are included in the National GHG Inventory.** This allows to avoid double counting.

- In 2017 estimates of biomass emissions within the national inventory have been adjusted as a result of the adjustment of manure per 1 cow.

# TIME SERIES OF CO$_2$ EMISSIONS IN "OTHER SECTORS" CATEGORY DURING 1990-2017
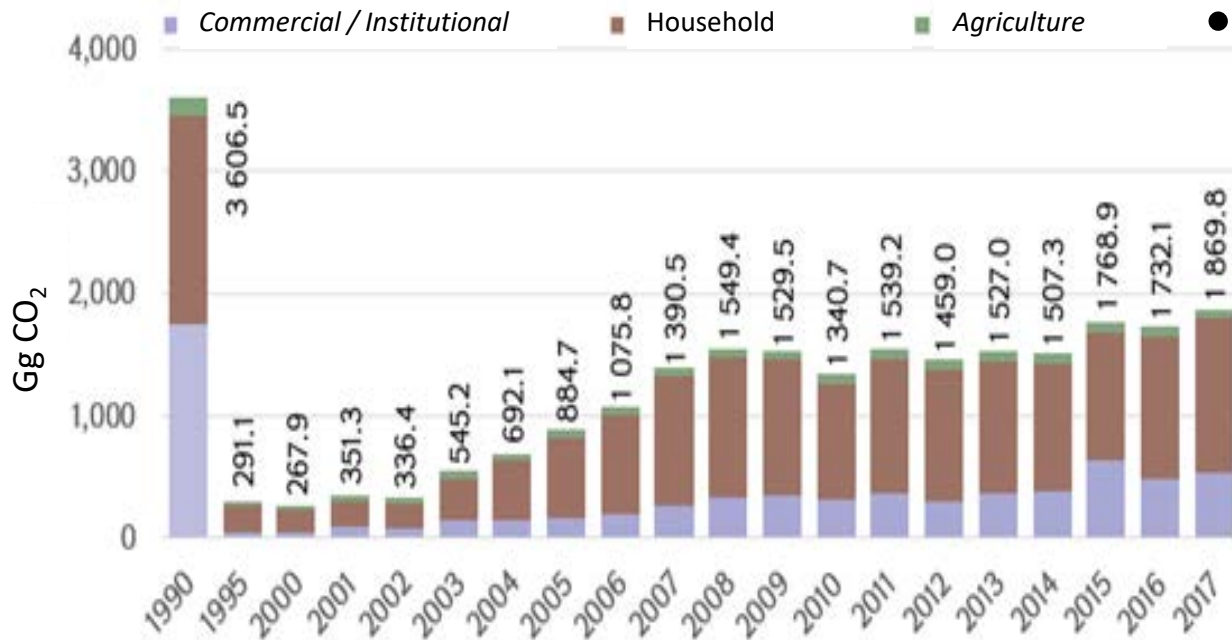
- The increase in GHG emissions in the "Other sectors" subcategory is mainly conditioned by the increase in "Household" subcategory emissions. In 2017 the growth of emissions in "Household" subcategory is due to weather conditions in 2017. The average winter temperature was quite low compared to previous years.

- Despite some fluctuations in the *Commercial / Institutional subcategory*, there is a steady increase in emissions.

- The time series of CO$_2$ emissions for 2000-2017 in "Agriculture" sub-category is generally stable throughout the range.

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QUALITY CONTROL / REFERENCE APPROACH

The reference approach is a top-down approach that uses the country's energy supply data (as a result of fossil fuel combustion) to calculate CO_2 emissions.
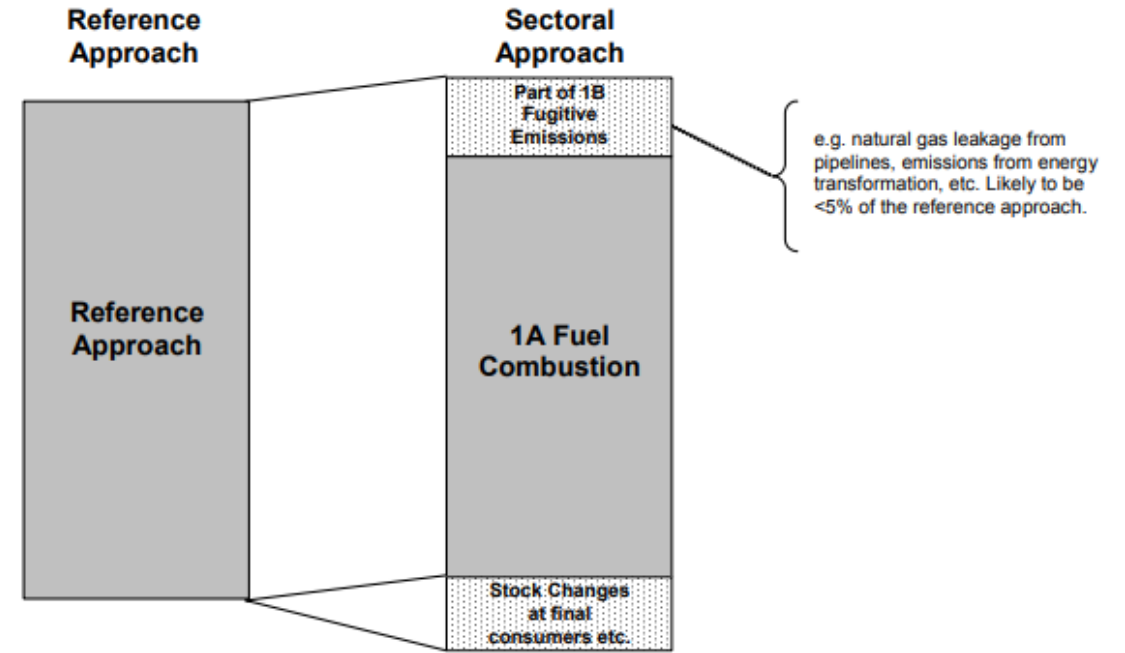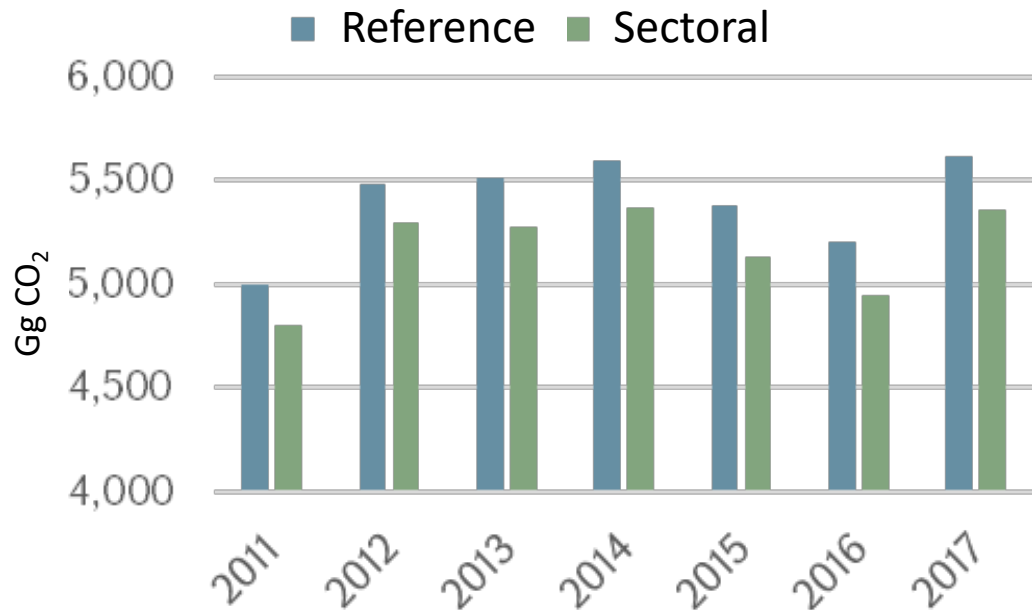
According to 2006 IPCC Guideline the difference in emissions from Reference and Sectoral Approach is within 5%.

The difference by years is 4.1%, 3.5%, 4.4%, 4.3%, 4.8%, 5.0%, 4.8%.

FUGITIVE EMISSIONS OF NATURAL GAS

- Fugitive emissions are estimated in the following subcategories of natural gas transportation and distribution systems:

➢ Transportation and storage

➢ Distribution

  - In Armenia fugitive emissions of methane occur mainly during the operation of natural gas systems (accidental leaks, leaks from operating regulations, technological losses).

  - Fugitive emissions of natural gas subcategory is a major source of emissions [gas fuel, methane (CH_4)], both in terms of level and trends.

RA GAS TRANSPORTATION SYSTEM AND CALCULATION METHODOLOGY
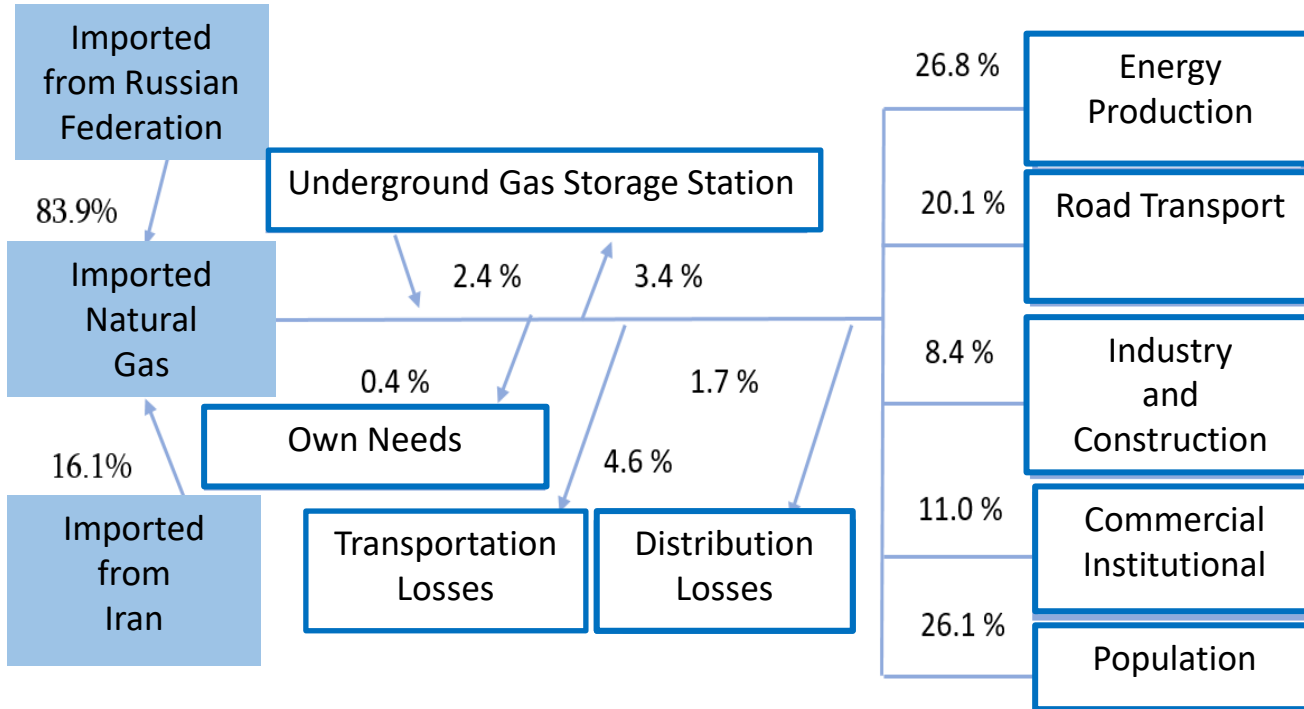
Armenia is one of the leaders in the world with 96% gasification index.

- Natural gas fugitive emissions are estimated according to type two methodology (Tier 2) of 2006 IPCC Guideline using national emission factors, taking into account the physicochemical parameters of the supplied [mixed (medium weight)] natural gas (official data).

ACTIVITY DATA AND EMISSION FACTORS

- **Activity Data**

  The calculation of natural gas transmission and distribution systems data was performed on the basis of official data presented in the annual balance sheets provided by Gazprom Armenia CJSC.

- **Emission Factors**

  The calculation of national coefficients for estimating fugitive methane emissions was carried out on the basis of official data presented in the annual balance sheets provided by Gazprom Armenia CJSC and the average annual physicochemical parameters of natural gas in gas supply transportation and distribution systems: components, density, thermal properties.

COMPARISON OF METHANE FUGITIVE EMISSIONS

Methodology	Activity Data	GHG Emission Ratios Gg/TJ	Fugitive Emissions
IPCC 1996	Imported Gas (**87,193 TJ**)	**0.0006280 Gg/TJ** (max) **0.0002880 Gg/TJ** (min)	**80.7 Gg CH4** (max) **36.9 Gg CH4** (min)
	Consumed Gas (Not by population **56,415 TJ**)	**0.0003840 Gg/TJ** (max) **0.0001750 Gg/TJ** (min)	
	Consumed Gas (By population **22,242 TJ**)	**0.0001920 Gg/TJ** (max) **0.0000870 Gg/TJ** (min)	
IPCC 2006	Transported Gas (**2,327.7 mln m3**)	**0.0025000 Gg/mln m3** (maximum rate)	**26.8 Gg CH4**
	Distributed Gas (**1,941.4 mln m3**)	**0.0108000 Gg/mln m3** (maximum rate)	
IPCC 2006 Tier 2 Using National Ratios	Transported Gas (**2,327.7 mln m3**)	**0.0236837 Gg/mln m3**	**77.5 Gg CH4**
	Distributed Gas (**1,941.4 mln m3**)	**0.0115081 Gg/mln m3**	

Density of natural gas 0.7513 kg / m3, Methane content 88.31%,
Thermal power 35.79 TJ / mln m3

TIME SERIES OF FUGITIVE EMISSIONS OF NATURAL GAS
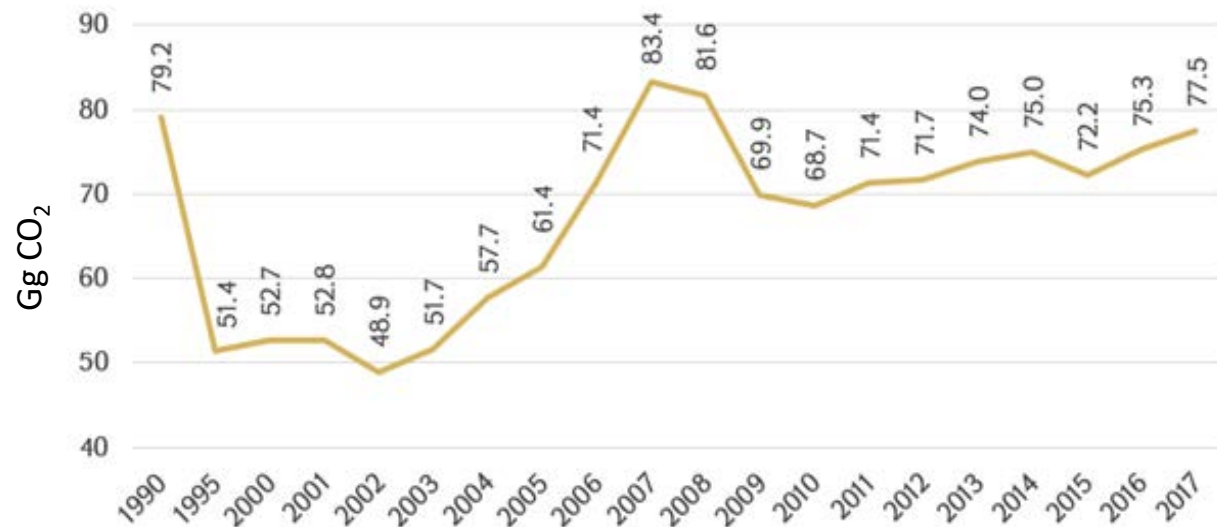
- Fugitive emissions of natural gas have been growing steadily since the 2000-s, mainly due to the rate of gasification in the country.

- As in all previous time series, the decline in 2009 emissions due to the global economic crisis is significant.

- The increase in fugitive emissions since 2010 is due to the increase in the volume of imported natural gas, according to the Iran-Armenia *Electricity for Gas* exchange agreement.

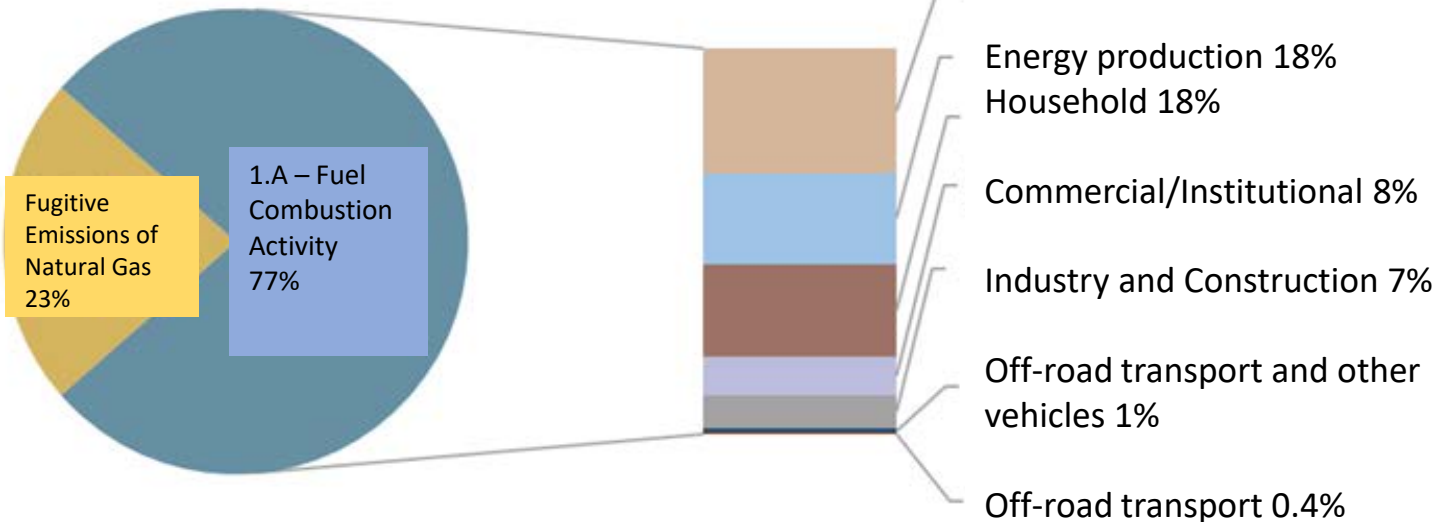# TIME SERIES OF GHG EMISSIONS IN THE "ENERGY" SECTOR
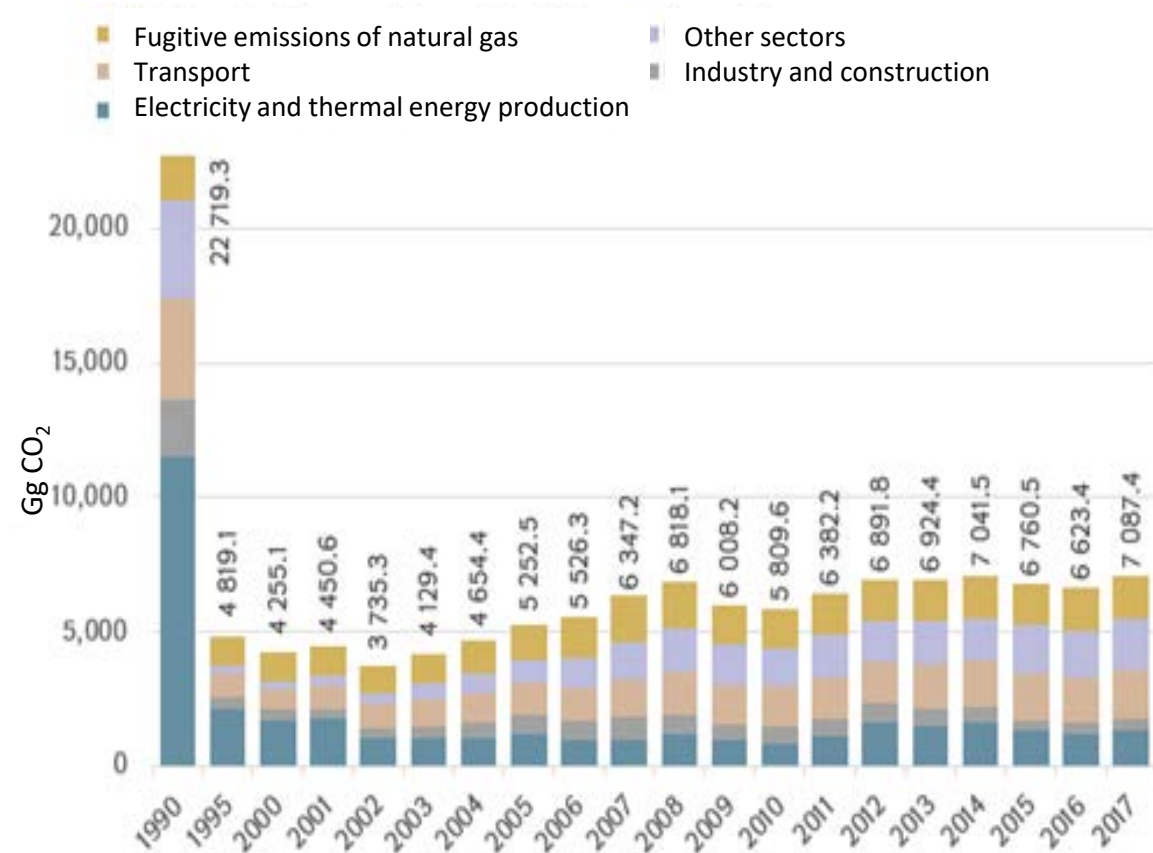
- GHG emissions in the "Energy" sector decreased by 3.2 times compared to 1990 (moreover, the total supply of primary energy decreased by 2.4 times, natural gas imports - by 1.8 times, electricity production - by 1.3 times). These changes are due to structural changes in the economy, such as the widespread use of more environmentally friendly fuels such as natural gas (coal and fuel oil use is negligible), the re-launch of the nuclear power plant, and the rapid growth of small hydropower.

GHG EMISSIONS OF "ENERGY" SECTOR, 2017

CH$_4$
23.9%

N$_2$O
0.5%

CO$_2$
75.6%
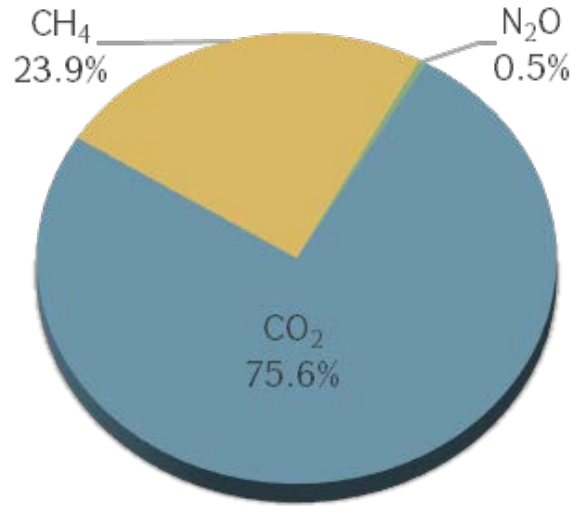
The main greenhouse gas in the "Energy" sector is carbon dioxide (CO_2). In 2017, about 76% of emissions from the "Energy" sector were CO_2, methane (CH$_4$) - about 24% and a small amount of nitrous oxide (N$_2$O) - about 0.5%.

Fugitive Emissions of Natural Gas 23%

1.A – Fuel Combustion Activity 77%

Road transport 25%

Energy production 18%
Household 18%

Commercial/Institutional 8%

Industry and Construction 7%

Off-road transport and other vehicles 1%

Off-road transport 0.4%

The largest share of emissions was road transport (about 25%), followed by natural gas fugitive emissions (23%); emissions from electricity generation and the housing sector were equal, at 18.3% each.

UNCERTAINTY ASSESSMENT

Activity data uncertainty is assessed:

- For natural gas
  - ➢ 3% in the category of electricity and thermal energy production
  - ➢ 5% in other categories
- For diesel fuel, gasoline and LPG - 20%
- For coal - 40%.

Emission factors uncertainty is assessed:

- For natural gas
  - ➢ 3% in all fuel combustion categories
  - ➢ 5% in the category of natural gas fugitive emissions
- For diesel fuel, gasoline and LPG - 5%
- For coal - 10%:
- For natural gas fugitive emissions category

NEXT STEPS

- Given that the "Transport" category is the main source of emissions, in order to improve the accuracy and completeness of emissions, it is necessary to consider the emissions of this category by subgroups of vehicles.

- Continue the close collaboration between the GHG Inventory Expert Group and the Energy Balance Development Experts to ensure cross-checking and comparability of data.

- Improve performance data on liquid fuel and firewood consumption, helping to reduce uncertainty.

- In order to improve the integrity and accuracy of GHG inventory, it is necessary to take into account the consumption of natural gas in the "Agriculture" category.

THANK YOU

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