



**ENERGY BALANCE  
OF THE REPUBLIC OF ARMENIA  
FOR 2021**



Scientific Research Institute of Energy  
2022

# **“Energy Balance of the Republic of Armenia, 2021”**

**Developed by the “ RA Scientific Research Institute of Energy” CJSC under the UNDP -  
GCF/00098348-00101711 “ De-risking and scaling-up investment in Energy Efficient  
Building Retrofits” project**

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## ABBREVIATIONS

CNG FS	Compressed natural gas fueling station
NPP	Nuclear Power Plant
CN FEA	Commodity Nomenclature of Foreign Economic Activity
HVEN	High Voltage Electric Networks
GEF	Global Environmental Fund
UGSF	Underground gas storage facility
EU	European Union
EB	Energy Balance
HPP	Hydro Power Plant
AEB	Armenia Energy Balance
ENA	Electric Network of Armenia
PSRC	Public Services Regulatory Commission
RA	Republic of Armenia
WPP	Wind Power Plant
R2E2	Armenia Renewable Resources And Energy Efficiency Fund
UNDP	United Nations Development Program
M&A	Monitoring and assessment
IEA	International Energy Agency
TPP	Thermal Power Plant
RF	Russian Federation
EDRC	Economic Development and Research Centre
MTAD	Ministry of Territorial Administration and Infrastructure
OECD	Organization for Economic Cooperation and Development
ILCS	Integrated Living Conditions Survey
CJSC	Closed Joint Stock Company
PV	Photovoltaic

## Measurement units

mln.	million
km	kilometer
t	ton
toe	ton oil equivalent
ktoe	kiloton oil equivalent (1000 toe)
m <sup>3</sup>	cubic meter
mln. m <sup>3</sup>	million. cubic meter
W	Watt
kW	kilowatt (10 <sup>3</sup> W)
MW	megawatt (10 <sup>6</sup> W)
Wh	Watt*hour
kWh	kilowatt*hour (10 <sup>3</sup> Wh)
MWh	megawatt*hour (10 <sup>6</sup> Wh)
GWh	gigawatt*hour (10 <sup>9</sup> Wh)
J	Joule
MJ	megajoule (10 <sup>6</sup> J)
TJ	terajoule (10 <sup>12</sup> J)

## 1. INTRODUCTION

The given report was developed in the framework of United Nations Development Program (Armenia) UNDP -GCF/00098348-00101711 “De-risking and scaling-up investment in Energy Efficient Building Retrofits” project coordinated by RA Ministry of Environment.

Development of the RA Energy Balance is important for the assessment of the energy security level of the country, the diversification of power supply and the trends in greenhouse gas emissions, as well as for evaluation of the progress in achieving the targets of the United Nations Framework Convention on Climate Change (UNFCCC).

Energy balance is a valuable instrument for the assessment, documentation and monitoring of the energy efficiency and renewable energy indicators in the country for the given year.

Energy balance is one of the main sources for the collection of the initial data on GHG emissions in the Energy sector. It serves as a ground for the development and implementation of mitigation measures addressing the environmental challenge of climate change. Implementation of the mitigation measures is of a great importance under the Paris agreement and commitments undertaken by the Republic of Armenia.

The Energy Balance of Armenia for 2021 was compiled by the support of the UNDP - GCF/00098348-00101711 “De-risking and scaling-up investment in Energy Efficient Building Retrofits” project following the request of the RA Ministry of Territorial Administration and Infrastructures. The Energy Balance was developed in cooperation with the UNDP project expert team.

For the compilation of the Energy Balance following actions were undertaken:

- Collection of the official data from the Statistical Committee of RA (Armstat);
- Business meetings and discussions have been organized to improve data collection, in particular: (a) for the assessment of the consumption volumes of liquid fuels by sectors; (b) for evaluation of bio fuels consumption (particularly, firewood and manure);(c) to assess the production and consumption of solar PV and water heating energy;
- Methodology for the compilation of 2020 Energy Balance was analyzed;
- Collected data were analyzed, the balance indicators were calculated and the initial data were archived;
- 2021 Armenia Energy Balance was compiled and presented in Eurostat and International Energy Agency’s formats.

Compilation and publication of Armenia Energy Balance is defined by the RA Law on “Energy Efficiency and Renewable Energy”.

The guideline<sup>1</sup> published by the IEA, Eurostat and Organization for Economic Cooperation And Development (OECD) as well as the “Explanatory Note on Energy Balance of Armenia” developed by the Economic Development Research Centre (EDRC) serves as methodological base for the compilation of the 2021 Armenia Energy Balance. The main sources of the initial data and the major applied approaches for the compilation of the energy balance are reflected within the mentioned Explanatory Note.

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<sup>1</sup> “Energy Statistics Manual”, OECD/IEA, 2007  
([https://ec.europa.eu/eurostat/ramon/statmanuals/files/Energy\\_statistics\\_manual\\_2004\\_EN.pdf](https://ec.europa.eu/eurostat/ramon/statmanuals/files/Energy_statistics_manual_2004_EN.pdf))

During the compilation of the 2017 Energy Balances the Excel program has been developed by the EDRC which was revised by “Scientific Research Institute of Energy” CJSC. Slight upgrades were also made in 2021 Energy Balance, in particular, the values of imported oil products were clarified with Armstat on the basis of 10-digit classifier, as well as the values and structure of energy consumption in industrial branches.

## 2. SIGNIFICANCE OF THE ENERGY BALANCE

Energy balance is represented in the form of a standard spreadsheet format, which reflects amounts of the energy resources extracted, produced, imported, exported, stored, processed, converted, transported, distributed and used in various sectors in Armenia during the reporting period. The Energy balance of the country is presented in the Eurostat or IEA standard formats, which comply with the regulation No 1099/2008 of the European Parliament and of the Council of 22 October 2008 on energy statistics.

During the compilation of the energy balance, it is necessary to take into account the flows of energy carriers and all types of the energy by their generation, recycling, transformation, distribution, storage and final consumption cycles, as well as energy costs and possible losses for own needs.

According to the Eurostat requirements energy balances are composed using natural (TJ) units, and as for the IEA standards - the oil equivalent (1 ktoe equals to 41.868 TJ).

Collection and processing of the statistical data and compilation of the energy balance are the first steps for the analysis of the energy situation in the country allowing the assessment of the previous trends and formation of the future policy addressed to the development of the energy sector. Data in the energy balance enable the assessment of the energy efficiency level in the different sectors of the economy and households. It should be noted that emissions indicators are closely related to those of energy efficiency.

The role of clear and comprehensive information is constantly increasing and allowing to not only be limited to the qualitative conclusions, but also to reveal quantitative assessments for energy policy.

According to the IEA, in order to develop an energy policy it is necessary to have clear information about the final consumption, in particular:

- Information on the driving forces of the energy consumption,
- Information on the current energy consumption situation,
- Information about the responses on the implementation of the policy options.

All this makes an information environment, which is regularly updated and provides with a basis for the policy review and correction.

Amounts of the electricity produced by renewable sources (wind, solar, etc.) in different countries of the world still grow. The increase of their share in the energy balance ensures a reasonable level of energy independence of the country and the reduction of greenhouse gas emissions.

Development of the energy balance is necessary for:

- Assessment of the country's energy independence, including the power produced at the renewable energy sources in the energy balance;
- Study of the fuel and energy production and consumption structure;
- Study of the fuel and energy resources demand;
- Analysis of the fuel and energy balance structure for its improvement;
- Definition of the capital investments volumes for the development of the fuel and energy complex in the country;
- Identification of the export and import volumes of fuel and energy resources;
- Assessment of the energy efficiency potential;
- Identification of the greenhouse gases & other emissions volumes and the development of the measures to minimize their negative impacts on the environment, etc.

During compiling the energy balance for 2021, the recommendations presented by IEA experts were taken into account in order to exclude items that are absent in Armenia from the rows and columns of the standard balance sheet. This applies, for example.

- in terms of transfer technologies: Electric boilers, Chemical heat for electricity production, Oil refineries, etc.,
- in terms of energy resources – Crude oil, etc.

### 3. BALANCE COMPILATION AND APPLIED APPROACHES

This chapter presents the initial data of the main energy carriers included in the energy balance and the basic approaches applied for compilation of the balance.

#### 3.1. Electricity Balance

##### General information and overview

Electric energy is one of the most developed areas in the economy of Armenia. There are both the traditional sources for electricity production that are NPP, TPP and HPPs, and the alternative sources. Recent governmental decisions contributed to the development of several alternative energy projects which includes installation of licensed and autonomous solar PV systems, solar water heaters, as well as wind power monitoring and geothermal energy exploration, etc.

Armenia exports electricity to Iran, Artsakh and to Georgia as well as imports electricity from the mentioned countries. Electricity export to Iran is realized on electricity-for-gas swapping agreement and was 85.7% amounting to 852.6 mln of the overall exported electricity in 2021. The import from Iran amounted to 64.9 mln. kWh in 2021, which is mainly conditioned by the power system regimes. Electricity export to Georgia is mainly organized in the emergency switched off the 500 kW Caucasian power transmission line feeding the Georgia's power system from Russia and in 2021 it was practically absent. In high flood seasons the power supply to the Northern parts of Armenia is performed from Georgia in the island mode and amounted to 287.0 mln. kWh in 2021. In 2021, electricity export to Artsakh was 142.6 mln. kWh and the import amounted to 16.5 mln. kWh.

Armenian NPP produced 1998.4 mln. kWh electricity in 2021 which is around 25.8% of the total production. These indicators reduced against those of 2020 due to the maintenance activities undertaken for extension of the ANPP operation life time.

There are four large thermal power plants in Armenia. “Yerevan TPP” CJSC, which although is combined cycle production unit, operated in condensation mode during 2021 and produced 1652.7 mln. kWh of electricity. The “Hrazdan TPP” OJSC condensing power unit, owned by “Gazprom Armenia” CJSC, produced 1576.9 mln. kWh of electricity. “Hrazdan-5” condensing power unit owned by “Gazprom Armenia” CJSC was not operated in 2021.

A new 254 MW combined cycle production unit has been operated by “ArmPower” CJSC since 29 November, 2021 with 148.1 mln. kWh electricity production. Shares of the mentioned plants in the total electricity production accordingly amount to 21.3% -Yerevan TPP, 20.4% - Hrazdan TPP and “ArmPower” CJSC -1.9%. So, the shares of “Yerevan TPP” CJSC and “Hrazdan TPP” OJSC respectively increased against those of 2020.

Some amount of electricity was also produced at small-scale combined cycle power plants. Total electrical energy production of “Yerevan State Medical University after Mkhitar Heratsi” and “ArmRuscogeneration” CJSC cogeneration plants in 2021 amounted to 6.0 mln. kWh or 0.08% of the overall production.

Hydro energy of Armenia are presented by two major HPP cascades owned by “International Energy Corporation” CJSC and “Contour Global Hydro Cascade” CJSC, as well as by a number of small HPPs. The HPPs of “International Energy Corporation” CJSC produced 456.5 mln. kWh and “Contour Global Hydro Cascade” CJSC – 940.7 mln. kWh electricity in 2021, which accordingly amount to 5.9% and 12.1% of the total electricity production. Thus, the production of large hydroelectric power plants in 2021 increased in comparison with 2020, including 1.5 times at the hydroelectric power station of “Contour Global Hydro Cascade” CJSC. According to the RA PSRC information, number of the small HPPs in 2021 was 187, with total installed capacity of 384.6 MW, and the actual electricity production of 804.6 mln. kWh. The share of small HPPs in the total net electricity supply was 10.6.% which is 0.4 percent points less than in 2020.

Introduction of solar PV sites has significantly developed in 2021. According to PSRC official website, the total installed capacity of licensed solar PV plants reached 51 MW in 2021 and electricity production amounted to 89.6 mln. kWh. There is a significant increase in the amount of electricity produced in the PV installations of autonomous producers. Following to the expert estimation the total installed capacity of the autonomous solar PV producers reached 136.1 MW (<https://www.facebook.com/armenianenergyagency/photos/3442638579393264>), with 204.1 mln. kWh electricity annual production, according to estimates based on the number of sunny days indicated in the Solar Map of Armenia<sup>2</sup>. Compared to 2020, the volume of electricity produced by autonomous solar PV installations increased by about 1.8 times.

Electricity is transmitted and distributed by HVEN and ENA CJSCs wherein inevitable technical losses occur. Losses in 2021 amounted to 552.0 mln. kWh which are very close to 2020 indicators.

## **Data Sources**

Data on the production and the own needs of each of the plants, as well as on the losses in the transmission and distribution processes have been collected from the Armstat official website. The installed capacity of autonomous solar PV installations was estimated based on information on the number of installations imported to Armenia, published by the customs service, as well as

information on locally produced installations. The volumes of electricity produced in autonomous solar PV installations were estimated taking into account the data on sunny days indicated on the Solar Map of Armenia. Data on the installed capacity and production of the licensed PV installations were collected from the official website of the RA PSRC. Data on solar water heating systems are published by the RA customs service in type-quantity format for the given data compilation. The electricity consumption by the industrial branches has been provided by Armstat. Information on the electricity consumption in other sectors has been collected from the official website of the RA PSRC.

## 3.2. Natural Gas Balance

### General Information and Overview

The supply and sale of the natural gas in the RA domestic market is realized by the “Gazprom Armenia” CJSC. The total length of the main gas pipelines and pipes’ branches operated in the gas transportation system amounts to 1683 km. Transportation of the gas carried out through the 1583.9 km length gas pipeline (<https://armenia-am.gazprom.com/about/today/>). Unused pipelines are in operational reserve mode.

The underground gas storage facility (UGSF) owned by Gazprom Armenia, located in Abovyan, is also used to store gas reserves. UGSF has strategic importance since it ensures the reliability of the gas supply in the country while being used to cover the seasonal and peak demand of the gas. In 2021, 36.8 mil.m<sup>3</sup> of gas was taken from the gas pipelines and UGSF (15.1% more than in 2020), meanwhile, 28.6 mil.m<sup>3</sup> was pumped into the UGSF (27.6% less than in 2020).

The gas distribution network includes 19350 km of high, medium and low pressure gas pipelines, as well as engineering structures located on them. In gas distribution system were operating 2642 gas regulating points, 8568 individual pressure regulators, 1433 head measuring nodes, as well as 327 electrochemical protection stations.

Diversification of the gas supply to the Republic of Armenia is ensured by the gas imported from the Russian Federation and the Islamic Republic of Iran. The agreement with Iran provides for the exchange of gas for electricity. Currently, a 400 kV double-circuit power transmission line is under construction to ensure the contractual volumes of gas imported from Iran.

In 2021, natural gas in amounts of 2449.2 mln. m<sup>3</sup> (10.9% more than in 2020) imported from the Russian Federation and 344.6 mln. m<sup>3</sup> (10.9% less than in 2020) imported from Iran. Overall import of natural for 2021 was 2793.8 mln. m<sup>3</sup>, which has 7.6% increase in comparison with the previous year.

Data on the imported gas are published in the annual report of the Armstat and posted on the PSRC’s official website.

Following to the estimations of “Gazprom Armenia” CJSC, around 80% of the vehicles park in Armenia operates in compressed natural gas. Currently, Armenia has leading positions among the countries in the world that apply natural gas as an engine fuel. It is economically advisable compared to the oil products consumption and leads to the significant reduction of hazardous substances and greenhouse gases emissions in the atmosphere. According to the official website of "Gazprom Armenia" CJSC, today there are about 358 CNG FSs operating in Armenia. Transport sector consumed 505.3 mln. m<sup>3</sup> of natural gas in 2021 which is 6.9% more than in

2020. Amounts of the natural gas consumption in the transport sector (505.3 mln. m<sup>3</sup>) was about 1.5 time less that in the household (766.3 mln. m<sup>3</sup>) and 2.1 times higher than in the industry for energy purposes (239.6 mln. m<sup>3</sup>).

The volume of natural gas consumption for heating greenhouses by technical method in agriculture has been clarified as 87.2 mln. m<sup>3</sup>. Natural gas consumption in service and other sectors was 259.1 mln. m<sup>3</sup>.

### **Data Sources**

Data provided by the RA PSRC, RA MTAI and Armstat served as the information source for the compilation of the natural gas balance. Information about the gas amounts imported and taken from the gas pipelines and UGSF as well as data on the gas volumes pumped into the UGSF, losses in transportation and distribution systems, transported gas amounts, own needs consumption, recovered gas volumes and consumption in the transportation sector were taken from the RA PSRC's official website. Information on the average monthly calorific value of the supplied gas is supplied by "Gazprom Armenia" CJSC by the request of RA Ministry of Territorial Administration and Infrastructure and posted on the PSRC official website. Data on the natural gas used in the industry sector for energy purposes and in separate power plants were provided by the Armstat.

### **3.3. Thermal energy balance**

#### **General information and overview**

Share of the thermal energy in the overall energy balance of Armenia is quite small (0.55%). Thermal energy is equally consumed for households and service sector.

In the beginning of 1990's, energy crisis occurred in Armenia caused by the irregular gas supply due to Armenia's low solvency and regular explosions of the gas pipeline. That was the reason for the collapse of the centralized heat supply systems. After the gas supply restoration, individual thermal equipment was widely used for hot water and heating preparation.

Currently, centralized heat supply in Armenia is implemented by small combined cycle power plants. "Yerevan State Medical University after Mkhitar Heratsi" foundation and "Lus Astkh" LLC produce heat energy for its own needs, and "ArmRuscogeneration" CJSC realizes heat supply to Hovhannisyanyan, Varuzhan, Isahakyan, Tumanyan, Kuchak and Narekatsi blocks of Avan administrative area in Yerevan. There is no data on the thermal energy produced in 2021 at the cogeneration station of the "Yerevan State Medical University after Mkhitar Heratsi" foundation while electricity supply to grid was 3.6 mln. kWh. In 2021, amounts of the thermal energy produced "ArmRuscogeneration" CJSC were 11.3 thousand GJ, which is 70% less than in 2020 and electricity supply to the grid – 1.9 mln. kWh. Thermal energy losses remain high in the distribution which was 9 thousand GJ in 2021 (79.6% of the produced energy). There was no heat supply from the main thermal power plants – "Hrazdan TPP" and "Yerevan TPP". Electricity at the "Hrazdan TPP" was produced by condensing-type units. The Combined cycle unit at "Yerevan CHPP" in 2021 operated in condensing mode.

There are some small capacity boiler houses in Armenia designed for the heating of one or several buildings.

Thermal energy sources also include solar water heaters and fruit drying equipment. There is no reliable information about the individual solar water heaters' areas and the volumes of their utilization in different sectors, particularly, in food industry and service sector. According to expert estimates based on type-quantity data of water heating systems from the tax service, solar thermal power was calculated for 2021 towards 2020 increased heat energy and added to the value of 2020 balance. In 2021, thermal power generated by solar units comprised 648.7 TJ, about 1.1 times more than 2020. The share of this energy is still insignificant and is accounted for in the chapter “Renewable energy balance”.

#### **Data sources**

Information about the thermal energy produced by the "ArmRuscogeneration" CJSC combined cycle power plants was provided by the Armstat, the basis for data on the solar water heaters was the information available at the Tax Service.

### **3.4. Oil product balance**

#### **General information and overview**

Data on the following oil products are presented in the oil product balance:

- Motor fuel types (engine gasoline, diesel fuel, petrol for jet engines, aviation kerosene)
- Liquid oil gases,
- Mazut and oil bitumen,
- Other oil products (other kerosene types, special types of gasoline, lubricants, paraffin and other oil products).

There is no oil extraction in the territory of Armenia and all the oil products are imported. Some types of the imported oil products are used in the limited amounts for the production of varnish, paints and the other products in Armenia. Imported bitumen and mazut are utilized for non-energy purposes either.

99.37% of motor gasoline was consumed in the transport sector.

In 2021, the main volume of the diesel fuel in amount of 83.4% was consumed in the transport sector. Industrial sector used around 8.5% of the diesel fuel. Diesel fuel consumed by the industrial sector is utilized to operate different types of the mechanisms (drilling rigs, cranes, telescopic towers and other mechanisms). The major consumers of the industrial sector was the mining industry and non-ferrous metallurgy.

Around 7.9% of the diesel fuel was utilized by the agriculture sector (tractors, combines and other mechanisms).

In Household sector was consumed 0.16% of diesel fuel.

Insignificant amounts of diesel fuel are also consumed by the diesel generators which are reserve sources for power production. Data on this sector consumption aren't available.

Minor volumes of diesel fuel were also used for non-energy purposes in the chemical industry and other sectors. The share of diesel consumed for non-energy needs was 0.67% compared with total consumption.

In 2021, the main volumes of liquid petroleum gases, that are 77.9 %, were used by the transport sector and are 6.5 percent points less than in 2020. The share of liquid petroleum gas consumption in the industry was only 0.41%, and in the service sector 21.26% and households 0.47%.

Other oil products are consumed for non-energy purpose and is 12.4% in total oil product consumption.

### **Data sources**

Information on the imports and exports of oil products is provided by the Armstat and could be revised. The Armstat supplied data on the volumes of the oil products consumption in the industrial sector and the information about sowing and total harvesting areas of the agricultural crops for 2021, as well as on fuel consumption in the agriculture sector are the expert assessment of the RA Ministry of Agriculture.

## **3.5. Coal Balance**

### **General information and overview**

The Armstat data on the imported coke, semi-coke, anthracite, peat and other coal types were used to compile the coal balance.

In 2021, the share of coal consumed for energy purposes was only 0.4% of total energy consumption. About 89.9 % of coal was used in the household sector.

There are lignite deposits in Jajur and Dilijan. They haven't got any industrial significance, and according to the expert estimations around 500 families collect the lignite manually. Therefore, consumption of the lignite in 2021 remained at the level fixed in 2020.

### **Data Sources**

The Armstat supplied data on the volumes of the coal consumption in the industrial sector. Information about the mining and consumption of the lignite was revealed using the expert assessments.

## **3.6. Balance of wood and other biofuels**

### **General information and overview**

Wood and other types of biofuel are considered renewable energy sources.

Types of the biofuels are:

- Industrial wastes,
- Solid household wastes,
- Solid biomass (including charcoal),
- Biogases.

Firewood and timber in Armenia are revealed in the following ways:

- Sanitary deforestation (solid biomass),
- Illegal deforestation (solid biomass),
- Fallen dry wood (solid biomass),

- Wastes from woodworking and furniture manufacturing (industrial wastes),
- Import.

Data on the timber products and firewood used for the energy purposes in the industrial sector are available and provided by RA Statistical Committee. It is more difficult to estimate the amounts of timber products and firewood consumed in the households, which also provided by the RA Statistical Committee based on the surveys.

Official data on the individual biogas facilities isn't available. In Armenia, these technologies mainly use manure. Manure is also utilized for the energy purposes as a furnace fuel, mainly for the heating purposes. Consumption of manure was evaluated by experts of industrial sector based on the data per cattle provided by the Armstat.

Limited amounts of crude and other solid residues are also imported to Armenia.

### **Data sources**

Data on the imports and exports of the wood and other biofuels have been provided by Armstat. The data on the consumption of firewood and manure in households were also provided by the Armstat based on the results of survey. Data on manure consumption are based on expert calculations considering annual outputs per farm animal provided by Armstat.

Armstat also provided information on firewood and wood consumption in industrial sector.

## **3.7. Renewable energy balance**

### **General information and overview**

This chapter observes hydro, wind, solar and geothermal energy.

Hydro energy is the most developed among the other renewable energy resources in Armenia.

Total installed capacity of seven HPPs owned by the “International Energy Corporation” CJSC amounts to 561.4 MW and the production in 2021 was 456.5 million kWh.

Total installed capacity of three HPPs owned by “Contour Global Hydro Cascade” CJSC amounts to 404.2 MW and the production in 2021 was 940.7 million kWh, and electricity production in 2021 was 70% more than in 2020.

In 2021, 187 small HPPs were operated in Armenia which total installed capacity amounted to 384.6 MW and the actual annual useful supply was 786 million kWh.

Two wind power plants (WPP) operated in Armenia in 2021. Total supply of the useful electricity from the WPPs was 1.4 million kWh in 2021.

Armenia has significant potential for solar energy production. Solar energy is represented by solar water heating and PV power plants. In 2021, amounts of the hot water and electricity produced by the solar technologies increased significantly compared to 2020 due to the policy realized by the RA Government. The method of balance calculation of electric energy for the calculation period between an autonomous producer and a distributor carrying out RE flows has been applied for the autonomous consumers in PV sector.

According to PSRC's official website, useful supply among the autonomous producers in the electricity exchange amounted to 73.9 million kWh in 2021, and delivery from licensed solar PV

plants was 88.7 million kWh. Since only a part of the electricity produced by the autonomous producers is delivered to the power system the 73.9 million kWh according to PSRC's official website doesn't allow to assess the primary production at the solar PV systems. According to the information received from the website of the Armenian Energy Agency, in 2021, the total installed capacity of autonomous PV systems was about 136.1 MW.

The total amount of electricity generated by autonomous solar installations is estimated at 204.1 million kWh. If we add to this the electricity supplied from solar power plants, we get 293.7 million kWh. This indicator is about 2.2 times higher than those in 2020.

The Government of Armenia is implementing a promoting policy for the development of solar water heating technologies. The data of the customs service on water heating technologies imported to Armenia in 2021 were analyzed. According to expert estimates, the implementation of various initiatives led to an increase in energy production by 1.1 times compared to 2020.

Share of the energy produced using solar technologies in the primary production of renewable energy carriers was 11.9% in 2021.

Geothermal energy in Armenia is represented by several pilot installations which haven't been included in the energy balance due to their insignificant production volumes.

### **Data sources**

Data on the WPP production amounts were taken from the RA PSRC's official website. Sources for the information on the solar technologies were the "ENA" CJSC, customs service and R2E2. The Solar Map of Armenia, as well as information on the installed capacity and the amount of electricity generated by licensed PV installations, published on the PSRC official website, served as a source of data on the sun hours duration.

## 4. CONCLUSION

During the task implementation:

- Energy balances of Armenia for 2010, 2011, 2012, 2014, 2015, 2016, 2017, 2018, 2019 and 2020 have been analyzed,
- Collection of the official data from Armstat, PSRC, MTAI and R2E2 have been accomplished,
- Energy Balance of Armenia for 2021 has been compiled in the formats of Eurostat and International Energy Agency,
- Draft Energy Balance of Armenia for 2021 has been discussed with the specialists from Armstat and MTAI.
- The analysis of changes in indicators included in the balance for 2015-2021 has been carried out.
- Based on compiled balance the Fact sheet was developed.

Suggestions for improving data collection.

1. In the section “Final energy consumption” of the Energy Balance, for a more precise presentation of information on the volumes of electricity and natural gas consumption by sector, it is proposed to use in the subscriber databases of "Electric Networks of Armenia" CJSC and "Gazprom Armenia" CJSC the classifier of types of economic activities approved by 2013 September 19, N 874-N the order of the RA Minister of Economy (see <https://armstat.am/am/?nid=370>).
2. To increase the accuracy of the calculation/estimation of solar thermal energy generation, it is recommended to get the data of solar water heaters from the RA Customs Service in "type-quantity" format.



<b>3</b>	<b>Transformation output</b>	<b>463.0</b>						<b>0.3</b>	<b>462.8</b>
3.1	Nuclear power stations (MA El. Gen.)	171.8							171.8
3.2	Thermal power stations (MA El. Gen.) (condensing)	290.4							290.4
3.3	Combined heat and power stations (CHP) (cogeneration)	0.8						0.3	0.5
3.4	Non-specified transformation output								
<b>4</b>	<b>Exchanges and transfers, returns</b>					<b>-230.2</b>		<b>15.5</b>	<b>214.7</b>
4.1	Hydro power stations (MA El. Gen.) (large)					-120.1			120.1
4.2	Small hydro power stations (MA El. Gen.)					-69.2			69.2
4.3	Wind power stations (MA El. Gen.)					-0.1			0.1
4.4	Solar power stations (MA El. Gen.)					-40.7		15.5	25.3
<b>5</b>	<b>Consumption of the energy branch (for own use)</b>	<b>-36.1</b>				<b>-5.3</b>			<b>-30.7</b>
5.1	Nuclear power stations (MA El. Gen.)	-12.5							-12.5
5.2	Thermal power stations (El. Gen., CHP)	-14.9							-14.9
5.3	Hydro power stations (MA El. Gen.)	-3.2							-3.2
5.4	Wind power stations (MA El. Gen.)	0.0							0.0
5.5	Gas transportation	-5.3				-5.3			
5.6	Other stations	-0.1							-0.1
<b>6</b>	<b>Distribution and transmission losses</b>	<b>-138.7</b>				<b>-91.0</b>		<b>-0.2</b>	<b>-47.5</b>

<b>7</b>	<b>Available for final consumption</b>	<b>2,843.3</b>	<b>11.2</b>	<b>596.6</b>	<b>1,551.2</b>	<b>123.4</b>		<b>15.5</b>	<b>545.4</b>
<b>7.1</b>	<b>Final non-energy consumption</b>	<b>73.8</b>	<b>0.0</b>	<b>73.7</b>		<b>0.1</b>			
7.1.1	<i>Chemical Industry</i>	0.3		0.3					
7.1.2	<i>Other sectors</i>	73.5	0.0	73.4		0.1			
<b>7.2</b>	<b>Final energy consumption</b>	<b>2,769.5</b>	<b>11.2</b>	<b>522.9</b>	<b>1,551.2</b>	<b>123.3</b>		<b>15.5</b>	<b>545.4</b>
<b>7.2.1</b>	<b>Industry</b>	<b>370.6</b>	<b>0.0</b>	<b>17.5</b>	<b>200.1</b>	<b>0.0</b>			<b>153.0</b>
7.2.1.1	<i>Iron and steel</i>	25.5		0.0	15.8				9.6
7.2.1.2	<i>Chemical and petrochemical</i>	3.2		0.1	1.6	0.0			1.5
7.2.1.3	<i>Non-ferrous metals</i>	23.9		5.4	0.8	0.0			17.7
7.2.1.4	<i>Non-metallic minerals</i>	119.5		0.5	103.0				16.0
7.2.1.5	<i>Transport equipment</i>								
7.2.1.6	<i>Machinery</i>	2.8		0.0	0.9	0.0			1.9
7.2.1.7	<i>Mining and quarrying</i>	87.8		8.8	7.1	0.0			71.9
7.2.1.8	<i>Food, beverages and tobacco</i>	78.7	0.0	0.0	55.9	0.0			22.8
7.2.1.9	<i>Paper, pulp and printing</i>	6.4			4.4				2.0
7.2.1.10	<i>Wood and wood products</i>	0.1			0.0				0.0
7.2.1.11	<i>Textiles and leather</i>	2.9		0.0	1.0				1.9
7.2.1.12	<i>Construction</i>	13.7		2.7	8.1				2.9
7.2.1.13	<i>Non-specified (Industry)</i>	6.2		0.1	1.5				4.6

<b>7.2.2</b>	<b>Transport</b>	<b>899.8</b>		<b>469.7</b>	<b>422.0</b>				<b>8.1</b>
7.2.2.1	<i>Rail, metro, other electric transport</i>	6.0							6.0
7.2.2.2	<i>Road</i>	891.7		469.7	422.0				
7.2.2.3	<i>Aviation</i>	1.3							1.3
7.2.2.4	<i>Non-specified (Transport)</i>	0.8							0.8
<b>7.2.3</b>	<b>Households</b>	<b>961.6</b>	<b>10.0</b>	<b>2.2</b>	<b>639.9</b>	<b>121.0</b>		<b>7.8</b>	<b>180.7</b>
<b>7.2.4</b>	<b>Agriculture</b>	<b>103.4</b>		<b>15.8</b>	<b>72.9</b>				<b>14.8</b>
<b>7.2.5</b>	<b>Services</b>	<b>434.1</b>	<b>1.1</b>	<b>17.7</b>	<b>216.3</b>	<b>2.3</b>		<b>7.7</b>	<b>188.9</b>
7.3	Statistical differences	<b>0.0</b>							<b>0.0</b>

**Energy Balance of Armenia for 2021, IEA Format, aggregated, (ktoe)**

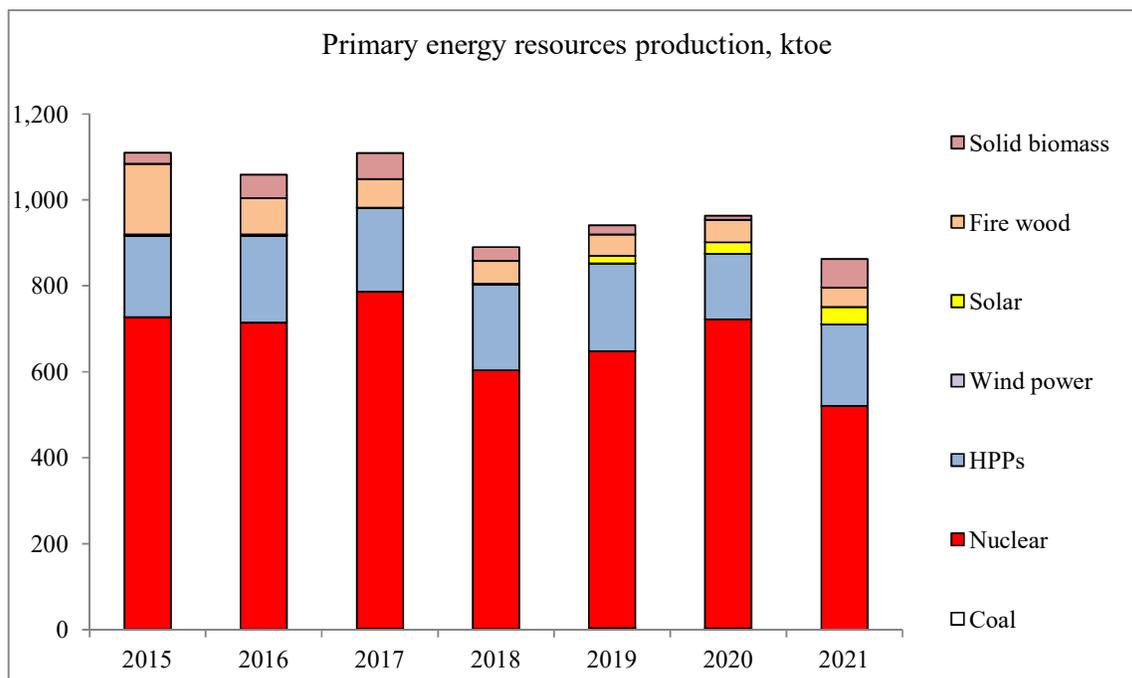
N	Energy Balance of Armenia, IEA, 2021.	Coal	Oil products	Natural Gas	Nuclear	Hydro	Geothermal	Solar, Wind, Others	Biofuels and waste	Electricity	Heat	Total
1	2	3	4	5	6	7	8	9	10	11	12	13
1.1	Production	0.0			520.7	189.3		40.9	111.4			862.4
1.2	Imports	11.2	671.6	2,333.1					12.4	31.7		3,059.9
1.3	Exports		-0.4						-0.5	-85.6		-86.4
1.4	International aviation bunker		-54.8									-54.8
1.5	Stock changes		-19.8	6.8								-12.9
<b>1</b>	<b>Total primary energy supply (TPES)</b>	<b>11.2</b>	<b>596.6</b>	<b>2,339.9</b>	<b>520.7</b>	<b>189.3</b>		<b>40.9</b>	<b>123.4</b>	<b>-53.9</b>		<b>3,768.1</b>
<b>2</b>	<b>Transfers</b>											
<b>3</b>	<b>Statistical differences</b>									<b>0.0</b>		<b>0.0</b>

<b>4</b>	<b>Transformation processes</b>			<b>-692.3</b>	<b>-520.7</b>	<b>-189.3</b>		<b>-40.9</b>		<b>677.5</b>	<b>15.8</b>	<b>-750.0</b>
4.1	Main activity electricity plants			-691.1	-520.7	-189.3		-7.8		659.4		-749.5
4.2	Autoproducer electricity plants							-17.6		17.6		
4.3	Main activity producer CHP plants			-1.2						0.5	0.3	-0.4
4.4	Autoproducer CHP plants											
4.5	Main activity producer heat plants											
4.6	Autoproducer heat plants							-15.5			15.5	
4.7	Non specified (transformation)											
<b>5</b>	<b>Energy industry own use</b>			<b>-5.3</b>						<b>-30.7</b>		<b>-36.1</b>
<b>6</b>	<b>Distribution losses</b>			<b>-91.0</b>						<b>-47.5</b>	<b>-0.2</b>	<b>-138.7</b>

<b>7</b>	<b>Total final consumption</b>	<b>11.2</b>	<b>596.6</b>	<b>1,551.2</b>					<b>123.4</b>	<b>545.4</b>	<b>15.5</b>	<b>2,843.3</b>
<b>7.1</b>	<b>Final energy consumption</b>	<b>11.2</b>	<b>522.9</b>	<b>1,551.2</b>					<b>123.3</b>	<b>545.4</b>	<b>15.5</b>	<b>2,769.5</b>
<b>7.1.1</b>	<b>Industry</b>	<b>0.0</b>	<b>17.5</b>	<b>200.1</b>					<b>0.0</b>	<b>153.0</b>		<b>370.6</b>
7.1.1.1	<i>Iron and steel</i>		0.0	15.8						9.6		25.5
7.1.1.2	<i>Chemical and petrochemical</i>		0.1	1.6					0.0	1.5		3.2
7.1.1.3	<i>Non-ferrous metals</i>		5.4	0.8					0.0	17.7		23.9
7.1.1.4	<i>Non-metallic minerals</i>		0.5	103.0						16.0		119.5
7.1.1.5	<i>Transport equipment</i>											
7.1.1.6	<i>Machinery</i>		0.0	0.9					0.0	1.9		2.8
7.1.1.7	<i>Mining and quarrying</i>		8.8	7.1					0.0	71.9		87.8
7.1.1.8	<i>Food, beverages and tobacco</i>	0.0	0.0	55.9					0.0	22.8		78.7
7.1.1.9	<i>Paper, pulp and printing</i>			4.4						2.0		6.4
7.1.1.10	<i>Wood and wood products</i>			0.0						0.0		0.1
7.1.1.11	<i>Textiles and leather</i>		0.0	1.0						1.9		2.9
7.1.1.12	<i>Construction</i>		2.7	8.1						2.9		13.7
7.1.1.13	<i>Non-specified (Industry)</i>		0.1	1.5						4.6		6.2

<b>7.1.2</b>	<b>Transport</b>		<b>469.7</b>	<b>422.0</b>					<b>8.1</b>		<b>899.8</b>
7.1.2.1	<i>Rail, metro, other electric transport</i>								6.0		6.0
7.1.2.2	<i>Road</i>		469.7	422.0							891.7
7.1.2.3	<i>Aviation</i>								1.3		1.3
7.1.2.4	<i>Non-specified (Transport)</i>								0.8		0.8
<b>7.1.3</b>	<b>Other sectors</b>	<b>11.2</b>	<b>35.7</b>	<b>929.1</b>				<b>123.3</b>	<b>384.3</b>	<b>15.5</b>	<b>1,499.1</b>
7.1.3.1	<i>Households</i>	10.0	2.2	639.9				121.0	180.7	7.8	961.6
7.1.3.2	<i>Agriculture</i>		15.8	72.9					14.8		103.4
7.1.3.3	<i>Services</i>	1.1	17.7	216.3				2.3	188.9	7.7	434.1
<b>7.2</b>	<b>Non-energy use</b>	<b>0.0</b>	<b>73.7</b>					<b>0.1</b>			<b>73.8</b>
7.2.1	<i>Chemical Industry</i>		0.3								0.3
7.2.2	<i>Other sectors</i>	0.0	73.4					0.1			73.5

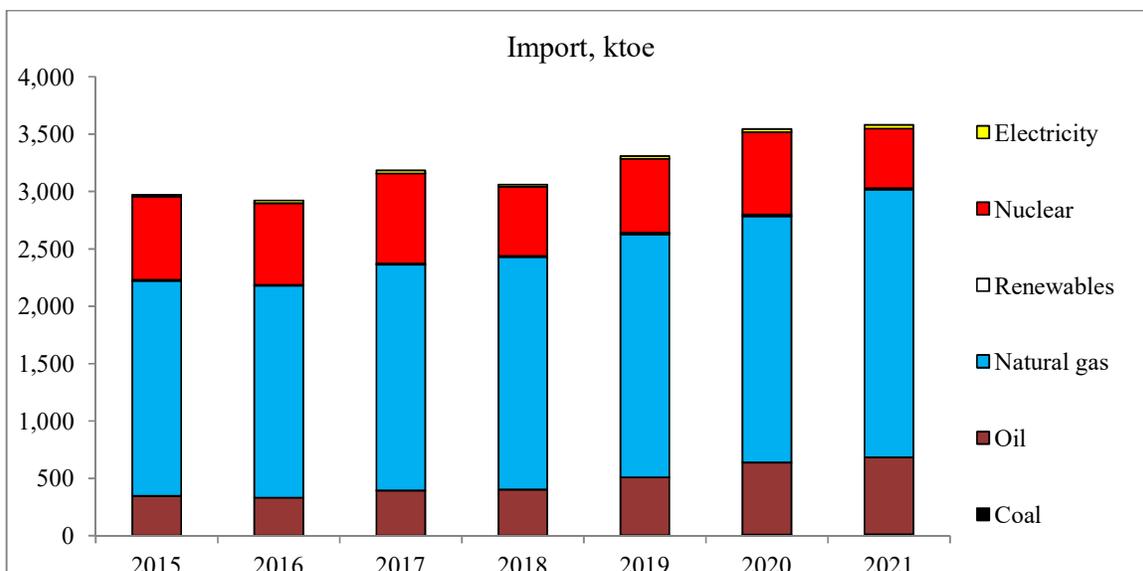
## Dynamics of changes in the energy balance indicators of the Republic of Armenia for 2015-2021



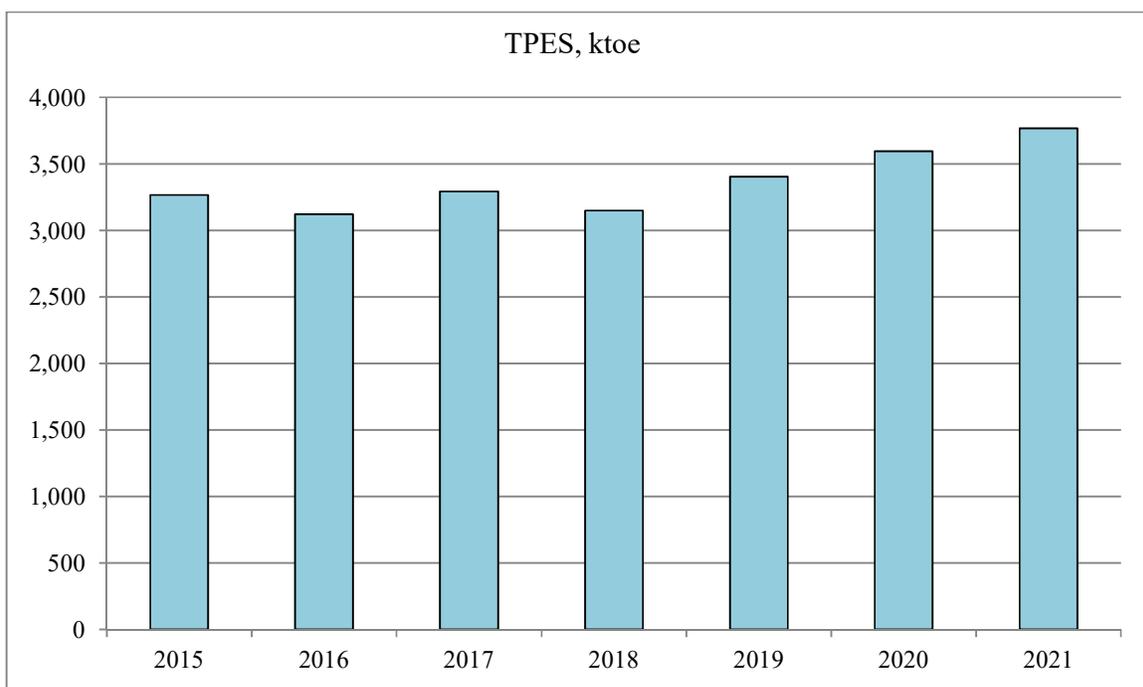
The main domestic sources of primary energy production are nuclear energy and hydro energy which share amounted to 60.4% and 22.0% correspondingly in 2021. The volumes of energy produced in HPPs have increased compared to previous years.

The data of renewable energy production in 2015-2016 are not reliable, as the volumes of energy production from firewood, other biomass (manure) and solar installations in those years were overestimated. Since 2017, the Armstat has been adjusting the amount of firewood and other biomass consumed in households. The analysis revealed that the volume of firewood consumption in households in 2018-2021 was almost the same - about 49.2 ktoe per year. The volume of manure consumption for energy purposes in the same period was about 67 ktoe per year.

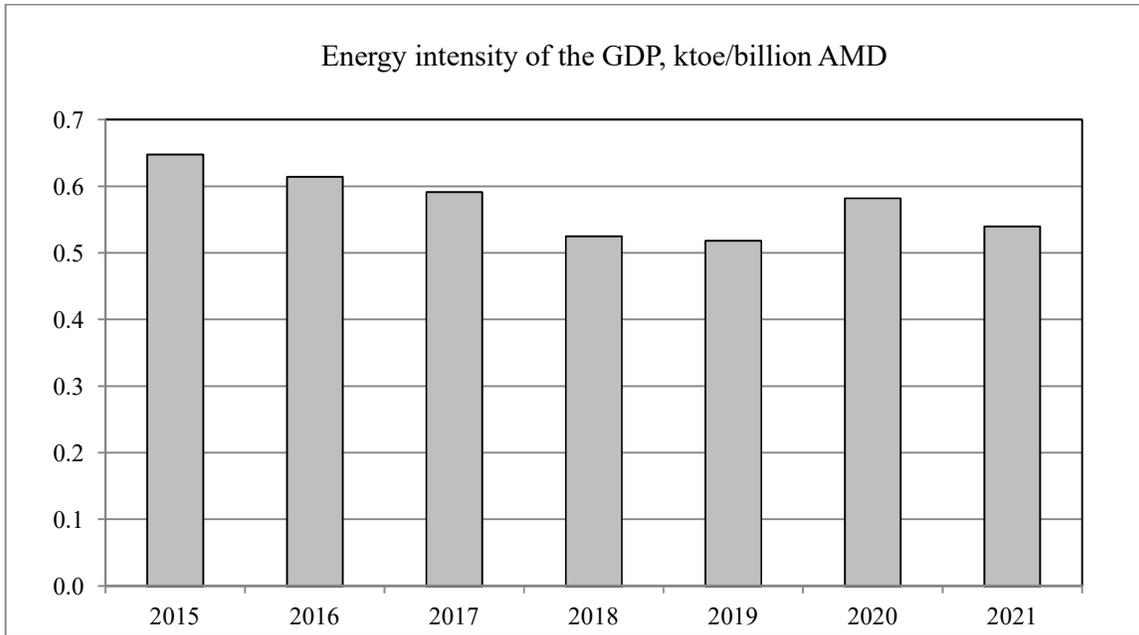
Growth of the solar energy production is significant in the result of encouraging of development of photovoltaic and solar water heating installations. For comparison, note that if in 2020 the share of energy production using solar technologies was 2.7%, then in 2021 it increased up to 4.7%.



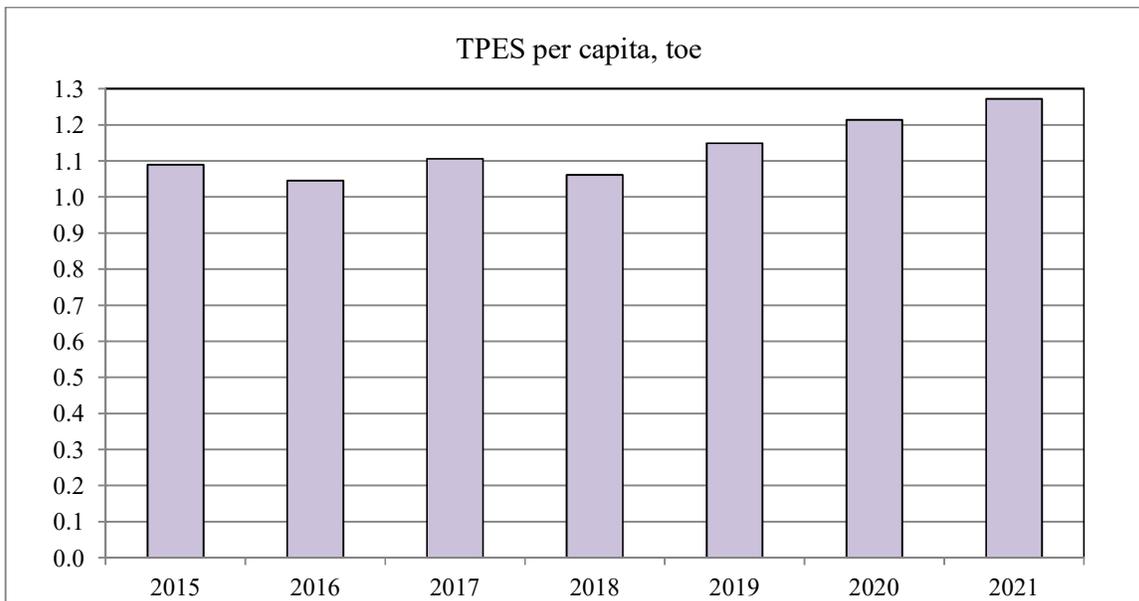
Armenia remains a country with great dependence on the imports of the energy resources. In 2021, imported energy resources in the total primary supply of energy were 81.2%. In 2021, energy imports increased by 8.3% compared to 2020. This is mainly due to an increase in imports of oil products and natural gas.



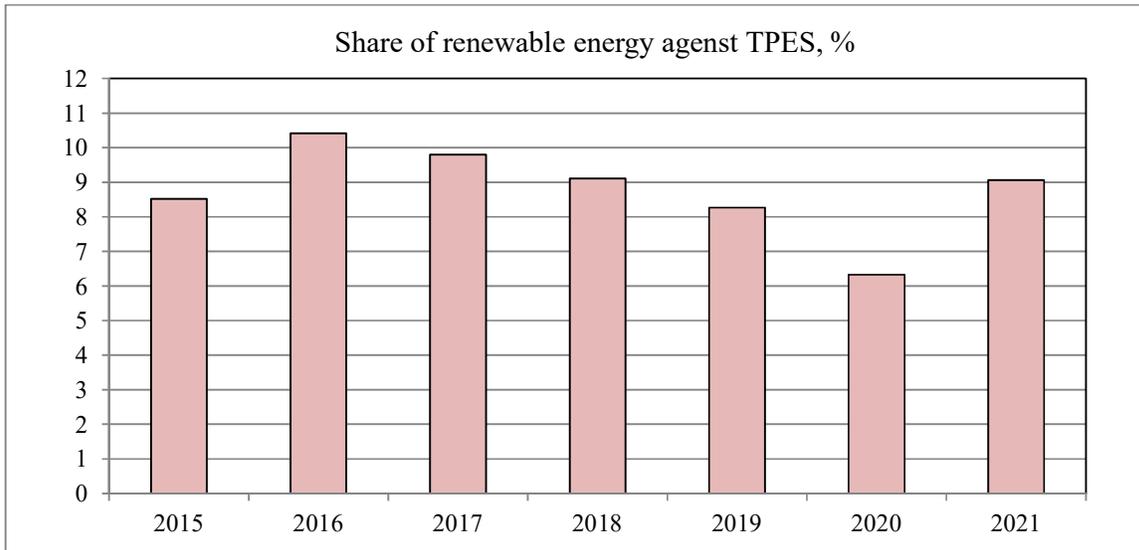
In 2021 the volume of the total primary energy supply increased by 4.8% compared to 2020.



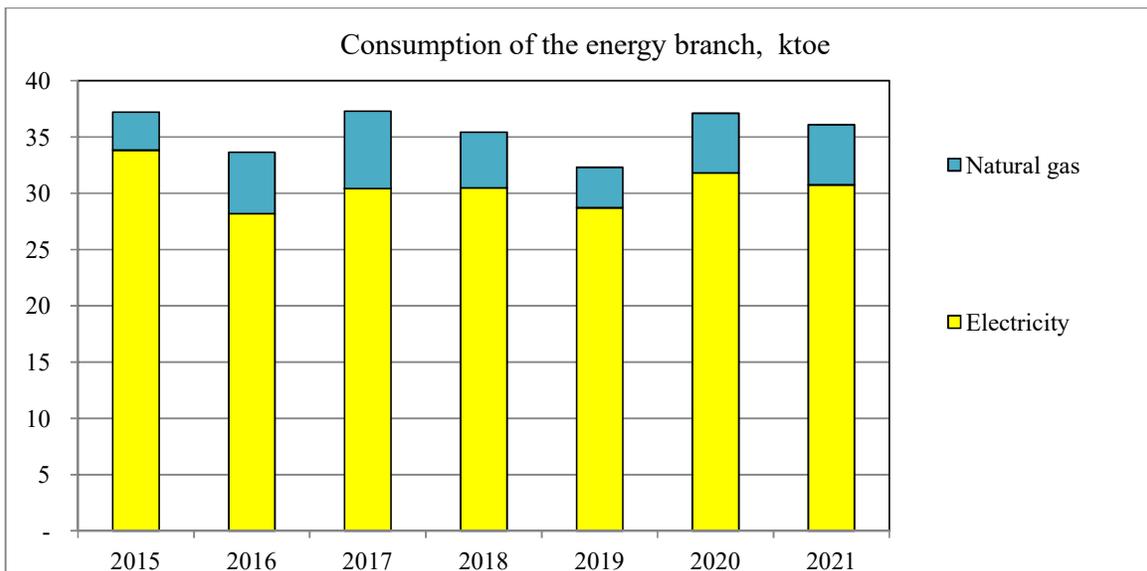
As can be seen from the depicted graphs the energy intensity of the gross domestic product continuously dropped during 2015-2019, except for 2020. In 2021 a decrease in energy intensity of 7.2% was registered compared to 2020. The reason for this decrease is the growth in gross domestic product (GDP) by 13.0% (according to the section "11.10. Production of gross domestic products" of the «Statistical Yearbook of Armenia, 2022», GDP in 2020 amounted to 6181.9 billion drams, and in 2021 - 6982.96 billion drams).



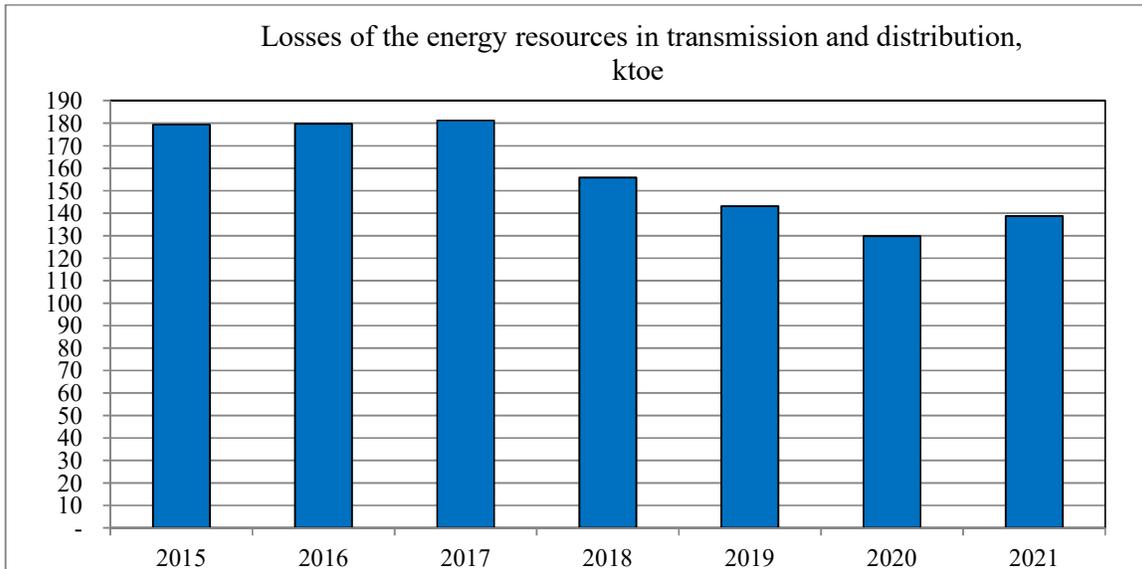
In 2021 primary energy supply per capita increased by 4.8% compared to 2020.



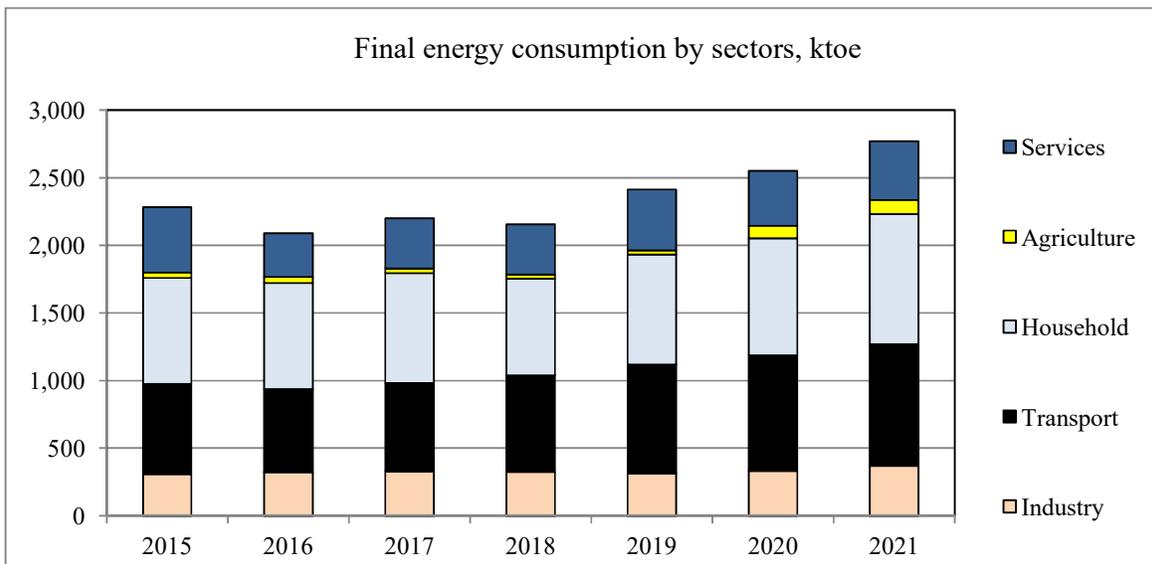
As it has already been mentioned 2015-2016 data are not reliable, as the volumes of energy production from firewood, other biomass (manure) and solar installations in those years were overestimated. In 2017-2019, as a result of adjusting the volume of these energy resources, there is a decrease in the share of renewable energy production in relation to the supply of primary energy. In 2021, there is an increase in the share of renewable energy production, which is due to the increase in the generation of HPPs and solar power plants.



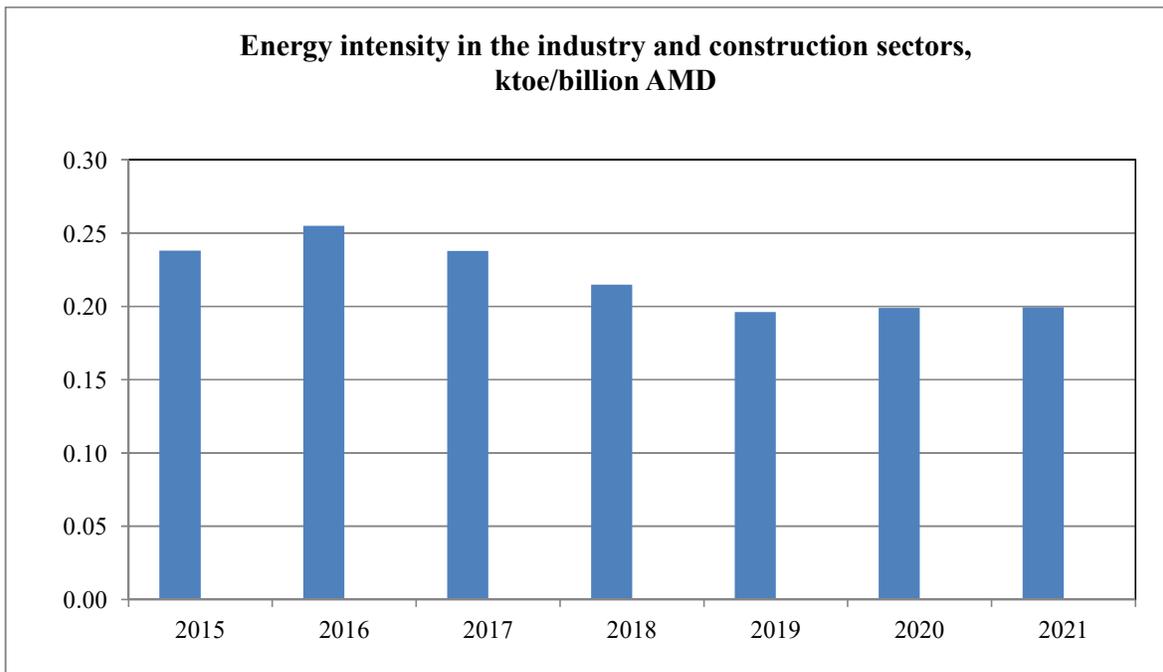
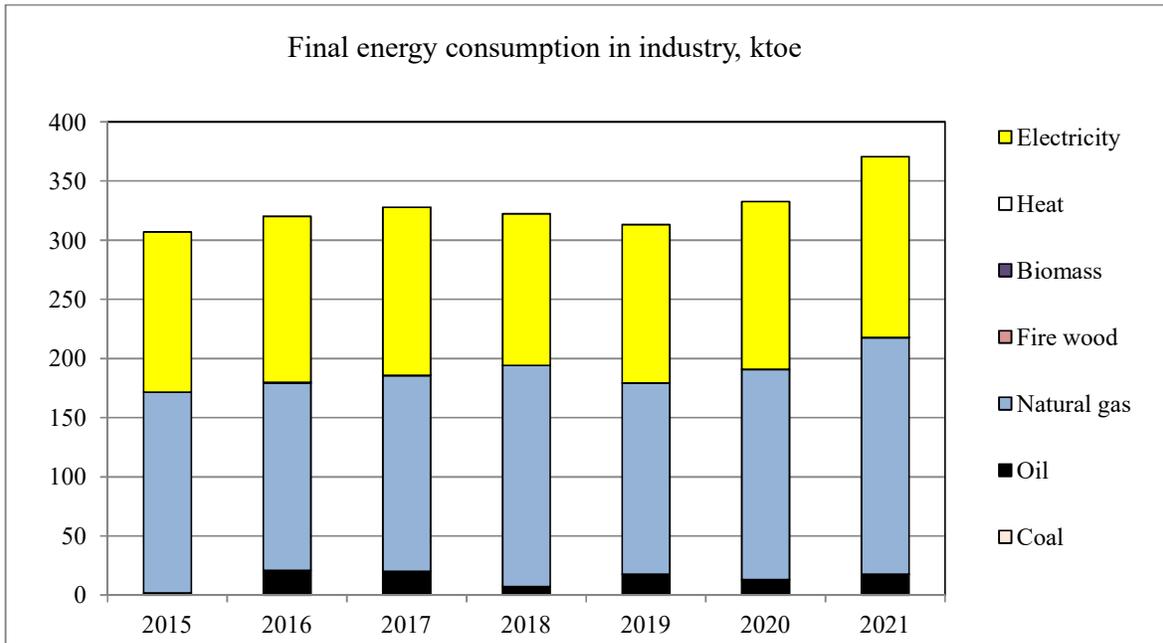
In 2021, there is a certain increase in energy consumption for own needs in comparison with 2020, though it increase by 0.8% in the case of natural gas and decreased by 3.3% in electricity. This decrease is due to the termination of the operation of the Hrazdan-5 station in 2021, as well as a decrease in the generation of the NPP.



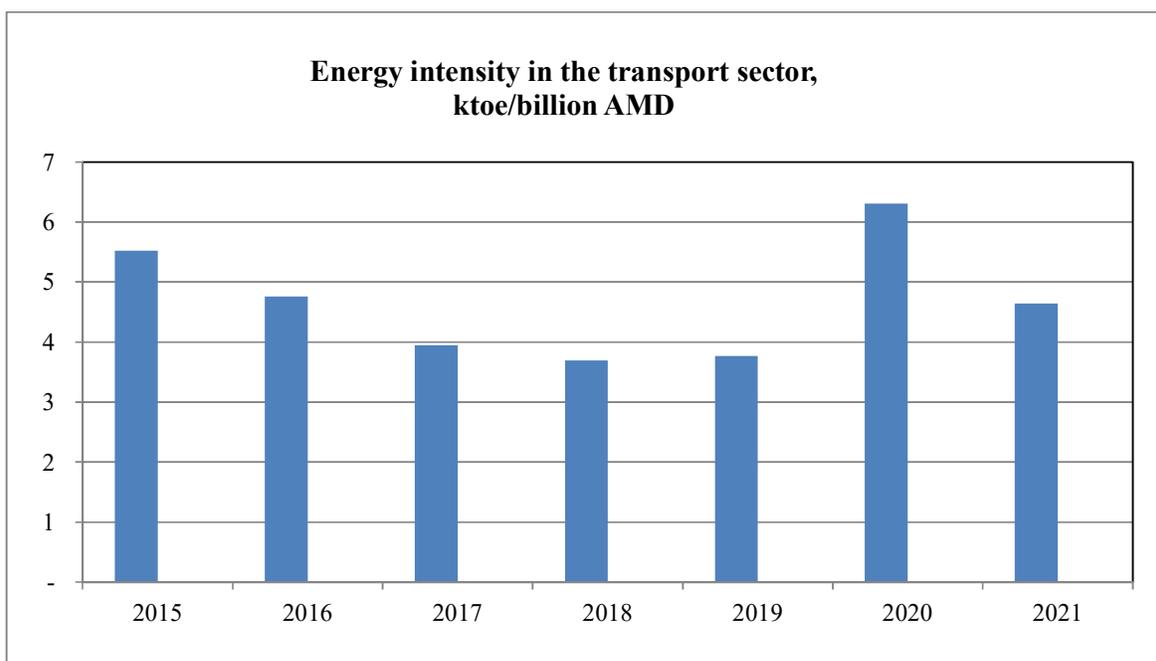
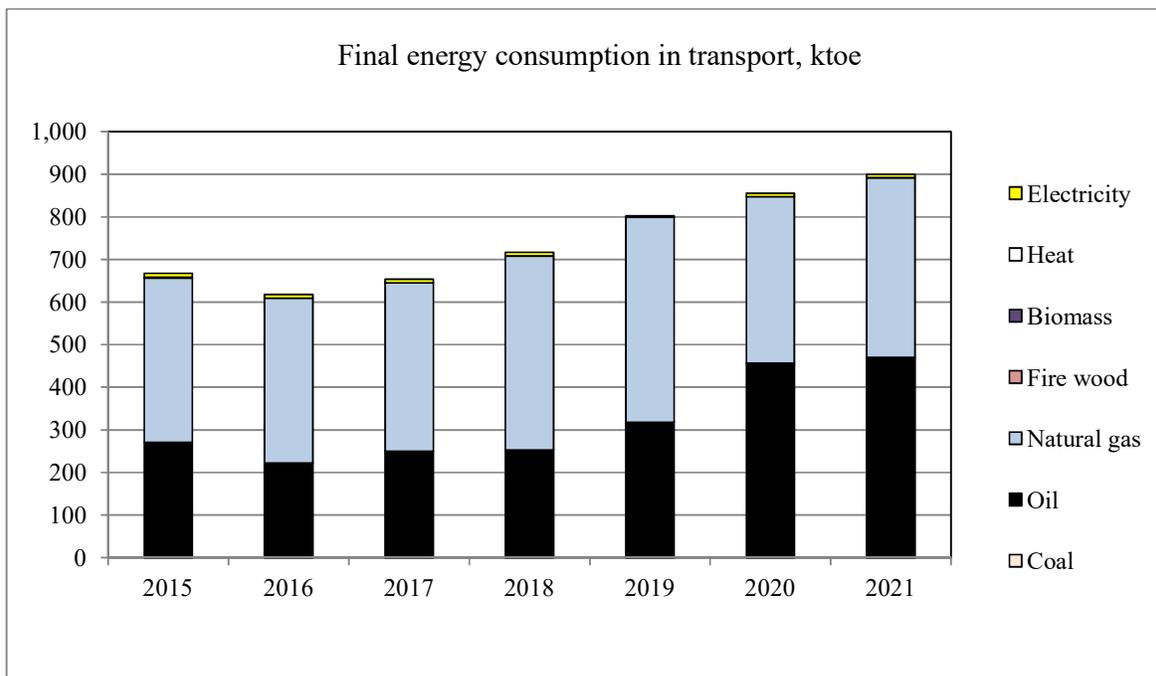
Loss of energy resources increased in 2021 by 6.9% compared to 2020, which is mainly conditioned by increased losses in the natural gas distribution and transmission system.



In 2021 the main sector of the energy consumption was the household which share was 34.7% against the total amounts of the final consumption for energy purposes. The transport share was 32.5%. The share of service sector was 15.7%, and industry – 13.4%.

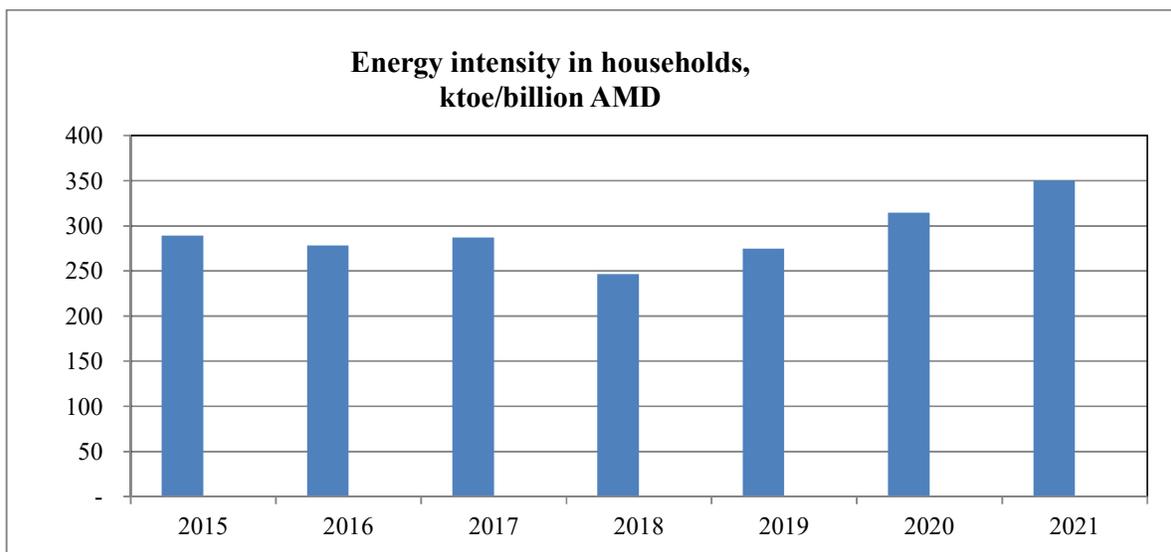
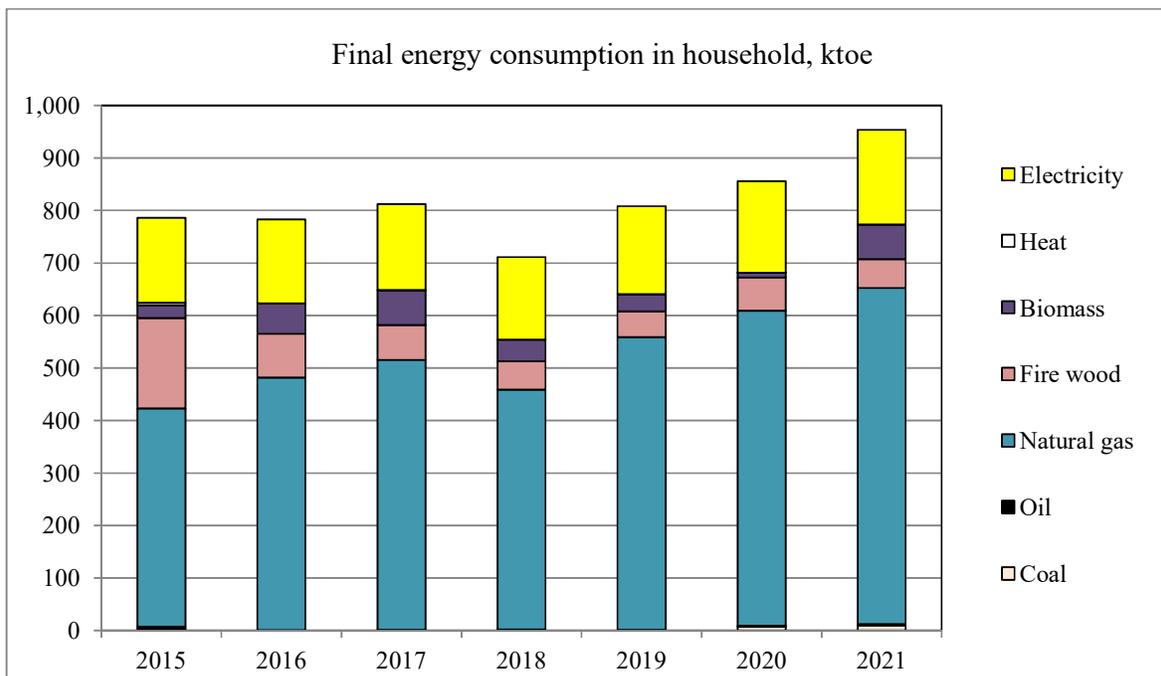


In 2021, a certain increase in energy consumption is observed - 11.5% the industry, including construction compared to 2020. This increase is due to the increase in the consumption of oil product, natural gas and electricity in the industry, including construction. Insignificant increase is also observed in the energy intensity of these sectors - by about 0.2% compared to 2020.



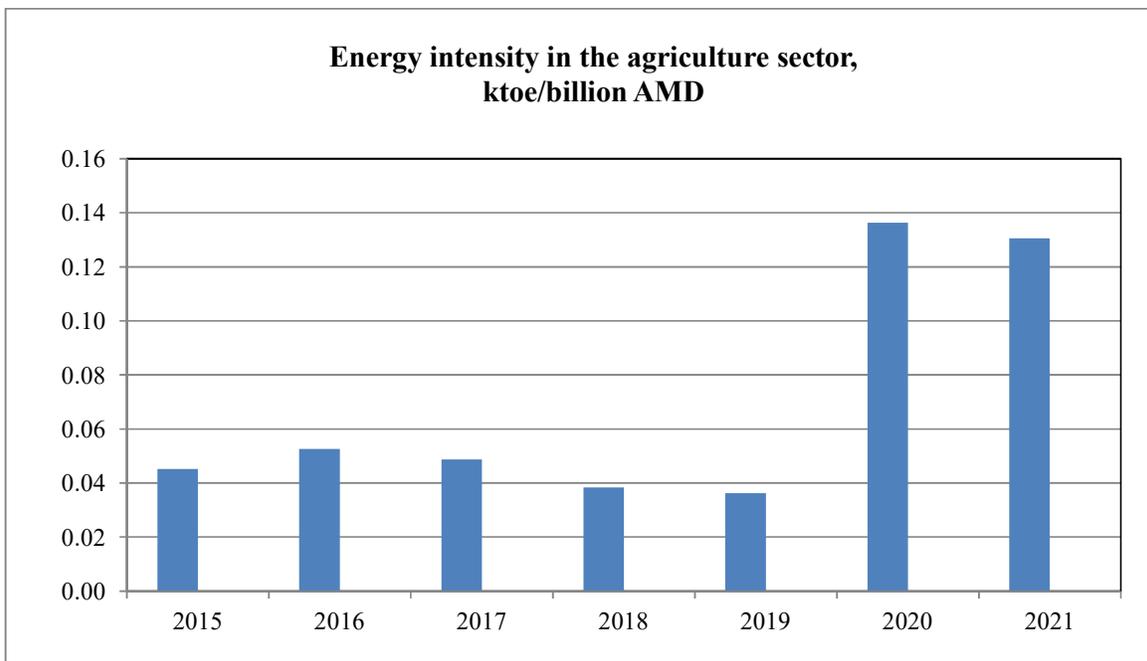
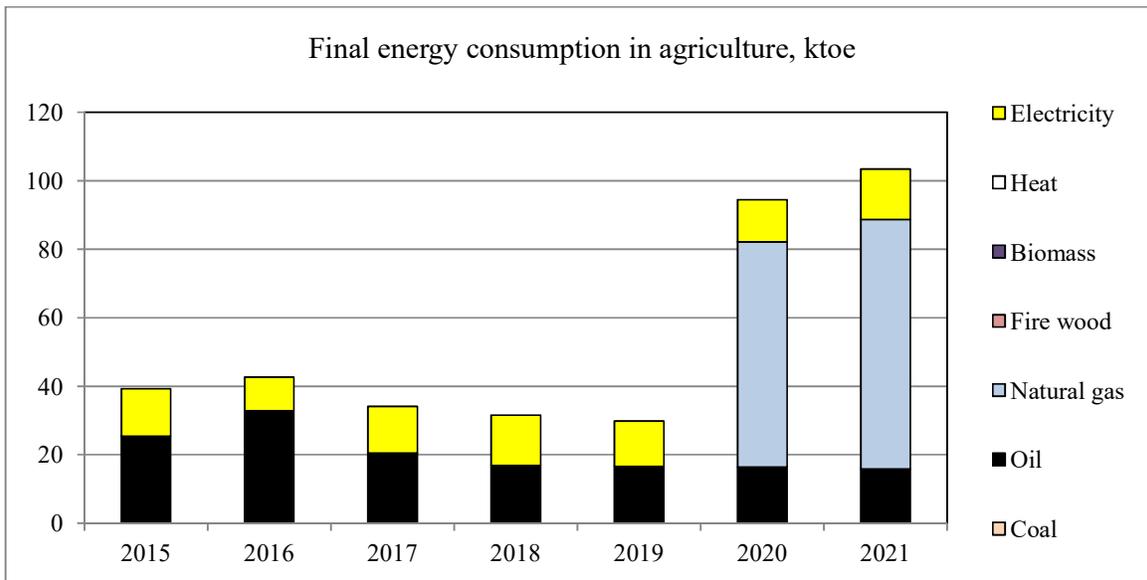
2021 continues to see a certain increase in energy consumption. in the transport sector (5.2% compared to 2020), This is mainly due to the increase in the use of natural gas as motor fuel and the consumption of oil product.

The energy intensity of the transport sector has decreased by about 1.4 times compared to 2020. This is mainly due to the increase in value added in the transport sector by 42.8% (according to the section "11.10. Production of gross domestic products" of the «Statistical Yearbook of Armenia, 2021», value added in the transport sector in 2020 amounted to 135.7 billion drams, and in 2021 – 193.8 billion drams).



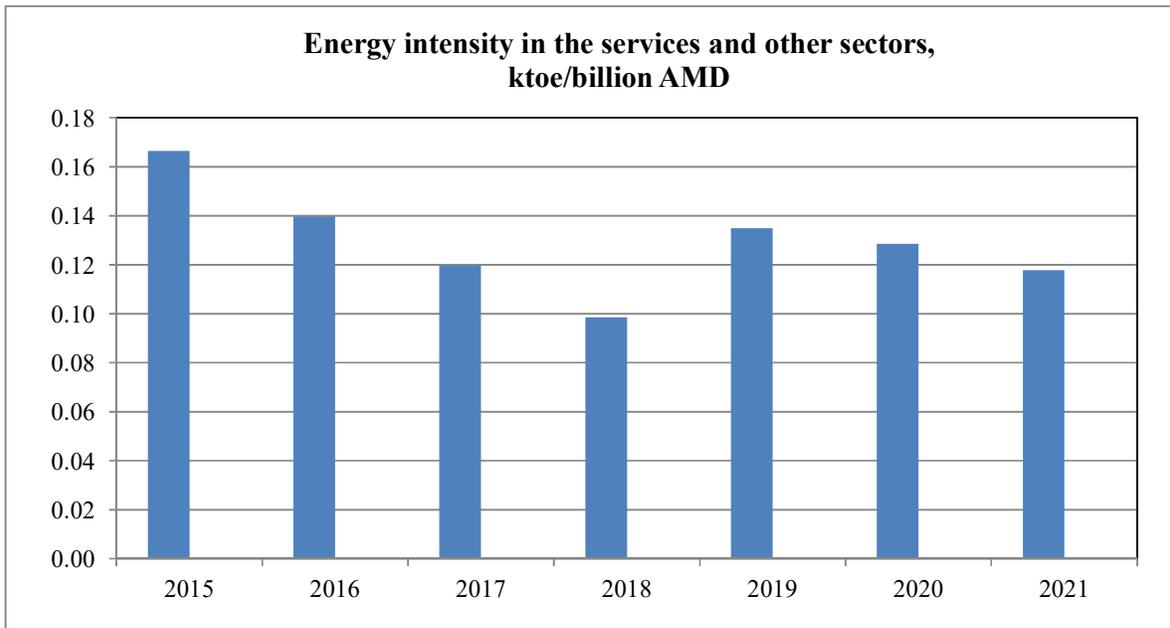
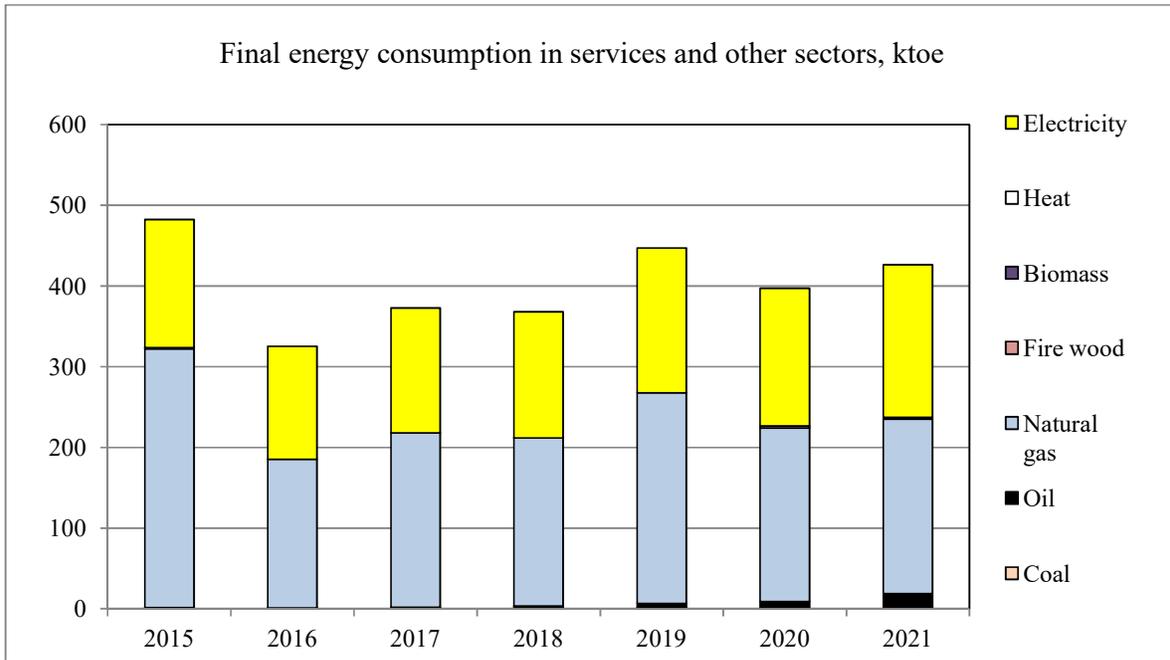
The consumption of the energy resources in the households increased by 11.4% in 2021 compared to 2020, This is mainly conditioned by the increase of biogas by 611.5 %, as well as by the increase in the consumption of natural gas by 6.7%, of coal by 41.0% and of electricity by 3.9%.

The energy intensity in the households was almost at the same level in 2015- 2017 (around 285 ktoe/billion drams). Since 2019 there is an increase in energy intensity, which in 2021 increased by 11.4% compared to 2020. This is mainly due to the increase of energy resources consumption and increase in value added in the household by 0.02%. (according to the section "11.10. Production of gross domestic products" of the «Statistical Yearbook of Armenia, 2022», value added in the household sector in 2020 amounted to 2.7436 billion drams, and in 2021 – 2.7441 billion drams).



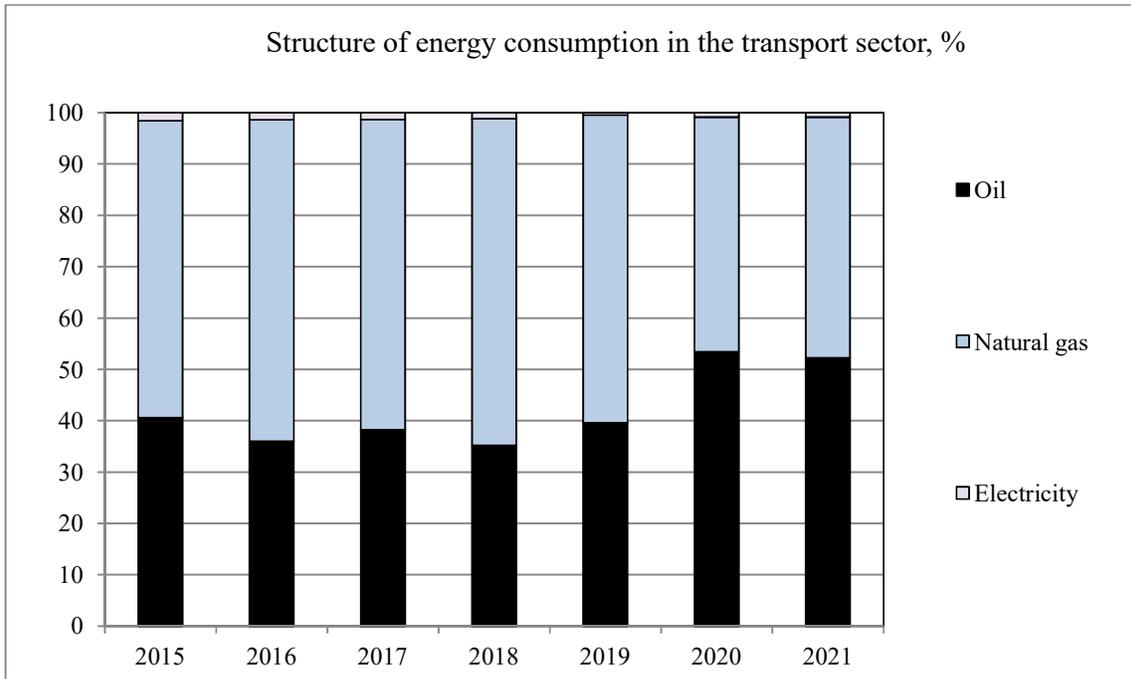
The energy consumption in the agriculture sector increased in 2021 by around 9.4% compared to 2020. This is mainly due to the increase of the natural gas consumption by 10.9%.

While the energy intensity in the agriculture sector decreased by 4.2% compared to 2020. This is mainly due to the low growth of consumption of energy resources compared to the increase in the value added of the sector by 14.2%. (according to the section "11.10. Production of gross domestic products" of the «Statistical Yearbook of Armenia, 2022», value added in the agriculture sector in 2020 amounted to 693.2 billion drams, and in 2021 – 791.7 billion drams).



The consumption of the energy resources in the service and other sectors in 2021 increased by about 7.3% compared to 2020. This is due to an increase in the consumption of oil product and electricity.

The energy intensity of these sectors was continuously dropping during 2015-2018 and increased only in 2019. The energy intensity of services and other sectors decreased by 8.3% in 2021 compared to 2020.



It can be seen from the graph that there is an insignificant increase in the natural gas and electricity consumption. In 2021, the share of consumed natural gas in the transport sector was 46.9% of the energy consumed, oil products - 52.2%, and electricity – 0.9%.

## Conclusions

1. During 2015-2017 there was growth in the total primary energy supply, and in 2018 there was some certain decrease (around 4.5% decrease in 2018 compared to 2017). Subsequently, there was an increase in the total primary energy supply in 2019 by 8.1% compared to 2018, and in 2020 by 5.6% compared to 2019, and in 2021 by 4.8% compared to 2020.
2. The energy intensity of the gross domestic product continuously dropped during 2015-2019, except for 2020. But in 2021, there is a decrease in energy intensity by 7.2% compared to 2020 due to an increase in gross domestic product (GDP) by 13.0%.
3. Total primary energy supply per capita increased around 4.8% in 2021 compared to 2020.
4. The main source for the domestic production of the primary energy resources remains nuclear energy which share amounted to 60.4% of domestic production in 2021 and hydro energy - amounted to 22.0%.
5. The volume of firewood consumption in the household during 2018-2021 was at the level of about 49.2 ktoe and the volume of biomass (manure) - about 67 ktoe.
6. The volume of energy production using solar technologies has significantly increased, the share of which in the volume of domestic production of primary energy resources in 2021 amounted to 4.7%.
7. Armenia remains a country with great dependence on the imports of the energy resources. In 2021 the share of imported energy resources in the total primary supply was 81.2%, while the share of domestic production – 22.9%.
8. A certain decrease of the energy consumption for own needs by 2.7% is observed in 2021 compared to 2020. At the same time the losses of the energy resources in 2021 increased by 6.9% compared to 2020.
9. The main sectors for the energy consumption were the households and transport the share of which in 2021 amounted to 34.7% and 32.5% against the total amounts of the final consumption for energy purposes. The share of service sector in 2021 was 15.7%, and industry sector – 13.4%.
10. Energy consumption in 2021 compared to 2020:
  - increase in industry by 11.5%,
  - increase in transport by 5.2%,
  - increase in households by 11.4%,
  - increase in agriculture by 9.4% (as a result of clarification of gas consumption in agriculture),
  - increase in service and other sectors by 7.3% (as a result of clarification of gas consumption).
11. Energy intensity in 2021 compared to 2020:
  - increase in industry by 0.2%,
  - decrease in transport by 26.3%,
  - increase in households by 11.4%,
  - decrease in agriculture by 4.2%,
  - decrease in service and other sectors by 8.3%.

The increase and decrease in the values of energy intensity is due to an increase and decrease in the gross domestic product and its components.

12. The structure of energy consumption in the transport sector in 2021 consisted of:
  - share of oil products – 52.2%,

- share of natural gas – 46.9%,
- share of electricity – 0.9%.