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SOLAR ENERGY SUB-SECTOR IN ARMENIA

ARGUMENT Consulting Bureau

Report
Solar Energy Sub-Sector in Armenia

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Abbreviations and explanations

AC	▸	Alternating current
AMD	▸	Armenian Dram
ANPP	▸	Armenian Nuclear Power Plant
BIPV	▸	Building-integrated photovoltaics
BMUV	▸	The Federal Ministry for the Environment, Nuclear Safety and Consumer Protection (Germany)
CCGT	▸	Combined-Cycle Gas Turbine
CEPA	▸	Comprehensive and Enhanced Partnership Agreement
CJSC	▸	Closed Joint Stock Company
EAEU	▸	Eurasian Economic Union
EaP	▸	Eastern Partnership
EBRD	▸	European Bank for Reconstruction and Development
EIB	▸	European Investment Bank
ESCO	▸	Energy Service Company
EU	▸	European Union
EUR	▸	Euro
FMO	▸	Dutch Entrepreneurial Development Bank
GAF	▸	The German Armenian Fund
GEFF	▸	EBRD's Green Economy Finance Facility
GGF	▸	Green for Growth Fund
GHG	▸	Greenhouse Gas
GIZ	▸	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
GDP	▸	Gross Domestic Product
GW	▸	Gigawatt
GWh	▸	Gigawatt hours
HPP	▸	Hydro Power Plant
IDA	▸	International Development Association
IEA	▸	International Energy Agency
INDC	▸	Intended Nationally Determined Contributions
IRENA	▸	International Renewable Energy Agency
ISO	▸	International Organization for Standardization
KfW	▸	The German Kreditanstalt für Wiederaufbau
ktoe	▸	Kiloton of Oil Equivalent
kV	▸	Kilovolt
kWh	▸	Kilowatthour
LLC	▸	Limited Liability Company
MVA	▸	Megavolt-amperes
MW	▸	Megawatt
NDC	▸	Nationally Determined Contributions
NPP	▸	Nuclear Power Plant
NGO	▸	Non-Governmental Organisation
OECD	▸	Organisation for Economic Co-operation and Development
OJSC	▸	Open Joint Stock Company
PERC	▸	Passivated Emitter and Rear Cell
PSRC	▸	The Public Services Regulatory Commission of the Republic of Armenia
PV	▸	Photovoltaic

R2E2	▸	Renewable Resources and Energy Efficiency Fund of the Republic of Armenia
RA	▸	Republic of Armenia
R&D	▸	Research and Development
SC	▸	Statistical Committee of the Republic of Armenia
SHPP	▸	Small Hydropower Plant
SME	▸	Small and Medium Enterprise
TPP	▸	Thermal Power Plant
UCO	▸	Universal Credit Organisation
UK	▸	United Kingdom
UN	▸	United Nations
UNFCCC	▸	United Nations Framework Convention on Climate Change
U.S.	▸	United States of America
USD	▸	U.S. dollar
USAID	▸	United States Agency for International Development
VAT	▸	Value Added Tax
WB	▸	World Bank
WPP	▸	Wind Power Plant

1 BACKGROUND

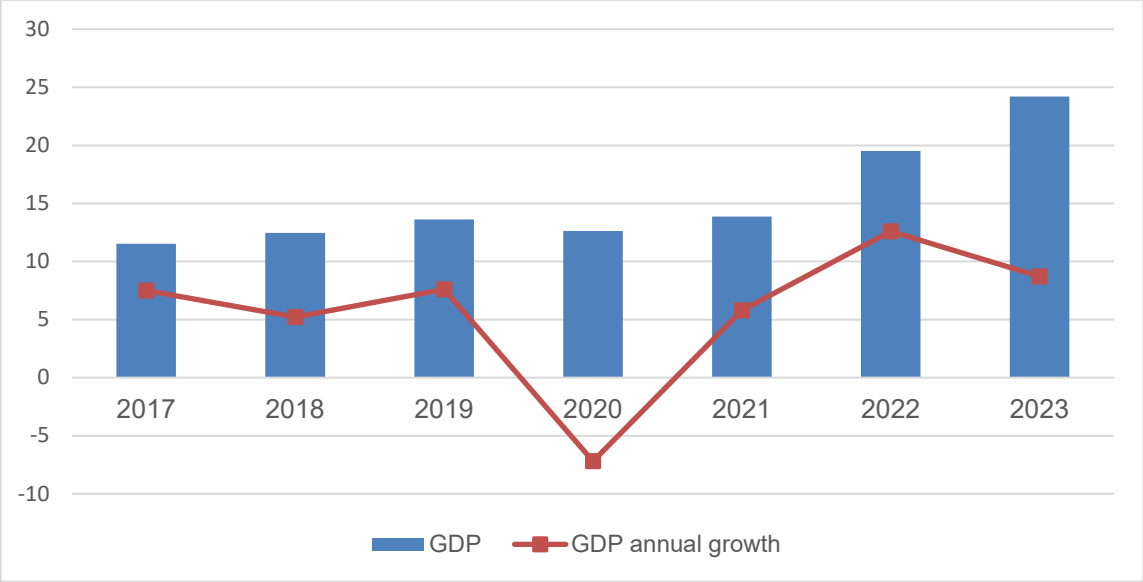
1.1 COUNTRY OVERVIEW

The Republic of Armenia (hereinafter referred to as RA) is a mountainous, landlocked country, located in western part of Asia at the crossroad between Europe and Asia. A significant portion of the country lies at high altitude (greater than 1,000 meters above sea-level), including a freshwater lake Sevan, with a surface area of 1,278.4 km^2.

Armenia is bordered by Türkiye to the west, Georgia to the north, Azerbaijan to the east, and Iran and the Azerbaijani exclave of Nakhichevan to the south. As of January 1, 2024, Armenia's population was estimated at 2.99 million people[1]. The total area of the country is 29,743km² [2].

Armenia has experienced significant socio-political and economic shocks in recent years. These events have included the 2018 Velvet Revolution, the 2020 twin shocks of the COVID-19 pandemic and the conflict with Azerbaijan, and more than 115,000 ethnic Armenians forcibly displaced from Nagorno Karabakh into the territory of Armenia in 2023[3]. Despite of these challenges, the Armenian economy has showed resilience and recorded growths. In 2022, the country experienced remarkable economic growth, emerging as the fastest-growing economy in Eastern Europe and Central Asia, with a growth rate of 12.6%. This expansion was driven by an influx of migrants, businesses, and capital following Russia's invasion of Ukraine[4]. Although growth slowed in 2023, Armenia's economy continued to expand, with its gross domestic product (GDP) reaching USD 19.5 billion - an 8.3% increase from 2022. The services sector, particularly information technologies, trade, and transportation, was a major contributor, accounting for 59.1% of the GDP in 2023.

Figure 1 - GDP and GDP annual growth or Armenia, 2017 – 2023, billion USD

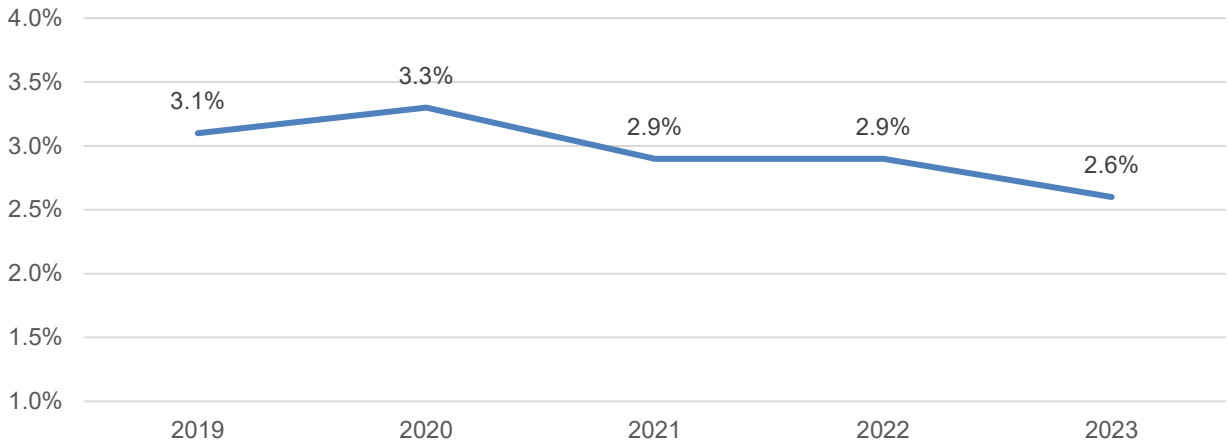


Source: World Bank, 2024

[1] https://armstat.am/file/article/population_01_01_24.pdf
[2] https://armstat.am/file/doc/99541043.pdf
[3] https://data.unhcr.org/en/country/arm
[4] https://www.worldbank.org/en/country/armenia/overview#3

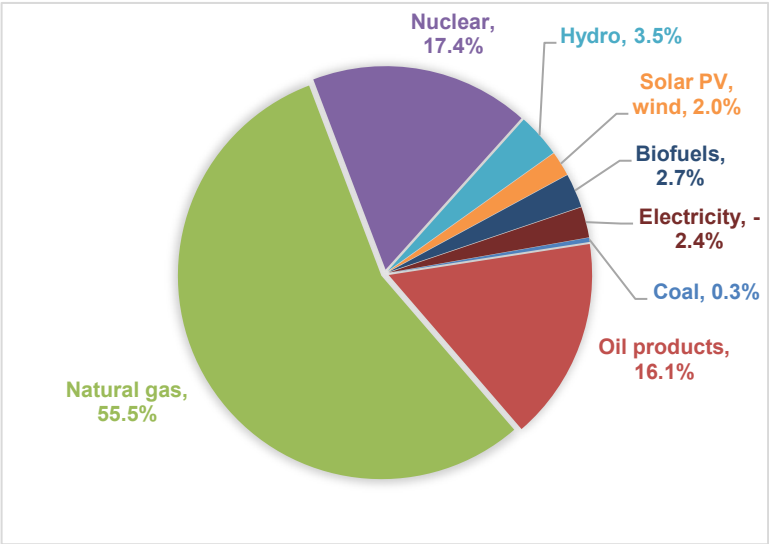
The "Electricity, gas, steam, and air conditioning supply"[5] sector contributed approximately 2.6% to the GDP of Armenia in 2023, which is 0.3 percentage points lower than in 2022. Over the last three years, the share of energy supply in GDP has shown a downward trend, primarily due to the growth of other sectors of the economy, such as construction, trade, and communication. In general, the energy sector's share in GDP has fluctuated between 2.6% and 4.5% over the past decade, with 2023 marking the lowest point.

Figure 2 – Share of "Electricity, gas, steam, and air conditioning supply" in the GDP of the RA, 2019-2023[6]



Source: Ministry of Finance of the RA, 2024

Figure 3 - Share of energy sub-sectors in the energy supply of Armenia, 2023



Source: Energy Balance of the RA for 2023, SC of the RA

Due to the lack of indigenous energy resources, Armenia relies heavily on imports of natural gas and oil to meet most of its energy needs. Natural gas represents the largest - 72.7% share of Armenia's energy imports, followed by oil products 22.6%. Import of fossil fuel and other energy sources reduced by almost 5% compared to 2022. The country primarily imports natural gas from the Russian Federation via a pipeline through Georgia. Additionally, Armenia imports gas from Iran under a barter agreement, in which it exports electricity in exchange for gas. While Armenia also engages in electricity trade with Georgia, the volumes remain low due to the lack of synchronized power networks between the two countries. Armenia has no energy trade or interconnections with Azerbaijan and Türkiye due to the blockade imposed by these neighbouring countries.

[5] The Statistical Committee of Armenia does not publish the share of the energy sector in the GDP structure separately. Instead, it is grouped under broader category "Electricity, gas, steam, and air conditioning supply", which makes it challenging to isolate the energy sector's exact contribution.

[6] Historical data for the last 10 years is inconsistent due to changes in statistical reporting methodology

Although Armenia does not produce any fossil fuels, the country manages to cover 27% of its energy supply with domestic energy production: nuclear energy, hydro energy, as well as other renewable energy resources in 2023, maintaining the same share as in 2022. However, given the approximately 4% decrease in energy supply in 2023, the share of production from local sources has increased.

Doing business in Armenia

Armenia is considered one of the countries with a favourable business environment. According to the World Bank's latest Doing Business report (published in 2021), Armenia ranked 47th out of 190 countries. The report highlighted that starting a business and registering property are the easiest procedures in Armenia, where the country ranked 10th and 13th, respectively. Since 2020, several changes have taken place in Armenia's business environment, offering enhanced opportunities for entrepreneurs looking to establish successful businesses.

- *Efficient business registration process*[7]*:*
  - companies and individual entrepreneurs can obtain name reservations, business registrations and tax identification numbers simultaneously in a single location,
  - electronic registration allows to register a company in 5 minutes (personal presence might be required),
  - registering a limited liability company is free of charge, while the cost for registering as an individual entrepreneur is less than EUR 10,
  - opening a corporate bank account takes 1 to 10 days, depending on the bank,
  - there are no minimum requirements or restrictions regarding investment amount, value and quantity.
- *Tax and customs incentives:*
  - businesses operating in bordering rural communities are exempt from value added tax (VAT) and profit tax[8].
  - investment projects exceeding AMD 2 billion (approximately EUR 5 million) in the Dilijan community and adjacent territories of Tavush province receive additional VAT and profit tax exemptions[9],
  - customs duty exemption applies to the import of equipment and raw materials from non-Eurasian Economic Union countries in the scope of investment projects.
- *Open investment regime:* Armenia offers one of the most open investment environments among emerging markets:
  - the Constitution of Armenia protects all forms of property and grants everyone to own, use and dispose a legally acquired property,
  - the Law "On Foreign Investments" ensures enterprises with foreign investment can engage in any economic activity. There are no restrictions imposed by the legislation of Armenia, except in cases where national security requirements apply,
  - foreigners can own 100% of resident legal entities and access nearly all sectors and geographical areas in the country,
  - companies registered by a foreign citizen in Armenia have the right to own land and enter into long-term lease contracts.

International partnerships and reporting

Armenia is a member of the World Trade Organisation since 2003 and is a contracting party of the Energy Charter and Protocol on Energy Efficiency and Related Environmental Aspects (signed in 1994). The country is also a signatory to the International Solar Alliance.

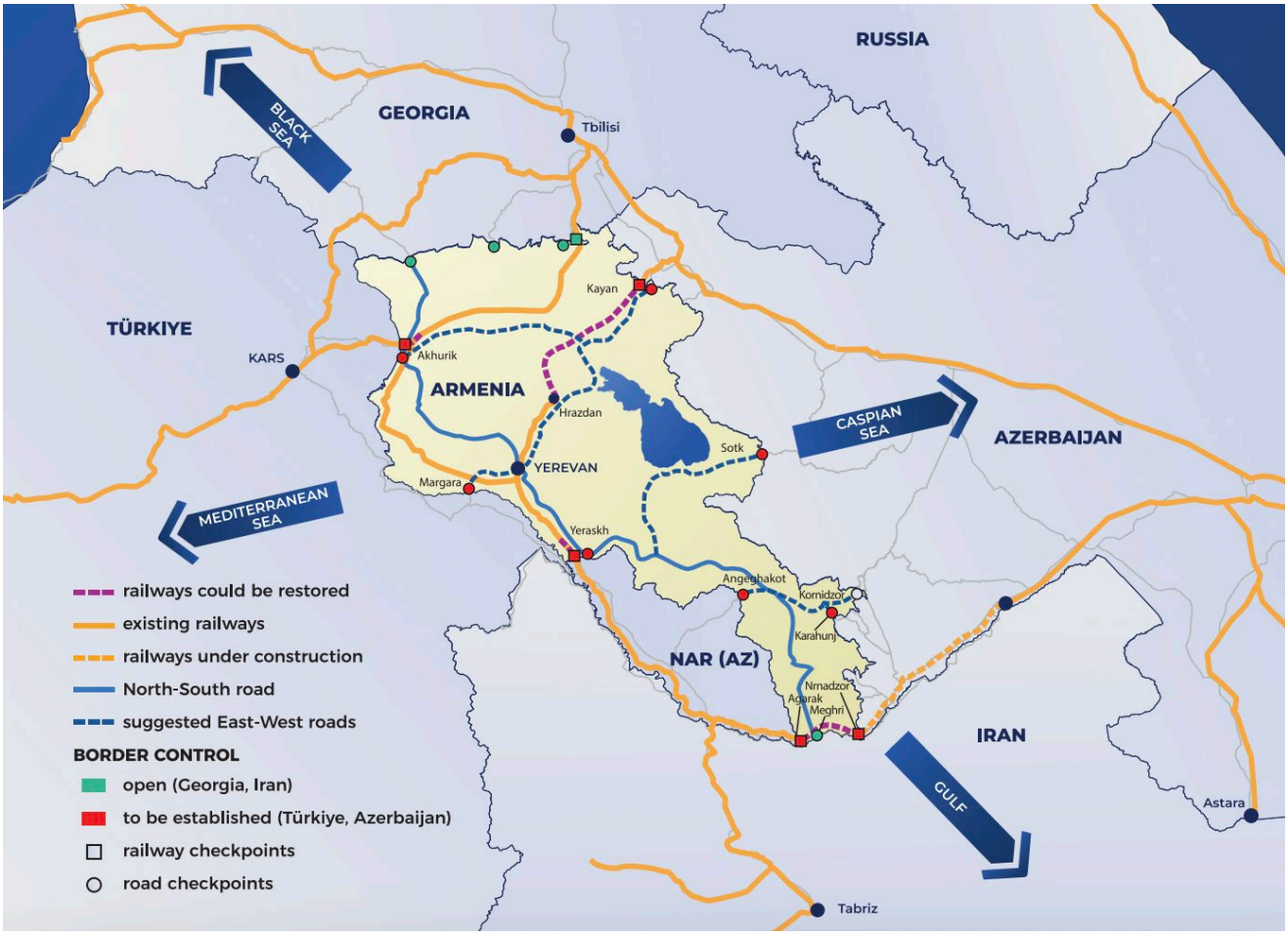
[7] https://www.e-register.am/en/

[8] https://www.arlis.am/DocumentView.aspx?DocID=137521 and https://www.arlis.am/DocumentView.aspx?DocID=166961

[9] https://www.arlis.am/DocumentView.aspx?DocID=102908

Armenia ratified the United Nations Framework Convention on Climate Change (UNFCCC) in 1993, the Kyoto Protocol in 2002 and the Paris Agreement in 2017. The country's position under the Convention and the Paris Agreement is set out in the "Intended Nationally Determined Contributions" (INDC), approved by the Government of Armenia and submitted to the UNFCCC on 22 September 2015[10]. With the ratification of the Paris Agreement, the INDC of Armenia became its Nationally Determined Contributions (NDC) for the period of 2015 – 2050. In its updated NDC (2021)[11], the Armenia intends to adhere to a ten-year NDC implementation period (2021-2030), including up-front information on the emission reductions to be achieved by 2030 and on adaptation measures to be undertaken as part of the NDC.

Picture 1 - Crossroads of Peace initiative



Source: https://www.primeminister.am

Armenia's regional policy focuses on strengthening its position within the region, opening borders with neighbouring countries, and expanding market integration. In November 2017, Armenia signed the European Union (EU) - Armenia Comprehensive and Enhanced Partnership Agreement (CEPA), which entered into force in 2021. This agreement provides a framework for collaboration between Armenia and the EU across a wide range of sectors. Additionally, since 2015 Armenia is a member of the Eurasian Economic Union (EAEU) - an international organization for regional economic integration which provides for free movement of goods, services, capital and labour, as well as pursues coordinated or single policy in different sectoral spheres within its members. Members of the Union are Armenia, Belarus, Kazakhstan, Kyrgyzstan and Russian Federation.

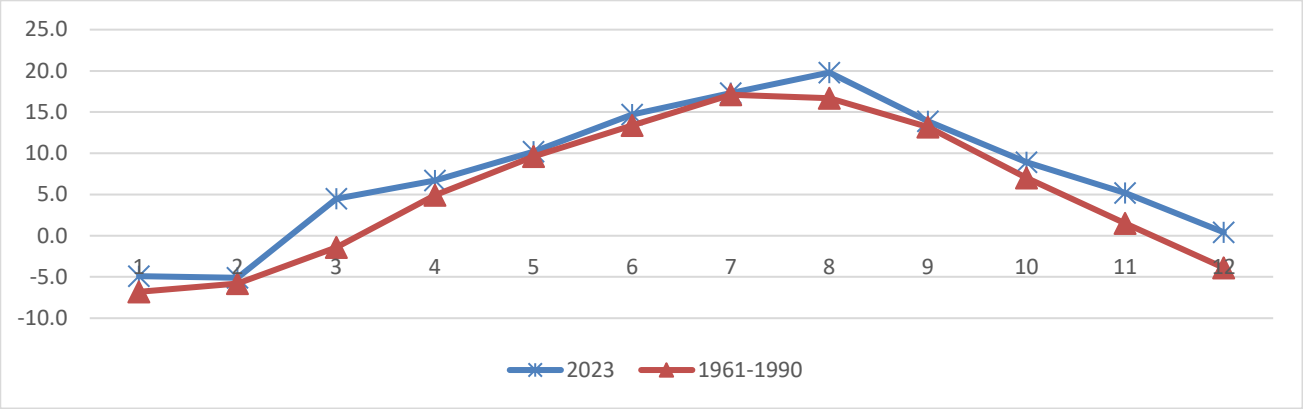
[10] https://policy.asiapacificenergy.org/sites/default/files/INDC-Armenia.pdf
[11] https://unfccc.int/sites/default/files/NDC/2022-06/NDC%20of%20Republic%20of%20Armenia%20%202021-2030.pdf

The new initiative of the Government of Armenia, "Crossroads of Peace"[12] aims to encourage neighbouring countries to open borders and establish economic ties, fostering trust and promoting peace in the region.

Climate

Armenia's climate can be described as highland continental, with large variation between summer highs (June to August) and winter lows (December to February). The country also experiences large climatic contrasts because of its intricate terrain, and the climates range from arid to subtropical and to cold, high mountains (World Bank data, 2022[13]). In 2023 the average annual temperature in Armenia was 7.7°C, which is 2.2°C higher from the norm of 1961-1990 (5.5°C)[14], 0.5°C higher than in 2022, and 0.5°C lower than in 2010. The average annual air temperature ranges from -8°C in high mountainous areas (2500m and above) to 12-14°C in low valley regions[15].

Figure 4 - Monthly average air temperature and norms, 2023 (°C).



Source: Statistical Committee of Armenia (SC), 2024

Table 1 - Monthly and annual average temperatures in 2019 - 2023 and their deviations from norm of 1961-1990

Month	Average temperature, °C					Deviation of average temperature from norm of 1961-1990, °C					1961-1990
	2019	2020	2021	2022	2023	2019	2020	2021	2022	2023	
January	-4,2	-5,4	-4,3	-5,8	-4,9	2,6	1,4	2,5	1,0	1,9	-6,8
February	-2,8	-4,0	-1,9	-1,7	-5,1	3,0	1,8	3,9	4,1	0,7	-5,8
March	-0,6	3,1	-0,9	-3,3	4,5	0,8	4,5	0,5	-1,9	5,9	-1,4
April	3,9	3,9	8,9	7,7	6,7	-1,0	-1,0	4,0	2,8	1,8	4,9
May	11,5	10,9	12,5	8,7	10,2	1,9	1,3	2,9	-0,9	0,6	9,6
June	16,7	15,6	17,6	16,1	14,7	3,3	2,2	4,2	2,7	1,3	13,4
July	18,3	18,1	18,6	18,3	17,3	1,2	1,0	1,5	1,2	0,2	17,1
August	18,5	15,9	19,0	19,5	19,8	1,8	-0,8	2,3	2,8	3,1	16,7
September	12,6	15,7	14,0	15,6	13,9	-0,6	2,5	0,8	2,4	0,7	13,2
October	10,4	9,8	6,7	9,6	8,9	3,4	2,8	-0,3	2,6	1,9	7,0

[12] https://www.primeminister.am/u_files/file/documents/The%20Crossroad%20of%20Peace-Brochure.pdf
[13] https://climateknowledgeportal.worldbank.org/country/armenia/climate-data-historical
[14] Statistical Committee of the Republic of Armenia
[15] Armenia's Fourth National Communication on Climate Change, https://unfccc.int/sites/default/files/resource/NC4_Armenia_.pdf

November	1,3	2,0	3,2	3,3	5,2	-0,2	0,5	1,7	1,8	3,7	1,5
December	-1,1	-3,0	-2,3	-1,7	0,4	2,8	0,9	1,6	2,2	4,3	-3,9
Annual	**7,0**	**6,9**	**7,6**	**7,2**	**7,7**	**1,5**	**1,4**	**2,1**	**1,7**	**2,2**	**5,5**

Source: SC, 2024

The analysis of the last five years revealed that the annual average temperature in Armenia has remained consistently above the 1961-1990 norm, ranging from 6.9°C (2020) to 7.7°C (2023). Both winter and summer months have shown an increasing trend, with 2023 being the warmest year in this period.

The consistently rising temperatures result in longer sunny days, enhancing solar energy production. At the same time, hotter summers lead to a higher demand for cooling, which boosts overall energy consumption - an increased demand that can be met with solar energy generation. However, prolonged high temperatures may also negatively impact the lifespan of PV panels.

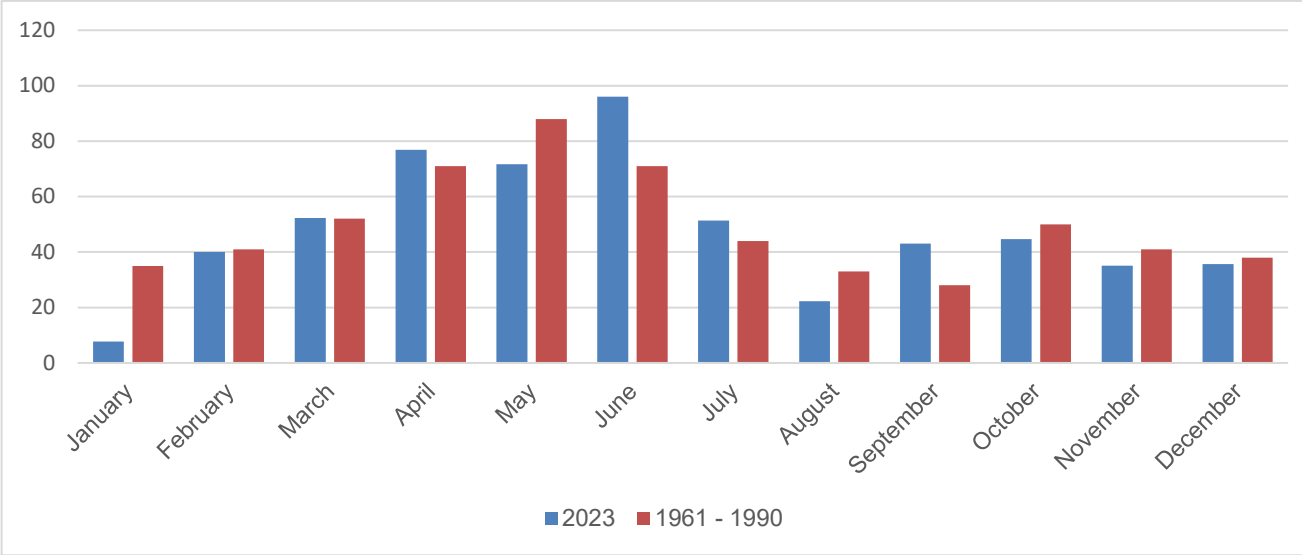
Table 2 - Annual Average wind speed by altitudes, 2022*, (m/s)

Altitude	Annual	Norm	Deviation
500 – 800	1.6	1.2	0.4
800 – 1000	1.4	1.1	0.3
1000 – 1500	1.3	1.4	-0.1
1500 – 2000	1.8	2.0	-0.2
2000 – 2500	2.7	3.1	-0.4
2500 and more	4.0	4.6	-0.6

Source: Hydrometeorology and Monitoring Center SNCO, Ministry of Environment of the RA, 2023
** On the date of preparation of the report annual average data for 2023 were not published*

Usually, high-speed winds are registered at attitudes higher than 2000m. In 2022 the average annual wind speed in the country was within the norm, with slight positive and negative deviations. In the valley (500-800 m) regions, a wind speed of 1.6 m/s was observed, which is 0.4 m/s higher than the norm. At altitudes of 1000-2000m, 1.2-1.8m/s was observed, which is 0.1-0.2m/s below the norm. In summer and autumn, the wind speed was close to the norm.

Figure 5 - Monthly average precipitations and norms, 2023 (mm)



Source: SC, 2024

The average annual precipitation is low at 576.8 millimetres (mm). Precipitation intensity is greater in Armenia's high-altitude regions with May and June the wettest months. For Armenia, altitude is the strongest controlling factor determining the spatial distribution of temperatures and precipitation. Sub-zero average temperatures are common in Armenia's mountain ranges while its highest average temperatures are experienced in the relatively low-lying western plains. Similarly, Armenia's highest peaks may receive up to 1,000 mm of annual precipitation while precipitation can be as low as 200 mm in the western plains[16].

Table 3 - Monthly and annual values of precipitations in 2019-2023 and their deviations from norm of 1961-1990 (mm)

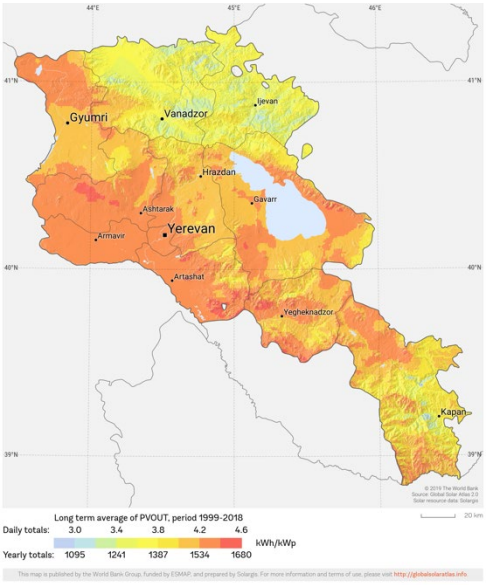
Month	Amount of precipitations					Deviation of amount of precipitations from norm of 1961-1990					1961-1990
	2019	2020	2021	2022	2023	2019	2020	2021	2022	2023	
January	28,5	15,3	30,2	33,6	7,7	-6,5	-19,7	-4,8	-1,4	-27,3	35,0
February	33,9	40,9	37,4	14,8	40,1	-7,1	-0,1	-3,6	-26,2	-0,9	41,0
March	61,0	47,0	80,7	90,7	52,3	9,0	-5,0	28,7	38,7	0,3	52,0
April	56,8	109,6	35,7	31,8	76,9	-14,2	38,6	-35,3	-39,2	5,9	71,0
May	55,0	83,7	71,3	103,8	71,7	-33,0	-4,3	-16,7	15,8	-16,3	88,0
June	54,7	42,9	19,3	62,6	96,0	-16,3	-28,1	-51,7	-8,4	25,0	71,0
July	31,0	52,9	52,7	9,7	51,4	-13,0	8,9	8,7	-34,3	7,4	44,0
August	21,9	37,5	29,5	14,5	22,3	-11,1	4,5	-3,5	-18,5	-10,7	33,0
September	47,9	18,1	27,4	21,8	43,0	19,9	-9,9	-0,6	-6,2	15,0	28,0
October	7,2	28,2	43,1	29,9	44,7	-42,8	-21,8	-6,9	-20,1	-5,3	50,0
November	21,1	26,0	19,9	19,2	35,1	-19,9	-15,0	-21,1	-21,8	-5,9	41,0
December	29,8	35,8	22,9	12,9	35,7	-8,2	-2,2	-15,1	-25,1	-2,3	38,0
Annual	**448,8**	**538,0**	**470,1**	**445,2**	**576,8**	**-143,2**	**-54,0**	**-121,9**	**-146,8**	**-15,2**	**592,0**

Source: SC, 2024

Solar potential

[16] https://climateknowledgeportal.worldbank.org/country/armenia/climate-data-historical

Figure 6 - Photovoltaic potential map of Armenia



Source: World Bank, Global Solar Atlas

Natural climatic conditions in Armenia are enough favourable for solar energy use: average annual solar energy flow per square meter of horizontal surface is 1 720 kWh (the European average is 1 000 kWh), and one-quarter of the country's territory is endowed with solar energy resources of 1 850 kWh/m^2 per year[17] compared to 950-1050 kWh/m^2 in Poland, Czech Republic, and Slovakia or 1200 kWh/m^2 in Hungary.

Average monthly hours of sunshine vary from approximately 2048 (Ijevan) to 2968 (Ararat) hours. In Yerevan, the monthly hours of sunshine were approximately 2696 hours in 2020 (average duration of sunshine exceeding 2 200 hours with average of 4,773 MJ/m^2 solar radiation).

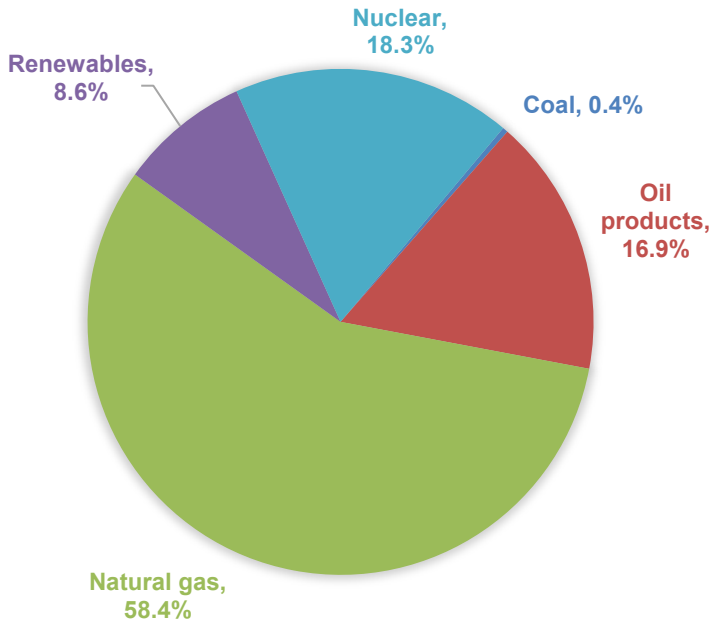
1.2 ENERGY SUPPLY AND DEMAND

1.2.1 Supply

Armenia has no domestic oil or gas reserves and has historically relied on imports of these resources, primarily from Russia. A significant portion of the country's energy is generated using these imported hydrocarbons. According to the Energy Balance of Armenia, a total of 3,854.6 thousand tonnes of oil equivalent (ktoe) of energy was supplied in 2023, with 75.3% generated from hydrocarbons. The reliance on these resources in energy production reduced by 0.2 percentage points compared to 2022. Approximately 58.4% of Armenia's primary energy supply came from natural gas, followed by nuclear energy at 18.3% and oil products at 16.9% (see Figure 6).

[17] https://www.iea.org/reports/armenia-energy-profile/energy-system-transformation

Figure 7 - Primary energy supply, 2023



Source: Energy Balance of Armenia for 2023, SC of Armenia

Armenia produced 8,845.1 million kWh of electricity in 2023 or 3,8% less than in 2022 (9,190.1 million kWh). Nevertheless, the total primary energy supply increased by 4% on average per annum between 2019 and 2023[18].

The main domestic sources of primary energy production are nuclear energy and hydro energy which share amounted to 30.6% and 18.6% correspondingly in 2023 (Figure 7). The volumes of energy produced in hydro power plans (HPPs) continue to decrease compared to the previous years. In the South Caucasus region Armenia is the only country producing nuclear energy. In general, energy generation in Armenia is represented by the Armenian nuclear power plant (ANPP), thermal power plants (TPP), hydro-electric power plants and alternative sources (solar and wind power plants).

Table 4 - Total primary energy supply, 2019 – 2023, ktoe

	2019	2020	2021	2022	2023
Coal	2,7	7,6	11,2	11,5	13,7
Oil products	475,1	560,5	596,6	594,7	652,7
Natural gas	2 120,3	2 141,2	2 339,9	2 427,3	2 250,3
Renewables	301,6	255	353,6	352,7	330,3
Nuclear	644,2	718,2	520,7	741,6	705,9

Source: Energy balance of the RA, Ministry of Territorial Administration and Infrastructure, 2024

Table 3 illustrates the primary energy supply in the period from 2019 to 2023. Despite some fluctuations, the energy supply from renewable sources shows a clear upward trend. An increase in primary energy supply was also observed from oil products and coal. However, the share of coal in the total energy supply remains minimal, and its growth has had no significant impact on the country's overall energy supply

Table 5 - Electricity output 2019 – 2023, (million kWh)

	2019	2020	2021	2022	2023
Nuclear power plant	2,197.8	2,756.3	1,998.4	2,846.2	2,709.2
Thermal power plants	3,046.9	3,165.5	3,383.7	3,878.7	3,715.6
Hydro-electric power plant	2,370.9	1,778.4	2,201.7	1,939.9	1,645.8
Solar power plants	23.6	56.5	163.5	523.5	772.2

[18] Public Services Regulatory Commission of the RA

	2019	2020	2021	2022	2023
Wind power plants	3.2	1.9	1.5	1.8	2.3
Total[19]	**7,642.5**	**7,758.6**	**7,748.8**	**9,190.1**	**8,845.1**

Source: SC, 2024

Installed generation capacity of the power system is 3.6 GW, but available capacity is lower due to the age and condition of plants: approximately 50% of Armenia's capacity is more than 40 years old.

Table 6 - Installed capacities of power generation plants, 2023

Name	Source	Installed capacity (MW)	Available capacity (MW)	Ownership
ANPP	Nuclear	407.5	407.5	State-owned
Hrazdan TPP (Unit 1-4)	Gas	410	0	Tashir Group
Hrazdan TPP (Unit 5 - combined-cycle gas turbine, CCGT)	Gas	467	450	Gazprom Armenia
Yerevan Thermal Power Plant (CCGT)	Gas	228.6	228.6	State-owned
Yerevan CCGT-2	Gas	254	254	ArmPower CJSC
Sevan-Hrazdan HPP Cascade	Hydro	561.4	561.4	Tashir Group
Vorotan HPP Cascade	Hydro	404.2	404.2	Contour Global Hydro
SHPP	Hydro	395	395	Various
Solar (including autonomous)	Solar	457	457	Various
Wind	Wind	4.2	4.2	Various
Total		**3,588.90**	**3,161.90**	

Source: own calculations based on IEA; IRENA; PSRC, Strategic program 2040

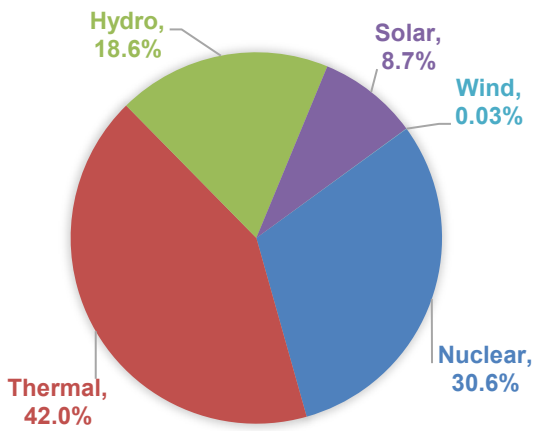
Nuclear power: The Armenian Nuclear Power Plant[20] consists of two WWER-440/270 units. Unit 1 was commissioned in 1976, and Unit 2 in 1980. Both units were shut down in 1989, but the government decided to restart Unit 2 in 1993. Today, the ANPP operates as a state-owned company and produced 2,709.2 million kWh of electricity in 2023, accounting for 30.6% of the country's total electricity production. The decommissioning of the plant has been postponed several times. On 14 September 2023 the government approved an action plan to extend the operation lifespan of the ANPP until 2036, from the current deadline of 2026, through ongoing improvements recommended by international nuclear experts. The government also has announced plans to build a new nuclear plant by 2036. In 2023 it set up an interagency working group to analyse various options for building the new facility.[21]

[19] Up until 2022, the recorded volumes of electricity production only included electricity supplied by autonomous producers to Electric Networks of Armenia CJSC, as measured by reverse commercial meters. However, the figures for 2022 and 2023 also include the electricity produced and consumed on-site by autonomous producers, which was not previously captured by reverse commercial meters.

[20] https://armeniannpp.am/en/

[21] Potential nuclear reactor model options being considered for Armenia include small modular reactors (SMRs) proposed by the U.S. company NuScale Power Corp, a 1200 MW reactor suggested by Rosatom (Russia), and other alternatives proposed by Framatome (France) and South Korean companies.

Figure 8 - Annual electricity generation, 2023



Source: SC, 2024

Hydropower: Most of Armenia's hydropower potential is already utilized that is why it is considered the most developed among the other renewable energy resources in Armenia. The country's main hydropower capacity is privately owned and consists of two HPP cascades, most of which are well over 30 years old:

- The Sevan-Hrazdan Cascade, built between 1923 and 1962, is a complex of hydroelectric power plants located along the Hrazdan river. It is owned by International Energy Corporation CJSC[22], a subsidiary of the Tashir Group. With a total capacity of 561.4 MW, the cascade generated 398.7 million kWh of electricity in 2023, contributing 4.7% to the country's total energy production.
- Vorotan Cascade, built between 1970 and 1989, is a series of three HPPs on the Vorotan River and is owned by "Contour Global Hydro Cascade" CJSC[23]. The complex has an overall capacity of 404.2 MW and produced 543.2 million kWh of electricity in 2023, contributing 6.4% to the country's total energy production. To strengthen Armenia's renewable energy sector and support the modernization of the cascade, the Dutch Entrepreneurial Development Bank (FMO) contributed USD 65 million as part of a USD 140 million financing package arranged by the International Finance Corporation in 2016.

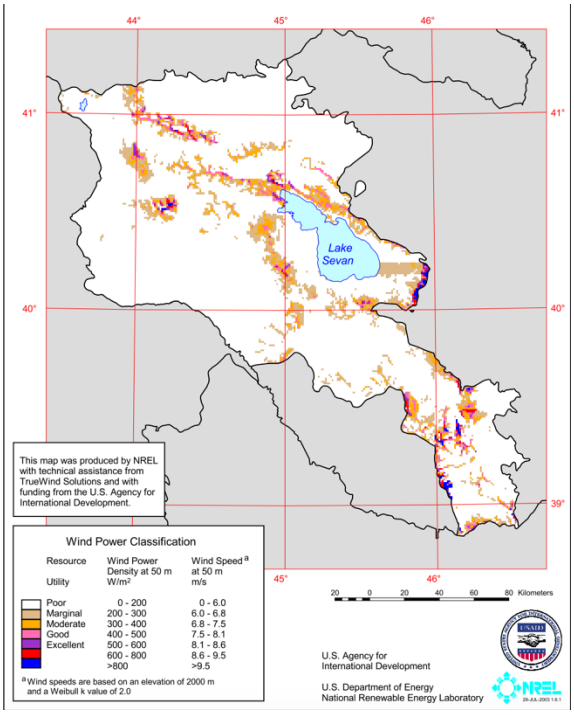
Constructing small HPPs (under 30 MW) is Armenia's one of the favoured courses of action to develop the renewable energy sector and secure energy independence. Most designated, under-construction or operational small HPPs are derivational stations on natural water flows[24]. According to licenses issued by the PSRC as of July 1, 2024, there were 190 SHPPs operating in Armenia, with a total installed capacity of 402 MW and an actual electricity generation of 925.5 million kWh. In 2023, SHPPs produced 703.9 million kWh of electricity, accounting for approximately 8% of the country's total energy production. Additionally, 16 more SHPPs are under construction, with a combined installed capacity of 59.3 MW.

Wind power: Three wind power plants (WPP) are currently operating in Armenia with a combined installed capacity of 4.2 MW. The total supply electricity the existing WPPs was 2.3 million kWh in 2023 or 0.03% of total energy production. In 2018 the PSRC granted a license for operation of a new wind power plant in Gegharkunik region which has not yet entered the construction phase. It is planned to construct the plant with 4 MW installed capacity with an annual generation estimated at 10 GWh.

According to the Armenian Wind Atlas[25], developed in 2003 by the U.S. National Renewable Energy Laboratory, Armenia could potentially support up to 5000 MW of installed capacity. In 2010 the USAID published a report titled "Wind energy in Armenia: overview of potential and development perspectives", where wind energy potential of Armenia was estimated "at about 500 MW with annual generation potential of more than 1 billion kWh."[26] On the request of the Government of Armenia the Asian Development Bank is currently developing a viability assessment for potential wind power projects.

[22] https://www.mek.am/en/pages/index/company/
[23] https://www.contourglobal.com/asset/vorotan-complex
[24] Armenia Energy Profile 2024, International Energy Agency
[25] https://www.nrel.gov/docs/fy03osti/33544.pdf
[26] https://advisory.am/pdf/8_USAID_Wind-Potential-Report_Eng.pdf

Picture 2 - Wind resource map of Armenia



Source: Wind Energy Resource Atlas of Armenia

However, it is important to note that some experts argue the 2003 data is outdated and underestimated. According to the Global Wind Atlas[27], 10% of Armenia's territory has a mean wind power density of 600 W/m² or higher at 50 meters above ground level, indicating greater potential for wind energy development.

Considering this, by the "Energy Sector Development Strategic Program to 2040" the Government of Armenia envisages the construction of small and systemic wind power plants with a total capacity of up to 500 MW in the years 2025-2040, provided that the prices of electricity delivered from them are competitive.

Thermal Power: Armenia operates four thermal power plants:

- *Hrazdan TPP (Units 1-4)*: This facility, with four condensing power-generating units, has an installed capacity of 410 MW. In 2023, it generated 328.0 million kWh of electricity, contributing 3.9% to the country's total energy production.
- *Hrazdan TPP (Unit 5-CCGT)*: This condensing power unit, with an installed capacity of 467 MW, produced 179.5 million kWh of electricity in 2023, accounting for 2% of total energy production.
- *Yerevan CCGT*: A combined-cycle production unit with an installed capacity of 228.6 MW, it generated 1,371.2 million kWh of electricity in 2023, contributing 16.2% to the total energy supply.
- *Yerevan CCGT-2 (ArmPower)*: This newly constructed combined-cycle power plant, owned by Renco and Siemens Project Venture, has an installed capacity of 254 MW. In 2023, it produced 398.7 million kWh of electricity, contributing 4.7% to Armenia's total energy production.

A small amount of electricity is also produced by a few small-scale combined cycle power plants. In 2023, these plants generated 5.7 million kWh of electricity, contributing 0.07% to the country's total energy production.

All thermal power generation units operate on natural gas, the vast majority of which is imported from Russia. Additionally, all the electricity generated by the Yerevan CCGT is exported to Iran under the gas-for-electricity barter agreement.

Solar power: The wide implementation of solar photovoltaic (PV) systems is currently underway in Armenia. As of July 1, 2024, approximately 216.8 MW of solar PV installations were operational, with an additional 285.4 MW under construction. These figures do not include autonomous PV stations, which generated around 389.9 million kWh of electricity in 2023. Further details about the solar energy sub-sector are provided in Chapter 2 of this report.

[27] https://globalwindatlas.info/en/area/Armenia

Picture 3 - Solar power station Masrik-1, Gegharkunik province

Source: Shtigen Group

1.2.2 Demand

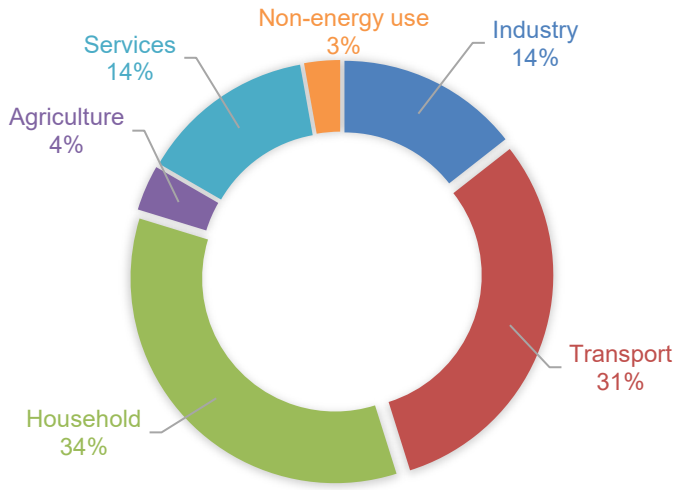
Table 7 – Energy consumption by sector, 2019-2023 (ktoe)

Sectors	2019	2020	2021	2022	2023
Industry	313.0	328.2	370.6	418.9	412.3
Transport	806.6	855.3	899.8	887.5	878.4
Household	812,.7	862.8	961.6	995.8	988.9
Agriculture	29.8	94.5	103.4	102.0	102.9
Services	451.4	409.2	434.1	463.1	395.5
Non-energy use	46.2	64.2	73.8	71.1	80.8
Total	**2 459.6**	**2 614.1**	**2 843.3**	**2 938.4**	**2 858.8**

Source: Energy Balance of the RA, Ministry of Territorial Administration and Infrastructure, 2024

Energy consumption in the transport sector has grown rapidly over the last five years, despite a slight decline in 2022. The highest growth rate was recorded in 2019, with a 13% increase compared to 2018.

Figure 9 - Final energy consumption by sector, 2023 (ktoe)



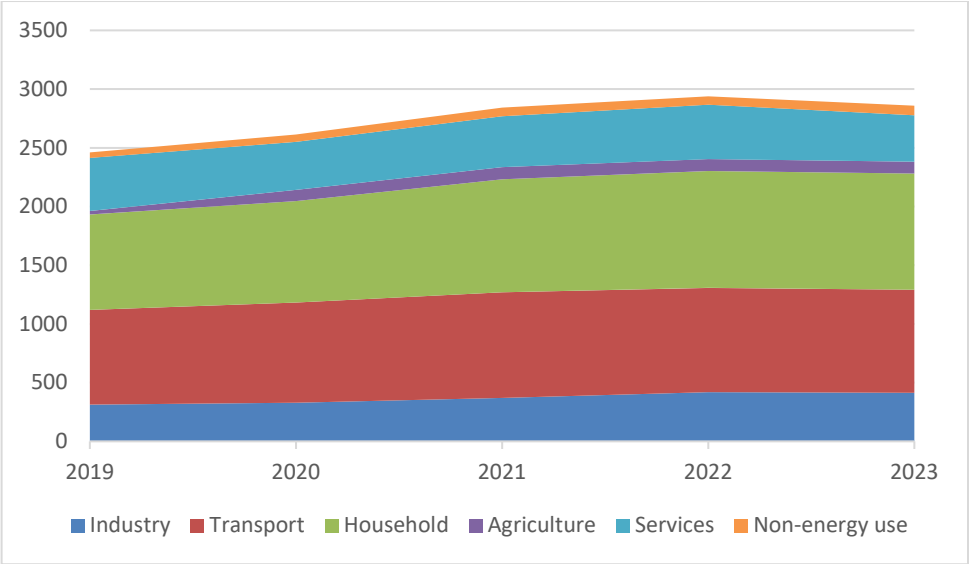
Source: Ministry of Territorial Administration and Infrastructure of the RA, 2024

The household sector remains the largest consumer of energy, with an average annual growth rate of nearly 9% from 2017 to 2022. In 2022, household energy consumption rose by 4% compared to 2021, driven mainly by a 4.7% increase in natural gas consumption and a 2.8% rise in electricity use.

The highest growth rate of energy consumption in the last five years was recorded in the agriculture sector – almost 4 times. This can be explained by the growth of greenhouses subsector and unprecedent growth of usage of innovation technologies in the sector.

In 2023, Armenia's final energy consumption amounted to 2,778.1 ktoe, reflecting modest growth over the past five years (+6% since 2018). The household sector was the largest consumer, accounting for 34% of total energy consumption, followed by the transport sector at 31%, and services and industry at 14% each in 2023.

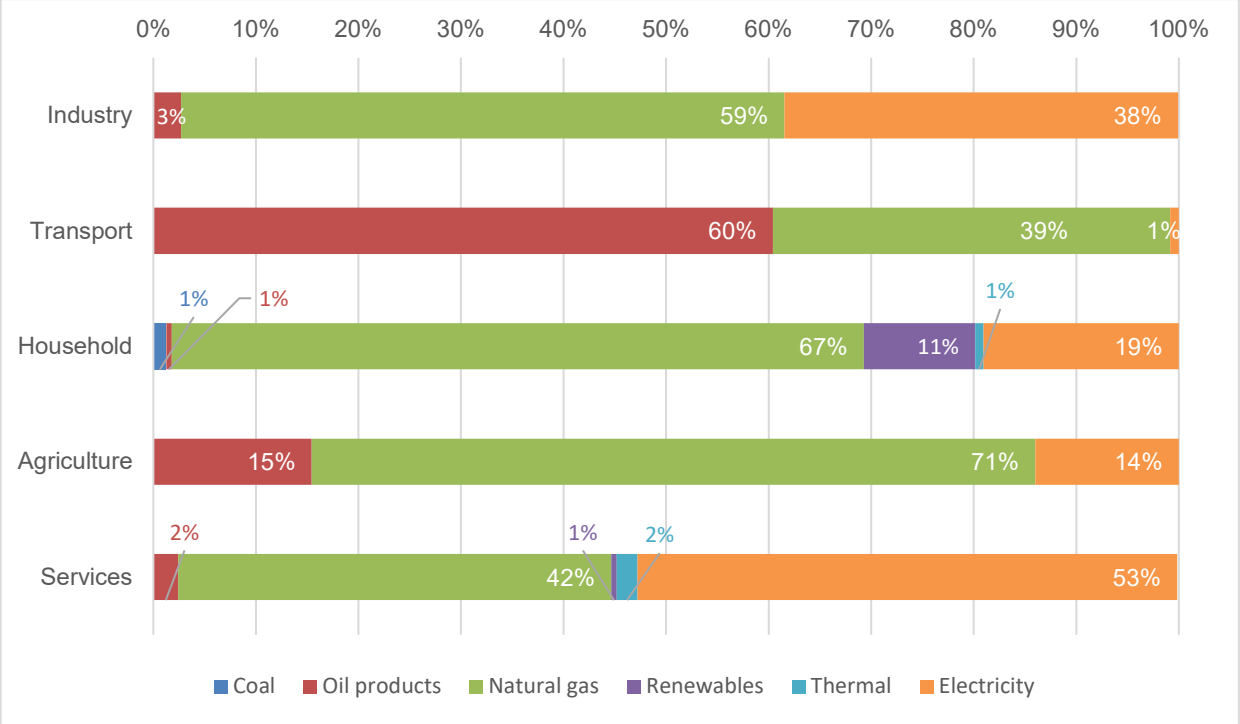
Figure 10 - Growth of energy consumption by sector, 2019-2023 (ktoe)



Source: Ministry of Territorial Administration and Infrastructure of the RA, 2024

Fossil fuels accounted for three-quarters of Armenia's total energy consumption in 2023 (75%), with natural gas holding the largest share at 52.1%. Natural gas consumption dominates nearly every sector of the Armenian economy, with the notable exception of the transport sector. Although natural gas is widely used in passenger vehicles, oil products constituted the largest share of transport fuel in 2023 (60%). Demand for natural gas in the transport sector decreased compared to 2022 and may continue to decline in the coming years, as the government promotes electric vehicles, including the elimination of VAT on e-vehicle imports.

Figure 11 - Total final consumption by source and sector, 2023



Source: Energy Balance for Armenia 2023; Ministry of Territorial Administration and Infrastructure of the RA, 2024

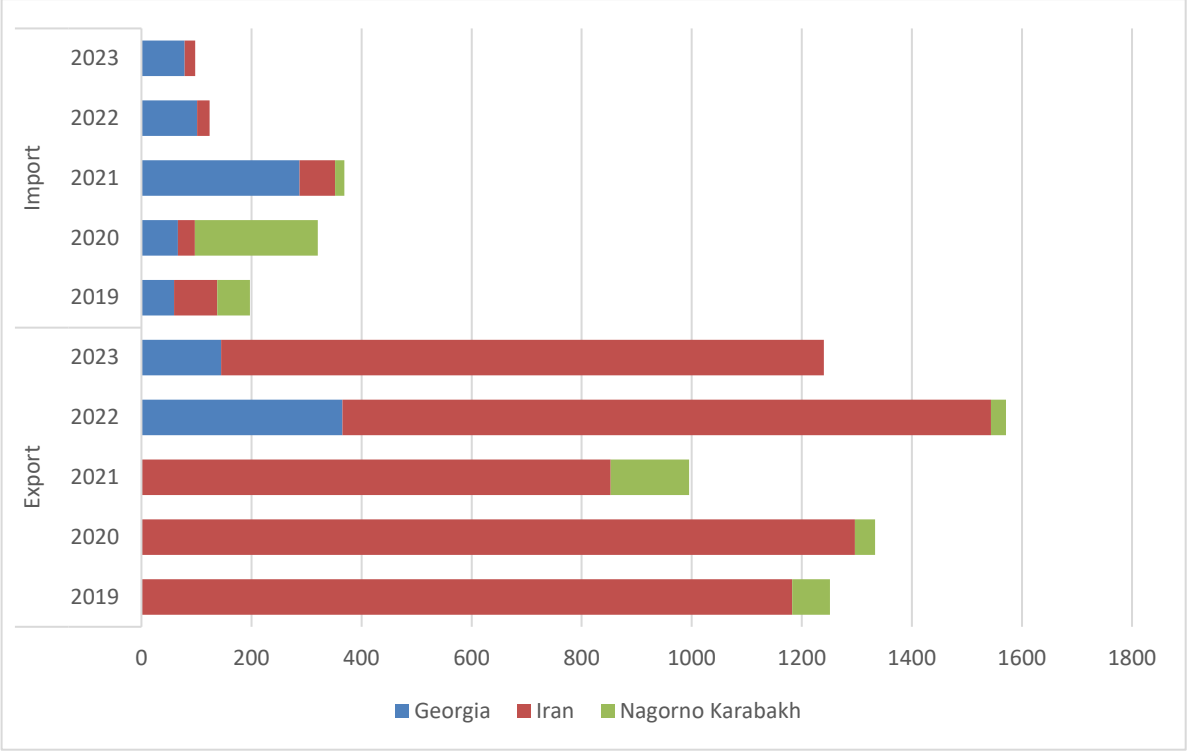
1.2.3 Import/Export

Armenia imports a significant portion of its energy resources, primarily hydrocarbons, while domestic energy production mainly comes from hydropower and nuclear energy. In 2022, imported energy resources accounted for 75.5% of Armenia's total primary energy supply, a decrease of around two percentage points compared to 2021. Despite this reduction, imported energy continues to play a critical role in the country's energy generation. Armenia's grid operates at 220 volts AC with a frequency of 50 Hz and is currently synchronous with Iran's grid. The country also maintains seasonal "island" connections with Georgia, although their main grids are not fully synchronized.

In 2023, Armenia exported 1,240.28 million kWh of electricity and imported 97.64 million kWh, resulting in net exports of 1,142.64 million kWh. The main trade partners for electricity are Iran and Georgia. Armenia has two electricity exchange agreements with Iran. The first involves seasonal electricity trade: during the summer months, Armenia exports electricity to Iran, which experiences increased demand for cooling. In the winter, when Armenia's hydropower generation is lower, it imports an equivalent amount of electricity from Iran. The second agreement is a gas-for-electricity swap, where Armenia imports Iranian gas and exports the electricity generated from it. This barter agreement, extended in 2023, will remain in effect until 2030. In 2023, Armenia exported 1,095.58 million kWh of electricity to Iran, representing over 85% of the country's total electricity exports. Imports from Iran primarily depend on Armenia's seasonal energy needs.

Electricity trade with Georgia remains limited due to asynchronous grid connections, with exports to Georgia totalling 144.70 million kWh in 2023. However, future trade with Georgia is expected to grow following the construction of a new interconnection.

Figure 12 - Electricity trade by country, 2019-2023 (million kWh)



Source: Ministry of Territorial Administration and Infrastructure of the RA and PSRC

The energy policy of Armenia prioritizes regional integration, with plans to strengthen interconnections with neighbouring countries: Georgia and Iran. Armenia currently has one 220-kV line and two 110-kV lines connecting it to Georgia. Armenia and Georgia are cooperating to construct a 400-kV interconnection in the near future. This interconnection will support parallel operation of their power systems, dispatch management, and emergency power supply. Armenia also aims to improve its electricity market integration with Iran by developing existing interconnections, including two 220-kV transmission lines and a new 400-kV line. Currently 400 kV Iran-Armenia double-circuit overhead transmission line and 400 kV "Noravan" substation are under construction. These projects are crucial to forming the North-South Corridor and could lead to greater cooperation with countries like Russia and Iran, as well as potential participation in a "Black Sea electricity cable" project, which aims to supply electricity to European countries.

Table 8 - Export and import of electricity, 2019-2023 (million kWh)

	Export					Import				
	2019	2020	2021	2022	2023	2019	2020	2021	2022	2023
Georgia	0	0	0	365,5	144,7	59,3	66,4	287,1	101,2	78,5
Iran	1 182,3	1 296,5	852,6	1 178,3	1 095,6	78,8	30,9	65,0	22,7	19,2
Nagorno Karabakh	68,8	36,6	142,6	27,4	-	59,3	223,0	16,5	-	-
Total	**1 251,1**	**1 333,1**	**995,2**	**1 571,2**	**1 240,3**	**197,4**	**320,3**	**368,5**	**123,8**	**97,6**

Source: Public Services Regulatory Commission of the RA

The construction of a new 400-kV connection with Iran is expected to increase this capacity from 350 MW to 1,200 MW, enabling electricity exports of up to 5 GWh. The construction is expected to be completed by 2025. Armenia's connection with Georgia, however, operates in island mode due to asynchronous systems. It is expected that construction of a set of 400-kV back-to-back high-voltage

direct current stations and transmission lines would increase exchange capacity with Georgia. The first stage would add 350 MW, with potential expansion to 1,000 MW in later stages[28].

Armenia is also a member of the EAEU common electric power market, which is expected to be launched in 2025. Although Armenia does not share a border with any of the other four member countries of the EAEU, trade between Armenia and these countries theoretically could take place via Georgia. EAEU member states currently are developing rules regarding cross-border trade.

1.3 Energy Sector Institutional Framework

The table below presents the roles and functions of main institutions involved in the energy sector of Armenia.

Table 9 - Main institutions involved in the energy sector of Armenia

Institution	Key functions
The Ministry of Territorial Administration and Infrastructure (https://www.mtad.am/)	The ministry is responsible for developing and implementing energy policy in the country. It develops relevant primary and secondary legislation, as well as investment plans for state-owned enterprises. According to the law "On Energy" of the RA, the ministry has several key responsibilities, including: - developing strategic plans for the energy sector's growth, as well as relevant legal acts and safety regulations, - collaborating with the PSRC to facilitate cross-border sales and enhance interstate cooperation, - advising the PSRC on the annual licensing limits for renewable energy plants with an installed capacity of up to 30 MW, considering the sector's strategic development plans and approving PSRC decisions regarding the licensing of power plants with an installed capacity exceeding 30 MW, - establishing market rules and defining indicators for the security and reliability of the energy sector.
The Ministry of Environment (http://www.env.am/)	Is the executive authority responsible for designating and implementing the national policy in the areas of environmental protection and sustainable use of natural resources. It also is responsible for implementation of the country's commitments under the UN Framework Convention on Climate Change.
The Ministry of Economy (https://mineconomy.am/)	The ministry is responsible for development of quality infrastructure and protection of consumers rights in the country. This task also includes setting of relevant standards, including energy efficiency standards.
Urban Development Committee (https://www.minurban.am/en)	The Committee is responsible for formulation and implementation of the policy of the Government of the RA in the field of urban development. One of its primary objectives is to enhance the maintenance, operation and reliability of buildings, with a strong emphasis on promoting modernisation, including energy savings and energy efficiency measures. To achieve this the Committee provides suggestions and recommendations to the government on approaches to improve energy effectiveness in the building sector. The institution

[28] Sources: Armenia Energy Profile, IEA, 2024; Armenia Energy Policy Review, IEA, 2022; expert assessments.

Institution	Key functions
	also is responsible for formulation and promotion of the principle of “green urban development”.
The Public Services Regulatory Commission (https://www.psrc.am/)	PSRC is an independent regulatory agency operating in the energy, water and telecommunication sectors. It is responsible for establishing tariffs for the production, transmission, and distribution of electrical and thermal energy. Additionally, the PSRC grants licenses for generation, transmission, and distribution activities within the energy sector and defines market rules to ensure fair competition and transparency.
The Renewable Resources and Energy Efficiency Fund (https://www.r2e2.am/)	R2E2 is a non-profit organization established by the Government of the RA. Its primary objectives are to facilitate the development of the renewable energy and energy efficiency sectors of Armenia, while promoting the market growth and attracting investments in these fields. It also is responsible for developing mechanisms that enhance the energy security and reliability of the national energy system. Additionally, the Fund implements credit, grant, and various programs aimed at advancing sector development on behalf of Armenia.
High Voltage Electrical Networks CJSC (https://www.hven.am/)	State-owned transmission company responsible for transmission of electric energy and generation of electricity through wind power plants. Its core functions include the construction, operation, and maintenance of the transmission network, ensuring reliable and efficient energy delivery throughout the country.
Electric Networks of Armenia CJSC (https://www.ena.am/index.aspx?lang=2)	The company is mainly engaged in regulated distribution and sales of electric energy. Power distribution is implemented under tariffs approved by the PSRC. This is the single distribution company.
Scientific Research Institute of Energy CJSC (https://www.energinst.am/)	The state-owned institute is dedicated to conducting scientific research in the energy sector and developing normative technical documents. Its responsibilities include analysing information related to energy policies and regulations, as well as formulating measures for energy efficiency and energy savings. Through these activities, the institute plays a crucial role in advancing knowledge and promoting best practices within Armenia's energy landscape.
Settlement Center CJSC (https://www.setcenter.am/)	According to the license for providing computing services to the electricity market of Armenia, issued by the PSRC, the company has the exclusive rights and obligations to carry out commercial accounting of electric energy (power) in Armenia.

Picture 4 - Installation of solar power station at “Doustr Marianna” LLC

Source: The picture is from https://sdif.am/

2 SOLAR ENERGY SUB-SECTOR OF ARMENIA

2.1 GENERAL OVERVIEW OF RENEWABLE ENERGY SOURCES

The contribution of renewable energy sources to energy consumption in Armenia averaged approximately 11% between 2015 and 2020. Most renewable electricity generation comes from two large hydropower plant cascades: Sevan-Hrazdan and Vorotan. The number of small hydropower plants expanded significantly over the past two decades, driven by favourable feed-in tariffs. However, SHPP development has recently slowed due to stricter regulations prompted by growing concerns about ecological impacts (Armenia Energy Policy Review, 2022, IEA).

Currently, solar photovoltaic capacity remains low but is expected to drive the growth of renewable energy sources, due to support mechanisms suggested by the government and other support organisations and globally declining solar PV equipment costs. Feed-in tariffs applied to autonomous producers and first solar power plants, investment projects initiated by the Government in the recent years resulted with the unprecedent growth of solar energy production in the country.

While several potential sites for wind farms have been identified, most are in remote, high-altitude areas, which diminishes their cost-competitiveness relative to other renewable sources, particularly solar. Nonetheless, the government has shown interest in developing wind farms based on international best practice. To promote this sub-sector the government requested support from the Asian Development Bank in exploring opportunities to develop Armenia's wind energy potential. The technical assistance started in 2022 and has two main objectives:

a) assess Armenia's wind potential and grid stability (should be achieved by 2024) – (1) initial findings and sector assessment reports; (2) screening tool developed to identify potential viable sites and (3) capacity of the implementing agency's staff to assess wind potential, legal and regulatory framework, and grid stability strengthened.
b) Armenia's wind power potential development increased (should be achieved by 2025) – (1) Feasibility study for at least one potential wind power project; (2) Capacity of the implementing agency's staff to prepare and process wind power project strengthened[29].

In 2023, renewable energy sources represented 42.3% of Armenia's total available generating capacity of 4.4 GW. Large hydropower plants, Vorotan and Sevan-Hrazdan Cascades, accounted for 52.5% of this capacity. Small hydropower plants, numbering 189 with capacities under 30 kW, contributed 21.5% of total renewable capacity. Grid-connected solar PV systems provided 473 MW (25.8% of renewable capacity), comprising 61 PV plants (205 MW) and 17,112 autonomous energy producers (268 MW). Additionally, four wind plants with a total capacity of 4.2 MW were connected to the grid.

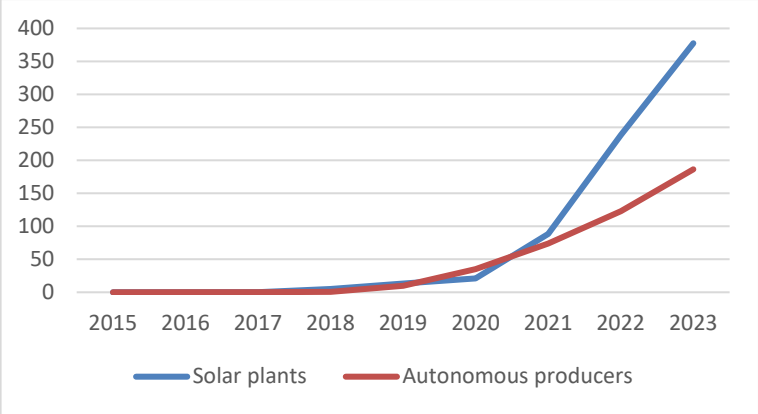
The Energy Strategy of Armenia adopted by the decree of the Government of RA No. 48-L in 2021, prioritizes renewable energy sources, aiming to increase their share in Armenia's power generation mix to 60% by 2040, with a strong focus on small hydropower, wind, and solar photovoltaic resources. A key objective is to boost solar power generation to at least 15% of the total mix by 2030. To support this goal, Armenia plans to develop solar power plants with a cumulative installed capacity of 1,000 MW, encompassing both grid-connected and autonomous systems.

[29] https://www.adb.org/projects/documents/arm-55332-001-tar

2.2 SOLAR ENERGY SUB-SECTOR OVERVIEW

By the end of 2023, Armenia's solar power capacity reached 473 MW, including autonomous producers, with 61 solar plants contributing 205 MW and 17,112 autonomous producers adding 268 MW. An additional 252 MW is expected to connect in 2024, which would bring the total installed solar capacity to 725 MW, underscoring Armenia's rapid renewable energy expansion. In November 2021, Masdar (United Arab Emirates) signed an agreement with the Armenian government to design, finance, build, own, and operate a 200 MW utility-scale solar power plant in Aragatsotn Province (Ayg-1), with commissioning planned for 2025.

Figure 13 - Solar energy supply in the period 2015 – 2023, million kWh



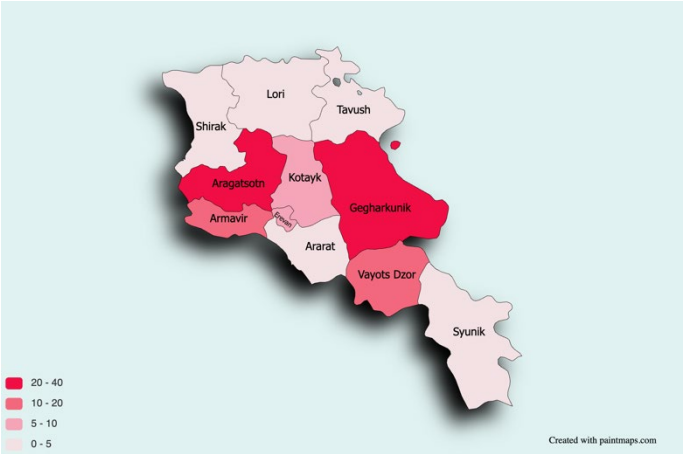
Source: PSRC, 2024

Solar energy's share in Armenia's generation grid reached 8.7% in 2023, marking a seven-percentage-point increase since 2020. As shown in Figure 13, electricity generation from solar stations increased more than fivefold in the past two years, from 162.6 million kWh in 2021 to 563 million kWh in 2023.

Solar energy now comprises 25.8% of total renewable electricity production, driven largely by rapid growth in the sector. Over the past five years, renewable energy's share in Armenia's overall electricity generation rose from 13.2% in 2019 to 15.2% in 2023.

According to the PSRC 61 solar power plants were operating in Armenia by the end of 2023 and additional 40 solar power plants with a combined capacity of 252 MW were under construction. The largest of these is the Masrik-1 power plant, developed by a consortium led by **Fotowatio Renewable Ventures B.V.** (the Netherlands). Electricity from Masrik-1 is priced at USD 4.19 per kWh under a 20-year power purchase agreement with Electric Networks of Armenia. This is formalized through a 2018 public-private partnership agreement signed with the Ministry of Territorial Administration and Infrastructure, which also includes offtake and payment guarantees. Financed by the International Finance Corporation, European Bank for Reconstruction and Development, and the EU (up to USD 38.4 million), Masrik-1 is expected to be completed by late 2024.

Picture 5 - Provinces of Armenia with solar power plants (existing and under construction)



Source: PSRC, 2024

As of October 1, 2024, 75 solar power plants were operational in Armenia with a combined installed capacity of 278.2 MW, while an additional 50 plants with a potential capacity of 304.6 MW were under construction.

2.2.1 Advantages of Armenia

The development of Armenia's solar energy sub-sector began in 2012. Prior to this, there was a legislation in place, but due to a lack of specific regulations, the laws were not effectively enforced. Between 2012 and 2016, the solar water heating market started to expand, driven by the efforts of two to three companies. In 2016, Armenia made several changes in the energy and tax legislation, introduced a system for autonomous producers and net-metering, which significantly advanced the solar energy sub-sector by creating incentives for private households and small businesses, with a relatively short payback period of 5-6 years for installations[30]. This growth was further supported by the introduction of financing instruments with lower interest rates, making installation of solar energy systems more accessible and attractive.

In 2017, the government piloted a high tariff (around USD 0.09) and announced tenders for ten 1 MW solar energy production licenses. These licenses sold quickly, stimulating the construction of Armenia's first industrial solar plants. Within a few years, the business community began to see the sector's potential, especially as international prices for solar components decreased. Later with support from the World Bank, the Armenian government launched the Masrik-1 solar power plant project and gave a mandatory purchase guarantee, though the tariff was determined by tender procedure. A consortium led by Fotowatio Renewable Ventures B.V. won the tender with a proposed tariff of USD 4.19 per kWh under a 20-year purchase guarantee. In 2019, the government set a new tariff of 24 drams per kWh for new solar power plants with a total installed capacity of 100 MW (5 MW per plant). Thanks to that, by the end of 2020 the country has around 420MW total capacity of solar energy producers. By 2022, the market had liberalized, allowing new plants to operate without guaranteed purchase agreements or fixed tariffs.

This rapid development has positioned Armenia's solar energy sub-sector as one of the most attractive industries in the country. Armenia's strengths in this field include its established capabilities, access to financing, skilled workforce, and a well-developed supply chain. The solar energy sub-sector in Armenia has several advantages compared to other countries:

- **Abundant solar resources**: Armenia has significant solar energy potential: Armenia has more than 300 sunny days in a year (2500-2600 hours of sunshine per year), average annual solar energy flow per square metre of horizontal surface is 1 720 kWh (the European average is 1 000 kWh), and one-quarter of the country's territory is endowed with solar energy resources of 1 850 kWh/m2 per year[31]. Armenia's solar PV potential is higher than the average for the EU, with a specific daily photovoltaic power output of 3.25-4.48 kWh/kWp and global horizontal irradiation of 3.86 – 5.43 kWh/m^2.
- **Strategic geographic location**: Situated between Europe and Asia, Armenia is well-placed to serve as a bridge for energy markets in both regions. This could potentially position Armenia as a renewable energy hub in the Caucasus. Solar power stations can be effectively installed in almost all provinces of Armenia, ensuring efficient operation. The current development and available resources in the solar sub-sector make it feasible to establish solar power stations even in areas with relatively low solar PV potential. However, as shown in Picture 5, the **Aragatsotn and Gegharkunik** provinces are preferred for constructing solar power plants. This preference is due to several factors: elevation (approximately 1,500 meters above sea level), air quality (reducing the frequency of cleaning required for solar PV panels), and suitable summer temperatures (averaging between 19-23°C), which support optimal performance of solar power plants.

[30] Today the payback period is reduced to 4 years for installation of both residential and industrial power plants
[31] https://www.iea.org/reports/armenia-energy-profile/energy-system-transformation

Businesses typically avoid installing high-capacity solar power plants in the **Ararat and Armavir** provinces for two main reasons: (a) these provinces are primarily agricultural. Due to Armenia's limited amount of agricultural land, converting such land for industrial purposes is generally discouraged to protect food security and maintain sustainable agricultural production, and (b) the high summer temperatures in these areas can negatively affect the lifespan of PV panels. Additionally, the **Shirak and Kotayk** provinces are also considered suitable for solar power installations.

- **Growing technical expertise**: Armenia has developed a local pool of engineers and skilled labour experienced in renewable energy projects, making it easier for companies to hire locally and maintain solar infrastructure with in-country expertise. Higher educational institutes of Armenia provide relevant specialists in renewable energy sources, ensuring on-the-job training at the companies involved in installation and maintenance of solar-power stations. Moreover, Armenia, with its professional potential, is exporting solar plant installation services to the neighbouring countries. Armenian specialists and companies were involved in installation and management of several solar power stations constructed in Georgia, Kazakhstan, Russia and Uzbekistan.

  Additionally, two companies in Armenia are involved in photovoltaic panel production, primarily in the assembly process. These companies continuously integrate emerging technologies in the solar energy field, distributing their products domestically and exporting to neighbouring countries and the United States.
- **Favourable and open business environment:** Armenia offers a supportive and efficient environment for establishing and operating businesses. Entrepreneurs can complete essential registrations, such as company name, business registration, and tax identification, in a single location in just 5 minutes and free of charge. Armenia imposes no minimum requirements or restrictions on investment amounts, values, or quantities, creating an inclusive and open environment for all types of businesses.
- **Support from the government and international organizations**: Armenia benefits from collaboration and financial support from institutions like the World Bank, EBRD, KfW bank and the EU, which actively fund renewable energy initiatives, provide technology transfer, and strengthen the regulatory framework. Additionally, government support programs aimed at improving infrastructure, business productivity, and attracting a highly qualified workforce add to the sector's attractiveness.
- **Tax incentives for business growth:** Armenia offers a range of attractive tax incentives aimed at encouraging business growth and investment. Businesses operating in bordering rural areas benefit from exemptions on VAT and profit tax. Additionally, investment projects exceeding approximately EUR 5 million in specific areas enjoy further tax relief. Furthermore, Armenia provides customs duty exemptions on the import of equipment and raw materials for investment projects, enhancing the financial attractiveness for both local and foreign investors.
- **Unexploited market potential**: With rising demand for energy and a small percentage of its energy coming from solar, Armenia has significant potential for scaling solar capacity. Enhancing the country's energy storage capacity could further boost solar energy production, creating significant opportunities for developers and investors in both large-scale and distributed solar projects.

As a summary, here are strengths and weaknesses of Armenian solar energy sub-sector:

Strengths

- Climatic advantages: Armenia benefits from favourable solar conditions, with abundant sunlight that supports efficient solar energy generation.

- Established expertise: the country has developed a skilled workforce and expertise within the renewable energy sector, facilitating effective installation and maintenance.
- Diverse market players: a variety of companies and stakeholders actively involved in the sub-sector, enhancing competitiveness and innovation.
- Untapped market potential: with only a small portion of Armenia's energy derived from solar, there is significant room for expansion.

Weaknesses

- Dependence on imports: the sub-sector relies heavily on imported materials and components, which can face delays or cost increases due to logistical issues.
- Limited storage capacity: a lack of energy storage solutions restricts the ability to use stored solar energy during peak demand hours.
- Challenging soil composition: Stony soils often require extra groundwork for solar installation, increasing the time and costs.
- Mountainous terrain: Armenia’s landscape complicates the logistics of solar plant construction, which can hinder scalability and accessibility.

2.2.2 Applied technologies and trends

Solar energy in Armenia is utilized in two main areas: solar water heating and solar power generation through power plants. While there are examples of solar energy being applied in street lighting and electric vehicle charging stations, these initiatives are usually driven by municipal efforts with donor support or by companies installing electric vehicle charging infrastructure, and they are not yet widely implemented across the country.

Solar water heating technologies offer a clean, reliable, and cost-effective method to harness solar energy year-round for residential and commercial hot water needs. Two primary types of solar water heating technologies are available in Armenia: non-pressurized (thermosyphon) and pressurized (active) water heaters.

- Active (pressurized) solar water heating systems use a circulation pump and come in two varieties:
  - direct circulation systems, where water circulates through the collectors directly and into the home, best suited for milder climates with minimal risk of freezing.
  - indirect circulation systems, which include two loops: a pump circulates a non-freezing heat-transfer fluid through the collectors and a heat exchanger to heat the water that is then supplied to the home.
- Non-pressurized (thermosyphon) water heaters rely on natural circulation: water is heated in pipes connected to the collectors, flows into a storage tank, and is then used within the building.

These technologies are efficient and adaptable to Armenia’s diverse building types and climate, making solar water heating a viable and growing choice in the country.

The costs for constructing **solar plants** vary depending on capacity, with smaller plants generally being more expensive per unit than larger ones. The rapid decline in solar PV technology costs has been consistent, creating favourable conditions for broader adoption, especially in the residential sector, where rooftop installations help meet household energy needs and allow surplus electricity to be fed back into the grid.

When the first panels were installed in Armenia in 2016, the capacity per panel was 345 watts (measuring 2m x 1m), with homojunction modules priced at USD 0.45 per watt and achieving an efficiency rate of about 15%. By the end of 2023, the capacity of panels used in Armenia has increased to 770 watts, with costs dropping to USD 0.09 per watt and efficiency reaching 22%. While in 2017, the cost of constructing solar plants exceeded AMD 400,000 (approximately EUR 952[32]) per kilowatt, recent market options show prices ranging from AMD 180,000 to AMD 200,000 (EUR 429 - 476) per kilowatt.

2.3 MARKET CONDITIONS

2.3.1 Products and services offered

The construction of solar power stations/plants has four main components:

- *Solar panels and modules*: previously **homojunction PV solar modules** were used in Armenia. Though these modules are cheap, their effectiveness is low. In recent years **heterojunction PV modules** started to use in the country. According to sector specialists, these panels still are expensive, though their effectiveness is high and payback period of investment for construction of solar power stations using these modules can be around two years. Armenian companies offer also Building Applied Photovoltaic and Building Integrated Photovoltaic modules (moreover, there are producers of those modules in Armenia). Vehicle integrated photovoltaics, mobile PV systems and agrivoltaics are offered as well.

  P-type and N-type TOPCon cells are widely used by Armenian companies operating in the solar energy sub-sector. Although the price of N-type panel is higher than P-type these type of panels offer higher efficiency, better performance in low-light conditions, and better resistance to degradation, making them especially advantageous for long-term reliability and efficiency. For a 100 kW N-type solar panel system, the average cost per kW is around USD 400, while for residential one it can vary from USD 700 to USD 800. Local producers of solar PV panels suggest also semi-transparent, coloured facade and PERC mono-crystalline solar cells that can be used for ON-Grid and OFF-Grid solar applications. Almost 99% of PV panels used in Armenia are imported from China.
- *Inverters:* Armenia's solar energy sub-sector utilizes several types of inverters, including on-grid, off-grid, hybrid, and microinverters. Most of the inverters used by Armenian companies are imported, with the primary suppliers being Huawei and Sungrow. Although inverters from other manufacturers, particularly those from Europe, are available in the market, the main supply remains dominated by Chinese manufacturers.
- *Construction materials.* For the installation of solar power stations, most companies in Armenia primarily use galvanized metals. However, to reduce costs, iron is sometimes used instead by small installation companies. Unlike other parts of solar power stations, construction materials are sourced both locally and internationally, with imports from countries like China and Iran diversifying the market. Armenia has a wide import geography for solar power cables, sourcing from countries such as China, India, Iran, Russia, and Ukraine, in addition to domestic production.
- *Transformer station*: There is not specific request relating to these stations. Companies use different stations produced in different countries. Import geography is based on established contacts and partnership of companies and varies from China to Ukraine.

Two main technologies for installing solar plants are used in Armenia:

[32] Exchange rate: EUR 1 = AMD 420

- fix construction, which has 30 degrees of slope and faces to south,
- tracker system that follows the movement of the sun. With this system, solar generation increases by 15%. There are 11 solar power stations with tracker system in Armenia.

In Armenia, almost all solar power plant/station installation companies provide a full spectrum of services, including import of materials, design, feasibility studies, construction, audits, and commissioning. This comprehensive approach has led larger companies to create holdings by establishing smaller, specialized subsidiaries that focus on one or two specific aspects of the installation process, offering these services either to the parent company or other smaller entities. Smaller companies, however, tend to offer design, consultancy, and construction services under a single structure.

Armenia imported photovoltaic cells (assembled and unassembled) and photosensitive semiconductor devices (excluding photovoltaic generators and cells) worth approximately USD 45 million in 2023. This represents a significant increase, being four times the import value in 2019. However, it also reflects a decline compared to more recent years: imports were 32% lower than in 2021 and 17% lower than in 2022. This trend indicates fluctuations in the demand or supply of photovoltaic and semiconductor products, possibly influenced by global market dynamics and domestic project timelines.

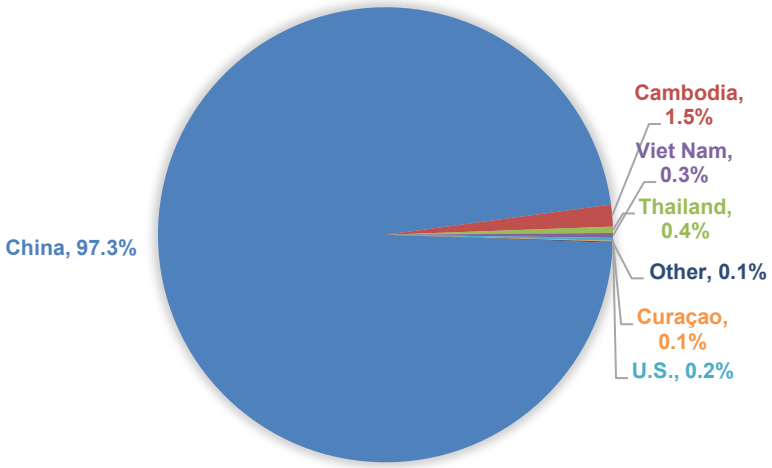
Table 10 - Import of photovoltaic cells in 2019-2020, thousand USD[33]

HS	Product label	2019	2020	2021	2022	2023
854143	Photovoltaic cells assembled in modules or made up into panels	-	-	-	39 579	34 971
854142	Photovoltaic cells not assembled in modules or made up into panels	-	-	-	12 288	8 467
854149	Photosensitive semiconductor devices (excl. photovoltaic generators and cells)	-	-	-	1 137	813
854140	Photosensitive semiconductor devices, incl. photovoltaic cells whether or not assembled in modules or made up into panels; light emitting diodes (excluding photovoltaic generators)	10 767	30 263	65 759	-	-

Source: Intracen.org, 2024

[33] The product code HS 854140 has been removed from the 2022 HS revision

Figure 14 – Import of photovoltaic cells per country, 2024



Source: Intracen.org, 2024

In 2023, nearly 97% of photovoltaic cells (assembled and unassembled in modules) imported into Armenia originated from China, reaffirming its dominant position as a supplier. Other countries, including Cambodia, Vietnam, Curacao, and the United States, accounted for the remaining share of photovoltaic panel imports, although in much smaller volumes.

Despite a reduction of over USD 20 million in the total import value compared to 2021, China's share decreased by only two percentage points during this period. 2021 showed greater diversification in Armenia's import sources, with France, Germany, Japan, Lithuania, Malaysia, and the Russian Federation being as important suppliers alongside China.

2.3.2 Main players

According to different estimations, more than 60 companies operate in Armenia's solar energy sector. While some specialize in the import and installation of solar heaters, the majority focus on importing, designing, and installing solar power stations for both household and industrial applications. Most of these companies are based in Yerevan or nearby provinces. Service and product quality across the sector varies widely. There are many small companies operating at the regional level, though their services often do not fully meet market requirements. Below is a brief overview of several companies and organisations that are well recognised in the market.

Shtigen Group of Companies (https://shtigen.com/)[34]

Shtigen Group's journey began in 2011 with the establishment of Shtigen Energy Systems LLC, initially focused on providing services to residential and small commercial customers with the mission of making affordable and safe solar-powered systems and technological solutions accessible to people worldwide. By 2016, Shtigen Energy Systems had expanded to larger-scale projects. In 2022 the Shtigen Group was established. The group now includes Shtigen Energy Systems, Andron, Enerex, and Shtigen Ventures.

Shtigen Energy Systems leads in constructing solar power stations and offers a range of solar-powered products, such as solar panels, water heaters, and generators. The company is involved in the whole cycle of construction of solar power stations (engineering, procurement, construction and commissioning). Additionally, they provide heating and cooling systems, storage batteries, air purifiers, and other related devices. Shtigen played a pivotal role in building Armenia's largest solar power plant, Masrik-1, with an installed capacity of 55 MW. The company has effectively designed, built, and maintained the largest solar thermal plant in the region (Grand Sport), as well as the largest solar power plants in Armenia (Green Energy, ArSun, Solar 5).

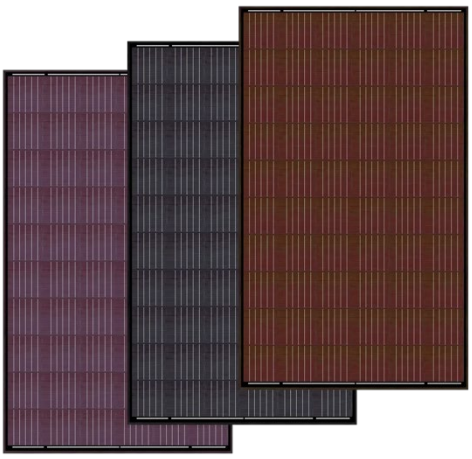
[34] https://shtigen.com/wp-content/uploads/2019/09/SHTIGEN-GROUP-Company-Profile.pdf

Optimum Energy (https://www.optimumenergy.am/)

Optimum Energy is one of the leaders in the solar energy sub-sector. Having experienced international and local consultants, engineers, architects and suppliers in the field of renewable energy, energy efficiency, building engineering systems and industrial components Optimum energy is focused on providing optimal and efficient energy solutions for commercial and residential buildings, small and medium enterprises, industries and infrastructures. Optimum Energy operates as a consultant, supplier, or implementing agency, providing a comprehensive suite of services. The company specializes in solar thermal systems, solar photovoltaic systems, heat pump systems, and renewable energy system maintenance. Additionally, they are active in product development within the renewable energy sector, reinforcing their commitment to innovation and sustainable energy solutions.

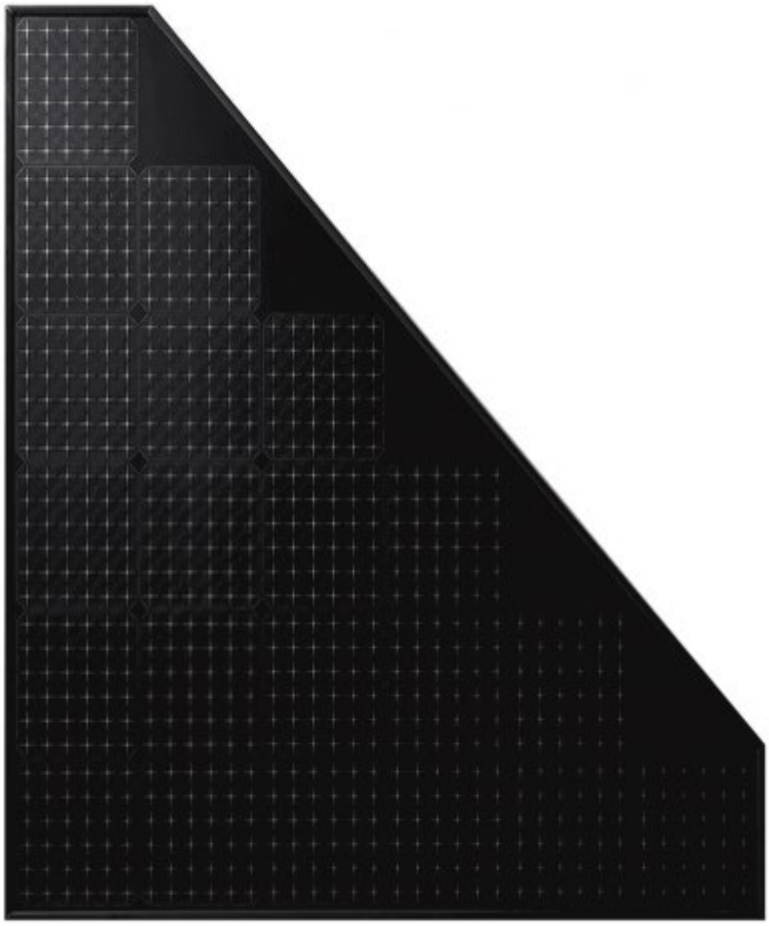
Solaron (https://www.solaron.am/)

Solaron (the brand of the company Profpanel) started its solar panel production activities in 2016, becoming the first Armenian manufacturer of solar panels. Annual production capacity of solar panels is 60 MW. In addition to manufacturing PV panels, Solaron provides comprehensive support through every stage of solar system installation and operation. The company's solar panels come with a 12-year warranty and are engineered for a 25-year lifespan. During the warranty period, Solaron ensures panel replacement with new units if performance falls below the specified standards. Solaron's product lineup includes semi-transparent and coloured facade panels, panels of varying capacities, as well as on-grid and hybrid solar systems, etc.



LA Solar (https://lasolarfactory.com/en)

Established in 2019, LA Solar specializes in producing high-quality solar modules utilizing the advanced Swiss Meyer Burger system. This technology, developed by Swiss company Meyer Burger, enables the production of cutting-edge generator equipment. LA Solar's modules undergo rigorous quality control stages, ensuring they meet U.S. and European standards. With a production capacity of 350 MW, LA Solar is based in Armenia and exports its modules to the U.S. market. Each solar panel comes with a 30-year warranty covering manufacturing defects.



Solara

(https://solara.am/en)

Founded in 2019, Solara has quickly established itself as a prominent player in Armenia's solar energy sector. This growth has been driven by its strategic partnership with the U.S.-based LA SOLAR GROUP, founded in 2011. As the owner of the LA Solar factory in Armenia's "Alliance" free economic zone, Solara delivers comprehensive installation and maintenance services for solar power systems. The company offers a full range of equipment for power plants, including inverters, hybrid inverters, batteries, and communication devices for panels. Their service package includes consultation, installation, maintenance, and monitoring, ensuring clients receive end-to-end support for sustainable energy solutions.

Armenian Energy Agency (https://energyagency.am/en)

The Armenian Energy Agency Foundation is a non-profit organisation dedicated to promoting the sustainable development of Armenia's energy sector. Serving as a knowledge-based center, the foundation offers support, consultancy, and mediation services to both private and public sectors. Functioning as a think-tank, it provides targeted consultancy to public institutions, private organizations, and donor communities. Additionally, the foundation undertakes charity projects and collaborates with international donor organizations as part of broader development initiatives.

Sustainable Development Investment Foundation (https://sdif.am/)

Sustainable Development Investment Foundation (SDIF) is a non-commercial organization and implements programs aimed at the sustainable development of the energy, agricultural, environmental, manufacturing industry and various other sectors. SDIF provides support and advisory services at both national and regional/local levels, funded by a wide range of organizations, including private sector companies, public sector institutions and international organizations. The foundation offers a broad range of services, including developing normative frameworks and technical standards in the energy sector, conducting energy audits, creating environmental impact assessments and management plans, implementing national and international standards, and providing design, construction, and operational support for energy projects.

Energy Systems LLC (https://www.energysystems.am/)

Energy Systems LLC specializes in renewable energy and energy efficiency solutions, offering a broad range of services. These include energy audits, monitoring, preliminary solar power plant design, feasibility studies, construction management engineering, and plant acceptance and commissioning. The company has extended its expertise internationally, successfully completing projects in Russia and Uzbekistan. Energy Systems LLC also provides green certification consulting services, covering areas such as design concept development, detailed design, energy efficiency solutions and modeling, and outdoor lighting photometric site plan development, etc.

2.3.3 Customers of solar energy in Armenia

The solar energy sub-sector serves a wide range of customers, primarily categorised as follows:

- **residential customers**: many Armenian homeowners invest in PV systems, particularly for rooftop installations, driven by cost savings on electricity and gas heating, especially during the winter months. Residential customers benefit from Armenia's net-metering policy, which allows them to feed excess electricity back into the grid, further lowering costs. Solar water heating systems are also popular in rural areas, reducing electricity expenses, with many installations funded by donor organizations or local civil society initiatives under energy efficiency and climate resilience projects. Residential systems fall under the "micro energy producer" classification in Armenian legislation, limited to a capacity of 150 kW.
- **industrial customers**: businesses across various sectors, including retail, manufacturing, and services, increasingly adopt solar energy to lower operational expenses and support sustainability goals. Industrial facilities, in particular, benefit from large-scale solar systems (up to 500kW) to reduce reliance on conventional power sources. In several cases companies choose off-grid systems to ensure energy stability and manage long-term energy costs. Previously, industrial users could install up to 500 kW capacity, but following market liberalization, only systems up to 150 kW are allowed without additional market regulation. For installations between 150-500 kW, these entities must operate within Armenia's energy market guidelines.
- **agricultural sector**: farms use solar energy for irrigation, particularly in intensive orchards, greenhouse operations, and refrigeration, which is critical in remote, off-grid areas. However, most greenhouses do not use solar energy due to land constraints for system installations (about ten square meters of land is used for installation of one kilowatt solar energy system. For the 150kW solar energy station 1500m^2 land will be needed, which very often is not available for greenhouses). Solar energy is prevalent in collection and cooling facilities where rooftops can support PV installations. There is also a growing interest in agrivoltaics, a dual-

use approach allowing solar energy production alongside crop cultivation and pastoral activities, although this remains in the experimental phase, with initiatives led primarily by NGOs focused on solar and energy efficiency.

- **public sector and government institutions**: the government and municipalities use solar energy to power public facilities such as schools, kindergartens, and administrative buildings. A government-led initiative for the renovation of 300 schools and 500 kindergartens includes the installation of solar stations on rooftops, which contributes to energy savings and boosts overall energy efficiency.

2.4 LEGISLATION AND REGULATORY FRAMEWORK

2.4.1 Legislation

The key legal act, regulating the energy sector of Armenia is the **Law "On Energy"** adopted in 2001[35]. It provides policies and regulations for the whole energy sector of the country, regulates relations between legal entities involved in the energy sector and provides the legal basis for producing and delivering electricity, heating, and natural gas to consumers. Key principles of the state policy in energy sector, according to this law, are, among others:

- efficient use of domestic energy resources and alternative sources of energy and implementation of economic and legal mechanisms for that purpose,
- enhancement of the energy independence of the country, including the differentiation of domestic and imported energy resources and ensuring the maximum utilization of generating capacities,
- enhancement of competition and efficient operation in the energy sector,
- encouragement of investments in the energy sector,
- ensuring transparency of the licensed operations in the energy sector,
- ensuring protection of the environment,
- promoting the formation and development of energy markets.

The law provides the primary regulatory measures for Armenia's energy sector, outlining the roles and functions of the PSRC, principles for tariff formation, and key requirements for setting tariffs.

According to Chapter 5 of the law, several energy-related activities require licensing, including production of electric energy (power), production of thermal energy, combined production of electric and thermal energy, transmission, distribution, supply, and wholesale trade of electric energy. Licenses are issued by the PSRC, with decisions made within 80 working days after the submission of relevant documents. In the case of SHPPs and other renewable energy sources, the timeframe is reduced to 25 working days. This chapter also details the rights and obligations of all licensees.

Chapter 5.1 of the law is dedicated to the electricity market and defines the main principles for the operation of both wholesale and retail markets. The PSRC is responsible for setting the rules governing these markets.

A specific chapter of the Law on Energy addresses autonomous energy production. Under this law, each consumer has the right to obtain the status of an autonomous energy producer. An autonomous energy producer is permitted to construct electricity-generating facilities using renewable energy resources, generate electricity, and consume it. Furthermore, the law stipulates that, within the

[35] https://www.arlis.am/DocumentView.aspx?DocID=198029

framework of autonomous energy production, the electricity supplied to the guaranteed provider and the electricity consumed by the autonomous energy producer are offset on a monthly basis, irrespective of the specific hours of production and consumption.

The law defines an **autonomous energy producer** as "*a consumer producing energy for their own needs using renewable energy sources, who has entered into an inter-processing agreement with a person holding a guaranteed supply license and does not possess a production license related to that autonomous energy production unit.*" The installed capacity of the unit for an autonomous energy producer is limited to 150 kW. The person, having a distribution license, is obliged to ensure connection of the production unit to the distribution network and conclude a crossflow contract according to the template defined by the PSRC.

Amendments to the law introduced in 2018 paved the way for competition among electricity suppliers, dismantling the monopoly previously held by a single firm over distribution in Armenia. As a result, consumers can now choose to purchase electricity from different suppliers. These reforms officially took effect on February 1, 2022. In 2021, new amendments to the law were adopted, specifying that electricity-generating units from renewable energy sources with an installed capacity of more than 150 kW, constructed after 1 May 2022, must sell the electricity exclusively on competitive terms. These units are not eligible for guarantees for the purchase of electricity, nor can they enter into public-private partnership agreements for electricity sales.

The next important legal act in the sector is the Law "**On Energy Saving and Renewable Energy**" adopted on 9 November 2014[36]. The law seeks to identify mechanisms to improve energy efficiency and develop additional sources of renewable energy. The law defines the principles of the state policy on energy efficiency and renewable energy with the following objectives:

- to strengthen the economic and energy independence of Armenia,
- to increase the economic and energy security of Armenia, reliability of power system,
- to create new productions and service organisations stimulating energy saving and development of renewable energy,
- to reduce adverse impacts on the environment and human health as a result of technological developments.

The main principles of the state policy in the area of energy saving and renewable energy include, among others:

- increase the level of supply of indigenous renewable energy to satisfy the energy demand of the economy,
- implementation of energy-saving, as well as the development and enforcement of legal and economic mechanisms for the promotion of renewable energy,
- ensure high priority of efficient use of energy sources given the increasing volumes of imported and extracted energy resources,
- ensure increasing usage of renewable energy resources as well as the application and development of new renewable energy technologies,
- ensure competitiveness of renewable energy resources and protection/enforcement of the rights of businesses engaged in the area of renewable energy,
- ensure high priority of issues of environmental protection and efficient (economic) usage of natural resources while implementing measures/activities aimed at the development of energy saving and renewable energy,

[36] https://www.arlis.am/DocumentView.aspx?DocID=162218

- promote integrated activities between autonomous energy producers, using renewable energy resources, and the energy system aimed at the exchange of electric energy.

Other legal acts, regulating the energy sector and particularly solar energy sub-sector are as follows:

- Decision of the PSRC No. 374-N "On approving the licensing procedure for activities in the energy sector" dated 1 November 2013 (https://www.arlis.am/DocumentView.aspx?docid=162211)
- Decision of the PSRC No. 150-N "On defining the template of the electric energy crossflow (autonomous energy producer-guaranteed supplier) contract" dated 20 April 2022 (https://www.arlis.am/DocumentView.aspx?DocID=181437)
- Decision of the PSRC No. 516-N "On approving the trading rules of the electricity wholesale market of the Republic of Armenia" dated 25 December 2019 (https://www.arlis.am/DocumentView.aspx?docid=160093)
- Decision of the PSRC No. 517-N "On approving the trading rules of the electricity retail market of the Republic of Armenia" dated 25 December 2019 (https://www.arlis.am/DocumentView.aspx?docid=159587)
- Decision of the PSRC No. 523-N "On approving the distribution network rules of the electricity market of the Republic of Armenia" dated 25 December 2019 (https://www.arlis.am/DocumentView.aspx?DocID=195515).
- Decision of the PSRC No. 375-N "On approving templates of financial statements of the person with the electric energy supply license" dated 09 October 2019 (https://www.arlis.am/DocumentView.aspx?DocID=135076)
- Decision of the PSRC No. 374-N "On approving templates of financial statements of the person with the license for wholesale trade in electric energy" dated 09 October 2019 (https://www.arlis.am/DocumentView.aspx?DocID=135061)
- Decision of the PSRC No. 519-N "On approving the model forms of contracts for the electricity retail market of the Republic of Armenia" dated 25 December 2019 (https://www.arlis.am/DocumentView.aspx?DocID=195519)
- Decision of the PSRC No. 518-N "On approving the model form of the electricity wholesale market contract of the Republic of Armenia" dated 25 December 2019 (https://www.arlis.am/DocumentView.aspx?DocID=176259)
- Decision of the PSRC No. 180-N "On the coordination of investment programs in the energy sector, the submission of a report on investments by licensed persons and the approval of the procedure for exercising control over the investment activities of licensed persons in the energy sector" dated 19 May 2021 (https://www.arlis.am/DocumentView.aspx?DocID=195002)

2.4.2 Regulatory framework

2.4.2.1 Licensing

The construction of a solar power plant for industrial use in Armenia requires a license according to the PSRC Decision No. 374-N, dated November 1, 2013. The PSRC issues the license within 25 working days after the submission of the following documents:

- a business plan according to the template provided by the above-mentioned decision,
- a copy of the certificate of state registration verifying the applicant's ownership of the land plot or building needed for the licensed activities,
- public notice posted on the official website of public notices of the Republic of Armenia http://www.azdarar.am/,

- a bank guarantee from any bank operating in Armenia, calculated based on the methodology outlined in the decision.
- a certificate confirming the ability to connect to the electric grid with the required capacity, provided by a licensed distributor or transmission service provider.

According to the PSRC, starting form 1 July 2024, new constructed power plants have in their contracts a provision, according to which if too much electricity is fed into the grid in relation to the quantity consumed, the plant could be disconnect from the grid for a maximum 1080 hours a year. This cases usually could happen in April and September months, when mild weather typically results in reduced electricity demand.

2.4.2.2 Tariffs

The electricity tariffs are set and reviewed by the PSRC. According to the law On Energy, a tariff should be based on:

- justified operational and maintenance costs
- reasonable profit
- justified costs of servicing the loan
- costs related to environmental standards
- preservation costs
- technical and commercial losses
- justified and necessary insurance costs
- costs of the safekeeping of the utilized nuclear fuel and requisite allocations to the Nuclear Plant Decommissioning Fund
- other justified costs provided by the legislation.

The PSRC or the licensee can request a tariff review every six months. However, the PSRC typically conducts tariff reviews on an annual basis. Once a request for review is submitted, the PSRC is required to complete the tariff assessment within 80 working days. For small hydropower plants and other renewable energy facilities, this review period is shortened to 25 working days. For electricity generators participating in the balancing market[37] controlled by the power system operator, the tariff structure has two components (electricity rate and capacity payment); for other generators, a one-part tariff is applied.

Table 11 - Tariffs of major producers and service providers applied from 01 February 2024 (without VAT)

Name organisation	Unit	Tariffs
Armenian Nuclear Power Plant CJSC	AMD/kWh	15.138
International Power Corporation CJSC	AMD/kWh	21.141
Contour Global Hydro Cascade CJSC		
Two-rate tariff system		
Electricity rate	*AMD/kWh*	*6.534*
Monthly payment for capacity	*AMD/kW*	*3,033.48*
One-rate tariff system	AMD/kWh	18.517
ArmPower CJSC		

[37] An energy balancing system is used to maintain the real-time balance between electricity supply and demand across the power grid.

Name organisation	Unit	Tariffs
Two-rate tariff system		
Electricity rate	*AMD/kWh*	*16.960*
Monthly payment for capacity	*AMD/kW*	*4,161.00*
One-rate tariff system	AMD/kWh	29.166
Yerevan Thermal Power Plant CJSC		
Tariff of electricity delivered to the Electric Networks of Armenia CJSC	AMD/kWh	18.536
Minimum balancing tariff	AMD/kWh	15.138
Maximum balancing tariff	AMD/kWh	30.517
Reserve service	AMD/kW/month	279.21
Gazprom Armenia CJSC – Hrazdan 5 station		
Two-rate tariff system		
Electricity rate	*AMD/kWh*	*21.317*
Monthly payment for capacity	*AMD/kW*	*2,906.59*
Hrazdan Energy Company OJSC		
Two-rate tariff system		
Electricity rate	*AMD/kWh*	*30.517*
Monthly payment for capacity	*AMD/kW*	*407.44*
High Voltage Electrical Networks CJSC		
Energy transmission service tariff	*AMD/kWh*	1.6825
Electric Networks of Armenia CJSC		
Tariff for distribution services	*AMD/kWh*	0.2508
Settlement Center CJSC		
Service fee	*AMD/kWh*	0.0715

Source: PSRC, 2024

Based on all these tariffs and payments the end-use tariff is calculated and published by the PSRC. The tariffs depend on the connection voltage. There are currently two main tariffs for each voltage level, a day-time rate and a night-time rate.

Table 12 - Customers electricity tariffs applied by the Electric Networks of Armenia CJSC (effective from 1 February 2022)

Connection voltage	Tariff (VAT included) – AMD/kWh	
	Day-time	Night-time
0.38 kV low-income families (according to the decree of the Government of the RA No. 1122-N dated 3 November 2016)	29.99	19.99
0.38 kV residential consuming up to 200 kWh/month	46.48	36.48
0.38 kV residential consuming from 201 to 400 kWh/month	48.48	38.48
0.38 kV residential consuming more than 400 kWh/month	53.48	43.48

Connection voltage	Tariff (VAT included) – AMD/kWh	
	Day-time	Night-time
0.38 kV consumers (except residential)	53.48	43.48
6 (10) kV consumers	50.48	40.48
35 kV consumers	44.48	40.48
110 kV consumers	41.98	37.98

Source: PSRC, 2024

2.4.2.3 Feed-in tariffs

According to the law On Energy, the PSRC is authorized to set feed-in tariffs for electricity generated by SHPPs and other facilities using renewable sources (solar, wind, biomass). These tariffs ensure the guaranteed purchase of electricity for a period of 15-20 years[38] from the date of the license issuance. The feed-in tariffs are reviewed annually to account for fluctuations in the exchange rate between the Armenian dram and the U.S. dollar as well as changes in inflation. For the period from 1 July 2024 to 30 June 2025, the applicable feed-in tariffs were established by the PSRC's decision on 19 May 2024[39], as outlined in the table below.

Table 13 - Feed-in tariff applied in Armenia as of 1 November 2024[40]

Source of electricity	Feed-in tariff (AMD/kWh without VAT)
Wind power plants that were granted a license up to 1 November 2018	42.148 (EUR 0.1)[41]
Wind power plants with an installed capacity of up to 30 MW that were granted a license after December 31, 2021	16.651 (EUR 0.04)
SHPP built on natural water steams	23.476 (EUR 0.06)
SHPP built on irrigation systems	15.648 (EUR 0.04)
SHPP built on drinking water pipelines	10.432 (EUR 0.03)
Biogas power plants	17.263 (EUR 0.04)
Solar power plants with an installed capacity of up to 1 MW (inclusive) that were granted a license up to 1 November 2018	42.148 (EUR 0.1)
Solar power plants with an installed capacity of up to 5 MW that were granted a license from 2 November 2018 to 31 December 2020	20.707[42] (EUR 0.05)
Solar power plants with an installed capacity of up to 5 MW that were granted a license after 31 December 2020	16.651 (EUR 0.04)
Solar power plants with an installed capacity of up to 1 MW, and where the license is granted to community non-profit organizations or the Renewable Resources and Energy Efficiency Fund of Armenia	18.636 (EUR 0.04)

Source: PSRC, 2024

[38] Article 35 of the Law on Energy of the RA
[39] Decision of the PSRC No. 152-N of 19 May 2024, https://www.arlis.am/DocumentView.aspx?DocID=193373
[40] Approved by the decision of the PSRC No. 152-N of 29 May 2024
[41] Exchange rate: EUR 1 = AMD 420
[42] If certain conditions are met

2.4.2.4 Tax legislation

There is currently no specific tax regulation for the industrial production of solar energy in Armenia. However, according to Article 108 of the Tax Code of Armenia, compensation received by an autonomous energy producer using renewable energy sources from a licensed electricity distributor is not considered taxable income for the purposes of profit tax calculation. Additionally, any remuneration received in the form of electricity for the energy supplied to a licensed transmission operator by an autonomous energy producer is also excluded from the taxable income base.

Double taxation agreement

Armenia has agreements for the avoidance of double taxation and the prevention of fiscal evasion with respect to taxes on income and on capital with 51 countries, including the Kingdom of Netherlands. The agreement with the Netherlands, signed in 2001, covers:

- criteria for determining residency and the persons to whom the agreement applies,
- the types of income to which the agreement is applicable - taxable income categories, such as immobile property income, business profits, dividends, interests, royalties, income from provision of independent personal services, employment income, and more, as specified in the agreement,
- procedures for resolving disputes related to the application of the agreement[43].

Armenian legislation also has provisions on double taxation. According to Article 20 of the Tax Code of Armenia, incomes received or to be received outside the territory of Armenia by resident legal entities and natural persons of Armenia are subject to taxation in accordance with the procedure established by the Tax Code. However, if taxes were collected from the RA resident legal entities and individuals in a foreign state in accordance with the legislation of the given state, then the amount of these taxes paid, but not exceeding the amount of the corresponding taxes calculated at the rate determined by the RA Tax Code for the given type of tax, shall be reduced in accordance with the RA legislation.

Taxes applied in Armenia

The following taxes are applied in Armenia:

- Value added tax (20%) - VAT applies to individuals and entities engaged in economic activities involving:
    - delivery of goods for compensation,
    - provision of services,
    - import of goods under the customs procedure for domestic consumption;
    - import of products from the EEU Member States to Armenia having the status of EEU product.
- Corporate income tax (18%) – Applies to resident entities, and non-resident entities operating through a permanent establishment in Armenia. Taxable income is the difference between a taxpayer’s gross income (all revenues received from all economic activities, unless exempt) and deductible expenses (all necessary and documented expenses, directly related to business activities),
- Income tax (20%) - applies to individuals classified as residents (spending 183+ days in Armenia in a tax year or with vital interests in the country) and non-residents,
- Profit tax (18%) - Profit tax is determined by calculating the taxable profit, which is the positive variance between the total income derived from the sale of goods, services, assets, and other property, minus the deductible expenses as prescribed by law,

[43] https://www.petekamutner.am/Shared/Documents/_ts/_tl/International_Treaties/pm_mh_krknaki_harkum_NLD.zip

- Turnover tax (1.5 – 25%) - Substitutes VAT and profit tax for legal entities and VAT for private entrepreneurs. It is applicable for taxpayers with previous year revenues from the sale of goods and provision of services not exceeding AMD 115 million (around EUR 274 000),
- Dividend tax (5%) applies to cash dividends, bonus shares, or other forms of profit distribution received by individuals or entities from both resident and non-resident companies. Income tax on dividends is refundable if the dividends are reinvested in the same resident company in the same tax year they are received.
- Other taxes, which include property tax (0.05% - 1.5%), excise tax (alcoholic products, cigarettes and fuel), road tax, environmental tax, property tax for vehicles[44].

2.4.2.5 Import

No significant issues have been identified regarding the import of equipment and materials essential for photovoltaic power station installations in Armenia. Approximately 99% of photovoltaic panels are sourced from China. According to import statistics published by INTRACEN and the Armenian Statistical Committee, Armenia imported photovoltaic panels worth USD 34.97 million in 2023, with USD 34.53 million sourced from China.

As a member of the Eurasian Economic Union, Armenia benefits from unified customs duties across the union. As of January 1, 2024, photovoltaic cells assembled in modules or panels (HS 854143) are exempt from customs duties when imported into Armenia.

Additionally, according to Government Decree No. 1118-N of 2015, imports of technological equipment, components, and raw materials (including those purchased through leasing) under investment programs in priority sectors, such as the energy sector, are exempt from customs duties. This exemption applies if the equipment or materials are not produced in the EAEU countries, or if the products produced in the EAEU do not meet the technical requirements of the investment program.

2.4.3 Policy direction

As Armenia relies heavily on hydrocarbon imports to meet its energy needs, the country's energy policy is centred around enhancing energy independence, improving energy security, and promoting the sustainable development of the sector. This strategy is based on the efficient use of local renewable energy resources, further expansion of the nuclear energy sector, diversification of energy supply sources, regional integration, and the adoption of energy-efficient technologies. These guiding principles were outlined in the National Energy Security Concept, adopted by the President of Armenia in 2013.[45] Particularly according to this concept, the key directions for strengthening energy security include:

- developing a comprehensive energy security system,
- efficient use of renewable energy resources and promoting energy-saving measures,
- expanding the role of nuclear power in ensuring energy supply,
- diversifying energy supply sources and enhancing regional integration of the electric power system.

[44] https://www.arlis.am/DocumentView.aspx?DocID=201478
[45] https://www.arlis.am/DocumentView.aspx?DocID=86169

On 14 January 2021 the Government of Armenia adopted Energy Sector Development Strategic Programme to 2040 and the relevant Action Plan to ensure implementation of the strategic program[46]. According to this strategic program the vision of the Government is to have an energy sector that is:

- free, competitive and non-discriminatory,
- inclusive and diversified with the energy independence at the highest level,
- clean and energy efficient: sustainable developing,
- of regional significance,
- reliable and safe,
- digitized and innovated, science-based, high technological,
- foreseeable and transparent,
- accessible and fair to everyone, sufficiently available to the vulnerable group, as well as attractive to investors.

The strategic document also defines five priority directives for the energy sector development:

Maximum use of renewable energy potential	"**Considering the available domestic resources and development tendencies of this technology throughout the world, the construction of solar power plants, will prevail over the rest of types, given the limitations of the system reliability and safety indicators**."[47] The Government of Armenia has set ambitious targets to increase the share of renewable energy in the country's power generation mix to 60% by 2040, focusing on small hydropower, wind, and solar photovoltaic resources. One of the key objectives is to raise solar power generation to at least 15% of the total mix by 2030, equivalent to around 1.8 billion kWh. To achieve this, Armenia plans to construct solar power plants with a total installed capacity of 1,000 MW, which includes both grid-connected and autonomous plants. Additionally, market mechanisms will be introduced to encourage the construction of energy storage facilities alongside these plants. From 2030 to 2040, an additional 500 MW of solar power plants are expected to be built, also in conjunction with storage solutions. Regarding wind power, the government aims to develop small and system-scale wind power plants with a total capacity of up to 500 MW between 2025 and 2040, provided that the electricity generated is competitively priced. In total, the government plans to increase the capacity of solar and wind power plants to at least 2,000 MW by 2040. As a result, the share of electricity produced from renewable energy sources in gross final electricity consumption, including large hydropower plants, will reach about 50% in 2030 and about 60% in 2040.
Realization of energy-saving potential	The Armenian government prioritizes energy saving across all economic sectors, as outlined in the Law on "**Energy Saving and Renewable Energy**" and the **National Program on Energy Saving and Renewable Energy**. In line with this policy, Armenia is working to

[46] https://www.arlis.am/DocumentView.aspx?DocID=184421
[47] Energy Sector Development Strategic Program to 2040, https://www.arlis.am/DocumentView.aspx?DocID=184421

	enhance its energy efficiency regulations, aligning them with national strategies and international commitments. A key aspect of this effort is Armenia's obligation under CEPA, which requires the country to harmonize its legislation with 65 EU directives, regulations, and guidelines that promote energy efficiency. This process is expected to be completed by 2025. In 2022, the government adopted the **National Program on Energy Saving and Renewable Energy 2022-2030**[48], which aims to improve energy efficiency across the economy over the next decade. The program focuses on promoting energy saving and expanding the use of renewable energy sources, contributing to greater energy security, reliability, and environmental protection. The program emphasizes three key sectors, which together account for the majority of final energy consumption: 1) households, 2) transport, 3) public schools. By targeting these areas, Armenia aims to achieve significant improvements in energy saving and efficiency, which will also support the country's broader sustainability goals.
Life extension of the ANPP Unit 2	The government will stay committed to the policy to maintain nuclear power plant in the country's generation mix. In this context the government intends to operate it at least until 2036 if it is well justified.
North- South Road Corridor construction program	This program provides an opportunity to Armenia to be a bridge for being engaged into the more global electricity markets as well as for using opportunities of mutually beneficial electricity trade with Iran and Georgia.
Gradual liberalization of the electricity market	The government started preparing for the market liberalization in 2018, by implementing several amendments to the law On Energy. It also adopted the "Programme-timeline of measures towards liberalisation and interstate trade development of the electricity system" in 2018 and new rules for both the wholesale and retail markets in 2019. These included network rules for transmission and distribution, sample contract forms, and indicators for safety and reliability (PSRC decisions 516-N, 517-N and 523-N). In February 2022 the electricity market was unbundled, opening up generation and retail sectors to private participation. However, this is still the first step of liberalization, and as it is mentioned in the energy sector development strategic paper, Armenia "*will transit to a new liberalized model in the coming years which will still be a subject to limited competition but will have precise milestones towards the full liberalization given the creation process of EAEU Common energy market and the EU Comprehensive and Enhanced Partnership Agreement.*" As part of the second stage of sector reforms, the government plans to develop a new law On Energy that will take into account the requirements of relevant EU directives under the CEPA agreement, as well as international models for introducing greater competition.

[48] https://www.arlis.am/DocumentView.aspx?DocID=187739

2.5 SUPPORT PROGRAMS

2.5.1 State support programmes

Energy-efficient renovation of apartments and individual residential buildings

This program supports citizens who have taken loans from approved financial institutions (listed in Annex 3) for energy-efficient renovations of apartments and residential buildings. According to the Government Decision No. 520-L, dated April 15, 2022[49], the government subsidizes interest rates on these loans for their entire term, up to a maximum of seven years. Eligible renovations include improvements utilizing alternative energy sources.

The subsidy applies if the loan is in Armenian dram, has a term of no more than 84 months, and does not exceed AMD 7 million (EUR 16,667) for apartments or AMD 10 million (EUR 23,810) for residential buildings. Subsidy rates are determined by the location of the residence:

- bordering or highly mountainous areas - 14%
- rural areas (non-bordering) - 12%
- urban areas (non-bordering) - 11%
- Yerevan: 9%

According to the Ministry of Territorial Administration and Infrastructure 7,638 citizens benefited from this support program in 2023.

Productivity promotion program

The goal of the program is to modernize production capabilities and encourage the adoption of new technologies in Armenia, which will enhance the competitiveness of manufactured goods and services and boost labour productivity. The energy sector is identified as one of the priority sectors under this initiative. Support for entrepreneurs is provided in the form of **subsidized interest rates** on targeted loans or leasing agreements obtained through banks or credit organizations that are licensed and operate within Armenia. This financial assistance aims to facilitate the modernization of businesses and promote innovation in key sectors.

Support under the program is provided for the following activities:

- purchase or import of new machinery, equipment and their parts,
- implementation of capital construction works,
- digitalization of business processes,
- involvement of advisory services and consultants.

To become a beneficiary of the support program, the following conditions must be met:

- **Loan/leasing currency**: the loan or leasing should be provided in AMD or foreign currency.
- **Loan/leasing term:** the term should be up to 120 months (10 years).
- **Subsidizing period:** support is provided for a period of up to 42 months (3.5 years).
- **Grace period:** a 6-month grace period is offered before repayment begins.

The maximum subsidy amounts under the support program are as follows:

- **purchase of machinery and their parts:** up to AMD 1 billion or its equivalent in foreign currency (calculated at the exchange rate at the time of signing the contract).

[49] https://www.arlis.am/DocumentView.aspx?DocID=190021

- **capital construction:** up to 30% of the amount spent on the purchased machinery and equipment.
- **software for digitalization of business processes and productivity consulting:** up to AMD 400 million or its equivalent in foreign currency (calculated at the exchange rate at the time of signing the contract).

According to the program, the amounts of subsidies for loans/leasing are as follows:

Purpose	Amount of subsidy (AMD)	Amount of subsidy (foreign currency)
Loan for machinery/equipment and their parts	8%	6%
Leasing for machinery/equipment and their parts	10%	8%
Loan for capital construction	8%	6%
Leasing for capital construction	10%	8%
Loan for the software for digitalization of business processes Loan for productivity consulting	8%	6%
Leasing for the software for digitalization of business processes Leasing for productivity consulting	10%	8%

Programme on state compensations of monthly salary for organizations attracting highly qualified specialists

According to the program, commercial and non-commercial organizations, including higher education institutions, can benefit from state compensation covering **20% to 70% of the monthly salaries** of highly qualified specialists they hire. The support program outlines specific criteria for eligibility, focusing on the academic qualifications and professional experience of the specialists. This state support initiative will remain in effect until December 31, 2025.

To apply for the state support program, the employer must hire a highly qualified specialist who has lived outside the Republic of Armenia for a cumulative period of 12 months during the 30 months prior to the organization's application. Additionally, the specialist must meet at least one of the following criteria:

- **Graduation from a Top University**: The specialist must have graduated from one of the 400 leading universities listed in the QS World University Rankings[50], published in the year of application for participation in the program. The degree obtained can be a bachelor's, master's, doctorate, or another equivalent higher education qualification recognized in the respective country, and/or
- **Experience in Leading Companies**: The specialist must have at least 10 years of experience working in any of the world's leading companies included in the following rankings or indices: Forbes[51], Fortune[52], HeadHunter[53], NIFTY[54], Dow Jones[55], FTSE[56], S&P[57], SSE Composite[58],

[50] https://www.topuniversities.com/world-university-rankings
[51] https://www.forbes.com/lists/global2000/?sh=64259d485ac0
[52] https://fortune.com/global500/
[53] https://www.huntedhead.com/2012/04/20/headhunter-top-15-worldwide/index.html
[54] https://en.wikipedia.org/wiki/NIFTY_50#Index_changes
[55] https://www.cnbc.com/dow-30/
[56] https://www.londonstockexchange.com/indices/ftse-100/constituents/table
[57] https://www.slickcharts.com/sp500
[58] http://english.sse.com.cn/markets/indices/data/list/constituents/index.shtml?COMPANY_CODE=000001&INDEX_Code=000001

SZSE[59], KOSPI[60], KOSDAQ[61], BSE SENSEX[62], NSE of India[63], BOVESPA[64], IBrX[65], ITEL, Nikkei[66], TOPIX[67], DAX[68], MDAX[69], MOEX Russia[70].

The following is the defined scale for state reimbursements:

Employer	Criteria	Reimbursement
LLC, CJSC, OJSC, University, Scientific or Research Institution, NGO, Foundation	Bachelor's or Master's degree from top 400 (no PhD from any university)	20% of the salary on the monthly basis, not more than AMD 1 mln.
	10+ years of work experience (no PhD from any University)	
LLC, CJSC, OJSC, University, Scientific or Research Institution, NGO, Foundation	Bachelor's or Master's degree from top 400, as well as PhD from any university	50% of the salary on the monthly basis, not more than AMD 1.5 mln.
	PhD from Top 400 universities	
	10+ years of work experience, as well as PhD from any university	
LLC, CJSC, OJSC Scientific or Research Institution, NGO, Foundation & University	Bachelor's or Master's degree from pop 400, as well as PhD from any university who teaches at Armenian university and at the same time works for a different works in an Armenian organization/company	50% of the salary on the monthly basis, but not more than AMD 1.5 mln. for other organization / company, 70% of the salary on the monthly basis, but not more than AMD 2 mln. to university
	PhD from Top 400 University who both work at an Armenian Organization/Company and teaches at university	
	10+ years of work experience, as well as PhD from any university who teaches at Armenian university and at the same time works for a different works in an Armenian Organization/company	

Support program for commercial companies engaged in the production of economically complex products

The primary goal of this program is to promote the production of economically complex products in Armenia. The list of eligible products, including those under HS code 8541[71], is approved by the

[59] https://www.szse.cn/English/
[60] https://topforeignstocks.com/indices/the-components-of-the-korea-stock-exchange-kospi-index/
[61] https://www.investing.com/indices/kosdaq-100-components
[62] https://www.bseindia.com/markets/equity/EQReports/TopMarketCapitalization.aspx
[63] https://www.nseindia.com/regulations/listing-compliance/nse-market-capitalisation-all-companies
[64] https://tradingeconomics.com/brazil/stock-market
[65] https://www.b3.com.br/en_us/market-data-and-indices/indices/broad-indices/indice-brasil-100-ibrx-100-composition-index-portfolio.htm
[66] https://indexes.nikkei.co.jp/en/nkave/index/component
[67] https://markets.businessinsider.com/index/components/topix-500
[68] https://markets.businessinsider.com/index/components/dax
[69] https://markets.businessinsider.com/index/components/mdax
[70] https://www.moex.com/en/
[71] HS 8541 - Semiconductor devices "e.g. diodes, transistors, semiconductor-based transducers"; photosensitive semiconductor devices, incl. photovoltaic cells whether or not assembled in modules or made up into panels (excl. photovoltaic generators); light emitting diodes "LED", whether or not assembled with other light-emitting diodes "LED"; mounted piezoelectric crystals; parts thereof

Minister of Economy[72]. To qualify for support under this program, commercial companies must meet the following criteria:

- the company must have paid all taxes and no administrative proceedings for collection of taxes should have been initiated against it within 365 days preceding application date,
- the company should not be involved in bankruptcy proceedings as a debtor and no bankruptcy petition should have been filed against it,
- the investment program must involve capital investments of at least AMD 1 billion (around EUR 2.4 million), fully directed toward the creation or expansion of the production of economically complex products and, with the exception of the case of provision of start-up support, the following criteria must be met:
    - the annual turnover from the sale of economically complex products must account for at least 30% of the company's total turnover and should not be less than the share of turnover from such products in the year preceding the start of production,
    - at least 30% of the company's annual turnover should be generated from sales in foreign markets.

The support is provided in three stages:

- Start-up support: equal to 10% of capital investments, provided after the start of production of economically complex products,
- One-time support: equal to 5% of the real value of assets created as a result of capital investments under the investment program.
- Ongoing support: equal to 20% of capital investments, with the maximum annual amount being the sum of 100% of profit tax and 50% of income tax paid by the company to the state budget.

The total support provided throughout the entire investment program can amount to up to 35% of the real value of assets created through the capital investments made by the company[73].

2.5.2 Donor support programs

Several donors are currently implementing programs and projects aimed at enhancing energy efficiency, promoting the use of renewable energy sources, and conducting climate adaptation activities in Armenia. While some of these initiatives focus on improving energy efficiency in buildings or communities - thereby indirectly supporting the adoption of solar and other renewable energy sources - others specifically promote the installation of autonomous photovoltaic stations. Below is a non-comprehensive list of these programs and projects:

[72] The list of economically complex products approved by the Minister of Economy of the RA is available here https://mineconomy.am/media/31380/Hraman.%20%20N%202432-%D4%BC.pdf

[73] https://arlis.am/DocumentView.aspx?DocID=184507

Program title	Short description
Enabling the Energy Transition project for Armenia[74] (World Bank)	In June 2024, the World Bank Group approved a USD 40 million project aimed at supporting the implementation of the Energy Sector Development Strategy to 2040. One of the key objectives of the project is to facilitate the integration of increased renewable energy capacity into Armenia's power transmission grid. This includes investments in substation rehabilitation and reforms designed to enhance the grid's readiness to accommodate variable renewable energy sources while ensuring the security and reliability of the electricity supply. The rehabilitation works will encompass several components, including the upgrade of existing switchyards, the replacement of transformers, batteries, lubricants, and protection relays, as well as civil works for renovating control buildings. These investments are expected to improve network stability and efficiency.
Sustainable energies for climate resilient municipal development in Armenia (SE4Resilience)[75]	This four-year project, with a budget of EUR 12.3 million, is financed by the European Union (EUR 6.2 million) and the Ministry for Economic Cooperation and Development (BMZ) (EUR 6.1 million). The objective of the project is to use renewable energy to provide an affordable, reliable, and environmentally friendly energy supply to social institutions, small and medium-sized businesses, and vulnerable households. The project aims to expand the adoption of energy-efficient and sustainable energy solutions within households and public buildings in rural communities located in the Tavush, Shirak, Gegharkunik, and Syunik regions of Armenia. Key components of the project include: • Creating conditions that facilitate the use of renewable energies and promote energy efficiency in municipalities. • Enhancing the capabilities of municipal administrations in implementing renewable energy and energy efficiency solutions. • Supporting skills development for citizens in the utilization of renewable energy and energy-efficient practices.
Decarbonisation and Climate Resilience in the Eastern Partnership (EU4ClimateResilience)	The multi-donor action with the total budget of EUR 19,583,849 is jointly co-financed by the European Union and the Federal Ministry for the Environment, Nuclear Safety and Consumer Protection (BMUV), and implemented by GIZ and OECD. This initiative supports the green transition, enhances decarbonization, boosts energy security, and increases climate resilience in the EaP countries.

[74] https://documents.worldbank.org/pt/publication/documents-reports/documentdetail/099051024102058477/bosib1a112d9ac023187bf193a9ff6e34c9
[75] https://www.giz.de/en/worldwide/141479.html

Program title	Short description
Promoting Green Deal Readiness in the Eastern Partnership Countries (PROGRESS)	Funded by the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety, and Consumer Protection and implemented by a GIZ-led consortium, this 4.5-year project supports Eastern Partnership countries in their transition to climate-oriented, resilient, and green economic development. It aims to transform selected agricultural and related industrial food value chains by promoting innovative technologies, tools, and methodologies that enhance sustainability, climate resilience, and long-term greenhouse gas (GHG) mitigation. As part of its interventions, the project may promote the construction of photovoltaic stations for agro-processing companies, with agrivoltaics identified as a potential intervention direction in Armenia. Two value chains in Armenia have been selected for further interventions within the project's scope: apricot and raspberry.
Recovery, resilience, development for Syunik (R2D SYUNIK)	The 11mln project is implemented within the Resilient Syunik Team Europe initiative in cooperation with local governments and co-financed by the European Union and Austrian Development Cooperation. The main objective of the project is to enhance recovery and resilience of micro, small and medium enterprises and sustainable small-scale communal infrastructure in Syunik region of Armenia. One of the components of this five-year project (implemented by the Austrian Development Agency) is improve the availability of sustainable, green community infrastructures in the Syunik region. This component foresees identification and renovation of sustainable and green community infrastructures. This includes infrastructures that help improve the environmental conditions of communities and contribute to the protection or sustainable use of natural resources, with a focus on climate protection.
Strengthening Research in Armenia for Energy Transition toward Climate Solutions[76]	This 36-month project (June 2024 to May 2027), funded by the EU Horizon Europe program, is implemented by a consortium led by the American University of Armenia Acopian Center for the Environment, along with six other partners from Armenia, Ireland, and Italy. The primary goal of the project is to "enhance Armenia's research capacity to support the country's efforts to accelerate its energy transition toward clean and renewable energy while enhancing its energy security". Additionally, the project aims to facilitate Armenia's integration into the European Research Area.

[76] https://ace.aua.am/projects/streacs/

Program title	Short description
German Armenian Fund – expansion of renewables and energy efficiency	The Central Bank of Armenia has partnered with the German Kreditanstalt für Wiederaufbau (KfW) to promote renewable energy in Armenia by improving access to loans for private investors in the renewable energy sector. The German Armenian Fund (GAF), established within the Central Bank of Armenia, provides funding to Armenian commercial banks, enabling them to offer loans for investments in renewable energy and energy efficiency measures. This arrangement allows local commercial banks to extend sub-loans on more favourable terms. To date, KfW has financed energy efficiency projects for SMEs with €35 million and supported the use of renewable energy with €136 million through the GAF. The current focus is primarily on photovoltaic systems. Over 2,000 loans have been granted for the installation of small solar panels in households, resulting in a combined capacity of 45 MW. Additionally, further photovoltaic power plants, each with a capacity of 5 MW, have been constructed with KfW-financed loans, contributing to a total capacity of 120 MW.
Energy Secure Armenia Activity (USAID)	The five-year project, started in 2022 (implemented by Tetra Tech), will support Armenia's efforts to increase cyber protection of the Electricity Market Operator, Electricity System Operator, and other energy entities; maintain cybersecurity and facilitate swift recovery from cyber-attacks; ensure continued functionality of the electricity market and integration of renewables into the system due to potential cyber-attacks. It will also support the development of cybersecurity operational policies and regulations, supports solutions for identified cybersecurity risks based on best practices for electricity market operations, helps to develop minimum cybersecurity requirements aligned with ISO 27001, ISO 27002, and ISO 27036-2 or other security standards, provides critical software along with respective training, and enhance staff skills in addressing cybersecurity issues[77]. Through this activity Tetra Tech will work with the Armenian government and the private sector to promote expanded energy and electricity options for consumers, and to advance renewable energy generation and energy efficiency initiatives to strengthen energy security for all Armenians[78].
European Bank for Reconstruction and Development (EBRD)[79]	EBRD's Green Economy Finance Facility (GEFF) is a framework designed to support businesses in their green transition journey and in investing in climate-adaptation and mitigation technologies. These technologies also help businesses to enhance their productivity and reduce costs. Through GEFF EBRD provides loans to several Armenian banks (ACBA leasing, ArmSwissBank, Inecobank, Ameria bank) to support businesses in Armenia by investing in green technologies. Possible investments include technologies that boost

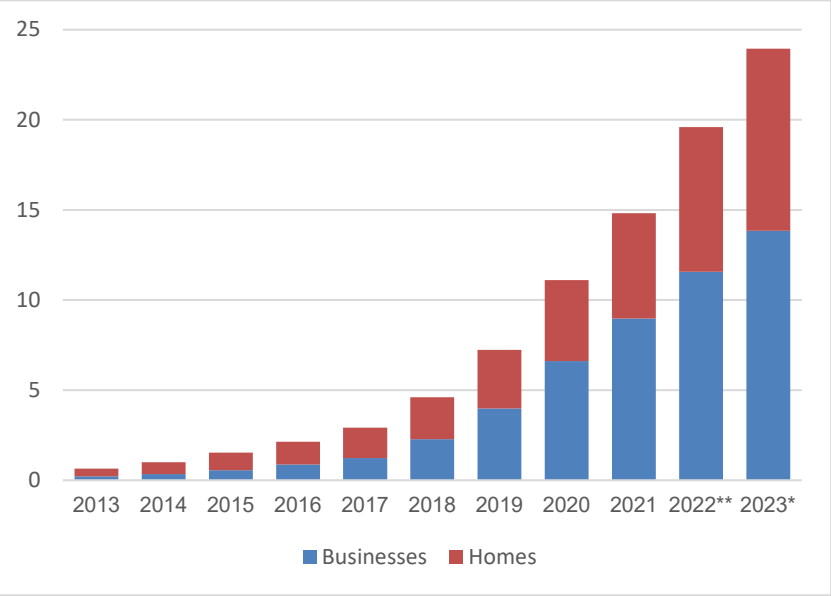
[77] https://www.highergov.com/contract-opportunity/energy-secure-armenia-activity-72011122f00001-u-7c4ad/
[78] https://www.linkedin.com/feed/update/urn:li:activity:6955513829548011520/
[79] https://ebrdgeff.com/armenia/financing/

Program title	Short description
	the sustainable use of energy and water resources such as thermal insulation, photovoltaic solar panels, geothermal heat pumps, electric vehicles, electric-vehicle-charging infrastructure and water-efficient irrigation systems.
Green for Growth Fund (GGF)[80]	Initiated by the European Investment Bank and KfW Development Bank, with risk capital from the European Commission and the German Federal Ministry for Economic Cooperation and Development the GGF is an investment fund that mitigates climate change and promotes sustainable economic growth, primarily by investing in measures that reduce energy consumption, resource use and CO_2 emissions. The fund provides financing to businesses and households through local financial institutions, and through direct investments to eligible projects and companies.
European Investment Bank (EIB) Loans for SMEs[81]	Implemented by the Central Bank of Armenia this program seeks to maximise the environmental benefits and to minimise the environmental costs of the projects financed. The loan supports the Armenian SMEs operating in agricultural production, agro-processing and tourism sectors to develop environmentally friendly and socially responsible businesses. EIB sub-loans are disbursed by financial institutions

2.6 Competition Potential, Existing Gaps and Challenges

2.6.1 Solar energy in the Netherlands

Figure 15 - Total installed solar panel capacity in the Netherlands (gigawatt)



Source: Statistics Netherlands
**Provisional figures*
***More detailed provisional figures*

Despite its small size and location, the Netherlands is one of the world's leaders in solar energy adoption. According to Statistics Netherlands (Centraal Bureau voor de Statistiek), the cumulative installed solar capacity reached 23.9 gigawatts in 2023. In that year alone, installed solar capacity increased by 4.3 gigawatts compared to 2022.

In 2023, homes with solar panels contributed approximately 10.1 gigawatts of power - an increase of 25 percent from the previous year's 8 gigawatts - accounting for just over 42 percent of total solar power capacity. Businesses with

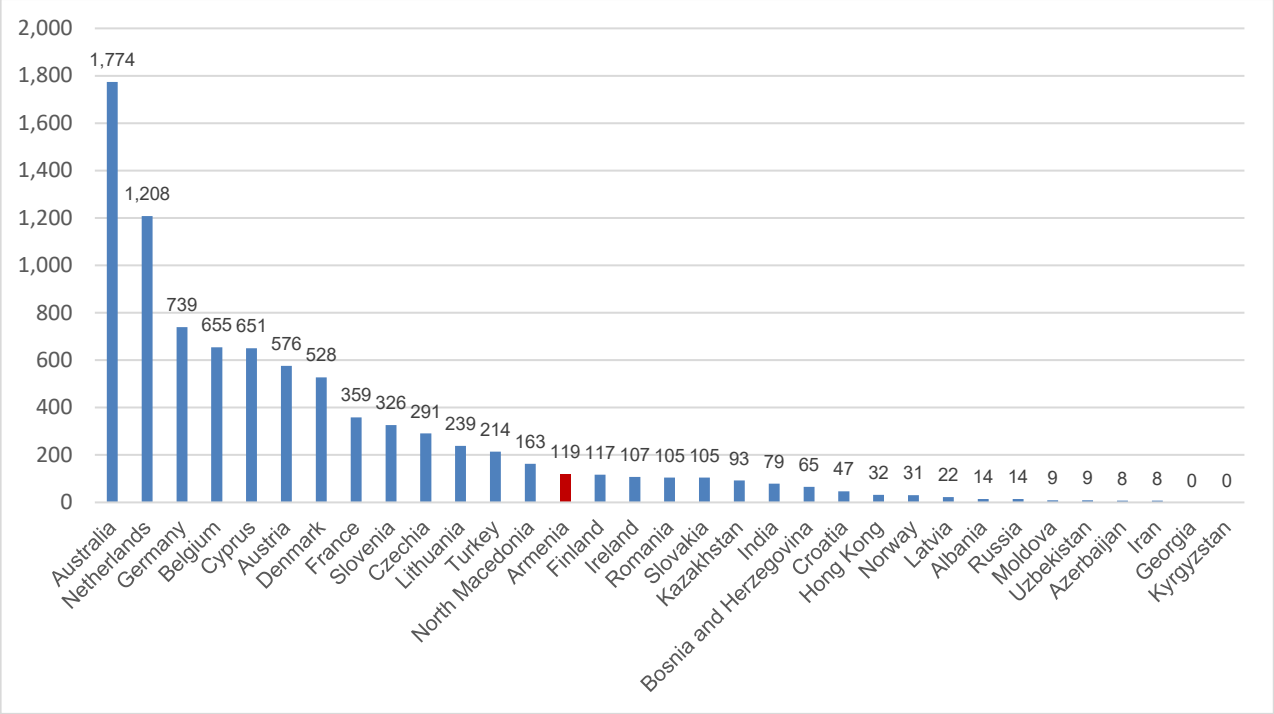
[80] https://www.ggf.lu/
[81] http://www.eib4sme.gaf.am/index51dd.html?option=com_quix&view=page&id=1&Itemid=724&lang=en

solar panels supplied the remaining 58 percent, with their installed capacity rising nearly 20 percent compared to 2022.

In 2023, solar panels generated nearly 20,000 gigawatt hours of electricity in the Netherlands - roughly equivalent to the total electricity consumption of all Dutch households and nearly 17 percent of the country's total net electricity production[82]. According to Dutch New Energy Research, the Netherlands could reach an installed PV capacity of 59 GW by 2030 and 98 GW by 2035[83]. Currently, solar energy contributes approximately 16.6 percent of the Netherlands' electricity generation, significantly exceeding the global average of 5.5 percent.

While Germany holds the highest overall capacity for solar power generation in Europe, the Netherlands leads in solar energy generation per capita. In 2023, the Netherlands ranked as the world's second-largest producer of solar energy per capita, generating 1,208 kilowatt hours per person - surpassed only by Australia, which produced 1,810 kilowatt hours per person[84]. This is nearly three times the EU average of 317 kWh per person and ten times higher than the per capita solar generation in Armenia.

Figure 16 - Solar energy generation per person, kWh, 2023



Source: https://ourworldindata.org/grapher/solar-electricity-per-capita?tab=table

Despite its relatively modest sunlight, the Netherlands has for decades been a global leader in both fundamental and applied solar research. Dutch innovators were among the first to establish fully functional solar energy systems and hold key patents that continue to be widely used by international manufacturers. The Netherlands is home to a vibrant ecosystem of companies and research institutes that covers virtually the entire solar technology chain: from materials and device design to manufacturing equipment, software, advanced solar modules, and full-scale project development.

[82] https://www.cbs.nl/en-gb/news/2024/25/power-from-solar-panels-increased-slightly-in-2023
[83] https://www.pv-magazine.com/2024/03/25/dutch-pv-additions-hit-4-82-gw-in-2023/
[84] https://www.statista.com/statistics/1475022/solar-electricity-generation-per-person-leading-countries-worldwide/

The success of the Dutch solar sector is largely attributed to strong partnerships and collaboration among the Dutch government, private companies, and research institutions. Through such cooperation, the Dutch solar sector became more competitive, with a focus on enhancing production efficiency and improving both the yield and lifespan of solar technologies. The sector's joint innovation agenda aims to reduce manufacturing costs of solar panels and thin films by 50% by 2030, boost efficiency by at least 25%, and extend the average lifespan of solar systems by at least 10 years.

Dutch researchers and companies are leaders in pioneering technologies that increase solar cell efficiency, with specialized expertise in thin-film photovoltaics. Additionally, efforts are focused on optimizing production processes by increasing output, reducing waste, and minimizing the cost of solar cells. Dutch enterprises are at the forefront of integrating solar technology into infrastructure, buildings, vehicles, and agricultural settings, as well as developing floating solar farms suited for increasingly complex environments.

Awareness of Dutch expertise and technology in solar energy remains low in Armenia. Discussions with Armenian solar energy companies revealed that most are unfamiliar with the advancements and innovations of the Dutch solar sector. Although a Dutch firm is involved in constructing the Masrik-1 solar power plant, its presence and visibility in Armenia are limited. Dutch companies currently do not maintain offices in Armenia, and sector-specific Dutch products and equipment are scarce in the Armenian market. Several reasons were identified by local industry stakeholders: the higher cost of European products, which has led Armenian construction companies to prioritize Chinese suppliers; well-established partnerships with Chinese manufacturers; and limited access to information on Dutch offerings in Armenia.

A similar situation is observed in the neighbouring country, Georgia, where market data analysis and communication with the embassy of the Netherlands in Georgia did not identify any Dutch investments in the solar energy sub-sector.

Given the Netherlands' leadership in solar energy innovation, the expertise of Fotowatio Renewable Ventures B.V., and Armenia's commitment to expanding its renewable energy capacity, there is significant potential for future Dutch investments in Armenia's solar energy sector. Such collaborations could harness Dutch technological advancements and industry experience to accelerate Armenia's transition to renewable energy.

2.6.2 Competition analysis

Armenia has made substantial progress in its solar energy sub-sector, particularly since 2016, driven by government-led regulatory reforms, tax incentives, and supportive financial initiatives. This growth is supported by Armenia's abundance of solar resources, favourable climate and continuously improving regulatory framework. In 2022 the government liberalized the market, allowing new solar plants to operate without guaranteed purchase agreements, thus fostering competition, operational efficiency and cost-effectiveness.

The solar energy market in Armenia comprises mainly local companies offering end-to-end services, including feasibility studies, design, installation, and construction of solar plants. Most of small and medium players are focused on the rooftop and small-scale installations, while larger companies operate at an industrial level. The market is open to imports from all over the world, with China leading the supply of key components such as PV panels and inverters.

Foreign investment is also actively encouraged which is proved with the projects Masrik-1 solar power station constructed by a Dutch-led consortium and planned Ayg-1 station by Masdar company. The involvement of international players has contributed to the transfer of technology and knowledge, leading to establishment of companies focusing on solar panel component assembly. This expertise supports both local installations and export of services to neighbouring countries. There is a growing interest in energy storage solutions and hybrid solar installations (e.g., solar with on-grid/off-grid capability) in agriculture sector, which can improve grid stability and increase solar usage during peak demand.

Armenia's solar energy sub-sector has a capacity to continue expansion, driven by decreasing costs, favourable regulatory framework and policy support, increasing local expertise and capacity. However continued growth depends on addressing the existing weaknesses, such as reliance on import of components from one source and limited storage capacity for generated energy. As Armenia looks for integration into regional energy markets and attracts additional foreign investments, advancements in these areas could strengthen its position as a competitive player in the renewable energy landscape of the world.

2.6.3 Gaps and challenges in the solar energy sub-sector in Armenia. Innovations and their demand

Several gaps and challenges have been identified in the energy sub-sector of Armenia. These can be broadly categorized as follows:

- ***Infrastructure***: One key challenge impacting the solar sub-sector is the capacity of the electric network to incorporate renewable energy sources. With the increase in renewable production, which can vary greatly depending on the weather, network stream becomes complex. Effective integration of solar power requires holistic policy frameworks and system-wide planning. Key solutions to these infrastructure challenges include:
    - *grid modernization and expansion*: expanding and modernizing grid infrastructure to handle fluctuating renewable outputs and increase storage capacity is critical. Additionally, a robust transmission network to neighbouring countries, such as Georgia and Iran, could reduce bottlenecks and increase export capacity.
    - *storage capacity*: improving storage capacity is a valuable approach to overcoming infrastructure-related challenges. Expanding energy storage solutions can help balance the grid by storing surplus solar power generated during peak sunlight hours and releasing it when demand is higher or production is lower, such as at night or on cloudy days. In the global market there is widening policy support for energy storage, including the G7 agreeing to contribute to a global target of 1 500 GW of installed capacity by 2030, a sixfold increase from the level in 2023, with the aim of strengthening energy security and helping to integrate rising shares of renewables[85].
- ***Legal:*** the regulatory framework for small-scale solar installations (especially residential) includes gaps in technical oversight, which leads to:
    - *shortage of supervision specialists*: construction firms, involved in installation of solar power plants within the framework of donor projects, apply to the R2E2 Fund for impartial technical oversight. The absence of a standardized, independent technical review process affects customer confidence and project quality.
    - *lack of national standards*: Armenia lacks a national solar power design standard, resulting in diverse materials, costs (from EUR 400 to EUR 800-900 per kilowatt), and quality levels for solar installations. This disparity can cause the lifecycle of solar

[85] World Energy Outlook 2024, IEA

systems to fall below the expected 15-20 years. Establishing national standards would support consistency and long-term reliability in the sector.

- ***Agrovoltaic***: Agrivoltaics, combining agriculture with solar energy generation, has theoretical potential in Armenia but faces regulatory and practical constraints:
    - *land classification change*: according to the Armenian legislation, there is no land unsuitable for agriculture. Any land can be converted into agricultural land and used for agricultural purposes by doing relevant melioration activities. As a result, it is difficult to reclassify agricultural land for other purposes, thus complicating potential agrovoltaic projects.
    - *soil impact*: high temperatures under PV panels could degrade soil quality. Testing and piloting agrovoltaic models that mitigate soil damage are essential before wide-scale adoption.
    - *environmental impact and disposal*: after the end of the power station's life, there is no guarantee that it can be properly dismantled and installed with appropriate structures without harming the environment.
- ***Environmental concerns***: As solar deployment expands, environmental impacts from decommissioning and panel recycling have emerged as issues. Certain pollutants may be emitted during end-of-life disposal. Some PV panels contain heavy metals that may require specialized disposal. PV panels require washing and water consumption could be higher depending on the size and location of solar power stations. The amount of water required also varies depending on the applied cleaning technologies. Developing Armenia's first solar PV waste management strategy would address potential risks and align with sustainability goals.
- ***Financial accessibility:*** The cost of constructing industrial-scale solar plants remains high, and current lending rates (12-14%) create barriers for companies seeking financing. While donor-supported subsidies for small-scale installations exist, large-scale projects face high upfront costs. Expanding affordable financing options, like low-interest loans or guarantees, would support wider industrial adoption of solar.
- ***Energy efficiency challenges***: The intersection of energy efficiency and solar usage reveals several additional gaps:
    - *low awareness:* limited public, commercial, and governmental awareness of energy efficiency and energy-saving technologies limits adoption. Promoting information dissemination on the benefits and methods of energy efficiency could bridge this gap.
    - *residential sector challenges*: in multi-apartment buildings, the absence of auditors or experts to evaluate energy needs hampers efficiency planning. Additionally, renovating old Soviet-era buildings to modern energy standards would require significant investment and technical support.

Armenian companies try to follow all innovations in the solar PV system and introduce them in Armenia. The country is ready for other sub-sector related innovation which can be grouped as follows:

- ***Energy storage and hybrid systems***: as Armenia plans to maximize solar generation, demand is growing for ON-grid and OFF-grid energy storage solutions. By improving grid stability and extending energy access, storage technologies are essential to address peak-hour energy needs and variable supply.
- ***Agrivoltaics***: given limited agricultural land, Armenia could benefit from agrovoltaic systems. This dual-use approach demands innovations to counter challenges such as heat management and soil health preservation.
- ***Solar PV recycling technologies***: As the sub-sector grows the country will need to invest and get innovations in PV recycling and disposal methods, particularly for heavy-metal-based PV technologies, to prevent environmental contamination and facilitate resource recovery.

3 CONCLUSION AND RECOMMENDATIONS

3.1 CONCLUSIONS

Conclusion 1. Geographical location

Armenia's strategic location at the crossroads of Europe and Asia provides substantial potential for the utilization of renewable energy resources. With favourable climatic conditions, the country benefits from an average annual solar energy flow of 1,720 kWh per square meter on a horizontal surface, exceeding averages in the Netherlands and across Europe. Additionally, Armenia experiences rare climate extremes and has wind speeds in specific regions that could support the development of the wind energy sub-sector. The significant part of the country is located at the attitude higher than 1,000 meter above sea level, which further optimizes conditions for the installation and maintenance of solar power plants.

Analysis of Armenia's photovoltaic potential map (see figure 5) and insights from industry experts highlight that while Armenia has substantial solar potential, not all provinces are equally suitable for industrial-scale solar installations. **Aragatsotn, Ararat, Armavir, Gegharkunik, and Shirak** provinces show high PV potential. Aragatsotn and Gegharkunik are particularly advantageous due to their elevation (around 1,500 meters above sea level), air quality, moderate summer temperatures (averaging 19-23°C), and optimal solar irradiance.

While **Ararat** and **Armavir** provinces also have high PV potential, businesses often refrain from installing large-scale solar plants here due to the agricultural purpose of much of the land and high summer temperatures. **Shirak** province has almost similar climatic conditions as Aragatsotn and Gegharkunik provinces, however this capacity is not fully used yet and could be explored further to strengthen the region's solar capacity.

Residential solar use is also expanding throughout Armenia due to favourable geographic conditions. Autonomous solar production is prevalent, with households in all provinces adopting solar PV systems or solar water heaters on residential rooftops.

Conclusion 2. Sector growth and government support

Since 2016, Armenia's solar energy sub-sector has seen substantial growth, transforming from near-zero solar energy contribution to 8.7% share of the national energy generation grid by 2023. This progress has been largely driven by targeted government reforms and international support, reflecting Armenia's commitment to renewable energy expansion.

To stimulate sector growth, the Armenian government introduced high tariffs (around USD 0.09 per kWh) in 2017, and awarded licenses for ten 1 MW solar projects, which were quickly taken up by investors. Additionally, with support from the World Bank, the government launched the construction of the 55 MW Masrik-1 solar power plant, marking a substantial step toward large-scale solar infrastructure. In 2022, the government advanced market liberalization by removing guaranteed purchase agreements, which has opened new opportunities for competition and increased operational efficiency among solar energy providers.

International partnerships have also played a critical role in Armenia's solar energy development. Organizations like the World Bank, the EBRD, KfW Bank, USAID and the EU have contributed funding, technology transfers, and regulatory support, enhancing Armenia's renewable energy capacity.

Domestic support initiatives are also contributing to the sector's expansion. For instance, the state's program on energy-efficient renovation offers citizens the option to secure loans for upgrading residential energy systems, including the installation of solar power stations.

The Armenian government has committed to raising the share of renewable energy to 60% of the total power generation mix by 2040, emphasizing solar, wind, and small hydropower resources. A specific goal has been set to increase solar power generation to at least 15% of the total energy mix by 2030, equating to around 1.8 billion kWh. This strategic target highlights the country's focus on solar energy as a key pillar in its renewable energy future.

Conclusion 3: Formed capacity and growing demand for innovation

Over the past several years, Armenia has developed a pool of skilled engineers and technicians proficient in solar energy projects, capable of installing and maintaining large-scale solar power plants. Higher educational institutions have incorporated renewable energy, with a focus on solar energy, as a core component of technical training programs, building a foundation of expertise in the sector among the younger generation. This technical capacity has enabled Armenian companies to expand into regional markets, conducting feasibility studies and constructing solar plants in neighbouring countries like Georgia, Kazakhstan, and Russia.

The growth of technical skills and the readiness to explore new markets have fostered the establishment of local plants involved in assembling and producing solar photovoltaic panels. These manufacturers now not only take steps to capture the domestic market but export their products, helping to position Armenia as a regional contributor to renewable energy technology.

Armenian companies also exhibit a proactive approach toward global solar energy innovations. They are actively looking for adoption of advancements in energy storage, hybrid systems, agrivoltaics, and PV recycling, implement pilot projects and gain expertise in emerging solar technologies. Integrating these innovations will strengthen Armenia's standing in the regional renewable energy market and further diversify its energy portfolio, promoting sustainability and long-term growth in the sector.

3.2 RECOMMENDATIONS

Despite the remarkable growth of solar energy adoption in Armenia, the analysis has highlighted several gaps and challenges that present opportunities for collaboration with Dutch investors and businesses. These gaps also underscore areas where expertise and innovation could make a significant impact. Armenian companies currently have limited knowledge and information on the Netherlands' solar energy sub-sector, including its expertise, best practices, and technological advancements. Nevertheless, there is a clear interest among local businesses and public authorities to learn from Dutch experience in solar and wind energy, energy storage solutions, electricity system regulation, and innovative renewable energy technologies.

The following recommendations, derived from interviews and discussions with Armenian stakeholders, aim to address these challenges, strengthen Armenia's energy infrastructure, and enhance sector efficiency. Furthermore, these suggestions outline pathways to foster mutually beneficial partnerships between Armenia and the Netherlands in the renewable energy domain.

- ***Facilitate knowledge and experience transfer on energy storage***: Energy storage is crucial for advancing solar energy and ensuring grid stability. According to the *World Energy Outlook 2024*, "*For clean energy to continue growing at pace, **greater investment in new energy***

systems, especially in electricity grids and energy storage, is necessary" [86]. The report mentions that today for every dollar spent on renewable power, only 60 cents are spent on grids and storage. It also stresses that achieving secure decarbonization requires a balanced investment ratio of 1:1 between renewable energy generation and storage infrastructure. In this context, Armenia's growing solar energy sub-sector necessitates modernization of grids and expansion of power system flexibility, particularly through diversified energy storage solutions.

Armenia has initiated steps to explore energy storage technologies.

- A World Bank-funded Armenia Energy Storage Program conducted an analysis and published a report "Energy Modeling and Economic/Financial Analyses," where a 30MW/120MWh battery was recommended as optimal for Armenia, offering substantial net economic benefits[87].
- Pumped storages also have been found to be a useful mechanism for quickly responding to changes in the supply-demand balance that can occur as the system share of renewables increases. Armenia's existing capacity is modest, but experts suggest potential for expansion to 390MW. Construction of pumped hydropower storage types were also suggested by the "Concept paper for alternative storage and management of electric energy in Armenia", adopted by the Government in 2018[88].
- Hydrogen-storage, though in early stages, this emerging technology presents significant long-term potential as well.

To promote usage of energy storages the new law On Energy of Armenia foresees provision of relevant incentives. However, gaps remain in regulatory frameworks, technical knowledge, and public sector capacity to design and implement effective energy storage policies.

The Netherlands is recognized for its advanced expertise in renewable energy regulation and innovation. Dutch companies are leaders in manufacturing and installing diverse energy storage solutions, ranging from batteries to hydrogen systems. Leveraging this expertise can support Armenia in addressing its storage challenges. In this regard the following activities are recommended:

  - knowledge exchange and regulatory support: facilitate connections between Dutch and Armenian regulatory institutions and relevant public authorities to exchange expertise on legislative frameworks and energy system management, including on the Dutch rules and actions in case of increased network load and congestion. Provide technical guidance and expertise to Armenian public bodies on developing incentives, regulatory mechanisms, and state support programs for energy storage investments.
  - organize workshops for Armenian public authorities and energy institutions to present detailed information on various storage technologies, including their advantages, disadvantages, and operational requirements.
  - conduct a business mission to Armenia, showcasing Dutch innovations in energy storage production and installation. This mission would enable Dutch companies to present their solutions, establish partnerships, and explore collaboration opportunities with Armenian counterparts.

- ***Promote investments in Armenia's solar energy sub-sector:*** The solar energy sub-sector of Armenia offers a range of promising opportunities, particularly as the government plans to

[86] https://www.iea.org/reports/world-energy-outlook-2024?utm_campaign=IEA+newsletters&utm_medium=Email&utm_source=SendGrid
[87] https://r2e2.am/uploads/page_content/509/Armenia_Energy_Storage_Economic_and_Financial_Analysis_ReportClean_2.pdf
[88] https://www.arlis.am/DocumentView.aspx?DocID=122058

increase the share of solar energy in the national energy mix. While the country has developed significant expertise in the construction and operation of solar power stations, it lacks experience in emerging areas such as agrivoltaics and floating photovoltaic (PV) systems. Additionally, Armenian businesses are largely unfamiliar with advanced Dutch technologies and practices in solar energy. Strengthening collaboration between Armenia and the Netherlands could unlock mutual benefits and new market opportunities. For that purposes it is suggested to implement the following activities:

- Facilitate business networking and knowledge exchange by organising B2B meetings and study visits between Dutch and Armenian solar PV producers, as well as companies specialising in solar power station construction and operation. These interactions will enable the exchange of innovation technologies, sharing of operational experiences and creation of partnerships for joint solar energy projects in Armenia, the EAEU and other regional markets.
- Promote investment in agrivoltaics and floating PV systems: agrivoltaics and floating solar PV represent untapped opportunities in Armenia. It is recommended to organize targeted missions for Dutch investors and experts specializing in these technologies to assess Armenia's potential and explore partnerships with local stakeholders. Particularly there is a potential of establishing synergies with existing greenhouse systems of Armenia for integrating agrivoltaics, as many of these greenhouses use Dutch agricultural machinery and technologies.
- With sanctions limiting the use of Chinese-origin PV materials (in the framework of support programs), there is growing demand for alternative production hubs. Armenia has an established capacity for assembling solar PV panels, skilled labour, and cost advantages. Dutch companies could invest in assembling PV panels using European-origin raw materials in Armenia. This strategy would create a competitive edge in European and global markets, offering an alternative to Chinese products.
- To foster interest in Dutch technologies, it is recommended to pack demonstration of Dutch technologies and innovations with financial incentives, such as low-interest loans, grants, or flexible financing schemes. Offering cost-competitive solutions would encourage Armenian companies to use Dutch technologies and strengthen bilateral economic ties.

- ***Encourage cooperation and partnerships in innovation***
  - Creating a sustainable green environment requires the rapid expansion of clean energy infrastructure and the development of innovative solutions. In addition to promoting green technologies, the Armenian government actively supports the integration of innovations into the economy. The solar energy sector in Armenia has accumulated valuable production experience, fostering direct innovation applications while benefiting from the country's scientific capabilities. This creates a solid foundation for further technological advancements. The Netherlands is recognized as a global hub for solar energy innovation. For decades, Dutch companies and research institutes have been at the forefront of the international solar PV sector, excelling not only in fundamental research but also in converting research into practical applications. Armenian businesses have demonstrated strong capabilities in adopting innovative technologies, identifying industry gaps, and developing solutions. Given these strengths, fostering mutual cooperation in solar energy innovation could be highly beneficial for both countries. In this regard, it is recommended:
    - Organize meetings and discussions between Armenian and Dutch higher education institutions, research organizations, and leading solar PV companies (including manufacturers, installation firms, and service providers) to explore partnership opportunities in dual-use solar panel production. This includes

agrivoltaics, floating solar panels, and solar panels integrated into buildings, roads, and other infrastructure.
        - Encourage the organization of exchange programs and internships for researchers, scientific professionals, and students in Dutch and Armenian research centers, universities, and solar energy companies. These programs would facilitate knowledge transfer, skill development, and the implementation of best practices in solar PV innovation.
- ***Enhance standards, recycling, and research in solar energy development.***
    - Armenia's solar power construction sector lacks standardized guidelines, leading to inconsistent quality and the use of substandard materials by smaller construction companies. Armenian stakeholders and experts expressed interest in establishing a national standard for solar power station construction, particularly for residential applications to ensure energy efficiency and energy saving. The EU Energy Performance of Buildings Directive introduces EU Solar Rooftop Standard, which requires all new buildings be solar-ready. This new law requires solar installations on buildings across the European Union.
      It is suggested to organise events to present the EU Energy Performance of Buildings Directive and the EU Solar Rooftop Standard. These events could include case studies from EU countries, demonstrating best practices in implementing solar energy standards.
    - As the solar energy sector grows, Armenia will face challenges in managing the end-of-life cycle of solar PV panels. Currently, the country lacks both the capacity and knowledge for PV panel recycling. No relevant analyses have been done in the country on recycling capacities as well as on required number of investments. In this regard it is suggested to (a) conduct feasibility studies on recycling capacities, assess required investments, and explore the potential of repurposing or recycling PV materials and (b) establish partnerships with Dutch companies experienced in solar panel recycling technologies to initiate pilot projects and build local expertise in Armenia.
    - Promote collaboration between Dutch and Armenian scientific and higher educational institutions to strengthen local capacity. Key initiative could include:
        - organisation of internships for Armenian students in Dutch solar energy companies,
        - invite Dutch professors and industry experts to deliver lectures and workshops in Armenian universities and schools,
        - implement joint research projects on solar energy innovations, such as advanced storage, recycling, or hybrid systems.
    - Strengthen laboratory and research capabilities of Armenia: the limited laboratory infrastructure of Armenia hinders the ability to optimize solar plant efficiency, conduct advanced research, and adopt innovative technologies. It is suggested to support the establishment or upgrade of energy efficiency and solar energy laboratories in collaboration with Dutch scientific centers and institutions. Enhanced laboratory facilities would enable more accurate measurements, promote innovation, and increase the overall efficiency of solar energy systems. These efforts would strengthen the sub-sector's resilience, environmental sustainability, and long-term growth potential.

One of the main reasons the government is promoting "maximum use of the country's renewable energy potential" in its 2021 Energy Strategy is energy security. Renewables have the potential to reduce Armenia's dependence on natural gas, all of which is imported. Alongside the ongoing development of the solar energy sub-sector and the promotion of related investments, there are additional opportunities for advancing renewable energy utilization and enhancing energy efficiency.

These areas, where the Netherlands has extensive expertise, present mutual benefits through potential collaboration and investment in Armenia. Specific suggestions for using these opportunities are provided below.

- ***Promote investments in wind power sub-sector of Armenia***: The data of the Global Wind Atlas shows that Armenia's wind resources are largely underestimated. Estimates suggest that the country possesses around **600 MW of wind energy potential**, reshaping the outlook for wind energy development. Recognizing the wind energy importance in the energy security of the country, the Government of Armenia has prioritized wind energy in its national energy strategy. To better understand the potential, the **Asian Development Bank** is currently conducting a viability assessment of prospective wind power projects.

  However, Armenia currently lacks substantial knowledge and experience in wind energy development, presenting a fascinating opportunity for Dutch investors and organizations. The Netherlands, a global leader in wind energy technology and expertise, is well-positioned to assist Armenia in establishing this sub-sector. By sharing its advanced technologies and innovative approaches, the Netherlands could gain a competitive advantage in Armenia's wind energy sub-sector. This collaboration could include:
  - organisation of professional training programs and technical workshops on wind energy topics, such as turbine installation, maintenance, and operational best practices.
  - Dutch companies can invest in, construct, and operate wind farms, benefiting from Armenia's potential while securing a leadership position in the regional market.
  - the Netherlands could also expertise with Armenian public authorities to assist in developing legislation, incentives, and regulatory frameworks to facilitate wind energy projects.
  - show Dutch technologies and innovations in wind energy through events, study visits, and collaborative research with Armenian stakeholders.
- ***Promote energy efficiency and savings through Energy service company (ESCO) projects:*** An **Energy Service Company (ESCO)** delivers energy efficiency solutions, including project implementation, equipment supply, and often financing, on a turn-key basis. ESCOs provide guaranteed energy savings or maintain equivalent energy services at reduced costs. Their compensation is typically linked to the achieved energy savings.

  Currently, Armenia lacks experience in ESCO-based models. However, this is increasingly critical as global investors demand environmental, social, and governance strategies and sustainable transition plans. Moreover, as Armenia advances in green financing, ESCO projects can serve as a significant contributor to meeting these goals. The Netherlands, with its extensive expertise in ESCO models and green energy financing, is well-positioned to assist Armenia in introducing this concept. Dutch involvement could bring substantial mutual benefits while promoting sustainable energy practices in Armenia. Considering this, it is suggested:
  - conduct targeted workshops to familiarize Armenian stakeholders, businesses, government agencies, and financial institutions, with ESCO concepts, operations, and benefits. This would include practical examples and case studies from Dutch successes.
  - collaborate with Armenian authorities to develop the regulatory framework necessary for ESCO projects, including financing mechanisms, and legal incentives to attract investment.
  - Dutch companies could invest in pilot ESCO projects in Armenia, showcasing their potential.
- ***Enhance capacity building through energy auditor training:*** Energy auditors play a critical role in assessing and improving energy efficiency in industrial facilities and residential buildings.

Their expertise is essential for identifying energy-saving opportunities, ensuring compliance with efficiency standards, and guiding sustainable energy practices.

Currently, Armenia faces a shortage of qualified energy auditors and institutions capable of providing specialized training in this field or conducting energy audits. As energy efficiency becomes a more priority directions for the country, addressing this skills gap is vital for achieving national sustainability goals. The Netherlands is famous for its achievements in energy-efficient construction and renovation of residential and industrial buildings. This expertise could be used to design and implement comprehensive training programs tailored to specific needs of Armenia. Therefore, it is suggested to implement the following activities:

- facilitate collaboration between Dutch and Armenian experts to develop a curriculum for training of energy auditors, with a focus on best practices in both new construction and renovation of old buildings,
- organize workshops and training programs for Armenian professionals, integrating field visits to Dutch projects to showcase practical applications of energy audit methodologies,
- support the creation of an energy auditor training center in Armenia to serve as a hub for education, certification, and professional development.

4 ANNEXES

4.1 ANNEX 1. ENERGY BALANCE OF THE REPUBLIC OF ARMENIA,

ENERGY BALANCE OF THE REPUBLIC OF ARMENIA, 2023 (format of IEA)

(1 000 tonnes of oil equivalent (1 000 t o e)

		Total	Coal	Oil products	Natural gas	Nuclear	Hydro	Solar, wind	Biofuels and waste	Electricity	Heat
1.1	**Production**	**1,021.9**				**705.9**	**141.5**	**79.3**	**95.2**		
1.2	**Imports**	**3,101.3**	**13.8**	**809.0**	**2,255.6**				**14.6**	**8.4**	
1.3	**International aviation bunker**	**(118.6)**		**(118.6)**							
1.4	**Exports**	**(110.3)**		**(3.4)**					**(0.3)**	**(106.6)**	
1.5	**Stock changes**	**(39.6)**	**(0.1)**	**(34.2)**	**(5.3)**						
1	**Total primary energy supply**	**3,854.7**	**13.7**	**652.7**	**2,250.3**	**705.9**	**141.5**	**79.3**	**109.5**	**(98.3)**	**-**
2	**Transfers**	**-**									
3	**Statistical differences**	**-**									
4	**Transformation processes**	**(792.9)**			**(639.7)**	**(705.9)**	**(141.5)**	**(79.3)**		**757.2**	**16.4**
5	**Energy industry own use**	**(37.8)**			**(6.2)**					**(31.6)**	
6	**Distribution losses**	**(165.1)**			**(114.3)**					**(50.8)**	
7	**Total final consumption**	**2,858.9**	**13.7**	**652.7**	**1,490.1**	**-**	**-**	**-**	**109.5**	**576.5**	**16.4**
7.1	Final energy consumption	2,778.1	13.1	572.6	1,490.1	-	-	-	109.4	576.5	16.4
7.1.1	Industry	412.3		11.2	242.6					158.2	0.3
7.1.2	Transport	878.4		530.7	340.4					7.3	
7.1.3	Other sectors	1,487.4	13.1	30.7	907.1				109.4	411.0	16.1
7.2	Non-energy use	80.8	0.6	80.1					0.1		

4.2 ANNEX 2. LIST OF FINANCIAL INSTITUTIONS PARTICIPATING IN THE "ENERGY-EFFICIENT RENOVATION OF APARTMENTS AND INDIVIDUAL RESIDENTIAL BUILDINGS" PROGRAM

1. ArmSwissBank CJSC
2. Evocabank CJSC
3. Armeconombank OJSC
4. Converse Bank CJSC
5. Araratbank OJSC
6. Inecobank CJSC
7. Ameriabank CJSC
8. Unibank OJSC
9. Byblos Bank CJSC
10. ID Bank CJSC
11. Ardshinbank CJSC
12. Artsakhbank CJSC
13. "Kamurj UCO" CJSC
14. "Farm Credit Armenia UCO" CJSC
15. "Bless UCO" LLC
16. "My Credit UCO" LLC
17. "Global Credit UCO" CJSC
18. "Express Credit UCO" CJSC
19. ACBA Leasing Credit Organization CJSC
20. "Premium Credit UCO" CJSC
21. "First Mortgage Company UCO" LLC
22. "CARD Agrocredit UCO" CJSC
23. "Agroleasing Leasing Credit Company" LLC
24. "ECLOF UCO" LLC