International Energy Agency

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Armenia 2022

Energy Policy Review

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Foreword

The International Energy Agency (IEA) has conducted in-depth peer reviews of the energy policies of its member countries since 1976. Since the early 1990s, it has also reviewed the energy policies of selected non-member countries. The IEA recently modernized these reviews to focus on countries' key energy transition and security issues. In-depth policy reviews play a prominent role in bilateral collaboration between IEA member countries and non-members.

Armenia is one of the focus countries of the EU4Energy programme, which is being implemented by the IEA and the European Union along with the Energy Community Secretariat and the Energy Charter Secretariat. The EU4Energy programme includes Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Moldova, Tajikistan, Turkmenistan, Ukraine, and Uzbekistan. It was designed to support the goals and aspirations of its eleven focus countries to implement sustainable energy policies and foster regional cooperation on energy-sector development. One of the key ways the programme does this is by conducting in-depth policy reviews of individual countries, updating and extending the analysis contained in the IEA's 2015 regional review, Energy Policies Beyond IEA Countries: Eastern Europe, Caucasus and Central Asia. The in-depth review of Armenia is the third in this regional series, joining recent reviews of Georgia and Azerbaijan.

Armenia faces a number of energy-related challenges. In particular, its energy supply is dominated by natural gas, almost all imported from Russia. Armenia is also the only country in the Caucasus region to possess a nuclear power plant.

Armenia has made progress in a number of areas since the 2015 review, including energy statistics, energy efficiency and the development of renewables. The government approved a new Energy Sector Development Strategic programme in January 2021 that establishes a basis for the sector's transition through 2040. Key government priorities include maximum use of the country's potential for renewable energy and energy efficiency, increasing power interconnections with neighbours, and gradual liberalisation of the domestic electricity market.

This in-depth review aims to guide Armenia in its energy-sector reforms and help it achieve its energy policy goals, including the provision of affordable, safe, secure and clean energy to its population.

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1. Executive summary

Country overview

Armenia's energy system depends primarily on natural gas, nuclear and hydroelectricity. Natural gas is by far the largest contributor to total energy supply (TES), as well as the main energy carrier in total final consumption (TFC). Since the transport sector depends primarily on natural gas, the importance of oil in the economy is relatively low. Apart from several large hydroelectric plants, the contribution of renewables to the energy mix is modest, although current policies aim for a substantial increase, especially solar photovoltaic (PV). Domestic energy production comes mainly from Armenia's one Soviet-era nuclear power plant (Armenian Nuclear Power Plant [ANPP]) and from hydroelectricity. Since Armenia does not produce fossil fuels, all of the natural gas and oil products used in the country have to be imported.

Key policy directions

The Armenian government approved the Energy Sector Development Strategic Programme (hereinafter "Energy Strategy") in January 2021, setting the path for the sector's transition through 2040. The publication and approval of this strategic document are welcomed and should form a useful basis for Armenia's future energy legislation. The 2021 Strategy replaces the government's previous energy policy document, which dates from 2015.

According to the 2021 Strategy, the government's priorities in the energy sector through 2040 are:

- Maximum use of the country's potential for renewable energy and energy efficiency;
- Extending the life of the ANPP beyond 2026, as well as construction of a new nuclear power plant to replace it;
- Construction of a "North-South Corridor" by increasing power transmission links between Armenia and Georgia and between Armenia and Iran; and
- Gradual liberalisation of the domestic electricity market.

Energy governance

The principal bodies involved in energy sector governance in Armenia include the Ministry of Territorial Administration and Infrastructure (MTAI), which is responsible for overall energy policy-making, the Ministry of Environment, the Public Service Regulatory Commission (PSRC) and the Committee on Nuclear Safety Regulation (ANRA). The Statistics Committee (ArmStat) is the main provider of energy-related data and statistics

In a recent government restructuring, the former Ministry of Energy Infrastructures and Natural Resources was integrated into the MTAI. The transfer and addition of the energy agenda to the already large portfolio of responsibilities of the MTAI risk placing existing resources under pressure and causing insufficient coordination among ministries and other governmental entities dealing with energy-related policies. This could negatively impact effective and timely implementation of several important programmes in the sector.

Regional market integration

Armenia has made considerable progress in enhancing regional market integration. The country has signed and ratified the Comprehensive and Enhanced Partnership Agreement (CEPA) with the EU that entered into force in March 2021 and includes a timetable for the approximation of Armenian laws and regulations to relevant EU laws over the next few years, and by 2029 at the latest. Armenia is also a member of the Eurasian Economic Union (EAEU), which aims to establish common EAEU gas and electricity markets by 2025. Implementing these ambitious objectives will require close cooperation and coordination between different institutions to achieve regulatory consistency and to eliminate potential contradictions and conflicts.

Liberalisation

Since the last IEA review in 2014/15, the government has taken decisive steps towards implementing a liberalised electricity market, with a launch in February 2022 (as this report was going to press) featuring a new wholesale market model, direct contracts, a balancing mechanism and long-term direct capacity contracts. Free and open trade, as well as cooperation among all energy market participants, as envisioned by these reforms, would help promote investments from the international community and strengthen regional integration.

Energy supply security

Armenia has a diverse generation mix that includes thermal, hydropower and nuclear. However, all of its thermal generation relies on gas, around 85% of which is imported from Russia. Furthermore, Armenia imports all of its nuclear fuel from Russia. Armenia therefore effectively relies on fuel imports from one country to produce nearly 70% of its electricity, raising concerns about the diversity of supply.

Energy data management and use

Armenia has adopted the international energy statistics methodology and standards and has released energy balances in the internationally comparable format since 2015. The cooperation of the national stakeholders to achieve this is to be commended. Unfortunately, however, compilation of the energy balance and GHG inventory does not receive funding from the state budget. Complementing and gradually replacing external

funding with contributions from the state budget would ensure sustainability for these activities and help retain relevant trained human capacity.

Modelling

Modelling based on good-quality data is a key component of effective policy-making. Policies and measures contained within the Energy Strategy were based on modelling performed by a local research institute. However, staff turnover in this and other key research bodies is high, risking frequent institutional memory loss and lack of staff for establishing regular monitoring systems to follow up on policy developments. Moreover, modelling capabilities in the country rely heavily on financial and (in some cases) personnel support from international donors. These might tailor modelling assumptions and parameters to their own needs, making comparison among models difficult. Furthermore, economy-wide modelling has not been carried out, as significant energy users, such as industry and transport, have been omitted.

An improved approach could include enhancing the government's own modelling capabilities and institutional learning capacity. The development of comprehensive energy system models demands sufficient and targeted allocations from the state budget, regardless of whether modelling is outsourced or capacities are developed within the ministry.

Exploration of modelling scenarios extending to 2050 and beyond will also be important for mapping pathways to reach Armenia's climate goals under the Paris Agreement. Since the energy sector is the largest source of GHG emissions in Armenia, a resolute and consistent implementation of its National Programme on Energy Saving and Renewable Energy will prove essential for reaching its recently updated Nationally Determined Contributions (NDCs).

Electricity

Armenia is moving from a regulated, single-buyer model to a competitive power market, with a launch date set for February 2022. The careful preparation of this work over many years is to be commended. As part of the first stage of market reforms, the government plans to improve protection mechanisms for vulnerable customers. This and other improvements to consumer protection, such as a complaints mechanism with legal recourse, will help enable consumers to participate fully in the new market structure. The government also plans to improve the efficiency of tariffs, which are set by the independent regulator.

Armenia is making progress in further diversifying its power generation mix, particularly by aiming to build significant solar PV capacity. Armenia's 2021 Energy Strategy calls for up to 1 000 MW of solar PV capacity by 2030, at which point grid-connected solar is expected to account for 15% of generation. However, this will be a significant amount of intermittent capacity relative to the country's current total capacity and demand, and integrating it will require the System Operator to be in a position to respond immediately to sudden surges and shortfalls in supply. A number of upgrades to the grid and related information and control systems have been made in recent years that will help address these challenges. However, additional investments may be necessary, including to help develop the necessary workforce skills to manage intermittent renewables and demand-side response.

Armenia is aiming to expand interconnections with Georgia and Iran. This highlights the need to develop new market rules to enable increased cross-border trading. Armenia is working on such arrangements within the context of its CEPA agreement with the EU, as well as within the EAEU Common Electricity Market, currently under development. Developing these two processes in parallel is likely to require careful coordination.

Since the late 1990s, the EU and several other international partners have strongly encouraged the closure of Armenia's WWER-400 nuclear reactor, a type that the EU views as particularly dangerous, further noting that the plant is located only 30 km from Yerevan, the capital city of 1 million people. The review team commends Armenia's efforts to continuously improve nuclear safety measures to meet International Atomic Energy Agency (IAEA) safety goals for existing NPPs and its long-term cooperation in this regard with the IAEA, EU, Russia and other international partners.

Gas

Armenia's natural gas sector remains a vertically integrated monopoly, operated and owned by Gazprom Armenia, a fully owned subsidiary of Russia's Gazprom. There is currently no competition nor third-party access in the sector. However, according to the 2021 Energy Strategy, the Armenian government intends to review all gas-sector legislation by 2024, and as part of this will begin to develop a new Gas Law in 2022.

Armenia, along with other members of the EAEU, is planning to launch a common EAEU gas market in 2025. An agreement signed by EAEU members in 2019 commits Armenia to introducing third-party access, among other reforms aimed at facilitating cross-border gas trade; a final agreement on this is expected to be signed in 2022.

Around 85% of Armenia's gas supply is procured from Russia via pipelines passing through Georgia. The remainder is imported from Iran, though Iranian gas is currently used only for the production of electricity at one power plant in a gas-for-electricity swap. Gas for domestic consumption is therefore fully sourced from Russia.

Potential security risks related to heavy reliance on a single source should also be seen in the light of Armenia's large dependence on natural gas, which accounts for the largest share of the country's total primary energy supply. Both the residential and road transport sectors rely on natural gas as their main fuel, though Armenia's Energy Strategy aims to increase the use of electric vehicles in the latter.

Current efforts to substantially increase the size of the Abovyan gas storage facility will help increase supply security, for example in the case of a disruption of supplies via Georgia. Nevertheless, this facility, like all other gas infrastructure in the country, remains under the control of Armenia's main gas supplier.

Residential heating is now dominated by small, individual gas boilers. Since such boilers do not require a license, there are no centralised records about their installation or efficiency. Given the large share of gas consumption currently represented by domestic heating and the lack of information about equipment employed, including possibilities for improving its efficiency, the government may wish to undertake a strategic review of this important consuming sector.

Oil

Armenia has no known oil reserves, no oil production and no refineries. As a result, it imports all of its oil products, both motor fuels and lubricants. The import and sale of oil products are privatised, and prices are unregulated.

Oil accounted for only 16% of Armenia's TES in 2020, one of the lowest shares in the world. The share of oil in TFC has been on a declining trend since the early 2000s. No oil is used in power production, while natural gas is the fuel of choice for road transport, mainly since it is significantly cheaper than gasoline and diesel. Most of the country's vehicle fleet can run on either gasoline or natural gas, thereby enhancing the country's energy security by providing flexibility in fuel use.

Although Armenia imports oil products from more than 40 countries, over half comes from just one country, Russia. Armenia currently has no known emergency stocks of crude or oil products, though importers and sellers reportedly maintain some commercial stocks. Given the small share of oil in the country's total energy consumption, however, the lack of strategic oil stocks arguably is not as great a risk for energy security as it would be for other countries. Due to Armenia's high dependence on natural gas, it is probably more important to prioritise storage of natural gas, as Armenia appears to be doing with current efforts to expand the Abovyan gas storage facility.

Renewable energy

The contribution of renewable energy sources (RES) to energy consumption in Armenia averaged about 11% during 2015-2020 (measured by the sustainable development goal indicator 7.2). This mostly consists of hydroelectricity.

Most of Armenia's hydropower generation comes from two sets of large plants. However, the construction of small hydropower plants (SHPPs) has been significant over the past two decades, responding to attractive feed-in tariffs and other support. However, growth in SHPP construction has slowed in recent years, due to stricter siting rules established in response to growing concerns over ecological impacts.

Solar photovoltaic capacity is currently low but is expected to become the major source of new RES growth, due to support mechanisms but also to falling costs worldwide for solar PV equipment.

Although several prospective sites for wind farms have been identified, most are in remote, high-altitude locations, reducing their cost-competitiveness vis-à-vis other RES, particularly solar.

The 2021 Energy Strategy considers maximum use of the country's renewable energy potential to be a key policy priority. The Armenian government expects solar PV capacity to reach 100 MW by 2024 and 1 000 MW by 2030, and at that point to account for at least 15% of total generation. Some increase in wind is also expected.

Experience elsewhere has shown that large increases in intermittent RES need to be accompanied by measures to ensure their technical and economic integration so that the system and market are able to efficiently respond to rapid increases and decreases in production. Such measures could include taking full advantage of smart metering to

institute differentiated tariff levels that recognise the locational, temporal and technological value of decentralised renewable power installations, as well as reinforcements to networks and training of network personnel.

One of the main reasons the government is promoting renewable energy 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, as well as dependence on the country's Soviet-era nuclear power plant.

There are several potential medium-sized hydropower sites in the country that have been studied for several decades. Such plants might not only help reduce dependence on imported gas and nuclear energy, but also help integrate the expected large increase in variable renewables in the system.

Experience in other countries has shown that pumped storage can also be a useful mechanism for quickly responding to changes in the supply-demand balance that can occur as the system share of renewables increases. According to several past studies, there may be significant potential for developing additional pumped-storage capacity in the country.

Energy efficiency

The government of Armenia has repeatedly affirmed the importance of energy efficiency for its economic development. The first comprehensive legislation on energy efficiency was adopted in 2004 as part of a law on Energy Saving and Renewable Energy, followed in 2007 by a National Programme on Energy Savings and Renewable Energy. A National Energy Efficiency Action Plan (NEEAP) was adopted in 2010 and updated in 2017. Mandatory energy efficiency requirements for newly constructed residential multi-apartment buildings, mandatory energy audits for buildings constructed with state funds, and the definition of labelling requirements for energy-saving devices and equipment feature among the rules adopted as part of these plans and policies.

The government of Armenia is developing a new National Programme on Renewable Energy and Energy Efficiency, scheduled for adoption at the end of 2021. This will be based in part on an assessment of the level of implementation of the 2007 National Programme on Energy Efficiency and Renewable Energy.

Armenia has also started to implement the energy efficiency provisions of the EU-Armenia CEPA. This includes requirements to approximate key EU laws on energy efficiency, such as the Energy Efficiency Directive (EED) and the Energy Performance of Buildings Directive (EPBD). In parallel, Armenia is due to implement a range of separate standards for energy-using technologies as part of its membership of the EAEU.

Armenia faces constraints in terms of energy efficiency governance. The merging of the former Ministry of Energy into the new MTAI has resulted in a significant reduction in both administrative staff and capacity to support energy efficiency policies and measures. In addition, the Ministry of Urban Development, which is responsible for key energy efficiency measures, has been downgraded to a State Committee with reduced capacity and staff levels. Armenia also does not have a dedicated energy agency to coordinate energy efficiency policy development and implementation across relevant ministries and departments. Compounding capacity challenges are energy end-use data quality and

availability issues that impact policy formulation, implementation and monitoring. There is also limited technical capacity to implement key legislative provisions.

Governance and capacity constraints are also expected to create challenges with respect to the simultaneous implementation of the CEPA and alignment with EAEU standards. While these standards are complementary, they constitute two separate reporting regimes and require dedicated resources for their effective administration. Nonetheless, Armenia has made progress in terms of aligning with EU legislation and norms, having already adopted more than 50% of the provisions of the EPBD, for example, at least in terms of approximating headline provisions of this directive into national law. Progress has also been made in the realm of appliances and equipment, with the adoption of the A-to-G labelling scheme in line with the EU Ecodesign Directive and Energy Labelling Directive for a range of energy-using devices such as refrigerators and washing machines. Based on training sessions and surveys conducted by the United Nations Development Programme (UNDP), Armenia is also making steady progress in phasing out inefficient technologies, notably with respect to lighting.

Despite progress on the efficiency of individual building technologies, significant potential remains in the buildings sector. As Armenia's largest energy-consuming sector, buildings account for around 40% of electricity demand and over 25% of gas demand. Significant efficiency potential exists, particularly in home heating.

No energy efficiency policies currently exist in the industrial sector, such as minimum energy performance requirements for industrial motors or tax breaks to incentivise the adoption of energy management systems.

Except for tax breaks for electric vehicles, Armenia has not adopted any energy efficiency provisions in the transport sector, such as fuel economy standards for passenger vehicles. However, as part of the CEPA provisions, Armenia is expected to approximate EU standards for transport efficiency between 2026 and 2030.

Energy, the environment and climate change

Armenia demonstrated its commitment to fulfil its obligations to the Paris Climate Agreement by ratifying the treaty in February 2017. It also ratified the Doha Amendment to the Kyoto Protocol, thereby establishing the Protocol's second commitment period. The acknowledgement of climate action as an important policy issue is also reflected in the creation of a Climate Change Policy Department within the Ministry of Environment, albeit with limited resources at the time of this review.

In April 2021, the Armenian government approved an updated NDC for 2021-2030, setting an economy-wide target for a 40% reduction of GHG emissions by 2030 (compared to the base year 1990). With this absolute emissions reduction target the government departed from the previous disputed concept of a per-capita carbon budget and aligned its NDC implementation period with that of most other countries, enhancing comparability and reporting transparency.

As a non-Annex I Party to the UN Framework Convention on Climate change (UNFCCC), Armenia submitted its Fourth National Communication (NC4) in 2020 and its Third Biennial Update Report (BUR3) in 2021. These provide improved transparency in Armenia's national inventory of anthropogenic GHG emissions by sources, consistent with

Intergovernmental Panel on Climate Change (IPCC) reporting guidelines. They also include assessments of the climate change mitigation potential in the energy sector based on official statistical data, highlighting the role of renewable energy and energy efficiency measures.

The latest data in the BUR3 show that the energy sector is by far the largest source of GHG emissions, with a total share of 67%. This includes fuel combustion in energy generation and transport. It further includes fugitive methane emissions from the natural gas system, which form 23% of energy sector emissions. Despite monitoring and response mechanisms in place, technical losses in the transmission and distribution systems, respectively, are reportedly 3.5% and 1.2%, resulting in a high share of methane emissions in the overall energy-related GHG emissions.

Assessments in the NC4 and BUR3 show that expansion of renewable energy resources and demand-side measures would have a significant impact on energy-related GHG mitigation.

Although emissions from the industrial sector currently trail those from the residential and transport sectors, industry's share is projected to grow significantly over the coming decades. With the European Commission's proposal to introduce a carbon border adjustment mechanism, the government of Armenia is assessing the implications for the country's exporting industries and exploring policy options for a carbon-pricing or emissions trading system. Aside from facilitating future trade with the EU, the introduction of such a mechanism could prove a significant incentive for increased energy efficiency in energy-intensive industries.

The prevalence of ageing hydropower plants and the development of new SHPPs reportedly are affecting natural river flows and putting a strain on biodiversity. These problems may be amplified in the medium term, since climate change has started already to affect Armenia with a significant decrease in precipitation. The government acknowledges these issues and plans to address them in the revamp of the national water resources management strategy.

Research, development and innovation

Armenian researchers in the energy sector, as in other sectors, face challenges that include low levels of state funding, lack of structures for cooperation among research institutes, universities and industry, and requirements for university professors to teach a large number of hours in order to receive a full salary. Despite the challenges, Armenia ranked 61st out of 131 countries in the 2020 Global Innovation Index.

The EU's Horizon Europe Policy Support programme undertook a review of Armenia's research sector in 2019. The main findings included a need to increase overall funding while prioritising the large number of subject areas covered, based on relevance for the country's social and economic development, among other criteria. While various government policy documents suggest that energy is a priority area for the country's development, this has yet to be fully translated into support for research in this area.

Given the lack of state funding, the main institutions involved in energy-related research and development in Armenia are primarily self-financed, with most funding coming from project-based contracts with international organisations. Such funding is helpful for

supporting and building local expertise, including attracting young researchers to the field. However, donor support, if significantly greater than the government's own funding contribution, risks research that focuses on donor priorities, and which may not be sustainable. Ideally, donor support should supplement a reliable baseload of government funding for research.

Key recommendations

The government of Armenia should:

Overall energy policy

- Increase resources and improve capabilities to enable the parallel implementation of CEPA and EAEU policies and measures. In particular, the government needs to be in a position to ensure regulatory consistency and legal certainty when approximating Armenian legislation to EU energy legislation, while at the same time setting up a common market for electricity and gas with EAEU member countries.
- Enhance the government's own modelling capability, dedicating a regular modelling budget to ensure consistency and comparability, and to avoid the loss of institutional memory. Work in this area should encompass the whole economy, and extend the time horizon at least to 2050 in order to chart net-zero pathways.
- Continue the government's considerable efforts to transition to a liberalised, competitive electricity market by reducing technical, economic and administrative barriers, and consider a similar path for gas.

Electricity

- Enhance the electricity management system and workforce skills necessary to integrate the country's ambitious target for renewables in the electricity grid while maintaining the reliability of the system and considering climate change goals.
- Continue the programme to renovate the transmission network, including the development of new interconnections with Iran and Georgia, and implementation of regulatory instruments enabling access rules for cross-border transmission service, free trade and transparent exchange of information.

Nuclear energy

- Make the necessary investments to ensure that the ANPP is compliant with international safety standards, in particular those concerned with emergency preparedness in the event of a nuclear accident.
- Continue close coordination with the IAEA, EU and other relevant international organisations on nuclear safety issues and legal aspects, and in particular ensure that continued use of the ANPP (and any future nuclear power plant) meet relevant international safety standards and are governed by legal instruments aligned with international practice.

- Maintain efforts in the development of a long-term national strategy for radioactive waste management. Such a strategy should be consistent with existing nuclear development plans and envision the creation of a sustainable funding mechanism for decommissioning and waste management activities (including final waste disposal), while addressing existing funding gaps.

Gas

- Aim to further diversify supply sources of natural gas, including within the framework of the emerging common market for gas in the EAEU.

Renewable energy

- In connection with ambitious plans for the introduction of solar and wind energy, develop and implement mechanisms for technical and economic integration of variable renewable energy sources, in order to ensure the power system's secure and cost-effective operation.

Energy efficiency

- Develop a detailed strategy, including implementation and enforcement mechanisms, to improve the energy efficiency of the building stock, with a particular focus on residential buildings, leveraging work already begun in this area.
- In tandem with efforts to improve building energy efficiency, develop a national strategy on heating, including improved data collection on heating technologies used by households as well as an assessment of the potential for greater use of district heating networks as an alternative to individual gas boilers.

Energy, the environment and climate change

- Continue to consider the trade-offs between GHG emissions reduction and potentially damaging environmental impacts when developing hydropower, particularly SHPPs.

Energy research, development and innovation

- Formulate an Energy Research, Development and Innovation Strategy, including the setting of clear priorities within thematic areas and applied research, to ensure that priorities are linked with those of the national energy strategy adopted in January 2021.

2. General energy policy

Key data

(2020 provisional)

TES: 3.6 Mtoe (natural gas 59.6%, nuclear 20.0%, oil 15.6%, hydro 4.3%, bioenergy 2.1%, other** 0.9%), +37.7%% since 2009

TES per capita: 1.2 toe/cap (world average 2019: 1.9 toe/cap)

TES per unit of GDP: 109 toe/USD million PPP* (world average 2019: 114 toe/USD million PPP)

Energy production: 1.0 Mtoe (nuclear 74.9%, hydro 15.9%, bioenergy 6.5%, other** 2.7%), +15.3% since 2009

TFC: 2.6 Mtoe (natural gas 55.5%, oil 21.4%, electricity 19.4%, bioenergy 2.9%, other*** 0.8%), +35.9% since 2009

* purchasing power parity

** includes solar, coal and wind

*** includes solar heat, coal and district heat

Country overview

The Republic of Armenia is a land-locked country in the southern Caucasus region. It is bordered by Turkey to the west, Georgia to the North, Azerbaijan to the east and Iran to the South. The country is approximately 29 800 km^2 and has a population of about 3 million, around one-third of which lives in the largest city and capital, Yerevan.

Armenia's GDP per capita was USD 4 269 in 2020. The World Bank classifies Armenia as an upper-middle income economy, the same category as neighbouring Azerbaijan and Georgia. In recent years, industry has been the largest contributor to GDP, followed by agriculture. Food processing and mining represent important components of the industrial sector.

Economic dislocation following the breakup of the Soviet Union at the end of 1991 was compounded by a blockade levelled against Armenia by several of its neighbours over the situation in Nagorno-Karabakh, an ethnic Armenian enclave inside Azerbaijan. This led to a severe energy shortage and economic downturn in the early 1990s and ultimately to the decision to re-start the ANPP, which had been mothballed following an earthquake a few years prior to independence. Armenia's economy has diversified and grown since then, but the shortages of the early 1990s continue to have an impact on energy policy, particularly with regard to the prominent role of nuclear power in pursuing energy security.

Figure 2.1 Map of Armenia

This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

After years of tension with Azerbaijan over Nagorno-Karabakh, full-scale war erupted between Armenia and Azerbaijan in September 2020. This resulted in six weeks of fighting, which ended in a Russia-brokered peace deal in November 2020. Under the settlement, territory that had been controlled by Armenia since the early 1990s was handed over to Azerbaijan and subsequently has been patrolled by Russian peace-keeping troops.

Energy supply and demand

Armenia's energy system depends primarily on natural gas, nuclear power and hydroelectricity. Natural gas is by far the largest energy source in TES, as well as the main energy carrier in TFC.

The importance of oil in the economy is relatively low, since the transport sector relies mainly on gasoline and natural gas. Apart from several large hydroelectric plants, the contribution of renewables to the energy mix is modest. Current policies aim for a substantial increase in renewables, especially solar photovoltaic (PV).

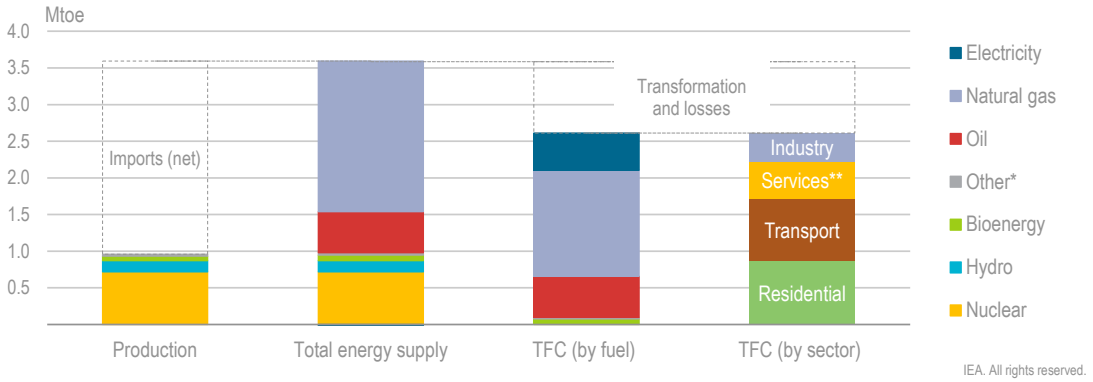
Domestic energy production comes mainly from Armenia's one Soviet-era nuclear power plant and from hydroelectricity. Armenia does not produce fossil fuels, so all natural gas and oil products used in the country have to be imported.

In 2020, TES was 3.6 Mtoe, of which over three-quarters were covered by imports. Fossil fuels (natural gas and oil) accounted for 75% of TES. Coal use is negligible.

TFC was 2.6 Mtoe in 2020, of which natural gas accounted for 55%, oil 21% and electricity 19%. The share of natural gas in Armenia's TFC is among the highest in the world.

The residential and transport sectors each consumed 33% of TFC, industry 15%, and services and other sectors the remaining 19%.

Figure 2.2 Overview of Armenia's energy system by fuel and sector, 2020



Armenia's energy production covers less than one-third of its energy needs.

Bunker fuels of around 0.07 Mtoe are not included in TES. Electricity exports accounting for 2.4% of TES (negative) are not shown in the chart.

* includes hydro, wind, solar PV and coal.

** includes commercial and public services, agriculture and forestry and unspecified energy consumption.

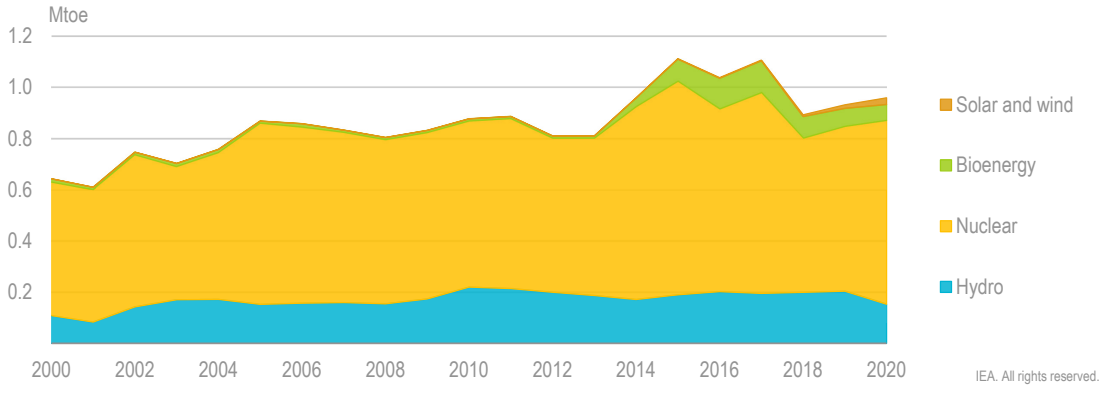
Note: Mtoe = million tonnes of oil equivalent.

Source: IEA (2022), *World Energy Statistics and Balances* (database), https://www.iea.org/data-and-statistics.

Energy production and self-sufficiency

Armenia's primary energy production amounted to 0.96 Mtoe in 2020. Domestic energy production mainly consists of nuclear (75% of production in 2020) and hydro (16%). Nuclear electricity generation has remained stable over the last two decades, varying only due to changes in available capacity at the country's one ageing nuclear plant. Overall self-sufficiency has remained relatively unchanged in the last two decades at around 30% of TES.

Figure 2.3 Primary energy production by source, 2000-2020



Nuclear power is the main domestic energy source.

Official data on bioenergy available only since 2014.

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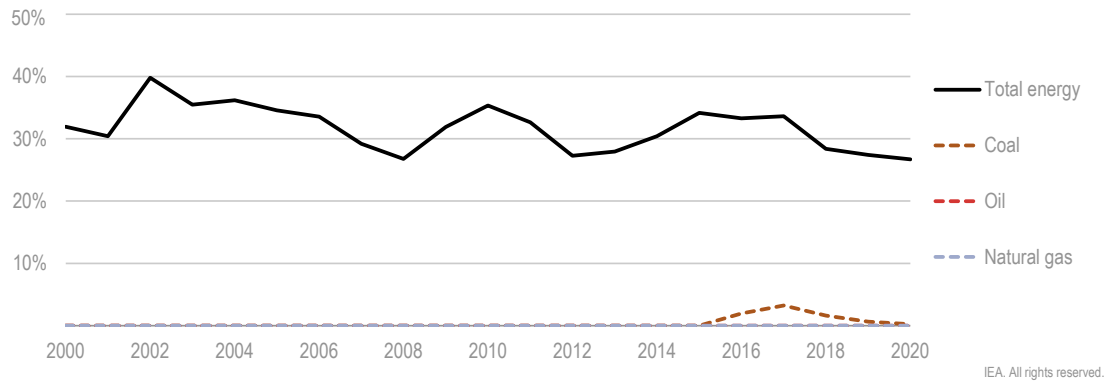
Figure 2.4 Self-sufficiency (production/TES) by energy source, 2000-2020



Virtually all hydrocarbons used in Armenia must be imported.

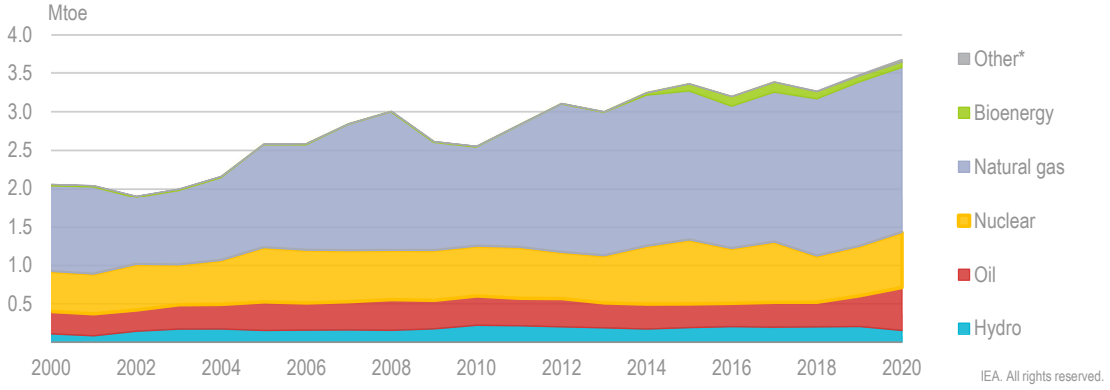
Note: Self-sufficiency is calculated by domestic production over TES. Values below 100% indicate the country produces less than it consumes, making it a net importer of energy.

Source: IEA (2022), *World Energy Statistics and Balances* (database), https://www.iea.org/data-and-statistics.

TES stood at 3.6 Mtoe in 2020, an increase of 38% since 2009. Natural gas accounted for 60% of TES, nuclear for 20% and oil for 16%. Renewables (mainly hydro) covered the remaining 7%.

Demand for natural gas has almost doubled since 2000. Given the importance of gas as an energy source across the economy, growth in gas demand has been the main driver of the increase in TES in recent decades.

Figure 2.5 Total energy supply by source, 2000-2020



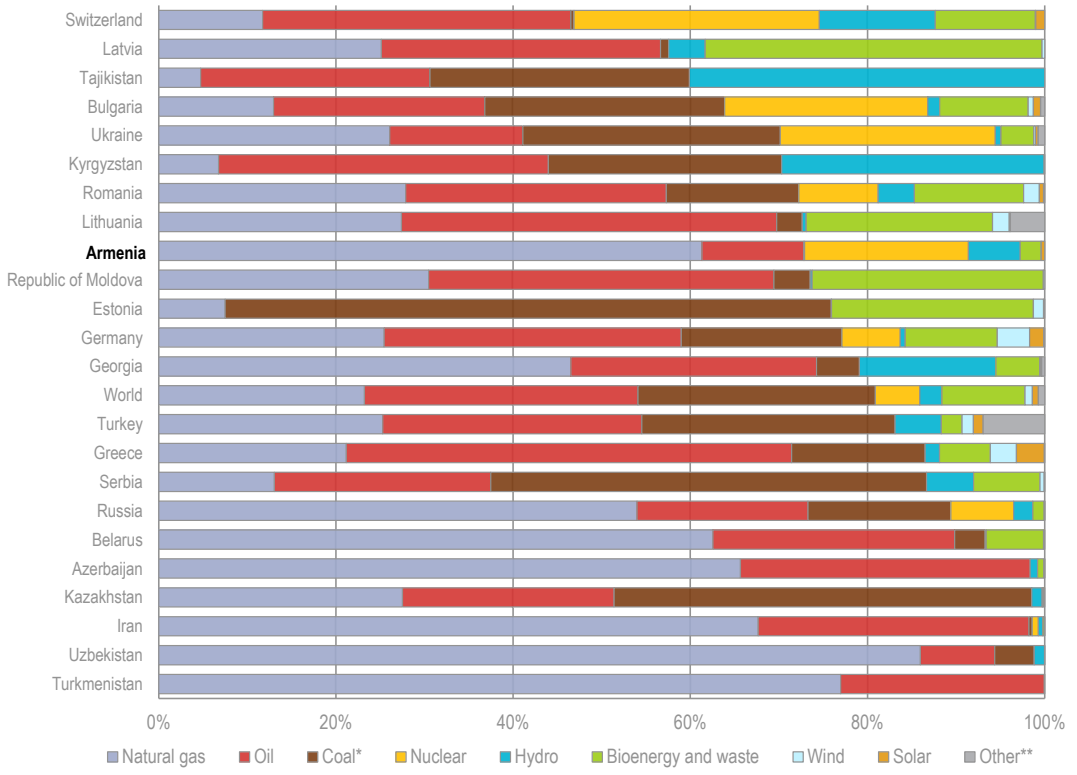
Armenia's TES increased by 38% between 2009 and 2020.

* includes solar PV, coal and wind; not visible at this scale.

Note: Electricity trade is not included in the graph.

Source: IEA (2022), *World Energy Statistics and Balances* (database), https://www.iea.org/data-and-statistics.

Figure 2.6 Breakdown of total energy supply in selected countries, 2019



The share of fossil fuels in Armenia's TES is below the world average.

* includes peat

** includes geothermal, primary heat, wave and ocean energy.

Note: Electricity trade not included.

Source: IEA (2021), *World Energy Statistics and Balances* (database), https://www.iea.org/data-and-statistics.

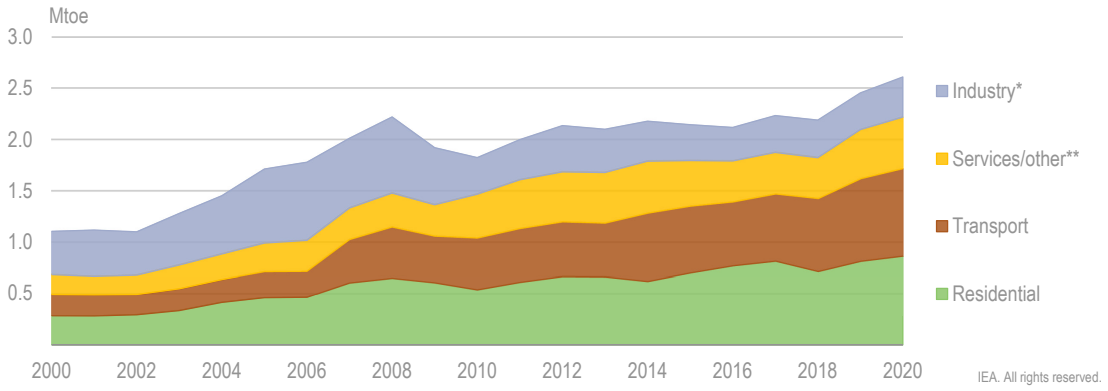
Compared with most of the other former Republics of the Soviet Union, Armenia relies significantly more on natural gas and nuclear power for its energy supply, and much less on oil, while coal use is insignificant. The share of fossil fuels in Armenia's TES is also well below the world average (75% vs. 81% of TES in 2019).

Energy consumption

Armenia's TFC amounted to 2.6 Mtoe in 2020, an increase of 35.9% since 2009. Demand in the transport sector has grown rapidly, and is now virtually on par with the residential sector as the largest energy consumer. Each of these two sectors accounted for 33% of TFC in 2020, followed by industry at 15%.

Fossil fuels (mainly natural gas) accounted for over three-quarters of TFC in 2020. The importance of natural gas for the economy becomes clear when looking at sectoral consumption patterns: gas is the primary energy source in every sector except for transport in 2020, with an overall TFC share of 55% in 2020. The rest of final consumption consists of oil (21%) and electricity (19%). Coal use is minuscule, though consumption of biofuels may be underestimated.

Figure 2.7 Total final consumption by sector, 2000-2020



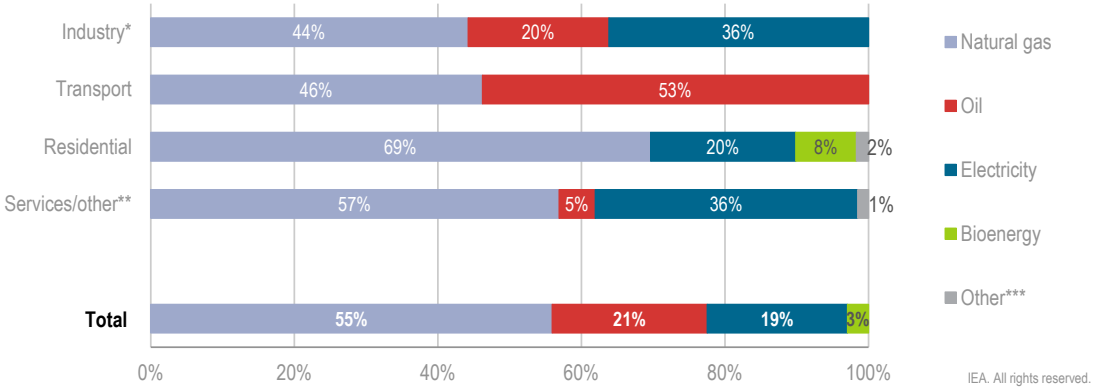
Final consumption of energy has more than doubled since 2000.

* includes non-energy consumption.

** includes commercial and public services, agriculture and forestry as well as unspecified energy consumption.

Source: IEA (2022), *World Energy Statistics and Balances* (database), https://www.iea.org/data-and-statistics.

Figure 2.8 Total final consumption by source and sector, 2020



Natural gas consumption dominates all sectors of the Armenian economy.

* includes non-energy consumption.

** includes commercial and public services, agriculture and forestry.

*** includes solar heat, coal and district heat.

Note: For ease of readability, shares of less than 1% are not shown. Therefore the sectoral totals may not add up to 100%.

Source: IEA (2022), *World Energy Statistics and Balances 2021* (database), https://www.iea.org/data-and-statistics.

Energy sector governance

The following are the main bodies responsible for energy sector policy and governance in Armenia:

The **Ministry of Territorial Administration and Infrastructure (MTAI)** is responsible for overall energy policy-making. The former Ministry of Energy Infrastructures and Natural Resources, which was previously responsible for energy policy, was integrated into the MTAI in a recent government restructuring.

The **Ministry of Environment** is the main body for environmental policy. It is responsible for approving environmental impact assessments for energy projects above certain thresholds and issuing water-use permits for hydropower projects. It is also responsible for coordinating Armenia's implementation of activities and communications under the UNFCCC, including National Communications, Biennial Updates and GHG Inventories.

The **Standing Committee on Economic Affairs of the National Assembly** deals with legislation concerning energy and natural resources, as well as competition and anti-monopoly issues, state property management, industry, services and investment, among other matters.

The **Public Service Regulatory Commission (PSRC)** is the independent government body that regulates investment in network sectors, including power and gas. Among other responsibilities, it is responsible for tariff setting, service quality and licensing.

The **Committee on Nuclear Safety Regulation** of the Republic of Armenia (ANRA) regulates the nuclear sector and radiation safety. This includes issuing licences for the operation of the ANPP and controlling the fulfilment of its licensing requirements.

The **Statistical Committee of the Republic of Armenia (ArmStat)** is the main provider of energy statistics, as well as activity data required for the assessment of GHG emissions used in Armenia's reporting under the UNFCCC.

Key policy directions

On 14 January 2021, the government approved the "Energy Sector Development Programme to 2040" (henceforth referred to as the "Strategy"), along with a timetable of specific measures for implementing it. The 2021 Strategy replaces the government's previous energy policy document, which dates from 2015.

According to the 2021 Strategy, the government's priorities in the energy sector through 2040 are:

- Maximum use of the country's potential for renewable energy and energy efficiency;
- Extending the life of the Armenian Nuclear Power Plant beyond 2026, as well as construction of a new nuclear power plant to replace it;
- Construction of a "North-South Corridor" by increasing power transmission links between Armenia and Georgia and between Armenia and Iran; and
- Gradual liberalisation of the domestic electricity market.

More details on each of these priorities are provided in the relevant sections of this in-depth review.

The priorities in the new energy strategy are echoed in the five-year "Programme of the Government of the Republic of Armenia" which was approved on 18 August 2021.

The government aims to present a revised version of its energy strategy by July 2024 for the period 2025-2050. The revision reportedly will include regulatory, social and environmental impact assessments of the present version; after this, the plan is to evaluate the effectiveness and impact of the Strategy every three years.

Regional integration

The 2021 Strategy was developed in the context of Armenia's CEPA with the European Union, as well as its membership in the EAEU.

The EAEU is an economic grouping that includes Belarus, Kazakhstan, Kyrgyzstan and Russia. Among other objectives, the EAEU aims to develop common markets in various sectors, including for power and gas by 2025. It also serves as a forum for the development of regional energy efficiency standards for tradeable goods.

For much of the past 20 years, Armenia's relationship with the EU was governed by a Partnership and Cooperation Agreement which came into force in 1999. In 2010, Armenia and the EU began negotiating a more comprehensive Association Agreement, which included a Free Trade Agreement. However, the Armenian government of the time broke off negotiations in 2013 when it decided to join the EAEU. Negotiations on a different type of partnership with the EU were renewed in 2015, taking into account EAEU membership. The negotiated CEPA agreement was signed by Armenia, the EU and its member states in 2017 and came into force in March 2021. The European Atomic Energy Community (Euratom) is also a signatory, indicating the importance that the EU places on nuclear safety cooperation with Armenia.

The CEPA aims to strengthen EU-Armenia cooperation across an array of issues, including democracy, justice, human rights and climate change. It also covers cooperation, investment and trade in a large number of economic sectors, including energy.

Among other objectives, the CEPA is designed to help Armenia gradually approximate the *acquis communautaire*, which is the body of legal acts that EU member states are required to adopt. The objective of non-EU countries approximating the *acquis communautaire* is to facilitate increased cooperation and trade among them and with the EU. The CEPA agreement includes a timetable for the approximation of Armenian laws and regulations to certain EU energy-related directives and regulations over the next few years, and by 2029 at the latest. These include:

- Directive 2009/72/EC on the Electricity Market;
- Regulation 714/2009 on Cross-border Trade in Electricity;
- Directive 2005/89/EC on Security of Electricity Supply;
- Directive 2009/28/EC on Renewable Energy;
- Directive 2012/27/EU on Energy Efficiency;
- Directive 2010/31/EU on Energy Efficiency in Buildings;
- Directive 2009/119/EC of 14 September 2009 on Imposing an Obligation on Member States to Maintain Minimum Stocks of Crude Oil and/or Petroleum Products;
- Regulation (EU) No 256/2014 of the European Parliament and of the Council of 26 February 2014 Concerning the Notification to the Commission of Investment Projects in Energy Infrastructure within the European Union.

Energy statistics

The collection, validation and dissemination of official energy statistics fall under the responsibility of the Statistical Committee of the Republic of Armenia (ArmStat).[1] ArmStat produces annual energy statistics regarding the production, transformation and consumption of energy commodities, as well as the external trade in such commodities. These data are produced following relevant international methodologies and standards. ArmStat also produces monthly short-term energy statistics on the supply of energy commodities. ArmStat receives and processes data from a number of government bodies, notably the MTAI, the Ministry of Economy, and the regulator (PSRC).

The PSRC requires licensed companies to submit certain data on a quarterly basis and publishes such data on the PSRC website (https://psrc.am/contents/fields/electric_energy/el_energy_reports).

Collected energy statistics in Armenia are generally in the public domain.[2] ArmStat has regular collaboration with the main (government) data users, building trust in and knowledge of the available data. The main national users of energy data include the MTAI and the Ministry of Environment. ArmStat also cooperates and regularly shares energy data with international organisations, including the International Energy Agency (IEA), the United Nations Statistics Division (UNSD), and the Joint Organisations Data Initiative (JODI).

Assessment

Energy strategy

The approval and publication of the Armenian government's Energy Sector Development Strategic Programme in January 2021 are welcome. The Strategy sets the path for the sector's transition through 2040 and should form a useful basis for Armenia's future energy legislation.

Regional market integration

Armenia has made considerable progress in enhancing regional market integration. The country has signed and ratified the CEPA with the EU that entered into force in March 2021 and includes a timetable for the approximation of Armenian laws and regulations to relevant EU laws over the next few years, and by 2029 at the latest. Armenia is also a member of the EAEU, which aims to establish common EAEU gas and electricity markets by 2025. Implementing these ambitious objectives will require close cooperation and coordination between different institutions to achieve regulatory consistency and to eliminate potential contradictions and conflicts.

Energy governance

In a recent government restructuring, the former Ministry of Energy Infrastructures and Natural Resources was integrated into the current MTAI. The transfer and addition of the energy agenda to the already broad portfolio of responsibilities of the MTAI risks a

[1] Law "On Official Statistics of the Republic of Armenia", adopted on 21 March 2018, https://www.armstat.am/file/doc/99514643.pdf.
[2] Statistical Committee of the Republic of Armenia, https://www.armstat.am/en/.

relegation of pressing energy issues. The implementation of the comprehensive and ambitious programmes mentioned above could put existing resources under pressure, risking insufficient coordination between ministries and other governmental entities dealing with energy-related policies and affecting the effective and timely implementation of these programmes.

Liberalisation

Since the last IEA review in 2014/15, the government has taken decisive steps towards implementing a liberalised electricity market with a planned launch in February 2022, featuring a new wholesale market model, direct contracts, a balancing mechanism and long-term direct capacity contracts. Free and open trade, as well as cooperation among all energy market participants, as envisioned by these reforms, would help promote investments from the international community and strengthen regional integration.

Energy supply security

Armenia has a diverse generation mix that includes thermal, hydropower and nuclear. However, all of its thermal generation relies on gas, almost all of which is imported from Russia. Furthermore, Armenia imports all of its nuclear fuel from Russia. Armenia therefore effectively relies on fuel imports from one country to produce nearly 70% of its electricity, raising concerns about the diversity of supply.

Nuclear safety

Since the late 1990s, the EU and several other international partners have strongly encouraged the closure of Armenia's WWER-440 nuclear reactor, a type the EU views as particularly dangerous, further noting that the plant is located only 30 km from Yerevan, the capital city of 1 million people. The review team commends Armenia's efforts to continuously improve nuclear safety measures to meet IAEA safety goals for existing NPPs and its long-term cooperation in this regard with the IAEA, EU, Russia and other international partners.

Energy efficiency

Energy efficiency plays a prominent role in the 2021 Energy Strategy, as well as in the CEPA and cooperation with the EAEU. The government is currently developing a National Programme on Energy Saving and Renewable Energy for the period 2021-2030. The focus on energy efficiency is commendable, given the significant potential for improvements. Data-driven solutions, such as collection of demand-side data from users, will be important for improving energy efficiency in buildings, industry and transport. Energy efficiency improvements will also depend on developing the necessary skills domestically, e.g. to perform energy audits.

In 2016, the parliament passed an amendment to the Energy Efficiency and Renewable Energy Law, mandating energy efficiency requirements for newly constructed multi-apartment buildings, energy audits for buildings constructed with state funding, the development of energy balances, and labelling requirements for white goods. However, more work will be needed in these areas to fully approximate the energy efficiency elements of the CEPA.

Conducting a specific household energy consumption survey (e.g. every five years) to obtain disaggregated energy information within the residential sector, would allow the development of important energy efficiency indicators,[3] which in turn would greatly support any future energy efficiency policies and measures for buildings and the household sector.

Modelling

Modelling based on good-quality data is a key component of effective policy-making. Policies and measures contained within the 2021 Strategy were based on modelling performed by the Scientific Research Institute of Energy, which is staffed with skilled and highly educated personnel. However, staff turnover in this and other key research institutions is high, risking frequent institutional memory loss and lack of staff for establishing regular monitoring systems to follow up on policy developments. Additionally, modelling capabilities in the country rely heavily on financial and (in some cases) personnel support from international donors. These might tailor modelling assumptions and parameters to their own needs, making a comparison among models difficult. Furthermore, economy-wide modelling has not been carried out, omitting significant energy users, such as industry and transport.

An improved approach could include enhancing the government's own modelling capabilities and institutional learning capacity. The development of comprehensive energy system models demands sufficient and targeted allocations from the state budget, regardless of whether modelling is outsourced or capacities are developed within the ministry.

Exploring modelling scenarios extending to 2050 and beyond will be important for mapping pathways to reach Armenia's climate goals under the Paris Agreement. Since the energy sector is the largest source of GHG emissions in Armenia, a resolute and consistent implementation of its National Programme on Energy Saving and Renewable Energy will prove essential for reaching its recently updated NDCs.

Energy data management and use

The 2015 IEA review[4] noted that Armenia "aims to institute the IEA balance methodology by 2015. The introduction of IEA standards will result in further quality improvements". Since then, Armenia has adopted the international energy statistics methodology and standards,[5] and has released energy balances in the internationally comparable format since 2015. The cooperation of the national stakeholders to achieve this is to be commended. There are no significant data gaps in the energy balance, and in particular, data for residential biomass in the energy balance are considered representative.

The large unallocated quantities of electricity and natural gas in final consumption statistics (over 10%) is linked to apparent challenges the distribution companies have in classifying customers by type (e.g. services, industry), in turn hindering the design of energy efficiency policies and measures for the affected sectors.

[3] As per the IEA methodology, see https://www.iea.org/reports/energy-efficiency-indicators-essentials-for-policy-making.

[4] IEA (2015), *Energy Policies Beyond IEA Countries: Caspian and Black Sea Regions 2015*, Energy Policies Beyond IEA Countries, OECD Publishing, Paris, https://doi.org/10.1787/9789264228719-en.

[5] United Nations Statistics Division, Energy Statistics, https://unstats.un.org/unsd/energystats/methodology/ires/.

Official energy balance compilation is the responsibility of the MTAI. However, the practical work is outsourced, risking the loss of institutional memory.

The energy module of the national greenhouse gas inventory is mostly based on the official energy balance. However, activities for energy balance and GHG inventory compilation do not receive funding from the state budget. Complementing and gradually replacing external funding with contributions from the state budget would ensure sustainability for these activities and help retain the trained human capacity.

Electronic dissemination of official energy information has improved in recent years. However, this could be further supported by adopting the integrated state administrative information system that reportedly has been planned for several years. A unified system between government entities would greatly facilitate the exchange of timely data in user-friendly formats, increase data transparency and reduce the burden of reporting data manually. ArmStat has plans for increasing the level of electronic data collection from respondents under a project with the World Bank. This is strongly encouraged, as it will not only improve the timeliness and accuracy of data, but release scarce staff resources for other tasks.

The development plan for energy statistics is included in the Statistical Programs of ArmStat. Regularly updating this plan would give such developments visibility and help prioritise the use of resources. This in turn would help ArmStat to continue to respond to emerging challenges, satisfy expanding user needs and increase the relevance of energy statistics for policy development purposes.

Recommendations

The government of Armenia should:

- Increase resources and improve the government's in-house capabilities to enable the parallel implementation of CEPA and EAEU policies and measures. In particular, the government needs to be in a position to ensure regulatory consistency and legal certainty when approximating Armenian legislation to EU energy legislation, while at the same time setting up a common market for electricity and gas with EAEU member countries.
- Ensure effective exchange between all relevant parties involved in energy-related policies and decision-making procedures, including ministries, other government entities, and research institutions. The aim should be to promote transparency and establish regular monitoring and impact assessments of the activities performed and of the measures set up by the different parties involved.
- Enhance the government's own modelling capability, dedicating a regular modelling budget to ensure consistency and comparability and to avoid the loss of institutional memory. Work in this area should encompass the whole economy, and extend the time horizon to at least 2050 in order to chart net-zero pathways.
- Continue the government's considerable efforts to transition to a liberalised, competitive electricity market by reducing technical, economic and administrative barriers and consider a similar path for the gas sector.

- Continue close coordination with the IAEA, EU and other relevant international organisations on nuclear safety issues and legal aspects, and in particular ensure that continued use of the current nuclear power plant (and any future nuclear power plant) meet relevant international safety standards and that they are governed by legal instruments aligned with international practice.
- Aim to reduce dependence on imported natural gas, and further diversify supply sources of gas.

Energy statistics

- Maintain the close cooperation between ministries and ArmStat and continue using official energy statistics as the foundation for analysis in strategic documents and in drafting new legislation.
- Encourage ArmStat to regularly update its strategic energy statistics development plan in line with the State Statistics Development Programme, in order to ensure continuous improvement of energy statistics.
- Provide sufficient resources (human and financial) for ArmStat to conduct household energy consumption surveys at regular intervals (e.g. every five years) in order to develop energy efficiency indicators to monitor the results of energy efficiency policies in the residential sector and to increase the level of data disaggregation. The government should also allocate funds from the state budget for the compilation of the energy balance and GHG inventory.
- Encourage ArmStat and the electricity and gas distribution companies to find a solution for allocating the large volume of unspecified final consumption of electricity and natural gas. This would further support the planning of accurate energy efficiency policies and measures.
- Ensure a clear division of work by assigning responsibilities for tracking, monitoring and verifying energy efficiency improvements in all sectors of the economy among relevant institutions, including ArmStat and the MTAI.
- Expand the use of electronic data reporting from respondents, including the further implementation of the Integrated State Administrative Information System, in order to enhance data transparency and facilitate information exchange between national stakeholders.

References

ArmStat (Statistical Committee of the Republic of Armenia) (2020), Statistical Yearbook, ArmStat, Yerevan.

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GoA (2021b), Program of the Government of the Republic of Armenia (2021-2026).

World Bank (2021), The World Bank in Armenia, (https://www.worldbank.org/en/country/armenia/overview (accessed 26 August 2021).

3. Gas

Key data

(2020 provisional)

Domestic production: none

Net imports: 2.60 bcm, +48% since 2009

Share of natural gas: 59.6% of TES, 40.4% of electricity generation, 55.5% of TFC

Gas consumption by sector: 2.56 bcm (power generation 28.3%, residential 28.0%, transport 18.3%, industry 8.1%, services 2.0%, other* 11.6%, losses 3.8%)

*includes agriculture, energy sector own use and unallocated natural gas final consumption, the share of which was 8% in 2020.

Overview

Natural gas is Armenia's main energy source, accounting for about 55% of TFC and 40% of electricity generation in 2020.

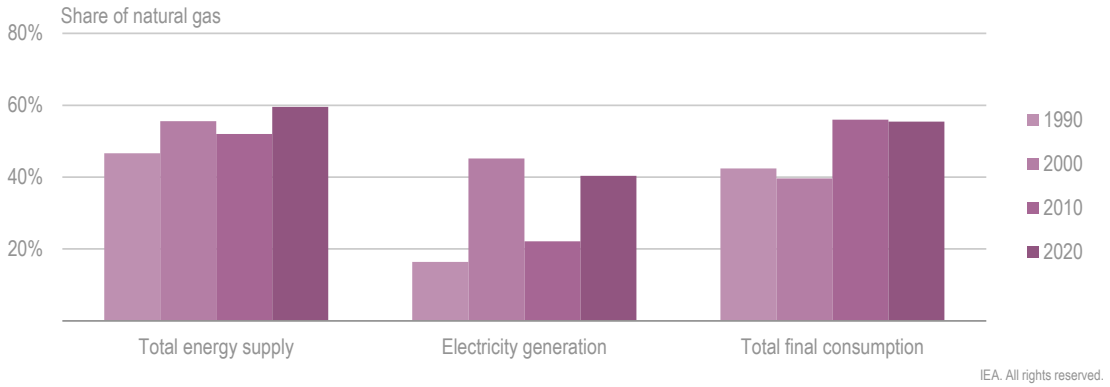
Armenia has no domestic gas production, so all demand is covered by imports, of which over 80% come from Russia. Since 2009, Armenia has also imported small amounts of gas from Iran, though this has been limited to a gas-for-electricity swap.

The main gas-consuming sectors are power generation, residential and transport. After intensive gasification activities over the past two decades, 96% of the communities have access to gas, and over 70% of road transport runs on natural gas.

The domestic gas sector remains a vertically integrated monopoly with no competition or third-party access. There are currently no specific plans to change this, though the Energy Sector Development Strategic Program to 2040 (Energy Strategy) published in 2021 notes that the government plans to review the situation over the next few years.

Armenia is a member of the EAEU, which is planning to launch a common gas market in 2025.

Figure 3.1 Share of natural gas in Armenia's energy system, 1990-2020



Natural gas plays a key role in Armenia's economy.

Note: 2020 data are preliminary.

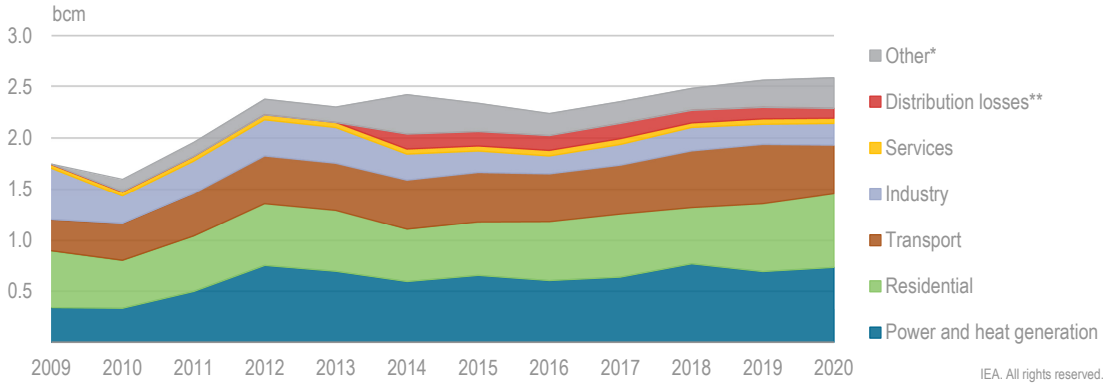
Source: IEA (2022), *World Energy Statistics and Balances* (database), https://www.iea.org/data-and-statistics.

Supply and demand

Consumption

Domestic consumption of natural gas was 2.6 bcm in 2020. The main gas-consuming sectors are power generation, residential and transport. Gas accounted for about 55% of primary energy consumption and 80% of fossil fuel consumption that year.

Figure 3.2 Natural gas consumption by sector, 2009-2020



Natural gas consumption has grown substantially since the 2008 global economic crisis.

* The share of unallocated gas consumption of the total is notable in Armenia. A share of consumption in the commercial and public is included in unspecified consumption, limiting the sectoral analysis.

** Data for losses available since 2014.

Note: bcm = billion cubic metres.

Source: IEA (2022), *World Energy Statistics and Balances* (database), https://www.iea.org/data-and-statistics.

Power sector

The power sector is the largest consumer of natural gas in Armenia, accounting for over 28% of total gas demand in 2020, a year in which gas-fired power plants produced over

40% of the country's electricity.[6] Although at least one of Armenia's gas-fired plants is also able to use fuel oil, all thermal generation units have run exclusively on gas for at least the past two decades. After the installation of two new gas-fired plants in the early 2010s, natural gas use for power generation more than doubled by 2020 from its 2010 level.

All gas-for-power production comes from Russia, with the exception of gas for the state-owned Yerevan CCGT-1 power plant, which imports gas from Iran in exchange for electricity exports to that country.

Residential

The residential sector is the second largest gas consumer, accounting for 28% of gas demand in 2020. Following a substantial gasification campaign, 96% of the communities now have access to pipeline gas (GoA, 2021). In 2020, the residential sector consumed 0.72 bcm and historically has represented over a fifth of TFC.

Gas is used in the residential sector for both cooking and heating. Most residential heating now consists of small, individual gas boilers.

During the Soviet period, gas-fired district heating systems served over 60% of residential areas in Armenia and provided heat to over 90% of the country's apartment buildings. For various reasons, including a blockade of gas supplies in the early 1990s, nearly all district heating systems were shut. Today, district heating is used only in one section of Yerevan, covering some 35 multi-apartment buildings. There are currently no reported plans to refurbish or expand district heating networks.

Transport

Armenia has one of the world's highest levels of gasification in the transport sector. Over 70% of vehicles run on natural gas, with a higher rate in Yerevan. Most use gas in the form of compressed natural gas (CNG), though some vehicles are designed to run on LNG.

There are 384 CNG filling stations, one for approximately every 38 km of road. All are privately owned, including seven by Gazprom Armenia. Nearly all vehicles running on CNG are also able to use motor gasoline, providing flexibility in case of a gas supply disruption.

The demand for natural gas in the transport sector is expected to decline in the coming years as the government promotes the use of electric vehicles. The number of electric vehicles in the country is currently small.

Industry

Industry accounts for less than 10% of natural gas consumption, although gas is the largest energy source for that sector. Natural gas consumption dipped as a consequence of the global economic crisis in 2008-2009 but has since grown from pre-crisis levels. Industrial production is mainly concentrated in Yerevan (GoA, 2020).

Imports

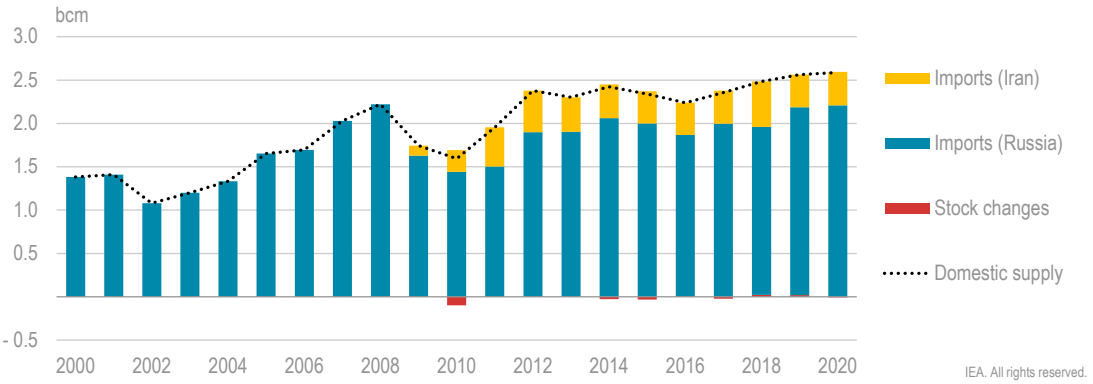
Armenia has no natural gas production, so all supplies are imported. Approximately 85% of imports in 2019 came from Russia via Georgia, and the remaining 15% from Iran.

[6] 2020 is arguably an atypical year, since generation at the nuclear power plant was reduced due to extensive measures to extend the lifetime of the plant.

Imports from Russia in 2020 were 2.21 billion cubic metres (bcm). Gazprom Armenia, a subsidiary of Russia's Gazprom, purchases its gas from another Gazprom subsidiary. However, the key issue of price is handled at the state level according to the 2013 agreement between the two governments regarding ownership of the network, as well as an agreement on pricing procedures (GoA, 2021). The terms of the latest price agreement, which expired on 31 March 2021, provided for a price of USD165 per 1 000 cubic metres, implying a substantial discount from potential market rates (Panorama.am, 2021). The contract duration was extended until the end of 2021,[7] and a new gas import agreement with Russia was still being negotiated as of early 2022.

Gas imports from Iran in 2020 were 0.39 billion cubic metres. Such imports take place under a 20-year agreement that began in 2009. So far they have been limited to a gas-for-electricity swap, under which gas is imported by the Armenian state-owned Yerevan CCGT-1 power plant in exchange for electricity exports. The price of gas imported from Iran reportedly is not defined in monetary terms. The IEA review team was informed that 1 cubic metre of Iranian gas is exchanged for 3 kWh of Armenian electricity.

Figure 3.3 Natural gas supply by source, 2000-2020



Natural gas demand almost doubled between 2000 and 2020.

Source: PSRC (2021), https://www.psrc.am/contents/fields/gas/gas_reports (available in Armenian); IEA (2022), *World Energy Statistics and Balances* (database), https://www.iea.org/data-and-statistics.

Gas sector structure

The gas sector remains a vertically integrated monopoly. Gazprom Armenia, wholly owned by Russia's Gazprom, has exclusive rights to import, transport and distribute gas to consumers as the sole holder of the country's transmission and distribution licenses, with rights defined under Article 36 of the Energy Law. Gazprom Armenia is also the owner of all gas infrastructure.

With no third-party access or competition, there currently are no features in place reflecting EU gas market rules. However, the government notes that it will start developing a new

[7] EurAsia Daily, [Pashinyan and Miller considered Gazprom's investment plans in Armenia], 14 September 2021, https://eadaily.com/ru/news/2021/09/14/pashinyan-i-miller-rassmotreli-investicionnye-plany-gazproma-v-armenii (accessed 24 November 2021).

law on gas supply by 2022 and plans to thoroughly review the current regulatory framework and bylaws by the end of 2024 (GoA, 2021).

Gazprom Armenia has over 7 000 employees, making it one of the largest economic entities in the country. It has 15 local gas supply branches, an engineering centre and several subsidiary companies. This includes TransGas, which operates the gas transmission system and the Abovyan underground gas storage facility. Gazprom Armenia also owns and operates the Hrazdan 5 gas-fired power plant.

The only other entity operating in the gas sector is the state-owned Yerevan CCGT-1 power plant, which has a license to import gas from Iran as part of the gas-for-electricity swap with that country. The gas transport between the border and the plant is handled by Gazprom Armenia through its transmission system.

Armenia is a member of the EAEU, which is planning to launch a common gas market in 2025 following a decision in May 2016 by the Supreme Eurasian Economic Council and an agreement signed in 2019 by member countries. (The other members of the EAEU are Belarus, Kazakhstan, Kyrgyzstan and Russia.) A final agreement to form the common gas market is expected to be signed by member countries in 2022. In the meantime, members are drafting common trading and access rules, which are expected to include provisions for third-party access.

Gas infrastructure

All gas-related infrastructure is owned by the Gazprom subsidiary, Gazprom Armenia. Similar to the situation in a number of other former Soviet Republics, Gazprom obtained ownership of this infrastructure in exchange for relief from accumulated gas-related debts.

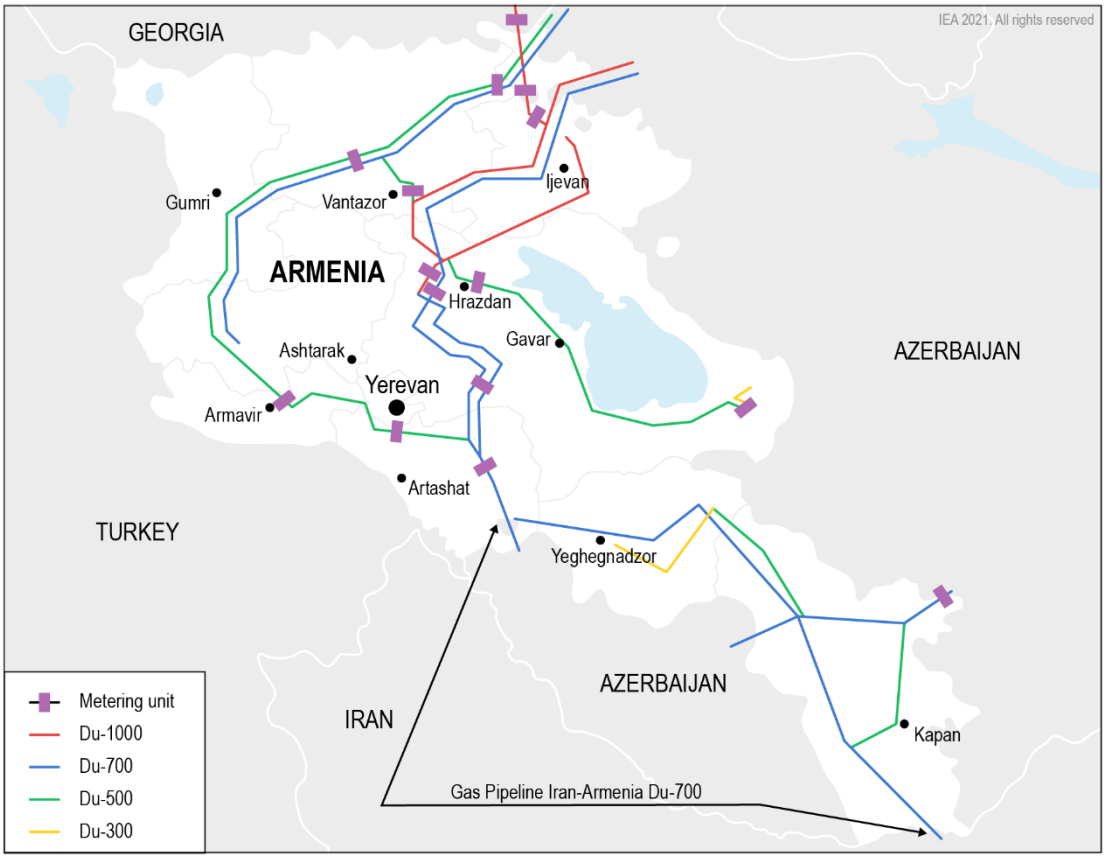
Gazprom Armenia's investment programme for 2021-2025 aims to modernise the country's ageing gas network infrastructure with planned investment volumes of around USD 500 million (GoA 2021). Much of this involves an expansion of the Abovyan gas storage facility and refurbishment of transmission pipelines. The investment programme is being carried out within the framework of the General Scheme of Gas Supply and Gasification until 2030, which was approved by the MTAI. The government's Strategy further calls for ten-year least-cost development plans for transmission and distribution networks to be developed and periodically updated (GoA, 2021).

Transmission and distribution network

Armenia has 7 411 km of high and medium-pressure pipelines, 14 199 km of low-pressure lines, 75 gas distribution stations and 21 measuring points, including measuring points on the borders with Georgia and Iran. Some 64 km of trunk pipelines and 131 km of medium and low-pressure lines were scheduled for repair in 2021, along with three gas distribution stations (arka.am, 2021).

The gas transmission system handled 2 576 million cubic metres in 2019, of which technical losses reportedly accounted for 86.8 million cubic metres (about 3.4%). Losses in the distribution network that year were reported to be 27.4 million cubic metres, or 1.2% of the 2 233.1 million cubic metres handled by the distribution network. The government estimates that fugitive methane emissions represent a significant share (24%) of total greenhouse gas emissions from the energy sector (GoA, 2020).

Figure 3.4 Armenia's natural gas infrastructure



This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

Source: Adapted from Gazprom Armenia, https://armenia.gazprom.com/_ah/img/nAEs-azB-Ebrd8wiuMmNuA.

Import pipelines

Armenia does not share a border with its main gas supplier. Russian gas flows via Georgia's North-South Main Pipeline. The 1 200-mm northern part of this line has a capacity of 16 bcm per year for gas entering Georgia. The 1 000-mm southern portion limits the annual transit capacity to Armenia to 10 bcm (GOGC, 2018), still well above Armenia's current import needs of approximately 2.2 bcm in 2019. Repair of the North Caucasus-Transcaucasia pipeline in early 2021 reportedly led to a temporary re-routing of Russian gas through Azerbaijan, although the gas still passed through Georgia and entered Armenia at the usual crossing point from that country (Panorama.am, 2021a).

A gas pipeline from Iran was commissioned in stages between 2007 and 2009, crossing into Armenia at the border town of Meghri with a capacity of 2.3 bcm per year (Teheran Times, 2008). This means that Iran could in theory meet most if not all of Armenia's current gas import requirements. In practice, however, actual imports have been limited to 0.33-0.38 bcm per year, or just enough to cover the gas-for-electricity swap agreement.

The potential for using Iranian imports to diversify gas supply may be complicated by the fact that Gazprom Armenia owns the Armenian part of the cross-border connection, as well as the rest of the pipeline infrastructure on the Armenian side. Gazprom involvement in the Iranian pipeline project led to speculation that its original motivation was to find an

alternative to supplying Armenia via Georgia, with which Russia was having a dispute at the time (EDM, 2007).

Gas storage

The gas system operator, TransGas, currently operates one underground storage facility, located near Abovyan. This facility enhances energy security by helping ensure daily load regulation and uninterrupted supply in heavy-demand periods and emergencies.

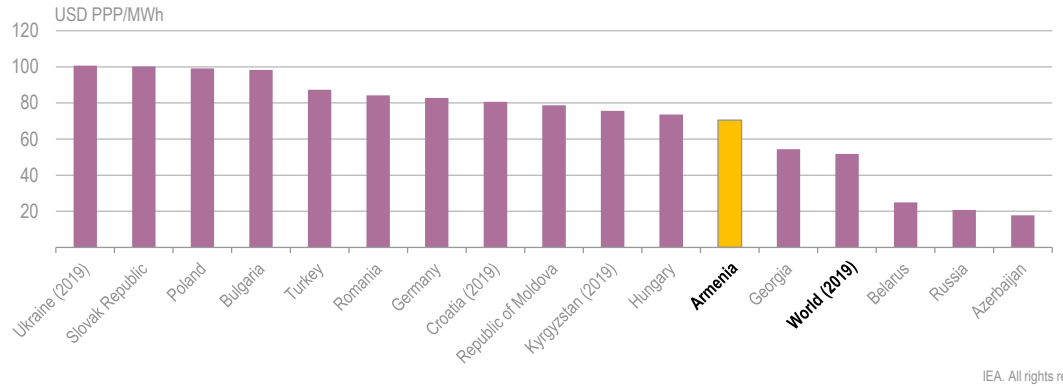
The storage facility at Abovyan currently has a capacity of about 135 million cubic metres, equivalent to about 7% of Armenia's annual gas consumption. It is divided into two separate storage wells. According to Gazprom Armenia, the withdrawal capacity of Abovyan is 6 million cubic metres per day. Expansion and modernisation of Abovyan are a major item in Gazprom Armenia's 2021-2025 investment programme, which aims to increase the capacity of the facility to around 250 million cubic metres.

Gas prices

Gazprom Armenia supplies all customers at prices regulated by the Public Sector Regulatory Commission. No deregulation of gas prices is envisaged in the 2021 Energy Strategy.

Residential gas prices in Armenia are low relative to the European average. However, they are similar to those in other former Soviet Republics which receive most of their supply from Russia, and somewhat higher than those in the other two Caucasus countries.

Figure 3.5 Residential natural gas prices in selected countries, 2020



Residential natural gas prices in Armenia are above the world average.

Notes: When recent data are not available, the year for the latest data is indicated in the chart. Prices expressed in constant 2015 USD and purchasing power parities (PPP).

Source: IEA (2022), *World Energy Prices* (database), https://www.iea.org/data-and-statistics/data-products?filter=prices.

Armenian prices for energy, including gas, are not subsidised. However, a rise in the import price in 2019 reportedly has not yet been allowed to be reflected in tariffs. In response to the rise in wholesale gas prices from Russia, the national gas distribution company, Gazprom Armenia, sought to increase consumer tariffs in a formal request to the PSRC in 2020, though the latter retained the previous rates.

Tariffs current as of June 2021 provide for five main categories. The general tariff is AMD 139 000[8] (including VAT) per 1 000 m^3 for the first thousand cubic metres, and USD 255.91 per 1 000 m^3 for amounts above this. Payment for the latter must be made in Armenian drams at the exchange rate defined monthly by the Central Bank of Armenia.

"Socially insecure families", as defined by a list drawn up by the Ministry of Social and Labour Affairs, pay a reduced rate of AMD 100 000 per 1 000 m^3 for their first 600 cubic metres of the year, after which the tariff rises to the general rate.

Individuals engaged in agricultural processing are charged USD 224 per 1 000 m^3. Greenhouses pay a rate identical to the agricultural processing rate during the winter and pay the general rate the rest of the year.

According to Gazprom Armenia, most customers are metered and the collection rate is 100%.

Table 3.1 Gas Tariffs in Armenia as of June 2021

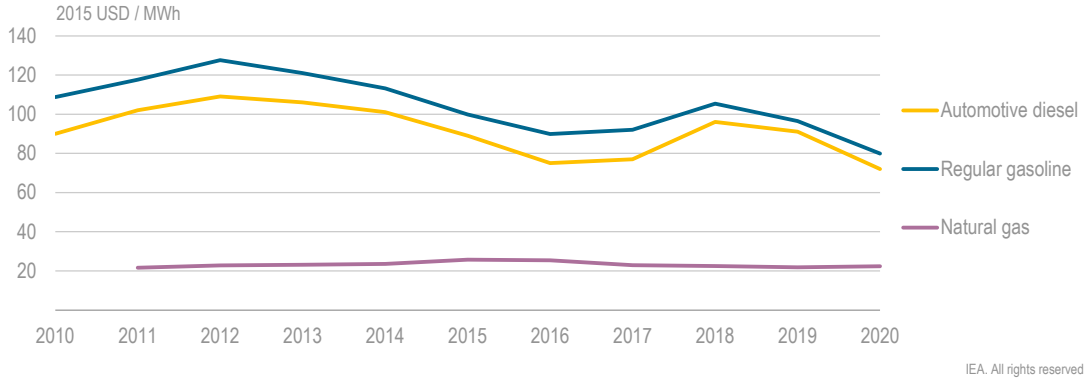
№	Consumers	Measurement unit	Tariff
1.	Socially insecure families		
1.1	For up to 600 m^3 of natural gas	AMD/1 000 m^3	100 000
1.2	For more than 600 m^3 of natural gas and for all others	AMD/1 000 m^3	139 000
2.	Greenhouse farms in agriculture		
2.1	For period from November 1 to March 31 inclusively	USD /1 000 m^3	224.0
2.2	For the period from April 1 to October 31 inclusively		
a.	For consumption of up to 10 000 m^3 per month	AMD/1 000 m^3	139 000
b.	For consumption of 10 000 m^3 per month and more	USD/1 000 m^3	255.91
3.	For individuals performing agricultural produce processing: preserves, beverages and dairy product producers	USD/1 000 m^3	224.0
4.1	For those licensed to generate electricity in thermal power plants (including CHPs), consuming up to 10 000 m^3 monthly	AMD/1 000 m^3	139 000
4.2	For those licensed to generate electricity in thermal power plants (including CHPs), consuming 10 000 m^3 per month and above	USD/1 000 m^3	255.91
5.1	For consumption of up to 10 000 m^3 per month, except for those covered in points 1 – 4	AMD/1 000 m^3	139 000
5.2	For consumption of 10 000 m^3 per month and more, except for those covered in points 1 – 4	USD/1 000 m^3	255.91

Source: PSRC (2021), https://www.psrc.am/contents/fields/gas/gas_tariffs.

[8] The average exchange rate between the USD and ARM in June 2021 was 513.07 AMD for 1 USD, http://rates.am/en/armenian-dram-exchange-rates/central-bank-armenia

Since most cars running on CNG in Armenia are also able to use motor gasoline, the decisive factor in the choice of fuel appears to be price, which currently strongly favours natural gas. 391 ktoe (46%) of fuel consumption for road transport in 2020 was natural gas, as opposed to 230 ktoe (27%) for motor gasoline and 175 ktoe (21%) for diesel. Liquefied petroleum gas (LPG) accounted for 6% and electricity for well under 1%.

Figure 3.6 Main transport fuel prices in Armenia, 2010-2020



Natural gas has been significantly less expensive than other motor fuels.

Notes: For oil products, price data are converted from litres to MWh using average calorific values for the time period. Natural gas price data is available from 2011.

Source: IEA (2022), *World Energy Prices* (database), https://www.iea.org/data-and-statistics/data-products?filter=prices.

Assessment

Armenia's gas sector remains a vertically integrated monopoly, operated and owned by Gazprom Armenia, a fully owned subsidiary of Russia's Gazprom. There is currently no competition nor third-party access in the sector. According to the 2021 Energy Strategy, however, the Armenian government intends to review all gas-sector legislation by 2024, and as part of this will begin to develop a new Gas Law in 2022. The drafting process for a new Electricity Law is already underway. Since the legal framework of the entire energy sector in Armenia is currently based on the general Energy Law, there is some concern that delays in developing the new Gas Law could retard liberalisation efforts in the power sector.

Armenia, along with other members of the EAEU, is planning to launch a common EAEU gas market in 2025. An agreement signed by EAEU members in 2019 commits Armenia to introducing third-party access, among other reforms aimed at facilitating cross-border gas trade, though a final agreement on this is expected to be signed in 2022.

Around 85% of Armenia's gas supply is procured from Russia via Georgia. The remainder is imported from Iran, though Iranian gas is currently used only for the production of electricity at one power plant in a gas-for-electricity swap. Domestic gas consumption is therefore fully sourced from Russia. One of the reasons for this reportedly is that Iran has been reluctant to trade on other than barter terms. Completion of a new high-voltage connection between Iran and Armenia may thus pave the way for further imports on a swap basis. Further expansion of gas imports from Iran also may be complicated by the fact that relevant infrastructure is effectively controlled by the local subsidiary of Russia's Gazprom, as well as by general difficulties trading with Iran due to international sanctions on that country.

Potential security risks related to heavy reliance on a single source for gas should be seen in the light of Armenia's large dependence on gas, which accounts for the largest share of the country's total primary energy supply (around 60%). Both the residential and road transport sectors rely on natural gas as their main fuel, although Armenia's Energy Strategy aims to increase the use of electric vehicles in the latter.

Current efforts to substantially increase the size of the Abovyan gas storage facility will help increase supply security, for example in the case of a disruption of supplies via Georgia. Nevertheless, this facility, like all other gas infrastructure in the country, is under the ownership of Armenia's main gas supplier.

Gas tariffs reportedly cover costs but have effectively been subsidised by below-market prices for Russian imports. Moreover, recent price rises for Russian gas have not always been matched with domestic tariff increases. For example, in response to a rise in the import price in 2019, the regulator proposed to retain the previous tariff structure, including special rates for the greenhouse sector and parts of the food-processing industry. Considering Armenia's aim to increase overall energy efficiency, low gas tariffs may hinder progress in efficiency gains in these sectors.

District heating is currently used in only one section of Yerevan, and there are no plans to refurbish or expand networks. Residential heating is now dominated by small, individual gas boilers. Since such boilers do not require a licence, there are no centralised records about their installation or efficiency. Given the large share of gas consumption currently represented by domestic heating, and the lack of information about equipment employed, including possibilities for improving its efficiency, the government may wish to undertake a strategic review of this important sector.

Recommendations

The government of Armenia should:

- Consider liberalisation of the gas sector, aiming for timely implementation of market structures with third-party access in line with the 2019 EAEU commitments.
- Ensure that the new Gas Law and Electricity Law are developed in tandem and that development of the Gas Law does not lag behind the development of the Electricity Law or inhibit progress on the latter.
- Re-evaluate the tariff structure for gas consumers, ensuring cost-reflectiveness, appropriate revenues for investments in the gas infrastructure and incentives for energy efficiency gains.
- Aim to further diversify the supply sources of natural gas, including within the framework of the emerging common market for gas in the EAEU.
- Undertake a long-term analysis of the heating sector, including the role of district heating networks and decentralised solutions (including heat pumps), as well as the role of gas, electricity, biomass and solid waste.
- Stimulate the introduction of gas boilers that meet high energy efficiency standards.

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4. Oil

Key data

(2020 provisional)

Domestic production: none

Crude oil net imports: none (no refining capacity)

Oil product net imports: 0.61 Mt (13.3 kb/d), +54.8% since 2009

Share of oil*: 16% of TES, no electricity generation, 21% of TFC

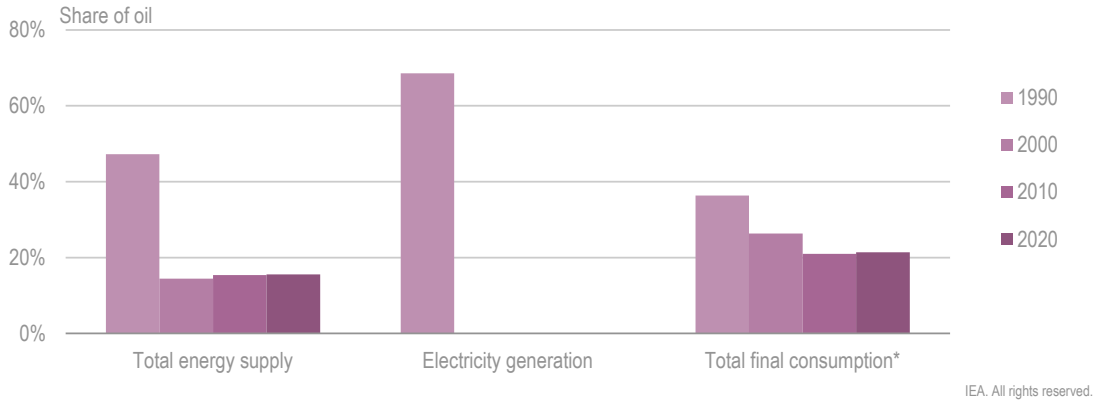
Consumption by sector: 0.58 Mt (road transport 75.3%, international bunkers 6.5%, industry 11.4%, services/other 6.4%, residential 0.4%)

* TES does not include oil used for international bunkering

Overview

Armenia has no known oil reserves, no oil production and no refineries. As a result, it imports all of its oil products. The import and sale of oil products are privatised, and prices are unregulated. The share of oil in energy consumption is low relative to the situation in most countries, since oil is not used in power generation, and the country relies on natural gas as the main fuel for road transport. Armenia currently has no known emergency stocks of crude or oil products, though importers and sellers maintain some commercial stocks.

Figure 4.1 Share of oil in Armenia's energy system, 2010-2020



Share of oil in Armenia's energy system is low.

Note: *includes non-energy use

Source: IEA (2022), *World Energy Statistics and Balances* (database), https://www.iea.org/data-and-statistics.

Supply and demand

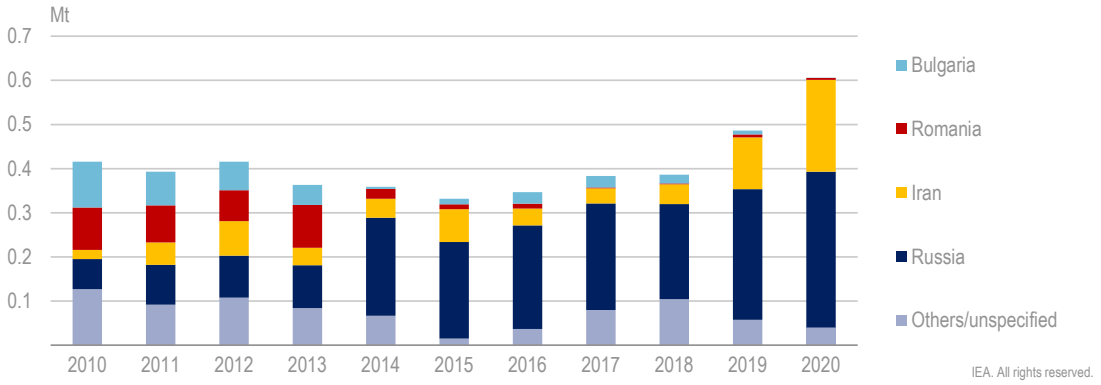
Armenia has no refineries, so all demand for oil products is met by imports. Oil products represented only 21% of Armenia's TFC in 2020. This is due to oil's very low share in road transport and current non-use in thermal power generation, both sectors where natural gas dominates.

Imports

Armenia imports refined petroleum products from around 40 countries, though since 2010 75% has come from the following four: Russia, Iran, Romania and Bulgaria. Deliveries from Russia since 2014 have constituted around 60% of annual imports, while the share of imports from Iran increased from 5% in 2017 to 34% in 2020. Most oil products arrive by train or road via Georgia.

Imports of oil products are carried out by private companies. The government is not involved in any planning of import activities, though taxes are collected on imported products at the border. Fuel quality is checked during import by the testing laboratory of the Armenian National Institute of Standards.

Figure 4.2 Armenia's oil product imports by country, 2010-2020



Domestic demand is met fully by imports, mainly from Russia.

Notes: 2020 data are preliminary.

Source: IEA (2021), *World Energy Statistics and Balances* (database), https://www.iea.org/data-and-statistics.

Armenia and Iran reportedly have discussed the construction of an oil or oil products pipeline for many years, though there are apparently no plans for either at present.

Consumption

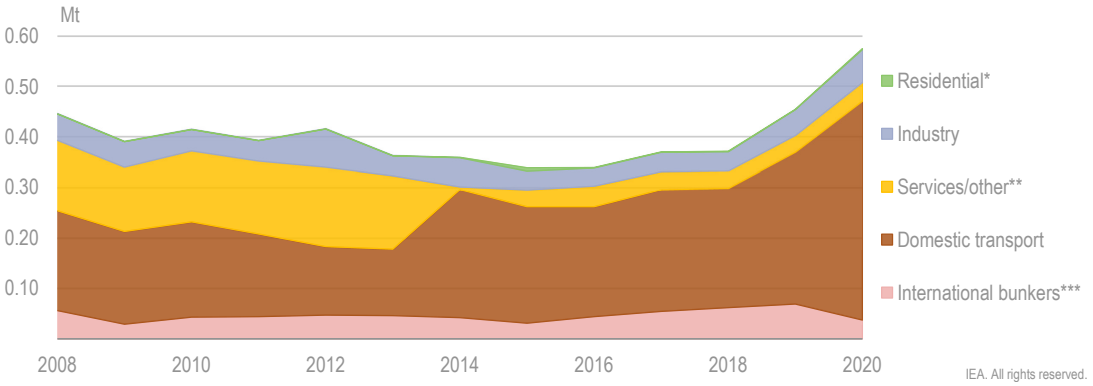
Despite the low use of oil products in the transport sector, motor gasoline and diesel form the bulk of product imports and consumption. These are followed by jet fuel and kerosene for aviation and bitumen for road construction.

Armenia has one of the world's highest levels of gasification in the transport sector (68%), though nearly all vehicles running on CNG are also able to use motor gasoline. Demand for gasoline slumped in the early 2010s in response to the worldwide economic crisis, but also due to continued inroads by natural gas in the transport sector, mainly due to price. By 2010, natural gas represented 58% of fuel consumption in the transport sector. Oil's

share in the transport sector has generally continued to decline since then, although year-on-year increases have occurred, most recently in 2020, apparently in response to rises in natural gas prices.

Demand for natural gas in the transport sector may decline in the coming years in response to government efforts to promote electric vehicles, notably by eliminating VAT on e-vehicle imports. Although most thermal power plants constructed in Armenia during the Soviet period were designed to run on heavy fuel oil as well as gas, the country has not used oil in the power sector since the mid-1990s. Armenia's one remaining dual-fired thermal power plant runs exclusively on natural gas.Given the reliable state of grid-based electricity supply in the country, the amount of oil used for private generators is negligible.

Figure 4.3 Oil consumption by sector, 2008-2020



Domestic transport is by far the largest consumer of oil products, even if their share in that sector is low.

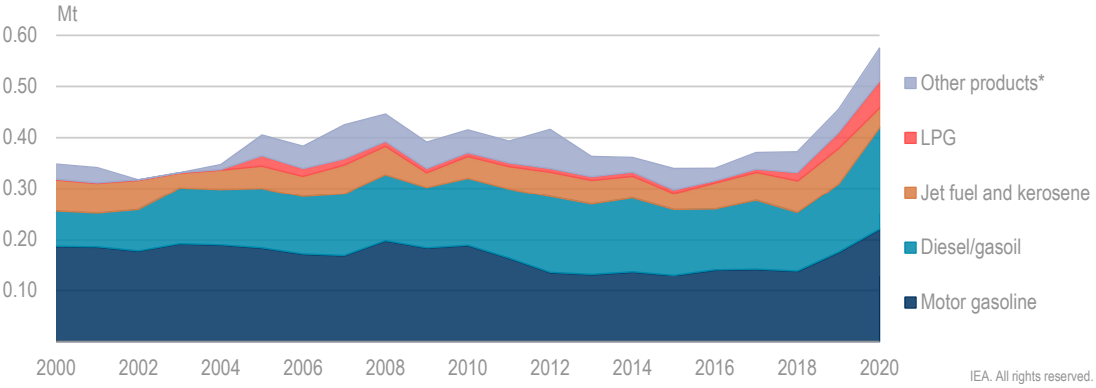
* Not visible on this scale.

** includes commercial and public services, agriculture, forestry and unspecified consumption. More data became available in 2014 allowing diesel /gas oil data to be re-allocated from the non-specified to the transport sector.

*** includes bunker fuels for international aviation bunkers.

Source: IEA (2022), *World Energy Statistics and Balances* (database), https://www.iea.org/data-and-statistics.

Figure 4.4 Oil consumption by product, 2000-2020



Oil product consumption mostly consists of gasoline and diesel.

Notes: 2020 data are provisional. LPG = liquefied petroleum gas.

* includes bitumen, lubricants, white spirit, fuel oil, paraffin waxes, aviation gasoline, petroleum coke and unspecified oil products. Total consumption includes international aviation bunkers, and excludes international marine bunkers.

Source: IEA (2021), *World Energy Statistics and Balances* (database), https://www.iea.org/data-and-statistics.

Oil market structure

Oil products fall under the responsibility of the Ministry of Economy, whereas network energy carriers such as gas and electricity are handled by the MTAI.

The import and sale of oil products on the domestic market are completely privatised. Companies in this market include operators of filling stations such as Rosneft-Armenia, City Petrol Service, Ran-Oil, Flash Petrol, CPS Oil and Max Oil, as well as suppliers of lubricants and other oil products. As of 2017, there were over 480 filling stations in Armenia selling gasoline and/or diesel, and over 360 selling CNG. (CNG stations are located separately from gasoline/diesel stations due to safety requirements.)

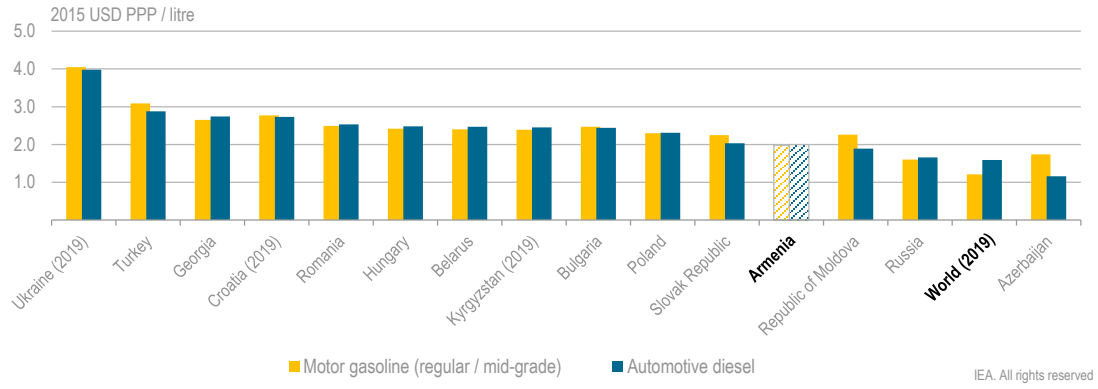
As a member of the EAEU, Armenia has agreed to form a common market for oil and petroleum products to complement those markets currently being formed by the EAEU for gas and electricity. The EAEU oil and petroleum market is expected to be launched in 2024, though member countries have yet to work out many of the details. (The other EAEU members are Belarus, Kazakhstan, Kyrgyzstan and Russia.)

Prices

While the prices for petroleum products are not regulated, the **State Commission for the Protection of Economic Competition** and the **Market Surveillance Inspection Body** monitor fuel prices to guard against “excess profits” and to ensure the absence of entry barriers (RoA, 2020).

Oil product prices in Armenia are not subsidised and include both excise taxes and VAT. They are above the world average, though near the average for the Caucasus region. They are somewhat higher than prices in Russia, and significantly lower than those in neighbouring Turkey.

Figure 4.5 Transport fuel prices in selected countries, 2020



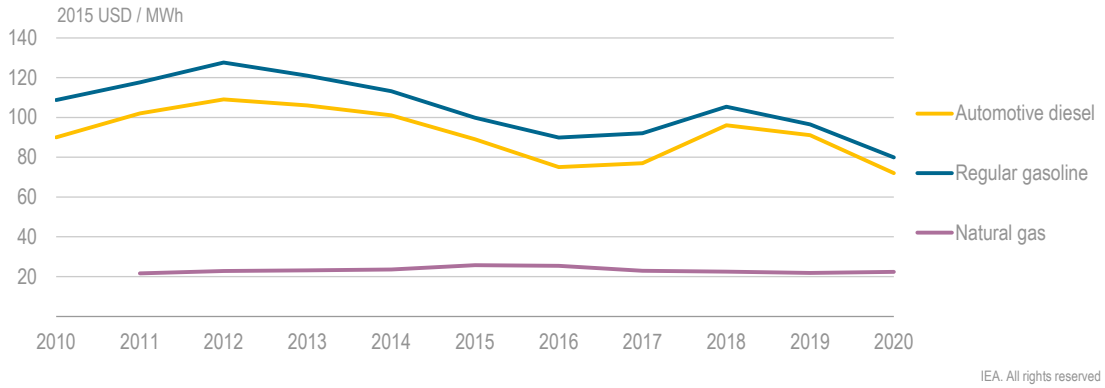
Prices for gasoline and automotive diesel in Armenia are above the world average.

Notes: Constant 2015 USD and PPP. When recent data were not available, the year for the latest data is indicated in the chart. For Armenia, Azerbaijan and Belarus, the price is for regular motor gasoline.

Source: IEA (2022), *World Energy Prices* (database), https://www.iea.org/data-and-statistics/data-products?filter=prices.

Despite a declining trend in oil product prices in Armenia since 2012 that reflect world prices, domestic prices for natural gas sold at filling stations have been significantly lower than those for gasoline and diesel, helping drive the conversion to natural gas in the transport sector. Since almost all vehicles equipped to run on CNG are also able to use gasoline, price would appear to be the main factor determining choice of fuel.

Figure 4.6 Main transport fuel prices in Armenia, 2011-2020



Natural gas has been significantly less expensive than gasoline and diesel.

Notes: Price data converted from litres to MWh using average calorific values for the time period. Natural gas price data are available from 2011.

Source: IEA (2022), *World Energy Prices* (database), https://www.iea.org/data-and-statistics/data-products?filter=prices.

Oil stocks

The Armenian government does not maintain emergency stocks of oil products, nor does it require private companies in the sector to do so, though some companies reportedly maintain commercial stocks. According to a report by the Energy Charter, oil product storage capacity was 1.2 Mt for light products and 0.9 Mt for fuel oil in 2008, though the state and use of such storage is unclear (IEA, 2015). Since 2012, Armenia's National Greenhouse Gas Inventory reports have assumed that all imported oil products are used during the year of import.

Assessment

Armenia does not produce any oil or refined products. Oil covered only 16% of Armenia's TES in 2020, one of the lowest shares in the world among countries for which all oil demand is covered by imports. Although Armenia imports oil products from over 40 countries, over half comes from just one country, Russia.

The share of oil in TFC has been on a declining trend since the early 2000's. No oil is used in power production, while natural gas is the fuel of choice for road transport, mainly since it has been significantly cheaper than gasoline or diesel. Most of the country's vehicle fleet can run on either gasoline or natural gas, thereby enhancing the country's energy security by providing flexibility in fuel use.

Further flexibility could be obtained by storing oil for the country's one remaining dual-fired thermal power plant, which currently runs exclusively on natural gas. This would allow it to operate on oil in the event of a disruption in the supply of gas.

Given the very low share of oil in the country's energy consumption, the lack of strategic oil stocks arguably is not as great a risk for security of supply as it is for other countries. Given the country's high dependence on natural gas, it is probably more important to prioritise storage of natural gas, as Armenia already appears to be doing with current efforts to expand the Abovyan gas storage facility.

Recommendations

The government of Armenia should:

- Encourage further diversification of sources for the import of oil products. This could include further study of a possible oil or oil product pipeline.
- In addition to plans for expanding the Abovyan underground gas storage facility, consider establishing an emergency fuel oil supply for the country's remaining thermal power station, to use as backup in emergency situations.

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5. Electricity

Key data

(2020 provisional)

Total generation: 7.8 TWh, +38.2% since 2009

Available capacity: 2.9 GW

Generation mix: natural gas 40.4%, nuclear 35.2%, hydro 22.7%, solar 1.7%, wind <0.1%

Electricity net exports: 1.01 TWh (imports 0.32 TWh, exports 1.33 TWh)

Electricity consumption: 5.9 TWh (residential 34.3%, industry 28.0%, services 3.3%, agriculture 2.4%, transport 1.5%, unallocated consumption 30.4%*), +31.2% since 2009

* Customers of the electricity and gas distribution companies cannot be distinguished by their ISIC/NACE classifiers, therefore accurate classification is not currently possible.

Overview

Armenia's power sector was originally developed as part of an interconnected system with the neighbouring now-former Soviet Republics of Georgia and Azerbaijan. Operating at 220-volts AC with a frequency of 50 Hz, the country's grid is currently synchronous with Iran's while maintaining small, seasonal "island" connections with Georgia. Planned increased interconnections with Georgia via a set of back-to-back high-voltage direct current stations and with Iran will help form a "North-South Corridor", facilitating trade with Russia and possibly other countries.

Though most capacity was built during the Soviet period, Armenia has a large generation capacity surplus. Around 14% of Armenia's available generating capacity is nuclear, and its one nuclear plant typically generates 30-40% of the country's electricity. The rest of Armenia's capacity is split between hydro and gas-fired thermal. While renewables other than large hydropower plants represent only a small portion of existing capacity, significant solar photovoltaic (PV) capacity is currently under construction or planned.

All of Armenia's thermal-powered generating units run on gas, nearly all of which is imported from Russia. Although capacity exists to import significant amounts of gas from Iran, the relevant pipeline infrastructure, which is operated by an affiliate of Russia's Gazprom, is currently used only to import small amounts of gas from Iran in exchange for electricity exports. All of the fuel used by the ANPP is also imported from Russia.

Almost all generating capacity is privately owned, with the notable exception of the ANPP and the combined cycle gas turbine plant, Yerevan CCGT-1. Armenia is currently moving from a single-buyer model to a competitive power market with a launch date set for February 2022.

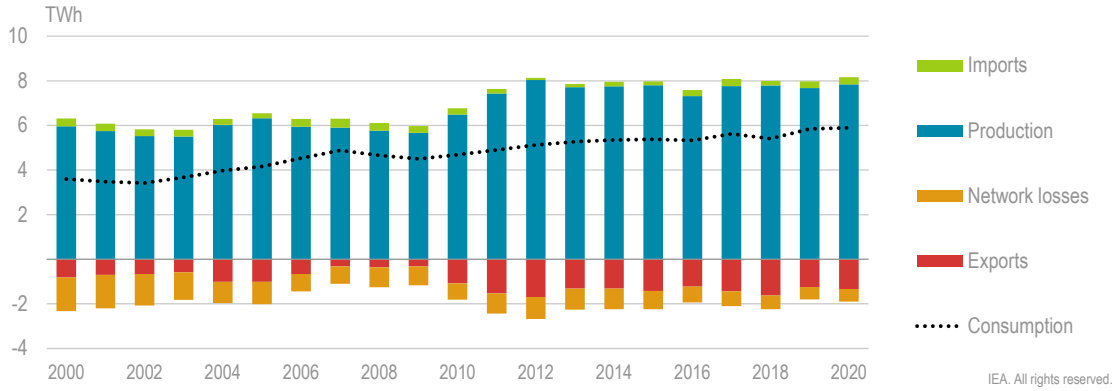
Supply and demand

Armenia is easily able to meet current domestic demand with its well-balanced supply of gas-fired thermal, hydroelectric and nuclear power. In 2020 the country generated 7.8 TWh, while domestic demand was 5.9 TWh. Demand has grown over 30% since 2009.

Armenia is a net exporter of electricity, though most exports are part of a gas-for-power swap with Iran.

In response to substantial grid investments, losses in the transmission and distribution networks have decreased substantially over the past decade, from about 16.1% of supply in 2012 to around 8.8% in 2020.

Figure 5.1 Electricity supply, 2000-2020



Electricity consumption is increasing.

Notes: 2020 data are preliminary.

Source: IEA (2022), *World Energy Statistics and Balances* (database), https://www.iea.org/data-and-statistics.

Capacity

The total available generating capacity in 2020 was about 2.9 GW, compared to total installed capacity of around 3.6 GW. Table 5.1 lists the power plants in operation in Armenia as of 1 July 2020, at which point available generating capacity consisted of about 47% hydro, 38% gas-fired thermal, 14% nuclear and less than 1% solar PV and wind. About 60% of the available capacity was built during the Soviet era.

Currently-operating gas-fired generating capacity consists of three main plants, all but one of which are privately owned:

- Hrazdan Thermal Power Plant (private) with an available capacity of 410 MW;
- Hrazdan Unit 5 (private) with an available capacity of 467 MW; and
- Yerevan CCGT-1 (state-owned) with an available capacity of 228.6 MW.

The country's main hydropower capacity is privately owned and consists of two sets of linked plants, most of which are well over 30 years old:

- Sevan-Hrazdan Cascade, built between 1936 and 1962, is a series of seven hydropower plants (HPP) on the Hrazdan River with an available capacity of 561.4 MW; and
- Vorotan Cascade, built between 1970 and 1989, is a series of three HPPs on the Vorotan River with an available capacity of 404.2 MW.

The Sevan-Hrazdan Cascade was recently partially renovated (one of its seven HPPs), and the Vorotan Cascade is currently under renovation as part of the requirements of its privatisation agreement.

Small (under 30-MW) renewable power plants represented about 14% of available capacity in 2020, most installed after the Soviet period. Nearly 95% of this capacity consisted of 188 SHPPs.

Built towards the end of the Soviet era, the ANPP is currently owned by the Armenian government. Both of its two units were shut following a major earthquake in 1988. While Unit No. 1 remains in long-term shutdown mode, Unit No. 2 was re-started in 1995 following a severe energy shortage in the country and currently has an available capacity of 407.5 MW.

Table 5.1 Power plants operating as of 1 July 2020

Plant	Available capacity (MW)	Year of Commissioning	Ownership
Armenia Nuclear Power Plant Unit 2	407.5	1980	State-owned
Hrazdan TPP	410	1966	Tashir Group
Hrazdan Unit 5	467	2011	Gazprom Armenia
Yerevan CCGT-1	228.6	2010	State-owned
Vorotan Cascade (3 HPPs)	404.2	1970-89	ContourGlobal Hydro
Sevan-Hrazdan Cascade (7 HPPs)	561.4	1936-62	Tashir Group
Small renewable plants (under 30 MW)	400, of which 380 SHPPs		

Source: GoA (2021), http://mtad.am/u_files/file/energy/Energy%20Strategy_%20Jan%2014%202021_English.pdf, p.5.

As of mid-2020, Hrazdan Unit 5 and Yerevan CCGT-1, which together represent nearly a quarter of available capacity, were the only utility-scale plants to have been built since the end of the Soviet era. However, as indicated in Table 5.2, a number of new plants are currently under construction and are expected to come on line within the next few years. This includes a second CCGT plant (250 MW) and over 250 MW of solar PV capacity, including Armenia's first utility-scale solar PV plant, Masrik-1 (55 MW).

Table 5.2 Power plants under construction

Plant	Capacity (MW)	Expected year of commissioning	Investment (USD million)
Yerevan CCGT-2	250	By July 2022*	250
Masrik-1 Solar PV Power Plant	55	By July 2022	60
23 small HPPs	50 [total]	By 2023	60
48 small solar [PV] plants	197-210	By 2022	
Wind Power Plant	4	By 2021	

* In operation from 29 November 2021

Source: GoA (2021), http://mtad.am/u_files/file/energy/Energy%20Strategy_%20Jan%2014%202021_English.pdf, p. 25-26.

Unit No. 2 of the ANPP was offline for five months in 2021, including for refurbishment, with the expectation of extending its operating life to at least 2026. For several years, the government also has been discussing the possibility of building a new nuclear power plant to replace the current one.

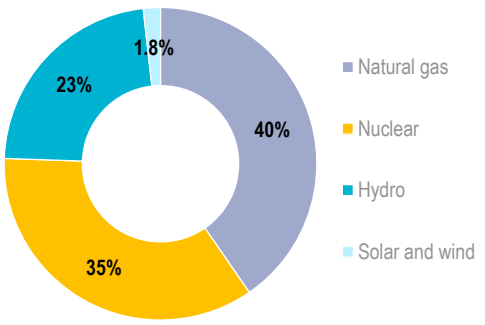
While most of the hydropower potential of the Vorotan and Hrazdan Rivers already has been harnessed, parts of the Pambak-Dzoraget-Debed River system and Araks River remain untapped. Full use of the country's hydropower potential could potentially provide more than 50% of its electricity needs under current demand assumptions through 2036 (USAID, 2019). However, the main large hydropower projects that have been under discussion for many years do not currently feature in the government's development priorities. These notably include:

- Meghri HPP (est. 100-130 MW) on the Araks River (feasibility study conducted in 2008 by an Iranian company);
- Shnogh HPP (est. 102 MW) on the Debed River (original design from 1966, feasibility study conducted 2020); and
- Lori-Berd HPP (est. 60-66 MW) on the Dzoraget River.

Generation

Gross electricity generation in 2020 was 7.8 TWh. Some 41% of this was generated from natural gas, 35% from nuclear and 23% from hydro. In 2019 the share generated from nuclear was below the ten-year average of 34%, due to a longer-than-average shutdown to implement life extension procedures at the ANPP. Total annual power generation has increased about 38% since 2009, with most of the increase fuelled by natural gas.

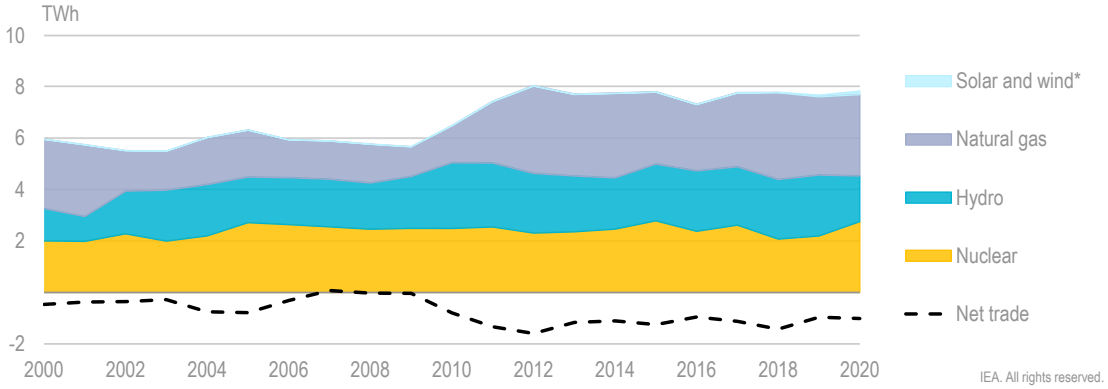
Figure 5.2 Electricity generation by source, 2020



Armenia's electricity generation mix is diverse.

Source: IEA (2022), *World Energy Statistics and Balances* (database), https://www.iea.org/data-and-statistics.

Figure 5.3 Electricity generation by source, 2000-2020



Electricity generation is relatively evenly based on gas, hydro and nuclear.

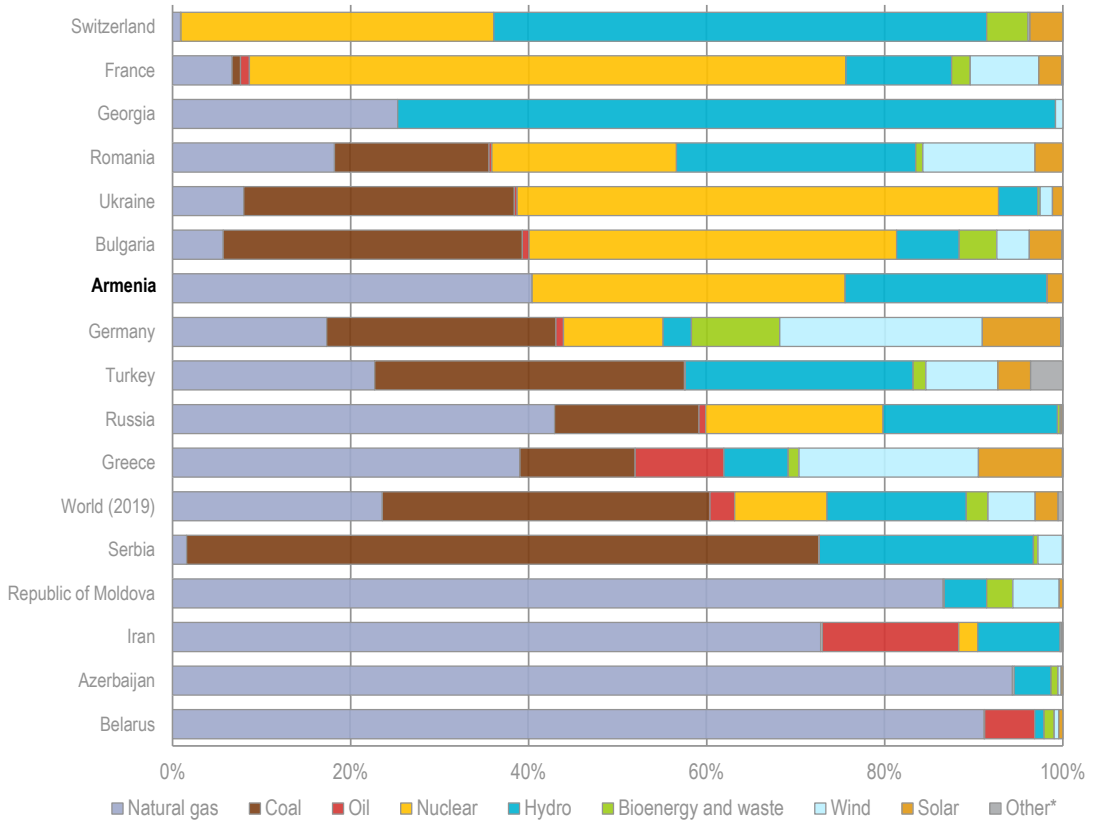
* solar and wind not visible on this scale.

Note: 2020 data are preliminary.

Source: IEA (2022), *World Energy Statistics and Balances* (database), https://www.iea.org/data-and-statistics.

Armenia's electricity production appears well diversified by generation type, particularly when compared to most of the other former Soviet Republics, as well as many IEA countries. However, this diversity in fuel type is not matched by diversity of geographic source. Almost 80% of Armenia's electricity generated in 2020 was produced with fuel imported from Russia: Armenia relies on Russia for almost all of its gas and for all of its nuclear fuel.

Figure 5.4 Electricity generation by source in selected countries, 2020



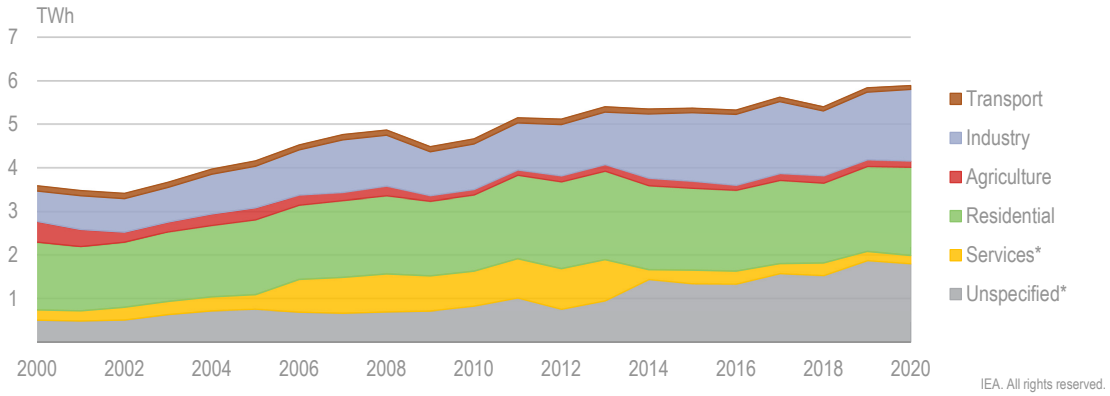
Over 60% of Armenia's electricity generation is from sources other than fossil fuels.

* includes geothermal, electricity from heat, wave and ocean power and other power generation (e.g. from fuel cells).
Source: IEA (2022), *World Energy Statistics and Balances* (database), https://www.iea.org/data-and-statistics.

Consumption

Electricity consumption in 2020 was 5.9 TWh, an increase of about 31% since 2009. The residential sector accounted for the largest share of consumption at 34%, up 18% since 2009. The industrial sector, which is dominated by food processing and some mining, was responsible for 28% (up 63%). The transport sector consumed about 2% (down 25%), though its share is likely to grow in the coming years in response to the government's promotion of electric vehicles. Agriculture accounted for 2.4%. Services officially consumed only 3.3% of the total, though the actual share is arguably higher, since almost one-third is officially unallocated to any sector due to limitations in the data provided by the electricity distribution company.

Figure 5.5 Electricity consumption by sector, 2000-2020



The industrial and residential sectors are the main consumers of electricity.

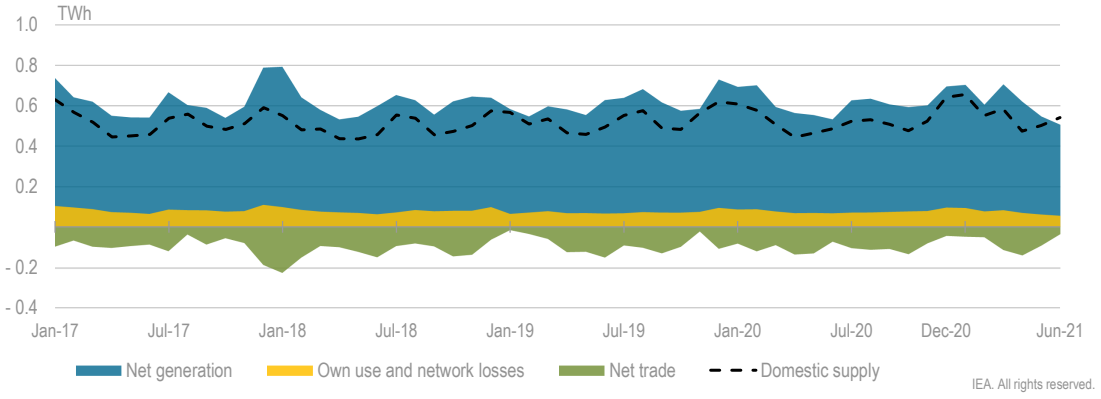
* The share of unallocated electricity consumption in the total is notable in Armenia. A share of consumption by the commercial and public services is included in unspecified consumption. Therefore these sectoral trends cannot be shown in detail.

Sources: PSRC (2021), https://psrc.am/contents/fields/electric_energy/el_energy_reports (in Armenian); IEA (2022), *World Energy Statistics and Balances* (database), https://www.iea.org/data-and-statistics.

Electricity demand in Armenia features seasonal peaks, one occurring towards the end of the year and another during July-August, the latter due mainly to crop irrigation. The rising use of air conditioners, combined with expected hotter summers, could lead to a more pronounced summer peak in the future.

Daily peak demand varies from 1040 MW in summer to 1300 MW in winter, leaving a margin of at least 100% with respect to the country's available generating capacity of 2900 MW in 2020. However, the small number of large generating units in the country means that this margin can be reduced substantially if several plants are taken out of service simultaneously, e.g. for upgrades.

Figure 5.6 Monthly electricity supply, January 2017-June 2021



Domestic electricity demand shows a seasonal pattern peaking in January and in July.

Source: PSRC (2021), https://psrc.am/contents/fields/electric_energy/el_energy_reports (in Armenian).

Imports and exports

Armenia has active interconnections with neighbouring Iran and Georgia (see below under Infrastructure). In 2020, Armenia exported 1.33 TWh and imported 0.32 TWh, resulting in net exports of 1.01 TWh.

Armenia has two electricity exchange agreements with Iran. During the summer months Armenia exports to Iran, which requires extra power during that period for cooling. Armenia imports an equivalent amount during the winter when Armenia's hydropower generation is lower. The current levels of exports to Iran do not significantly reduce the adequacy of Armenia's available capacity.

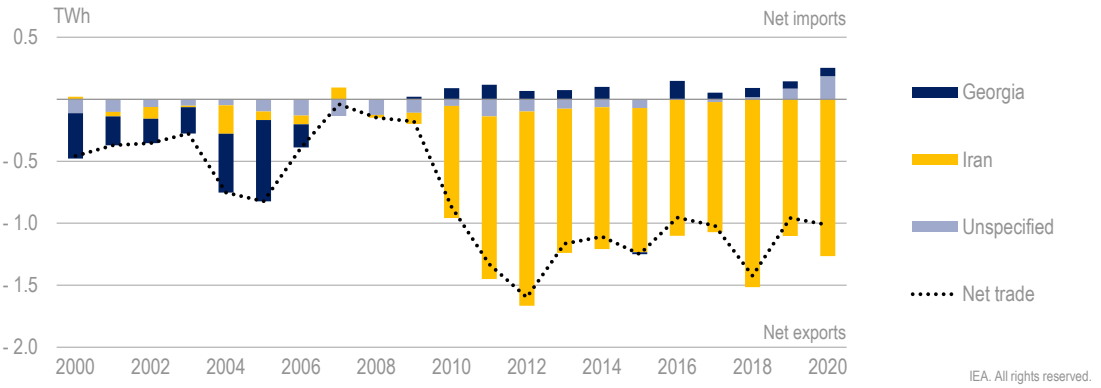
Armenia and Iran also have a gas-for-electricity swap arrangement under which the Armenian state-owned Yerevan CCGT-1 imports Iranian gas in exchange for exported electricity. (1 cubic metre of gas is bartered for 3 kWh of electricity.)

Armenia currently exchanges only small amounts of electricity with Georgia on a seasonal basis in island mode, as the two countries' main grids are not synchronous.

Electricity trade with both Georgia and Iran is expected to increase significantly in the coming years as new interconnections are constructed (see below). The government notes that electricity trade between Armenia and Georgia "will rely to the greatest extent possible on the requirements of the EU directives" regarding cross-border electricity trade, which both countries have undertaken to follow as part of their CEPA agreements (GoA, 2021). Such directives are designed to ensure non-discriminatory access to one another's power markets.

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 (Belarus, Kazakhstan, Kyrgyzstan and Russia), trade between Armenia and these theoretically could take place via Georgia. EAEU member states currently are developing rules regarding cross-border trade.

Figure 5.7 Electricity trade by country, 2000-2020



Armenia is a net exporter of electricity, and Iran is the main export destination.

Sources: PSRC (2021), https://psrc.am/contents/fields/electric_energy/el_energy_reports (in Armenian); IEA (2022), *World Energy Statistics and Balances* (database), https://www.iea.org/data-and-statistics.

Networks

Transmission and distribution

State-owned company, High Voltage Electric Networks of Armenia (HVEN), maintains the country's transmission system, which consists of 1 960 km of overhead transmission lines, 14 substations of 220 kV and 2 substations of 110 kV.

Figure 5.8 Armenia's electricity transmission system

This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

Source: Cartography Unit, World Bank, 2011.

Five of the substations have been completely reconstructed in recent years with support from the World Bank and Germany's Kreditanstalt für Wiederaufbau (Credit Institute for Reconstruction, KfW), and five others were under reconstruction in 2021.

The Electricity System Transmission Network Development Plan 2020-2024 was produced in 2019 by the Energy Research Institute at the request of the Electro Power System Operator, and is expected to be reviewed and biennially updated starting in 2022 (GoA, 2021).

The privatised company, Electric Networks of Armenia (ENA), owns and operates the distribution network. According to ENA's most recent annual report (ENA, 2019), this consists of:

- 26 000 km of overhead lines, including 2 800 km of 110-kV lines, 2 300 km of 35-kV lines, 8 280 km of 6 (10)-kV lines, and 12 800 km of 380-V lines;

- 102 substations of 110 kV (4 478 MVA), 226 substations of 35-kV (1 736 MVA), and 8 465 transformers of 6 (10) kV (3 200 MVA).

ENA has approximately one million customers, about 850 000 of which are households. Around half of its customers have smart metres, mostly in the Yerevan area. ENA expects to install automated metres for almost all of its remaining customers by 2027.

Combined transmission and distribution losses were about 9% in 2020, representing a significant improvement over the past decade. This reflects investments in line and substation rehabilitation and in automation. The review team was informed that losses in the transmission system were around 2%, while losses in the distribution system were about 7%.

Investment in both transmission and distribution over the past decades has contributed to good system reliability. The Asian Development Bank (ADB) is helping HVEN and the System Operator finance upgrades to a supervisory-control-and-data-acquisition (SCADA) system that was originally installed in 2010 with help from the Japan Bank for International Cooperation. ENA has implemented an automated electricity metering system which collects information on various parameters every half hour, including from small hydropower stations and solar PV stations above 5 MW that are connected to the grid. However, increased automation has also raised government concerns regarding cybersecurity.

Cross-border connections

Armenia has been in synchronous operation with Iran since 1996. Two overhead 220-kV lines provide 350 MVA of synchronous exchange capacity with Iran. Construction of a new 400-kV connection with Iran is expected to increase capacity to 1 200 MVA, allowing exports to Iran of up to 5 GWh by 2025.

Armenia is connected to Georgia through two 110-kV lines and one 220-kV line, with a total capacity of around 200 MVA. These operate in island mode, as Armenia and Georgia are not synchronous. (Georgia is synchronous with the Russian system.) There are plans to construct a set of 400-kV back-to-back high-voltage DC stations and related overhead transmission lines, which are expected to allow an additional 350 MVA of exchange capacity in the first stage, and up to 1 000 MVA in later stages.

Enhanced interconnections with Iran and Georgia are expected to result in a “North-South corridor”, facilitating major power flows between Russia, Georgia, Armenia and Iran. This could also potentially facilitate trade between Armenia and members of the EAEU common power market, which is scheduled to launch in 2025.

Electricity sector structure and reform

The present structure of Armenia’s electricity sector dates to 2004. Currently it has no elements of competition, and its wholesale and retail components are fully regulated. However, significant reforms are scheduled for 2022, based on plans developed over the years with support from the EU, USAID and other partners.

The main actors in Armenia’s power sector include:

The **Ministry of Territorial Administration and Infrastructure (MTAI)** is responsible for the overall energy policy in the country.

The **Public Service Regulatory Commission (PSRC)** is the independent government body that regulates investment in network sectors (including electricity and gas) and is responsible for tariff setting, service quality and licensing.

The **Committee on Nuclear Safety Regulation of the Republic of Armenia (ANRA)** regulates the nuclear sector, including radiation safety. This includes issuing licences for the operation of Armenia's Nuclear Power Plant and controlling the fulfilment of licensing requirements (see Nuclear section, below).

Electric Networks of Armenia (ENA) is the single distribution company that currently has an exclusive right to buy from generators and sell to consumers. Its license covers both distribution and sales, which are not unbundled. ENA was owned by Russia's Inter RAO between 2006 and 2015, at which point it was sold to the private Tashir Group, which also owns some generation assets in the country.

High Voltage Electricity Networks of Armenia (HVEN) is the state-owned company that maintains and develops the transmission grid.

The **Electro Power System Operator** is the state-owned, independent system operator that operates the high-voltage grid and manages the dispatch and transmission of generation to meet demand.

The **Settlement Centre** conducts commercial settlements between generators and the ENA, as well as electricity imports and exports. It provides metering and billing services to wholesale market participants, calculating amounts produced, delivered, purchased, imported and exported. A state-owned entity created in 2002, it receives a fixed annual fee for its services on the domestic market and a per-kWh fee for settlement services related to exports. The Settlement Centre also handles disputes between market participants (after which parties have recourse to the PSRC). The PSRC has issued a licence to the Settlement Centre to serve as **Market Operator** under the future liberalised power market.

Generators are a mix of state-owned and private companies consisting of several gas-fired thermal power plants and hydroelectric plants and one nuclear power station, as well as around 200 small hydro and solar PV installations that are allowed to supply electricity to the grid.

Liberalisation

The government began preparing market reforms in the power sector by implementing several amendments to the Law on Energy. It adopted the "Programme-timeline of measures towards liberalisation and interstate trade development of the electricity system" by decree on 14 September 2018, and new rules for both the wholesale and retail markets on 25 December 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).

The new rules envisage a wholesale market with three segments:

- bilateral contracts market,
- day-ahead market, and
- balancing market.

The bilateral contracts market is expected to consist of a long-term component, a regulated component, and a non-regulated component (USAID, 2020). Some 80% of the market is expected to be handled by bilateral contracts, at least initially.

The Market Operator has been working with the US company, Synergy, to develop software for the new market operations. It planned to test this software during 2021 in preparation for the official market launch, scheduled for 1 February 2022. At that point, qualified customers will be able to choose their suppliers. The first group of qualified customers will be those currently receiving power directly from the transmission grid. Further liberalisation to other customer groups will be introduced gradually.

The first stage of reforms is expected to include development of a more differentiated tariff structure, as well as protection mechanisms for vulnerable customers.

As part of the second stage of sector reforms, the government plans to develop an Electricity Law to replace relevant components of the more general Energy Law. According to the government's 2021 Energy Strategy, this will take into account the requirements of relevant EU directives under the CEPA agreement, as well as international models for introducing greater competition (GoA, 2021).

USAID, which has been assisting the Market Operator to develop the new market structure, has been working on some of the same issues with Georgia in order to promote consistency in approach and thereby help facilitate electricity trade between the two neighbours.

As a member of the EAEU, Armenia is also involved in establishing the EAEU Common Electricity Market, which the EAEU plans to launch in 2025, according to the Action Plan approved by the Supreme Eurasian Economic Council in December 2019. Members are currently preparing a number of key documents, including access rules for cross-border transmission capacity, trade rules and rules for cross-border network development.

Tariffs

The PSRC sets tariffs according to a cost-plus methodology. 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, which effectively serve as peak and off-peak tariffs, respectively. There is also a special tariff for low-income customers.

Table 5.3 Customers electricity tariffs (effective from 1 February 2021)

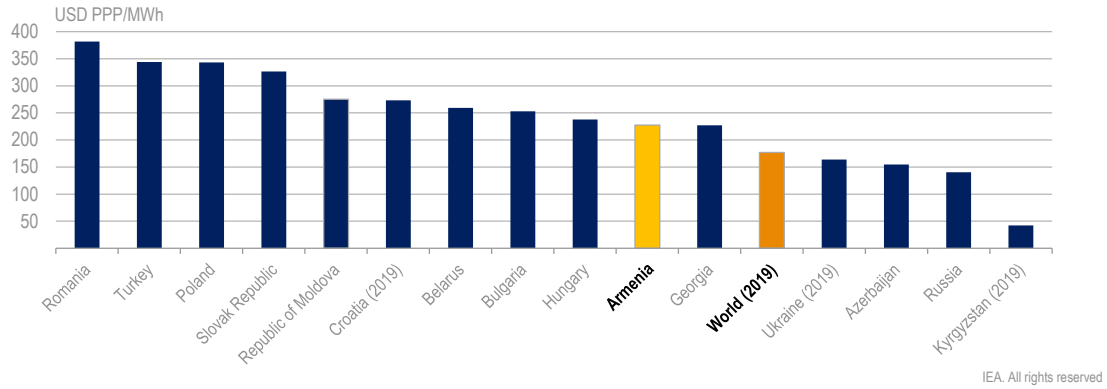
Connection voltage	Tariff (with VAT, i.e. 20%) AMD (US cents)/kWh (1 USD = 489.20 ֏)	
	Night-time	Day-time
110 kV and above	32.48 (6.64)	36.48 (7.46)
35 kV	34.98 (7.15)	38.98 (7.97)
6(10) kV	34.98 (7.15)	44.98 (9.19)
0.38 kV consumers (except Residential)	37.98 (7.76)	47.98 (9.81)
0.38 kV Residential consuming more than 400 kWh/month	37.98 (7.76)	47.98 (9.81)
0.38 kV Residential consuming up to 400 kWh/month	34.98 (7.15)	44.98 (9.19)
0.38 kV Residential Low Income (determined in accordance with the Resolution of the Government of the RA No1122-N dated 3 November 2016)	19.99 (4.09)	29.99 (6.13)

Note: Night rates are calculated if the consumer has a multi-rate electronic commercial metering device and are valid from 22:00 to 06:00 hours (starting from 02:00 on the last Sunday in March until 03:00 on the last Sunday in October), and from 23:00 to 07:00 (starting from 03:00 on the last Sunday in October until 02:00 on the last Sunday in March).

Source: PSRC (2021), https://psrc.am/.

Tariffs take into account the cost of power, network investments and an assumed loss rate. Average Armenian end-user electricity tariffs are higher than the world average. They are also higher than average tariffs in Russia, but similar to those in neighbouring Georgia. The tariffs reportedly have been high enough to cover costs and provide a “reasonable” profit for operating plants.

Figure 5.9 Residential electricity prices in selected countries, 2020



Armenia's residential electricity price is similar to that in neighbouring Georgia.

Notes: When recent data are not available, the year for the latest data is indicated in the chart. PPP = purchasing power parity.

Source: IEA (2022), *World Energy Prices* (database), https://www.iea.org/data-and-statistics/data-products?filter=prices.

A programme for improving metering, billing and the collection of payments has led to a collection rate of nearly 100%, ensuring adequate funds for sector maintenance and expansion.

Tariffs paid by the ENA to large electricity producers are currently set by the PSRC and based on the cost structures of the individual generators. In most cases, such tariffs consist of a per-kWh charge plus a capacity charge.

Tariffs paid by the ENA to renewable power plants above a certain threshold (5 MW for solar, 30 MW for wind, and 30 MW for hydro) are also set generally according to a cost-plus methodology. However, much new large renewable capacity is expected to be subject to tenders, particularly in the case of solar. In such cases, tariffs will be determined competitively by the tender and included in a power-purchase agreement with the ENA. The first such tender concerned the Masrik-1 55-MW Solar PV Plant, currently under construction by a Dutch-Spanish consortium with financial support from the World Bank and European Bank for Reconstruction and Development (EBRD). The consortium reportedly bid a price of around USD 0.04 per kWh.

Renewable plants below capacity thresholds benefit from feed-in tariffs, which the PSRC adjusts every year according to two factors: the inflation rate and the exchange rate with the US dollar.

Nuclear energy

Armenia has one nuclear power plant, the ANPP, which is located 28 km west of Yerevan and 16 km from the Turkish border. It consists of two Soviet-designed WWER-440 (V-270)[9] reactors, each of which has an installed capacity of 407.5 MW. Unit No. 1 entered

[9] Due to the seismicity of the ANPP site, significant changes were implemented in the design of WWER 440 V-230, as well as the reactor facility as a whole. As a result, the reactor was assigned the new identification of V-270 (IAEA, 2020).

into service in December 1976 and Unit No. 2 in January 1980. Currently, only Unit No. 2 is in operation. Representing about 15% of the country's generating capacity, the ANPP has produced around 30-40% of the country's electricity in recent years. Nuclear power is part of the Armenian Energy Strategy, which envisions the lifetime extension of the ANPP to 2036 as well as the construction of a new nuclear unit to replace the existing capacity.

The **State Committee on Nuclear Safety Regulation (ANRA)** develops safety regulations, issues licences for all nuclear-related activities and carries out inspections to ensure implementation of licensing terms. ANRA is assisted by the **Nuclear Radiation and Safety Centre**, a separate entity that conducts safety reviews and independent evaluations. The Ministry of Territorial Administration (MTAI) and Infrastructure is responsible for nuclear waste management, while ANRA is responsible for nuclear waste management regulation.

The main scientific-technical support organisation for the ANPP is the state-owned **Armenian Scientific Research Institute for Nuclear Power Plant Operation CJSC**[10] **("Armatom")**, established in 1973. Armatom is currently the only organisation in Armenia possessing licenses for the design and production of safety-related devices, equipment and systems for nuclear facilities (granted by ANRA). The **Scientific Research Institute of Energy (SRIE)** carries out some research related to nuclear energy. Education in the field of nuclear energy technologies is provided by the **Institute of Energy and Electrical Engineering at the National Polytechnic University of Armenia** and by the Faculty of Physics at **Yerevan State University**.

In 1988, an earthquake with a magnitude of 7 on the Richter scale struck near the town of Spitak, around 70 km from the ANPP. Although the power units were not damaged, concerns about possible future earthquakes led to a decision by the Soviet authorities to shut both reactors. Lack of available power from the ANPP, coupled with a sharp economic downturn and fuel blockade over the crisis in Nagorno-Karabakh, led to a severe energy shortage in the early 1990s and subsequently the decision to re-launch Unit No. 2 in 1995 with Russian assistance. The ANPP continues to maintain relations with the Russian institutes and manufacturing enterprises originally involved in the design and development of the plant, consulting with them on upgrades and other issues.

Numerous safety upgrades and improvements have been carried out since the re-start of Unit No. 2. Following the accident at Japan's Daiichi nuclear power plant in March 2011, Armenia voluntarily performed a series of comprehensive risk and safety assessments ("stress tests") taking into account specifications agreed by the by the European Commission and the European Nuclear Safety Regulators Group (ENSREG).

The Operational Safety Review Team (OSART) from the IAEA performed an in-depth review of the ANPP in May of 2011, and the ANPP developed an action plan to implement its recommendations. An OSART Follow-up team visited the ANPP in June 2013.

Armenia has been a member of the IAEA since 1993. It has bilateral cooperation agreements in place with other countries and international organisations, including the European Safety Regulators Group (ENSREG), which undertook a peer-review mission in June 2016, and the World Association of Nuclear Operators (WANO), which carried out its latest six-year corporate peer review of the ANPP in May 2019.

[10] Closed joint stock company.

Following a government decision in March 2014 to extend operations at Unit No. 2, the ANPP launched a Design Lifetime Extension project on which it is cooperating closely with Russia's state-owned nuclear power corporation, Rosatom. The ANPP took a decision in 2020 to shut down Unit No. 2 for five months in order to implement additional upgrades to support the further lifetime extension of the plant through 2026 and possibly beyond. The refurbishment works include replacement of power supply systems, automation and control systems, and turbine hall equipment, resulting in an increased electrical power output of around 10-15% without additional fuel consumption. Russia has provided USD 300 million in financial resources (grant and loan) for the implementation of the life extension programme, though Armenia decided in 2021 to not fully utilise the loan portion of this assistance and instead to allocate money from the state budget for much of the cost.

According to the government's 2021 Energy Strategy, the ANPP will continue to operate through 2026, though "in the event that a safe operation of the ANPP Unit No. 2 is justified after 2026, the government intends to operate it at least until 2036". After this, the government's strategy envisions replacing the current plant with a new nuclear plant (GoA, 2021).

The 2015 "Long-term Development Pathways for the Armenian Energy Sector" had called for a new nuclear power plant with up to 600 MW capacity by 2027, though these plans were put on hold in favour of life extension for the current plant. New plants with capacities over 1 000 MW have also been considered in the past, though the review team was informed that smaller models (e.g. 300-600 MW) are now also being considered as an alternative.

Armenia has no domestic nuclear mining and fuel manufacturing activities, and all nuclear fuel for the plant continues to be supplied by Russia.

Prior to independence, spent nuclear fuel was reprocessed and disposed of by the Soviet authorities. Since the plant's re-start in 1995, spent nuclear fuel has been stored on site, first in wet nuclear storage pools, and during the second stage in dry storage units built with French assistance in the early 2000s. The nuclear waste management programme at the ANPP for the period 2018 to 2023 reportedly complies with international standards and regulations and with IAEA recommendations (IAEA, 2020). A plan for the long-term disposal of spent fuel and high-level radioactive waste is to be developed as part of the ANPP decommissioning plan, for which Armenia is receiving assistance from the EU.

The government has created a set of Decommissioning Trust Funds, with a management board under the Ministry of Finance. The funds are financed from the electricity tariff of the ANPP and are reportedly working properly, though their financial resources have remained modest to date, leading to expectations of contributions from the international community. There is currently no fund for the disposal of radioactive waste.

Armenia adopted the Law on Population Protection in Emergency Situations in 1998. Emergency preparedness and response in cases of nuclear and radiation emergencies are regulated under Government Decree No. 2328 of 2005. Supplementing this is a Population Protection Plan concerning off-site emergencies related to the ANPP. In 2012, the IAEA published the final report of its "Peer Appraisal of the Arrangements in the Republic of Armenia regarding the Preparedness for Responding to a Radiation Emergency". In response, Armenia adopted a "Disaster Risk Management National Strategy and Action Plan" in 2017. However, it is unclear to what extent the protective

measures to be taken in the event of a nuclear accident are consistent with international safety standards, i.e. the IAEA Safety Standards for Protecting People and Environment, and Arrangements for Preparedness for a Nuclear or Radiological Emergency.

Since the late 1990s, the EU has asked Armenia to shut the ANPP as part of an EU policy encouraging the closure of first-generation WWERs (WWER V-179, V-230 and V-270) since they do not follow the same safety approach by design as western Generation-II light water reactors (LWRs).[11] The ANPP is one of the last four first-generation WWERs in operation in the world. The remaining three are in Russia, in the Kola and Novovoronezh Nuclear Power Plants. An agreement in principle to close the ANPP, along with offers of assistance to do so, have been part of almost every major agreement between the EU and Armenia since at least 1998. This includes Armenia's Action Plan under the EU Neighbourhood Policy in 2006, as well as the CEPA that was negotiated in 2017.

As part of the CEPA, Armenia is working on the adoption of five major laws based on EU directives regarding nuclear power, with the support of the EU's EURATOM agency. The review team was told that preliminary drafts of a new Atomic Law and National Basic Safety Standards are expected to be ready by the end of 2021.

The IAEA notes that in early 2021 senior Armenian nuclear officials took part in a virtual IAEA seminar "to assist the country in bringing its national nuclear legal framework in line with relevant international legal instruments on nuclear safety, security, safeguards and civil liability for nuclear damage".[12] In 1993, Armenia acceded to the Vienna Convention on Civil Liability for Nuclear Damage, which provides for a special third-party liability regime to compensate nuclear damage in case of accidents taking place at nuclear installations. A list of the other international conventions to which Armenia is a party to can be assessed in IAEA (2020).

Nuclear power appears to have a high level of acceptance among the Armenian public, much of which retains memories of the severe energy shortages of the early 1990s, as well as apparent national pride in possessing the only nuclear power plant in the region.

Assessment

Armenia is moving from a regulated, single-buyer model to a competitive power market, with a launch date set for February 2022. The careful preparation of this work over many years is to be commended.

As part of the first stage of market reforms, the government plans to improve protection mechanisms for vulnerable customers. This and other improvements to consumer protection, such as a complaints mechanism with legal recourse, will help enable consumers to participate fully in the new market structure. The government also plans to improve the efficiency of tariffs, which are set by the independent regulator. Approximately half of the ENA's one million customers now have smart metres, with installation planned for its remaining customers. So far, however, little use has been made of the metres'

[11] First generation WWERs do not have a concrete containment building as do western LWRs. On the other hand, this design possesses other features that are positive from a safety point of view, such as a low power density in the core and high amounts of water inventory in both the primary and secondary circuits of the reactor.

[12] IAEA assists Armenia to strengthen its national nuclear legal framework, 15 Feb. 2121, https://www.iaea.org/newscenter/news/iaea-assists-armenia-to-strengthen-its-national-nuclear-legal-framework (accessed 24 November 2021).

potential to develop dynamic tariffs that could incentivise shifts in consumption. Tariff setting could benefit from harvesting household consumption data from smart metres, as well as from engaging industrial consumers in demand-side response.

While Armenia currently has substantial generating capacity compared to peak demand, its small number of relatively large generating units means that capacity could be significantly reduced, at least temporarily, if several units are taken offline and/or retired simultaneously. Shifting peaks through dynamic tariff-setting and demand-side response could improve energy security and help reduce the need for future investments in additional capacity.

While Armenia has a diverse generation mix that includes thermal, hydropower and nuclear, all of its thermal generation relies on gas, almost all of which is imported from Russia. Furthermore, Armenia imports all of its nuclear fuel from Russia. Armenia therefore effectively relies on fuel imports from one country, Russia, to produce nearly 70% of its electricity, raising concerns about the security of supply.

Armenia is making progress in further diversifying its power generation mix, particularly by aiming to build significant solar PV capacity. Armenia's 2021 Energy Strategy calls for up to 1 000 MW of solar PV capacity by 2040, at which point grid-connected solar is expected to account for 15% of generation. However, this will be a significant amount of intermittent capacity relative to the country's current total capacity and demand, and integrating it will require the System Operator to be in a position to respond immediately to sudden surges and shortfalls in supply. A number of upgrades to the grid and related information and control systems have been made in recent years that will help address these challenges. However, additional investments may be necessary, including to help develop necessary workforce skills to manage intermittent renewables and demand-side response. With a wider development of renewable energy sources, it will also be useful to consider the possibility of installing energy storage systems.

There has been no systematic modernisation of smaller HPP infrastructure, much of which reportedly features equipment that is worn out or does not meet technical standards. The growing number of SHPPs (currently around 380 MW total) also reportedly has had negative impacts on local ecosystems.

Armenia is aiming to further expand interconnections with Georgia and Iran. This highlights the need to develop new market rules to enable increased cross-border trading. Armenia is working on such arrangements within the context of its CEPA agreement with the EU, as well as within the EAEU Common Electricity Market, currently under development. Developing these two processes in parallel is likely to require careful coordination.

Since the late 1990s, the EU and several other international partners have strongly encouraged the closure of Armenia's WWER-400 reactor, a type that the EU views as particularly dangerous, further noting that the plant is located only 30 km from Armenia's capital, Yerevan, a city of 1 million people, and in an active seismic zone. The review team commends Armenia's efforts to continuously improve nuclear safety measures and its long-term cooperation in this regard with the IAEA, EU, Russia and other international partners. However, it encourages Armenia to fully evaluate a wide range of options to replace needed capacity, including non-nuclear options.

Recommendations

The government of Armenia should:

- Enhance the electricity management system and workforce skills necessary to integrate the country's ambitious target for renewables in the electricity grid while maintaining the reliability and security of the system and considering climate change goals.
- Implement a dynamic system of demand-driven electricity tariffs to help manage electricity loads, generation and dispatch planning, using data that can be obtained from the ongoing programme to install smart metres.
- Strengthen government institutions, such as the independent regulator and the court system, to safeguard consumer interests in the competitive, liberalised electricity market, e.g. through an accessible complaints mechanism.
- Continue the programme to renovate the transmission network, including the development of new interconnections with Iran and Georgia, and implementation of regulatory instruments enabling access rules for cross-border transmission service, free trade and a transparent exchange of information.

Nuclear energy

- Make the necessary investments to ensure that the ANPP is compliant with international safety standards, in particular those concerned with emergency preparedness in the event of a nuclear accident.
- Continue close coordination with the IAEA, EU and other relevant international organisations on nuclear safety issues and legal aspects, and in particular ensure that continued use of the current nuclear power plant (and any future nuclear power plant) meet relevant international safety standards and are governed by legal instruments aligned with international practice.
- Maintain efforts in the development of a long-term national strategy for radioactive waste management. Such a strategy should be consistent with existing nuclear development plans and envision the creation of a sustainable funding mechanism for decommissioning and waste management activities (including final waste disposal), while addressing existing funding gaps.

Hydropower

- Encourage the refurbishment of SHPPs for more efficient and sustainable use of existing capacities and water resources.
- Consider the further development of large HPPs that could allow Armenia to take advantage of its significant hydro potential to increase energy security.

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6. Energy, environment and climate change

Key data

Total GHG emissions without LULUCF* (2017): 10.62 $MtCO_2$-eq, -58.9% since 1990, +25.0% since 2010

GHG emissions without LULUCF* by sector (2017): energy 66.7%, agriculture 18.5%, industrial processes 8.9%, waste 5.8%

Total GHG emissions with LULUCF* (2017): 10.15 $MtCO_2$-eq, -59.6% since 1990, +27.8% since 2010

Energy-related CO_2 emissions (2019):

CO_2 emissions from fuel combustion: 5.9 $MtCO_2$ (+71.1% since 2000, -70.5% since 1990)

CO_2 emissions by fuel: natural gas 81.9%, oil 18.0%, coal 0.2%

CO_2 emissions by sector: transport 35.2%, power and heat generation 23.1%, residential 22.4%, services/other 11.7%, industry 7.4%, other energy 0.1%

CO_2 intensity (CO_2 emissions per GDP): 0.17 $kgCO_2$/USD (2015 PPP) (world average 0.26)

* Land use, land-use change and forestry. For non-Annex I countries of the Kyoto Protocol, recent GHG data availability are limited. The latest national inventory covers 1990-2017.

Overview

Fuel combustion from road transport, electricity production and households, and fugitive emissions from the natural gas system are the main contributors to Armenia's greenhouse gas emissions. Under the scenarios presented in its Third Biennial Update Report, the largest reductions on the supply side are expected to come from the promotion of renewable energy and reduced losses in electricity distribution, and on the demand side from the residential and transport sectors.

Armenia ratified the UNFCCC in 1993 and the Paris Agreement in 2017. An Inter-agency Council chaired by the Minister of Environment coordinates Armenia's reporting under the UNFCCC. In 2021, Armenia submitted an updated version of its NDC for the period 2021-2030. It submitted its Fourth National Communication in May 2020 and its Third Biennial Update Report in May 2021.

The government approved the National Action Program on Adaptation to Climate Change in May 2021, though more specific sectoral plans are still under preparation, including for energy.

One of the most important environmental issues in the energy sector is the rapid growth of SHPPs, which some NGOs accuse of causing significant environmental degradation and loss of biodiversity. New rules place tighter restrictions on the siting of SHPPs.

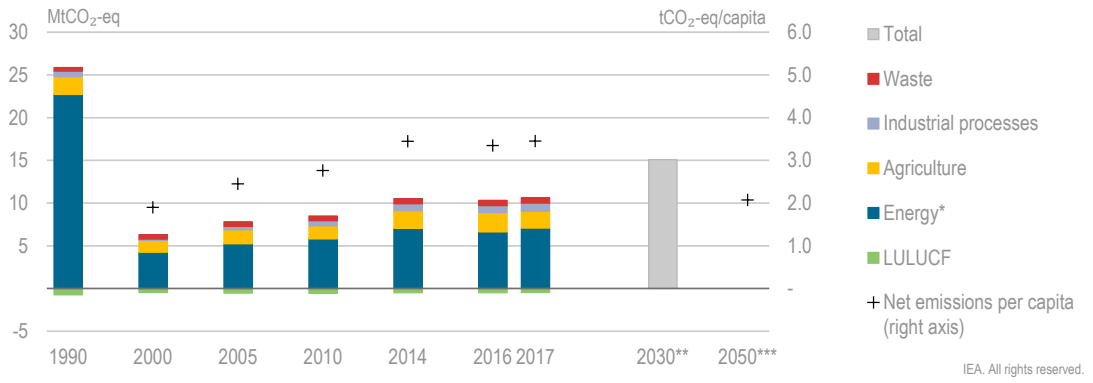
CO_2 emissions from fuel combustion

Though Armenia's overall greenhouse gas (GHG) emissions currently represent under 0.02% of global emissions (EU4Climate, 2019), they have increased by over 20% since 2010, reaching 10.62 Mt of CO_2-equivalent ($MtCO_2$-eq) in 2017, not including emissions related to land use and forestry.

By far the largest share (67%) of Armenia's GHG emissions comes from the energy sector, which in the terminology of the UNFCCC includes fuel combustion for both energy production and use (e.g., energy consumption in industry, transport and households), as well as fugitive methane emissions.[13] The energy sector is responsible for an estimated 95% of all CO_2 emissions in the country and over half of methane emissions. Road transport contributed 24.8% of GHG emissions from the energy sector in 2017. Fugitive methane emissions from natural gas systems produced 23.0%,[14] thermal electricity generation 18.3% and households a further 18.3% (GoA, 2021c).

Despite the widespread conversion of vehicles to natural gas, road transport emissions increased by over 150% between 2000 and 2017, mainly due to greater traffic volume. The increased use of natural gas for individual space heating (gas boilers) led to a five-fold rise in emissions from the residential sector between 2004 and 2017.

Figure 6.1 Armenia's greenhouse gas emissions by sector, 1990-2017 and NDCs



Armenia's GHG emissions have increased over 20% since 2010.

* Includes fuel combustion (for power and heat generation, and for industry, transport, residential and commercial energy consumption), fugitive emissions from fuels and energy industry own consumption.

** Armenia's target for 2030: 40% reduction from 1990 emission levels by 2030.

*** Target for 2050: 2050 mitigation goal of reducing GHG emissions to at most 2.07 tCO_2eq/capita.

Notes: $MtCO_2$-eq = million tonnes of carbon dioxide equivalent.

Data for the latest years may not be available for non-Annex I parties to the Kyoto Protocol.

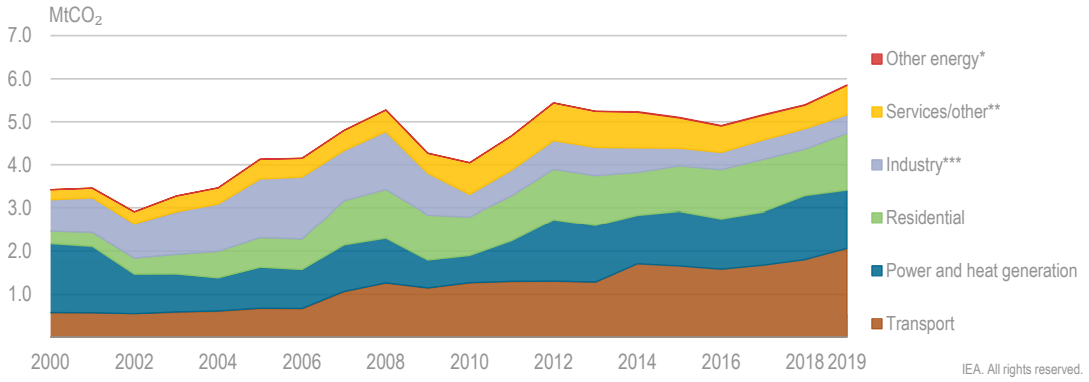
Source: UNDP Armenia (2020), Fourth National Communication on climate change under the UNFCCC.

[13] In addition to energy, GHG sectors used by the Intergovernmental Panel on Climate Change (IPCC) include industrial processes and product use (IPPU); agriculture; forestry and other land use (AFOLU); and waste.

[14] Emissions of methane and other non-CO_2 greenhouse gases are converted to CO_2-equivalents based on a 100-year time horizon.

In 2019, Armenia's CO_2 emissions from fuel combustion were 5.9 $MtCO_2$. This was significantly lower than in 1990, mainly due to structural changes in the economy and power generation since independence. In particular, heavy industry has declined, thermal power generation has switched from heavy fuel oil to natural gas, and in 1995 the country re-started its nuclear power plant, which had been closed as a precaution following a major earthquake in 1988.

Figure 6.2 Armenia's CO_2 emissions from fuel combustion by sector, 2000-2019



Transport is a key driver of Armenia's increasing emissions.

* Includes emissions from own use in electricity and heat generation and unspecified energy industry own use.

** Includes commercial and public services, agriculture, forestry and unspecified energy consumption.

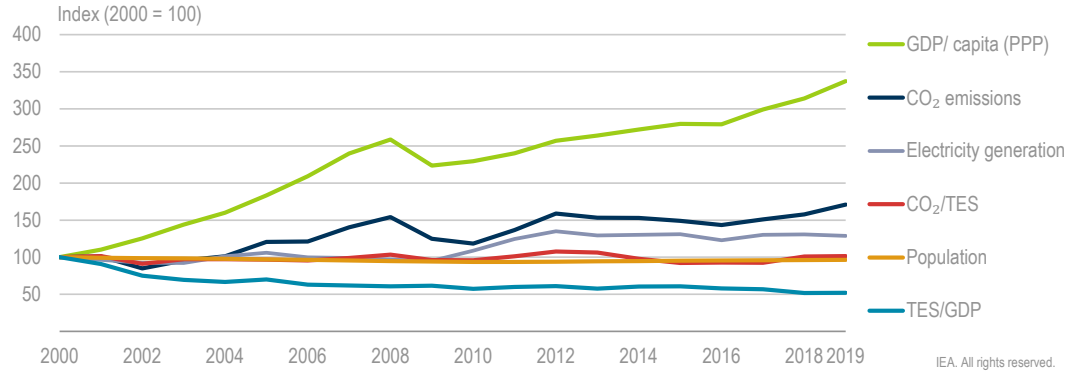
*** Includes CO_2 emissions from combustion in construction and manufacturing industries.

Notes: $MtCO_2$ = million tonnes of carbon dioxide.

Source: IEA (2021), *Greenhouse Gas Emissions from Energy* (database), https://www.iea.org/data-and-statistics.

Total annual CO_2 emissions increased by 71% between 2000 and 2019, while the economy grew over three-fold, measured both in per-capita and absolute terms. Emission increases from electricity production resulted from an increased share of natural gas in power generation during the 2010s. However, the rising use of natural gas in transport, accompanied by efficiency gains in industry, helped lower the CO_2-intensity of energy consumption and the amount of energy consumption per unit of GDP.

Figure 6.3 Energy-related CO_2 emissions and main drivers in Armenia, 2000-2019



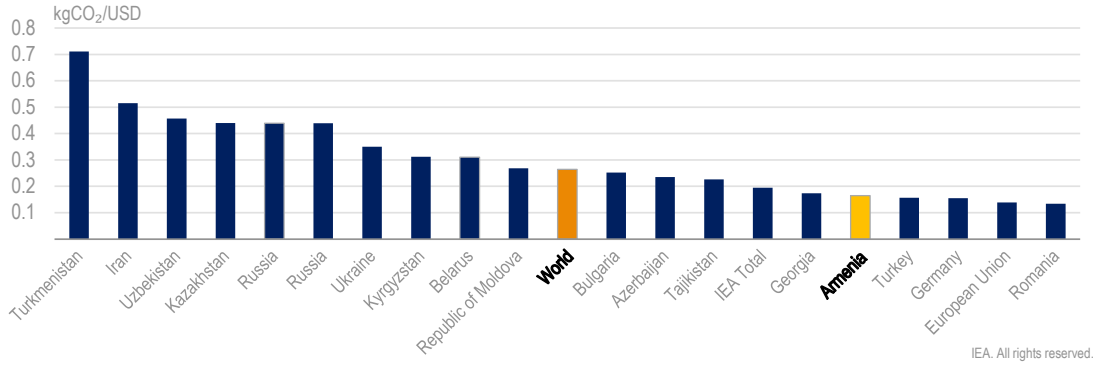
Annual CO_2 emissions increased around 70% since 2000 while the economy grew more than 300%.

Note: TES = total energy supply. GDP in constant 2015 USD and PPP.

Source: IEA (2021), *Greenhouse Gas Emissions from Energy* (database), https://www.iea.org/data-and-statistics.

Armenia's CO_2 intensity of 0.17 kilograms of carbon dioxide per US dollar of economic output ($kgCO_2$/USD) (2015 PPP) was below the world average of 0.26 in 2019. This is explained by the large, combined share of nuclear power and hydro in electricity generation.

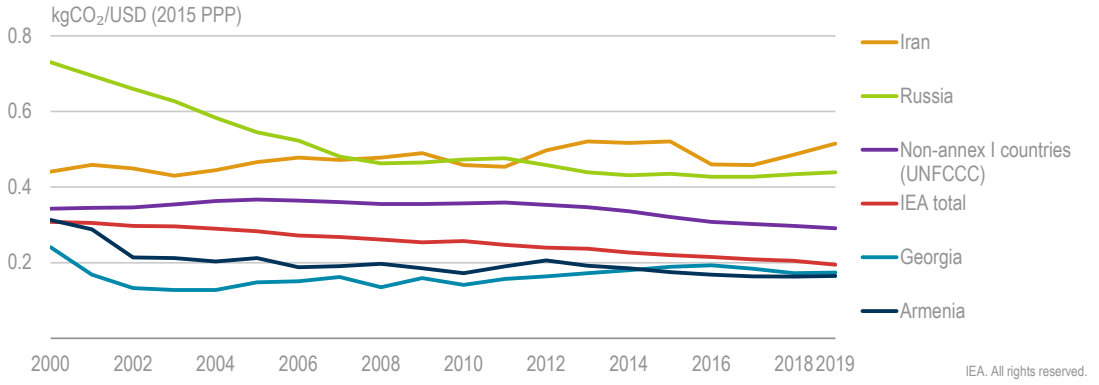
Figure 6.4 CO_2 intensity in Armenia and selected countries, 2019



Armenia's CO_2 intensity is below the world average.

Notes: kg CO_2 = kilograms of carbon dioxide. Real GDP in USD 2015 prices and purchasing power parities (PPP).
Source: IEA (2021), *Greenhouse Gas Emissions from Energy* (database), https://www.iea.org/data-and-statistics.

Figure 6.5 CO_2 intensity in Armenia and selected countries, 2000-2019



Armenia's economy has grown faster than its emissions, resulting in a decreasing CO_2 intensity.

Source: IEA (2021), *Greenhouse Gas Emissions from Energy* (database), https://www.iea.org/data-and-statistics.

Institutional framework

The Ministry of Environment is the main body for environmental policy. It is also responsible for coordinating Armenia's implementation of activities and communications under the UNFCCC, including National Communications, Biennial Updates and GHG Inventories. The Ministry of Environment is the National Focal Point and Designated National Authority for the Clean Development Mechanism (CDM) of the Kyoto Protocol as well as the Designated National Authority for the Green Climate Fund. In 2015, the Ministry created a Climate Change and Atmospheric Air Protection Policy Division within

its Environmental Policy Department, and in 2020 this division became a separate Climate Policy department.

The Inter-agency Coordinating Council for Implementation of Requirements and Provisions of the UN Framework Convention on Climate Change was established by Prime Ministerial decree in 2012 and its composition and functions updated by another decree in 2021. The Council is empowered to coordinate climate change reporting and ensure coherent policies to meet Armenia's commitments under the UNFCCC, as well as its NDCs under the Paris Agreement. The Council is chaired by a Deputy Prime Minister, and the Minister of the Environment is the Deputy Chairman. The Council consists of deputy ministers (11) and representatives of other authorities. Technical cooperation is provided by three working groups, composed of professionals appointed by relevant ministries and departments. The Secretariat function of the Council is carried out by the Climate Policy department of the Ministry of Environment.

The Statistics Committee is the main provider of energy and activity data required for the assessment of GHG emissions used in Armenia's reporting under the UNFCCC. Since 2017, it has published an annual Energy Balance, which serves as the basis for Armenia's inventory of energy sector GHG emissions.

Armenia's Third Biennial Update Report to the UNFCCC notes that additional formal and legal arrangements are still needed to specify the data reporting and quality-assurance obligations of different institutions. More formal arrangements are being developed under the United Nations Development Programme - Global Environmental Facility (UNDP-GEF) project, "Building Armenia's national transparency framework under the Paris Agreement". For example, proposals under this project have contributed to the changes to the composition and mandate of the Inter-agency Coordinating Council.

Climate change policy

Armenia ratified the UNFCCC in May 1993, the Kyoto Protocol in 2002, and the Doha Amendment to the Kyoto Protocol and the Paris Agreement in 2017. Armenia's obligations under these agreements arise from its status as a non-Annex 1 Party. This includes the need to update its GHG reporting every two years. Armenia, like many developing countries, relies on international donors for financial and technical assistance related to such actions, although much of the work is carried out by Armenian research institutes in partnership with international contractors.

Nationally Determined Contributions

Armenia delivered its Intended Nationally Determined Contribution (INDC) in 2015. This featured a target for per-capita net emissions of 2.07 tCO_2eq by 2050. Upon ratification of the Paris Agreement in 2017, Armenia's INDC became its NDC for the period 2015-2050.

In April 2021, Armenia approved an update to its NDC for the period 2021-2030. While maintaining the per capita mitigation goal, it added a target to reduce emissions from the 1990 level by 40%.[15] The new target is based on revised GHG inventory data for 1990-2017 and the 2021 Energy Strategy, particularly its ambitious plans to develop renewable energy, promote energy efficiency and further extend the life of the ANPP. The revised

[15] Total GHG emissions in 1990 were 25 855 Gg CO_2eq (=25.9 $MtCO_2eq$).

NDC notes that the main considerations taken into account in the update were maintaining economic growth, reducing poverty, protecting the environment, achieving the Sustainable Development Goals (SDGs), increasing national energy security and ensuring an affordable and clean supply of energy (GoA, 2021b).

The updated NDC notes that its implementation will be safeguarded by various national and sectoral strategies. This includes the 2021 Energy Strategy and provisions of the EU-Armenia CEPA Roadmap, which contains 12 actions on climate change and 34 actions related to energy efficiency, renewable energy and energy security. The NDC also points to a national Energy Efficiency and Renewable Energy Programme for the period 2021-2030 (currently under development), which is expected to define new sectoral efficiency targets.

National Communications on Climate Change and Biennial Update Reports

The main reporting responsibilities of Annex-1 countries to the UNFCCC are National Communications and Biennial Update Reports. Similar to many other Annex-1 countries, Armenia has received assistance from the UNDP in preparing its reports, with funding from the Global Environmental Facility (GEF).

Each Party to the UNFCCC is required to prepare periodically a National Communication to the Conference of the Parties (COP) that provides the information set out in Article 12 of the Convention. The purpose of the National Communication is to help the COP assess the aggregated implementation of the Convention, as well as to highlight problems and constraints faced by Non-Annex 1 Parties, including for the purpose of targeting assistance.

Non-Annex 1 Parties are required to submit their first National Communications within three years of ratifying the UNFCCC, and every four years thereafter. Armenia submitted its first National Communication in 1998, its second in 2010 (subsequently revised in 2011), its third in 2015 and its fourth in May 2020. Similar to its earlier submissions, Armenia's Fourth National Communication on Climate Change (NC4) provides, among other content, a GHG inventory for the energy sector; an assessment of mitigation potential in the sector; an overview of relevant sectoral strategies; a review of legislative changes, measures and projects; and a list of international agreements, cooperation and projects.

Biennial Update Reports contain revisions to national GHG inventories, as well as actions taken, technical assistance needs, and support received. Non-Annex 1 Parties have been required to submit Biennial Update Reports (BURs) every two years since 2014. Armenia submitted its first BUR in 2016, its second in 2018 and its third in May 2021.

National GHG inventory

Armenia prepared an updated National Inventory Report (NIR) in 2021 in accordance with the 2006 *Guidelines for national greenhouse gas inventories* by the IPCC. Among other improvements, the updated NIR incorporated new data sets and emission sources and re-calculated emission estimates for all sectors, providing more consistent time series for the period 1990-2017.

Mitigation

During the preparation of Armenia's BURs, the LEAP-Armenia[16] model was developed and used to estimate GHG emissions through 2030, as well as the impact of different mitigation projects and measures. Several scenarios were developed using 2012 as a starting point and compared to a base scenario in which no mitigation projects take place.

Under three reduction scenarios, total GHG emissions decrease between 16.6% and 26.0% by 2030, compared to the scenario under which no measures are taken from 2012 onwards. According to the model, the largest reductions on the energy supply side are expected to come from the promotion of solar PV and hydro plants and the reduction of losses in the electricity distribution system. On the demand side, the largest contributions are expected to come from measures in the residential and transport sectors. This is somewhat different from the scenarios presented in Armenia's Fourth National Communication, which suggest that construction of a new nuclear power plant would account for one of the largest reductions. However, the time-frame the government is considering for the new nuclear plant (2036 or later) is beyond that of the scenarios presented in the Third Biennial Update Report.

A list of projects and measures for the scenarios of the Third Biennial Update Report was compiled based on "the most recent strategic papers for the energy sector's development". It contains nearly 40 mitigation projects in the energy sector that are either completed, in progress or planned. Estimated annual emissions reductions are provided for each, based on calculations using the LEAP-Armenia model. Some 12 projects in the sector were expected to lead to annual emissions reductions of 100 Gg (Gigagrams) CO_2-eq or more each. Those projects already or largely completed by mid-2021 include the following:

- **Commissioning of SHPPs**: Goal of 430 MW total by 2023, of which 374.4 MW had been built by 1 April 2020 (253 Gg CO_2-eq reduction in 2023).
- **Energy Efficiency Program for SMEs**: Loan project by Central Bank of Armenia with Kreditanstalt für Wiederaufbau (KfW) financing 452 energy efficiency projects by SMEs (139.3 Gg CO_2-eq reduction in 2019).
- **Promotion of renewable energy**: Loan project by Central Bank of Armenia with KfW financing supported construction of nine solar PV units with individual capacities up to 1 MW (8.5 MW total), 53 SHPPs (136.7 MW total), and 514 solar PV units with individual capacities up to 500 kW, and 2 692 solar water heaters (131.5 Gg CO_2-eq in 2019).
- **Upgrading of Contour Global (Vorotan) Hydropower plant**: upgrade to 1 150 GWh completed in 2019 (105 Gg CO_2-eq in 2019).

Large mitigation projects still in progress or planned, i.e. whose main reduction impacts have yet to occur, include the following:

- **Construction of larger utility-scale solar PV power plants**: two plants, each with a capacity of 200 MW (352 Gg CO_2-eq after 2024).

[16] The long-range energy alternative planning model LEAP) is a scenario-based modelling tool for energy planning and GHG mitigation assessment developed by the Stockholm Environment Institute. It has been used by a number of countries in the development of their INDCs and other communications to the UNFCCC. LEAP-Armenia is a country-specific adaptation of the LEAP model.

- **Construction of medium-size utility-scale solar PV power plants**: Masrik-1 (55 MW) and two additional plants (120 MW) (166.1 Gg CO_2-eq in 2030).
- **Promotion of autonomous power producers**: Creation of a regulatory framework to allow customers to generate for own needs with solar PV capacities of up to 500 kW without licensing and to sell excess generation to the grid. As of November 2020, 3 785 autonomous producers (69.8 MW total) were connected to the grid (117.8 Gg CO_2-eq in 2023).
- **Commissioning of solar PV power plants with individual capacities up to 5 MW**: Total of 315 MW (176 Gg CO_2-eq in 2022 and 277 Gg CO_2-eq in 2029).
- **Upgrade of distribution networks implemented by ENA**: to reduce losses (298 Gg CO_2-eq in 2028).
- **Regulatory framework to promote energy efficiency in countries of the Eurasian Economic Union**: Joint UNDP-Russia project to introduce common EAEU efficiency standards (284.2 Gg CO_2-eq in 2030).
- **Green Urban Lighting**: Demonstration project completed in 2019 to promote energy-efficient municipal lighting, followed by replication in various municipalities (131 Gg CO_2-eq in 2030).
- **De-risking and scaling-up investment in energy-efficient buildings retrofits**: Project involving energy audits and retrofits in 46 kindergartens in Yerevan, with UNDP, Green Climate Fund (GCF) and European Investment Bank (EIB) (100 Gg CO_2-eq in 2023).

The Third Biennial Update Report notes that the following additional large mitigation actions are being considered:

- **Construction of new wind farms**: Assumes capacity of an additional 250 MW commissioned by 2030 (365.2 Gg CO_2-eq).
- **Promoting fuel switching to electricity in transport**: Assumes share of electric vehicles will reach 25% by 2030 (252.1 Gg CO_2-eq in 2030).
- **Further promotion of autonomous power producers**: Assumes total capacity of autonomous power producers of up to 500 kW each reaches 200 MW by 2030 (198.4 Gg CO_2-eq).
- **Construction of medium-size hydropower plant**: Assumes a 66-MW capacity plant for commissioning in 2027 (113.5 Gg CO_2-eq).

Industry

Armenia's industrial sector is relatively small. According to the country's Third Biennial Update Report, the industrial sector produced only 7% of the energy sector's GHG emissions in 2017, while emissions related to industrial processes accounted for an additional 7.5%. Perhaps due to its relatively small size, little has been done so far to map or address emissions from the industrial sector, which is under the responsibility of the Ministry of Economy.

In the future, it may be important for Armenia's manufacturers to demonstrate that they have accounted and paid for carbon emissions released in manufacturing exported goods.

For example, the European Union is currently examining the feasibility of proposals for a "carbon border adjustment mechanism", under which the EU would require foreign companies which wished to sell certain goods to the EU to pay the same price per tonne of emitted carbon as that paid by EU companies. (The main items expected to be initially targeted by the current EU proposals include cement, iron, steel, aluminium, fertiliser and electricity.) Foreign companies would need to monitor and verify the emissions associated with their products exported to the EU, or the latter would impose default "adjustment" fees.[17] Participation in national schemes that are similar to the EU's Emissions Trading System may help exporters demonstrate credible monitoring. A practical first step for Armenia to address industrial emissions could be to develop emissions profiles of its main industrial exporters.

Transport

According to the Third Biennial Update Report, the transport sector accounts for some 25% of Armenia's GHG emissions in the energy sector. Although transport is one of the largest emitting sectors, its contribution is significantly less than what it otherwise might be, given the already overwhelming use of natural gas in road transport in place of gasoline and diesel. Nevertheless, Armenia is aiming to reduce emissions in this sector by electrifying more public transport and promoting the introduction of electric cars, for example through the current policy of eliminating VAT on their import. However, it will be important for the government to carefully consider the overall impact of converting vehicle fleets to electricity, in particular to ensure that the grid emission factor of Armenia's electricity system does not exceed the current emission intensity of CNG vehicles.

Adaptation

Armenia is already experiencing an average annual temperature increase higher than the global average, as well as significantly less rainfall than it has had in the recent past (EU4Climate, 2019). While Armenia has made considerable progress analysing and pursuing options to mitigate climate change, adaptation so far has received relatively less attention.

Armenia's Third Biennial Update to the UNFCCC does not provide a list of adaptation projects similar to its list of mitigation activities, though a list of climate-related projects in all sectors receiving support from the international community may provide an indication of relative attention: Of the 40+ projects listed, only two deal with adaptation, one to develop forest-fire management capacities and another to support Armenia in developing its National Adaptation Plan. A list of Armenia's "Highest priority programmes undertaken for the different categories of climate risk management" on the UNFCCC website contains 27 adaptation projects; none of these involves energy infrastructure.[18]

The UNDP has been helping Armenia develop a "National Action Program of Adaptation to Climate Change" with financing from the GCF. This has been an iterative process, emphasising capacity building for future adaptation planning. It has included a gap assessment, the development of a Measurement, Reporting and Verification (MRV) system, and the formulation of a funding strategy. The government approved the "National Action Program of Adaptation to Climate Change and List of Measures for 2021-2025" in

[17] "Proposal for a regulation of the European Parliament and of the Council establishing a carbon border adjustment mechanism", 14 July 2021, https://ec.europa.eu/info/sites/default/files/carbon_border_adjustment_mechanism_0.pdf.
18 "Highest priority programmes undertaken for the different categories of climate risk management", https://unfccc.int/santiago-network/countries/country-page-armenia.

May 2021 (Government decree No. 749-L). The 26 measures primarily involve the development of more detailed sectoral and regional adaptation plans. According to the list, the adaptation plan for the energy sector will be one of the first to be developed, along with those for the water-resource and agricultural sectors.

Energy and the environment

Armenia has signed and ratified a number of international environmental conventions, including

- The Convention on Long-Range Transboundary Air Pollution (1983);
- The Montreal Protocol on Substances that Deplete the Ozone Layer (1989);
- The Basel Convention on the Control of Transboundary Movement of Hazardous Wastes and their Disposal (1992); and
- The Convention on the Environmental Impact Assessment in a Transboundary Context (1991).

Priorities and objectives for environmental protection and the rational use of natural resources are contained in the following main legislative acts.

- Law On Protection of Atmospheric air (1994)
- Law on Flora (1999)
- Law on Fauna (2000)
- Water Code (2002)
- Law on Waste (2004)
- Forest Code (2005)
- Law on Environmental Inspectorate (2005)
- Law on Specially Protected Natural Areas (2006)
- Mining Code (2011)
- Law On environmental impact assessment and expert examination (2014)
- Tax Code (2016)

A new Law on Protection of Atmospheric air is currently being drafted in the context of Armenia's CEPA with the EU.

The Law on Environmental Impact Assessment and Expert Examination (2014) requires environmental impact assessments for most projects in the energy sector above certain capacity thresholds. Information on public hearings for proposed projects is published on the website of the Ministry of the Environment, as are draft laws and regulations.

One of the most important environmental issues in the energy sector has been the impact of hydropower, particularly the substantial growth of SHPPs, which have benefitted from favourable investment incentives, such as feed-in tariffs and reduced requirements for licensing and environmental impact assessments. Rapid growth in SHPPs has led to increased opposition from environmental groups, which are reporting important negative impacts, including environmental degradation and reduced biodiversity.

In April 2021, the government adopted resolution 488-N "On defining the list of rivers prohibited for the construction of small hydroelectric power plants". This calls for applications by SHPPs for water-use permits to be rejected in areas determined to be spawning sites for Red-Listed fish species, as well as on rivers where 40% or more of the river flow is already routed through diversion pipes.[19] In June 2021, the Environment Ministry further proposed lowering the allowed SHPP capacity threshold to 10 MW from the current 30 MW, meaning that new applications for water-use permits for SHPPs above 10 MW would need to include environmental impact assessments and would no longer benefit from feed-in tariffs.

Assessment

Armenia has demonstrated its commitment to fulfilling its obligations under the Paris Climate Agreement by ratifying the treaty in February 2017. It has also ratified the Doha Amendment to the Kyoto Protocol, thereby establishing the Protocol's second commitment period. The acknowledgement of climate action as an important policy issue is also reflected in the creation of a Climate Policy department within the Ministry of Environment, albeit with limited resources at this point.

In April 2021, the Armenian government approved an updated NDC for 2021-2030, setting an economy-wide target for a 40% reduction in GHG emissions by 2030 (compared to the base year 1990). With this absolute emissions reduction target, the government departed from its previous focus on per-capita carbon emissions and aligned its NDC implementation period with that of most other countries, enhancing comparability and reporting transparency.

As a non-Annex I Party to the UNFCCC, Armenia submitted its Fourth National Communication (NC4) in 2020 and its Third Biennial Update Report (BUR3) in 2021. These provide improved transparency in Armenia's national inventory of anthropogenic GHG emissions by sources, consistent with IPCC reporting guidelines. They also include assessments of the climate change mitigation potential in the energy sector based on official statistical data, highlighting the role of renewable energy and energy efficiency measures.

The latest data in the BUR3 show that the energy sector is by far the largest source of GHG emissions, with a total share of 67%. This includes fuel combustion in energy generation and transport. It also includes fugitive methane emissions from the natural gas system, which form 23% of energy sector emissions. While monitoring and response mechanisms by the gas system operator are in place, technical losses in the gas transportation and distribution systems are reportedly 3.4% and 1.2% respectively, and the overall share of methane emissions from the gas sector in energy-related GHG emissions is apparently high. Working with an international initiative, such as the Climate and Clean Air Coalition's (CCAC) Oil & Gas Methane Partnership, could help Armenia's gas pipeline operator to more transparently identify and reduce methane emissions from its network.

[19] "Armenian Government Adopted Resolution on Defining List of Rivers Where SHPP Construction is Banned", Ecolur.am, 12/04/2021, https://www.ecolur.org/en/news/energy/13115/.

Assessments in the NC4 and BUR3 show that expansion of renewable energy resources and demand-side measures would have a significant impact on energy-related GHG mitigation. This is in line with the government's current development of a new National Programme on Energy Savings and Renewable Energy. In particular, targeted measures in buildings can play an important role in reducing overall GHG emissions, given that buildings are among the country's largest energy consumers.

The transportation sector is another leading source of GHG emissions, accounting for 25% of GHG emissions in the energy sector. The vehicle fleet is largely reliant on natural gas, with around 70% of road transport using CNG as a fuel. Recent interventions aimed at promoting electric vehicles, including tax exemptions for imports, have had an impact, with registration numbers of electric vehicles rising since the relevant amendment to the tax code in July 2019. While increasing the share of electric vehicles will reduce urban air pollution levels, in terms of climate change mitigation it is worth noting that the grid emission factor of Armenia's electricity system (as determined in the 2020 NC4 report to the UNFCCC) may currently exceed the emission intensity of CNG vehicles. Programmes to develop a network of EV charging infrastructure have thus far not been tied to the use or expansion of renewable energy in electricity generation.

The industrial sector constitutes 7% of energy sector GHG emissions, while emissions from industrial processes account for an additional 7.5%. Although emissions from industry currently trail those from the residential and transport sectors, industry's share is projected to grow significantly over the coming decades. The substantial potential for energy efficiency in industry largely remains unaddressed, with a lack of efficiency standards and benchmarks, as well as insufficient energy auditing procedures for energy-intensive industries.

The current growth in the renewable energy sector is mostly driven by the installation of solar PV and hydropower plants. While these developments are welcomed from a GHG-reduction perspective and contribute to the modernisation of the energy system, increased use of hydropower may carry risks of environmental degradation. In particular, the prevalence of ageing hydropower plants and the development of new SHPPs reportedly are affecting natural river flows and putting a strain on biodiversity. These problems may be amplified in the medium term, since climate change already has started to affect Armenia with a decrease in precipitation in some areas.[20] The government acknowledges this issue and plans to address it in the revamp of its national water resources management strategy.

With the EU signalling the possible introduction of a border carbon adjustment tax, the government of Armenia is assessing the implications for the country's exporting industries and exploring policy options for a carbon-pricing or emissions trading system. Aside from facilitating future trade with the EU, the introduction of such a mechanism could prove to be a significant incentive for increased energy efficiency in energy-intensive industries.

[20] For example, see https://unfccc.int/resource/docs/natc/armnc3.pdf, p. 3.

Recommendations

The government of Armenia should:

- Emphasise a systemic approach to climate change mitigation measures, for example, by introducing additionality requirements for renewable energy in electrification efforts in the transport sector and by enhancing energy efficiency in the building sector.
- Continue to consider the trade-offs between GHG emissions reduction and potentially damaging environmental impacts when developing hydropower, particularly SHPPs.
- Explore the introduction of carbon-pricing mechanisms in the medium term, assessing implementation options in dialogue with energy-intensive industries and other stakeholders.
- Encourage the gas transport and distribution company to demonstrate its monitoring and reduction of fugitive methane emissions in a transparent manner, e.g., by reporting emissions and actions under the CCAC Oil and Gas Methane Partnership.

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7. Energy efficiency

Key data

(2020 provisional)

Total final consumption (TFC): 2.6 Mtoe (natural gas 55.5%, oil 21.4%, electricity 19.4%, bioenergy 2.9%, other* 0.8%), +35.9% since 2009

Consumption by sector: residential 33.0%, transport 32.7%, services/other 19.3%, industry 15.0%

Energy consumption (TFC) per capita: 0.88 toe (world average 2019: 1.30 toe), +32% since 2009

Energy intensity (TFC/GDP): 79 toe/USD million PPP (world average 2019: 78 toe/USD million PPP), -4% since 2009

*includes solar heat, coal and district heat

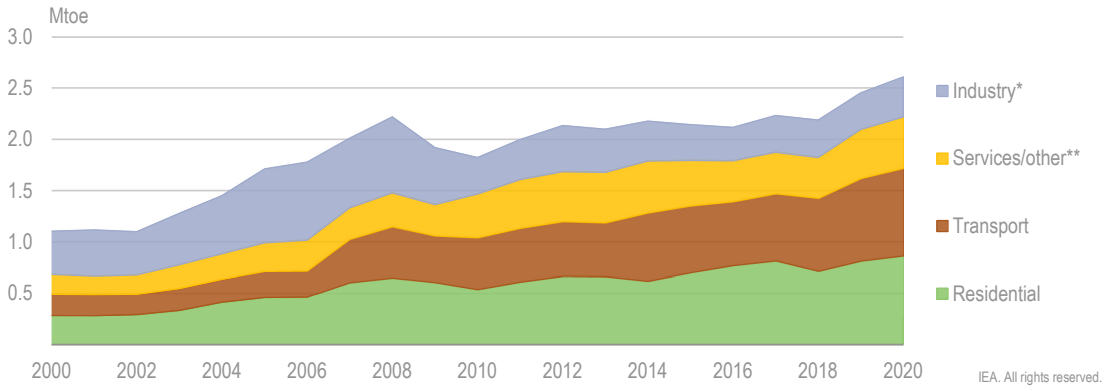
Overview

Energy consumption

Armenia's final consumption[21] of energy (TFC) amounted to 2.6 Mtoe in 2020, having grown modestly over the last decade (+10.5% since 2008). The transport sector TFC has grown rapidly, and is almost on par with the residential sector as the country's largest energy consumer. Both accounted for 33% of TFC in 2020, followed by industry (15%) and other sectors (19%).

[21] Armenia began following international methodology and standards for its energy data in 2015, Hence, the historical trends may not be fully compatible with recent data.

Figure 7.1 Total final consumption by sector, 2000-2020



TFC has more than doubled since 2000, with residential and transport accounting for approximately two-thirds of the total.

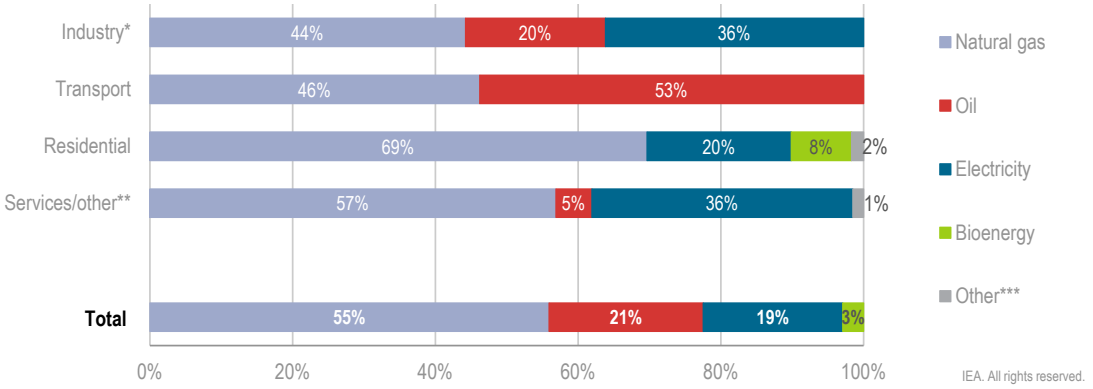
* includes non-energy consumption.

** includes commercial and public services, agriculture and forestry as well as unspecified energy consumption, which is relatively high, above 10% of final consumption of energy.

Source: IEA (2022), *World Energy Statistics and Balances* (database), https://www.iea.org/data-and-statistics.

Fossil fuels accounted for over three-quarters of TFC in 2020 (77%), with natural gas taking the largest share at 55%. Natural gas is the primary energy source in Armenia. Traditionally this holds true also for the transport sector, where it is used extensively in passenger vehicles. However, in 2020 oil products accounted for the largest share of transport fuel, ahead of natural gas. Remaining TFC consists mostly of oil (21%) and electricity (19%). Coal use is minuscule, whereas consumption of biofuels may be underestimated.

Figure 7.2 Total final consumption by source and sector, 2020



Natural gas consumption dominates all sectors of the Armenian economy.

* includes non-energy consumption.

** includes commercial and public services, agriculture and forestry and unspecified consumption.

*** includes solar heat, coal and district heat.

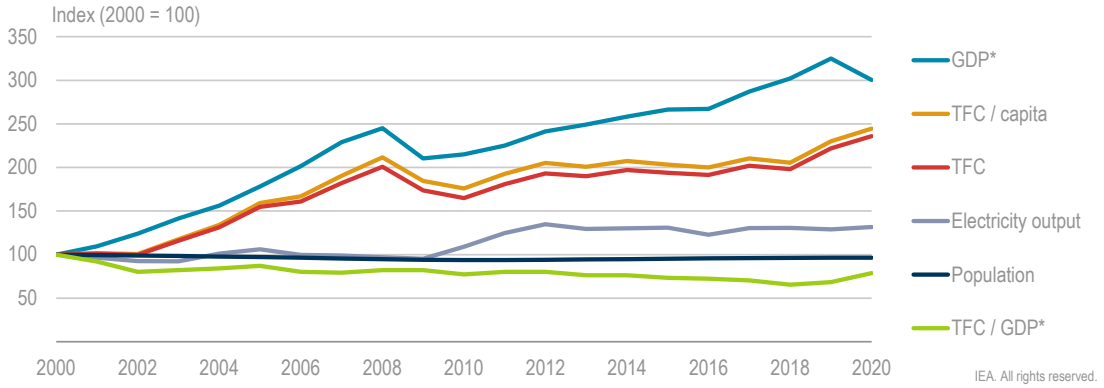
Note: For ease of readability, shares of less than 1% are not shown. Numbers may not add up to 100%.

Source: IEA (2022), *World Energy Statistics and Balances* (database), https://www.iea.org/data-and-statistics.

Energy intensity

Armenia's energy intensity has decreased steadily in recent decades (-21% in 2000-2020). This is due to GDP growing over three-fold during that period, whereas energy consumption (measured by TFC) "only" doubled. The direct, positive correlation between economic growth and energy consumption weakened after 2012 but strengthened in 2019.

Figure 7.3 Drivers for energy consumption and energy intensity, 2000-2020



The link between economic growth and energy consumption weakened from 2012 but strengthened in 2019.

* expressed in constant 2015 USD billion and purchasing power parity (PPP).

Source: IEA (2022), *World Energy Statistics and Balances* (database), https://www.iea.org/data-and-statistics.

In 2020, Armenia's energy intensity per unit of GDP at PPP was 79 tonnes of oil equivalent (toe) per million USD, around the world average of 78 toe per million USD (in 2019). Measured as TFC per capita, Armenia's energy intensity was 0.88 toe in 2020, 32% below the world (2019) average of 1.30 toe.

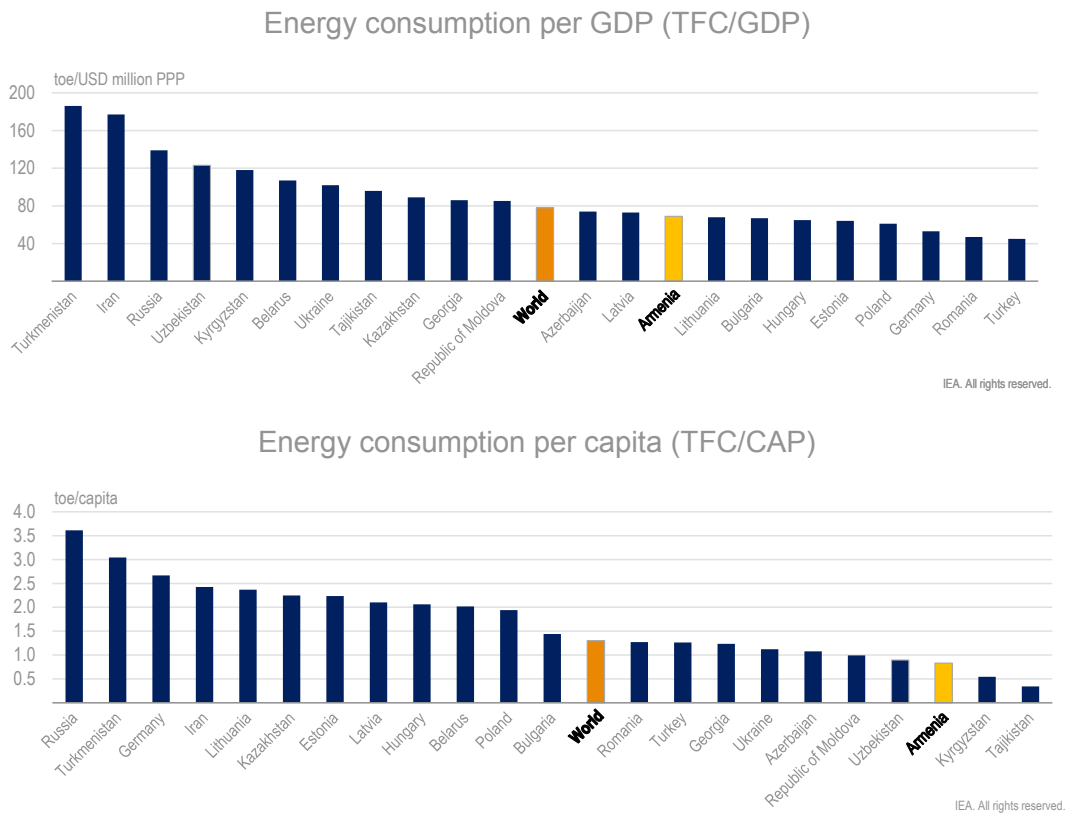
Armenia's relatively low energy intensity might indicate a gradual relative decoupling of economic growth from energy consumption, however the data sets required to substantiate this are limited. Experts consulted as part of this in-depth review point out that Armenia is a middle-income country with an unemployment rate hovering near 20% (19% in 2019), and one-third of the population living in rural areas[22]. In other words, Armenia's level of economic development inevitably influences its energy intensity. In addition, several sector-specific factors potentially contribute to this trend.

There are few energy-intensive industrial facilities in operation in Armenia; most are small-scale manufacturing operations with low levels of automation. Meanwhile, the residential sector consumes a large share of Armenia's energy use, as discussed separately in this chapter. In global comparison, however, Armenian households consume relatively small amounts of energy, and it is worth noting that, given the relatively poor condition of many residential dwellings in Armenia, low energy consumption is unlikely the result of energy efficiency. Rather, it is an indicator of the low thermal comfort levels in many Armenian homes.

[22] The middle-income classification is based on World Bank criteria - https://worldpopulationreview.com/country-rankings/middle-income-countries.

In transport, where energy use has increased and is on a par with residential consumption levels, a similar dynamic may be observed. While significant within Armenia, and potentially due to decreased rail travel and increased passenger vehicle use, the contribution of the transport sector to the country's energy intensity is relatively low compared to other countries.[23] This may be due to Armenia's relatively small size, which reduces average distances travelled, notably in passenger transport. High fuel costs may reduce transport-related energy use further.

Figure 7.4 Energy intensity in Armenia and selected countries, 2019



Armenia's energy intensity is below the world average.

CAP = capita. TFC does not include the energy transformation sector. GDP is expressed in constant 2015 USD billion at purchasing power parity (PPP).

Source: IEA (2021), *World Energy Statistics and Balances* (database), https://www.iea.org/data-and-statistics.

Box 7.1 Energy data in Armenia

Armenia has faced challenges regarding the quality and availability of data on energy use, particularly at sub-sector and household level. In addition, demand trends for Armenia, especially before 2010, are at least partially based on IEA Secretariat estimates and may not be fully compatible with recent data. It should also be noted that as significant share of

[23] See for example, global final energy consumption across end uses, where, on average, road transport alone consumes more than the residential sector as a whole: https://www.iea.org/reports/energy-efficiency-indicators-overview.

total final electricity and gas consumption in Armenia was reported as "unspecified" in recent years (e.g. 13% in 2020) due to data collection challenges.

Currently, only energy balances are available for Armenia, and there is no dedicated official body collecting and coordinating energy-efficiency information with ArmStat, the Statistical Committee of the Republic of Armenia.

Efforts have been made to improve the timeliness, coverage and quality of data on energy use. Armenia aligned its national energy data collection system and compilation of official energy balances with international methodologies and standards in 2015. Since then, data quality and coverage have improved notably. ArmStat cooperates with the IEA and strives to provide accurate and timely energy statistics to the latter, which collects energy statistics on supply and demand from national statistical offices worldwide. (Specifics on the IEA's approach to data collection on energy efficiency are publicly available as part of a series of dedicated manuals on energy statistics.)

Trends by sector[24]

Demand growth has been fastest in the transport sector, where consumption parallels that of the residential sector. In 2020, each of these two sectors was responsible for about one-third of demand. In the aftermath of the 2008 global financial crisis, TFC dropped especially for industry, and the sector has yet to recover. As a result, it held only a 15% share in TFC in 2020. The rest (19%) of TFC is accounted for by services and other sectors. The possibility for more detailed analysis is limited since around half of this category (13% of the TFC) is not allocated to any sector.

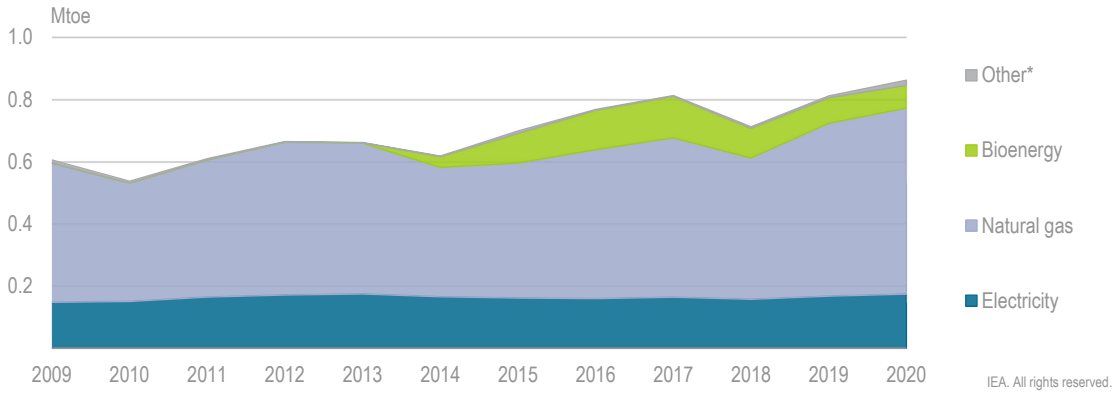
Residential

The residential sector consumed 0.9 Mtoe in 2020, accounting for 33% of TFC in the country. According to the available data, this sector's energy consumption has grown by 42% since 2009. It consists mainly of heating (both space and water) which fluctuates annually with outdoor temperatures.

Most homes are heated with individual gas boilers, which account for high residential gas demand (69% of the sectoral total in 2020). Gas consumption has also increased 34% since 2009, further solidifying its importance for the sector. Electricity accounts for 20% of the total consumption, and its demand has remained essentially flat over the past decade. Bioenergy, primarily in the form of solid biofuels (e.g. wood) covers around 8% of the demand in rural areas, according to available data, but consumption might be underestimated. Consumption of district heat is currently limited to a single area in Yerevan.

[24] Sectors ordered from largest to smallest in terms of energy consumption, also only showing 2009-2020 due to data quality issues.

Figure 7.5 Total final consumption in residential sector by source, 2009-2020



The residential sector relies mostly on natural gas for its heating needs.

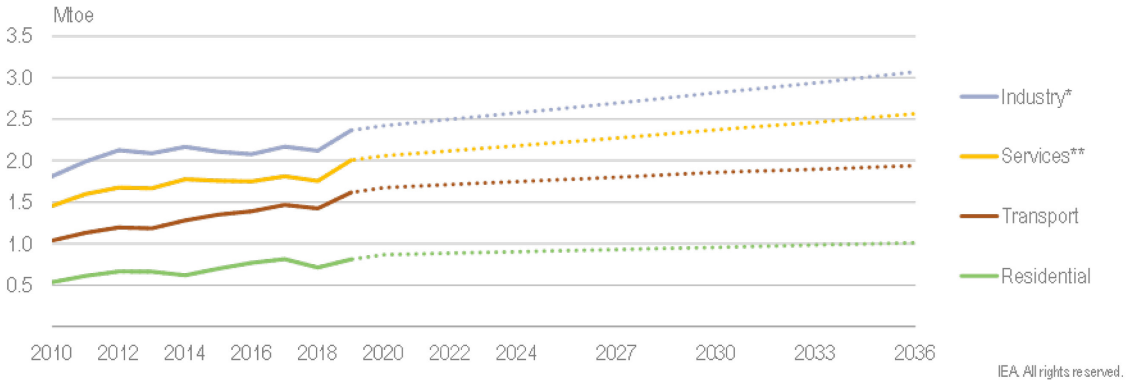
* includes solar thermal, coal, oil and district heat; not visible on this scale.

Bioenergy data available only since 2014.

Source: IEA (2022), World Energy Statistics and Balances (database), https://www.iea.org/data-and-statistics.

With the notable exception of transport in 2020, the residential sector consistently accounts for the highest share of TFC in Armenia. Residential energy demand growth is expected over the next 15 years.

Figure 7.6 Armenian total final energy consumption by sector, 2010-2036



The transport and residential sectors are likely to account for the largest share of TFC by 2036

* includes non-energy use.

** includes non-specified consumption of electricity and natural gas.

Note: Historical data (2010-2019) from the IEA via ArmStat. Projections (2020-2036) based on modelling by the Energy Strategy Centre of the Scientific Research Institute of Energy of Armenia.

Sources: IEA (2020d), *World Energy Statistics and Balances* (database), https://www.iea.org/data-and-statistics; USAID, 2019.

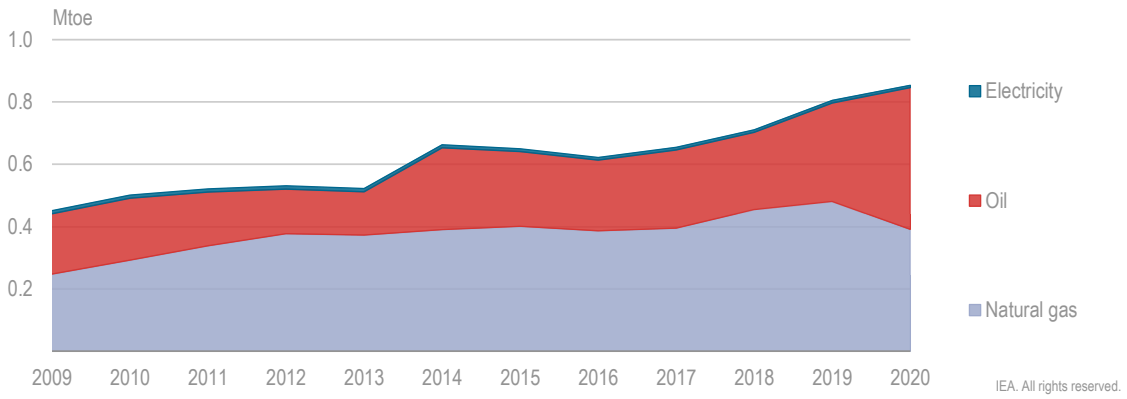
Transport

In 2020, the transport sector consumed 0.8 Mtoe (33% of TFC), virtually on a par with residential consumption. Consumption by transport has grown rapidly, over 60% since 2009. Unlike in most countries, natural gas, mainly in the form of CNG, plays a key role in

the transport sector (46% of the total sector consumption in 2020 with 61% average share of the total in 2009-2020, up 58% since 2009). Only in 2020 did oil product consumption exceed that of CNG. CNG accounts for most of the natural gas demand in the sector.

Oil-based fuels covered 53% the energy demand in the transport sector in 2020 (motor gasoline 22.9%, diesel 12.8% and LPG 3.5%) with 135% growth since 2009, the average share in 2009-2020 being just 37%. The share of electricity in consumption by the transport sector (mostly in rail) was just below 1% in 2020, having decreased by 25% from 2009. While data on passenger vehicle sales for Armenia are limited, there may be a correlation between declining rail transport use and increasing passenger vehicle use. If so, car use trends in Armenia during this period would have been similar to European and global trends.[25]

Figure 7.7 Total final consumption in transport sector by source, 2009-2020



Use of CNG in passenger vehicles drives natural gas use in the transport sector.

Note: Transport sector demand excludes international aviation and navigation.
Source: IEA (2022), World Energy Statistics and Balances (database), https://www.iea.org/data-and-statistics.

Industry

The industrial sector consumed 0.4 Mtoe in 2020, equivalent to 15% of TFC. While consumption has been declining since 2012 (-1.8% AAGR), following a sharp increase between 2010 and 2012, the aggregate levels of industrial energy use in Armenia are relatively stable.[26] Some variances are nevertheless visible at the level of individual fuels.

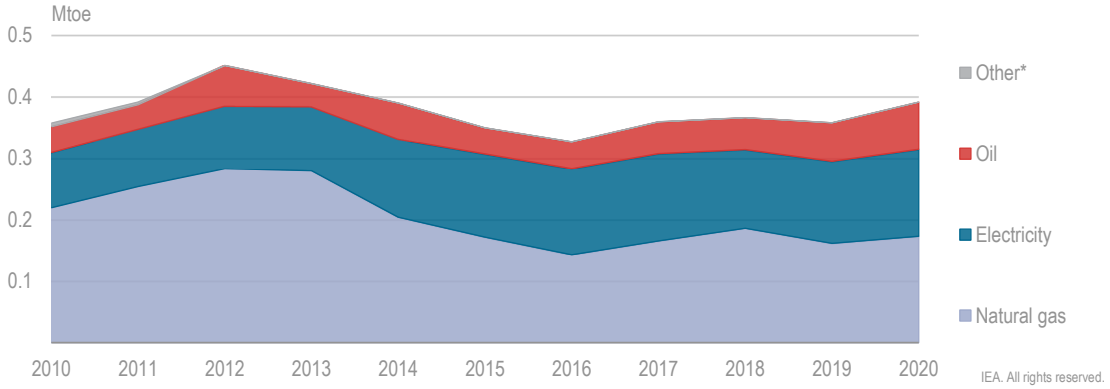
Natural gas consumption has declined 21% since 2010, while consumption of both electricity and oil has increased by over 50%. Natural gas was still the main energy source for industry with 44% of the sectoral total in 2020, above the EU average of 31% (2019). However, if current trends continue, industry's demand for electricity will surpass its demand for gas, marking a historical change in Armenia's TFC.

Non-metallic minerals (mainly cement) and food processing dominate demand by manufacturing (Figure 7.9), both relying mainly on natural gas. Outside of manufacturing,

[25] See for example, global passenger car sales per region between 2010 and 2020: https://www.iea.org/data-and-statistics/charts/passenger-car-sales-by-key-region-2010-2020e.
[26] It is worth noting that reliable data for industry is only available since 2010.

energy consumption in mining and quarrying is almost on par with non-metallic minerals, though the main energy source for mines is electricity.

Figure 7.8 Total final consumption in the industrial sector by source, 2010-2020



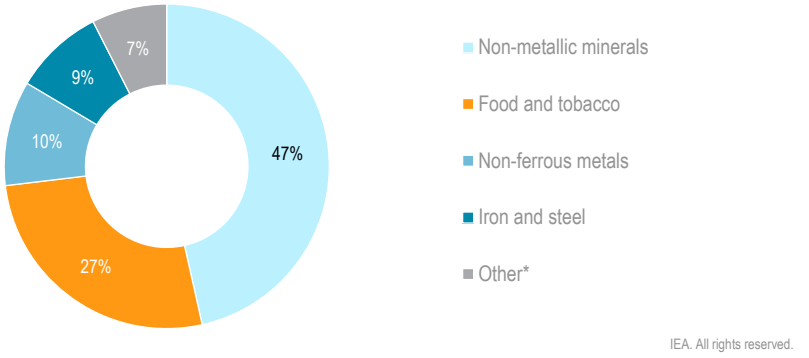
Industrial energy use has remained stable in Armenia, with a slight decline since 2010.

* includes coal, solid biofuels and district heat.

Note: Includes non-energy consumption.

Source: IEA (2022), World Energy Statistics and Balances (database), https://www.iea.org/data-and-statistics.

Figure 7.9 Energy consumption in manufacturing activities, 2020



Non-metallic minerals (mainly cement) accounts for the largest share of energy consumption by manufacturing.

Manufacturing excludes mining, quarrying and construction. It also excludes non-energy uses.

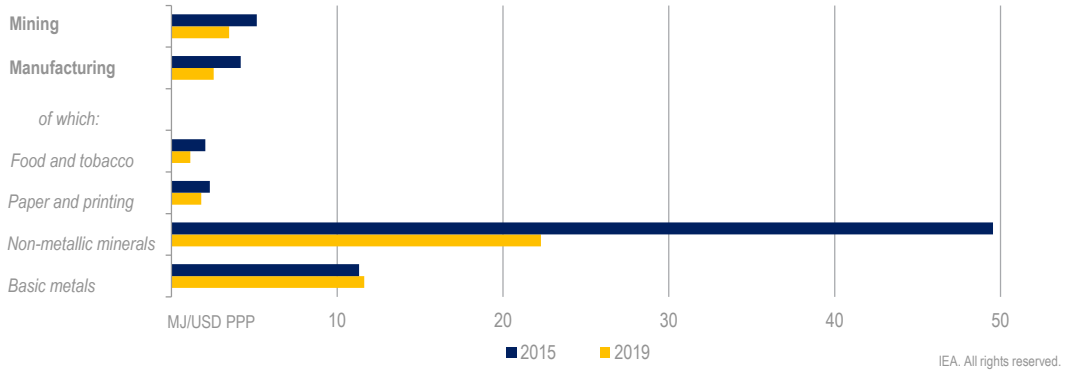
*includes paper, pulp and printing, chemical and petrochemical, machinery, textile and leather, wood and wood products, transport equipment, and unspecified industrial consumption.

Source: IEA (2022), World Energy Statistics and Balances (database), https://www.iea.org/data-and-statistics.

According to the available data, the energy intensity of Armenia's industries is decreasing. Measured as energy consumption per value added, the total energy intensity of manufacturing activities declined by 39% between 2015 and 2019. In other words, such activities have added more value per unit of energy consumed in 2019 than they did in 2015. Due to gaps in the available data, it is unclear whether this reduction stemmed from energy efficiency improvements or from structural changes to the economy (which could have been due to economic disruptions). The intensity development also varies for different industry sectors. For example, in the non-metallic mineral industries, which constitute the highest

share of energy consumption, energy intensity seems to have decreased by 55% since 2015, with some volatility between years. These numbers should be treated with caution, since there is limited data to validate this analysis. Since this is a significant decrease, however, it may merit further investigation by Armenian policy-makers.

Figure 7.10 Selected energy intensities in the industrial sector



Energy intensity appears to have declined in most industries in recent years.

The manufacturing industry excludes mining, quarrying and construction. It also excludes non-energy uses.
Source: IEA (2021), *Energy Efficiency Indicators* (database), https://www.iea.org/data-and-statistics.

Services/other

The remaining 19% of TFC consists of services, agriculture and unspecified energy consumption. (Unspecified was 0.3 Mtoe or 13% of TFC in 2020) As the majority of this is unallocated, the ability to conduct further sectoral analysis is limited. Half of the unspecified consumption consists of natural gas and the other half is electricity.

Policies and measures

Efforts are underway to complete the regulatory framework for energy efficiency in Armenia as part of an overarching national energy strategy, including a new national programme and a revised NEEAP. In parallel to domestic policies and efforts, the government is also working to align with EU policies and norms as part of the EU and Armenia CEPA, which entered into force on 1 March 2021. In parallel, Armenia is aligning technical norms with the EAEU, in which Armenia is a treaty member. International partners, including development agencies and lenders, play an important role in shaping the policy agenda for energy efficiency in Armenia.

Impacting these efforts are several important barriers to energy efficiency policy-making in Armenia. These include gaps in the availability of data as well as concerns about data quality, limited administrative capacity to develop provisions and enforce compliance, and generally low levels of public awareness about the benefits of energy efficiency. Major political developments, notably the 2018 Revolution, armed conflict with Azerbaijan, and the Covid-19 pandemic, have also delayed or disrupted several ongoing energy efficiency policy initiatives.

Legislative framework

Energy efficiency policies and measures have been in place in Armenia since at least 2004, when the first comprehensive legislation on energy efficiency was adopted as part of a law on Energy Saving and Renewable Energy. This was followed in 2007 by a National Programme on Energy Savings and Renewable Energy, and a NEEAP in 2010. In 2012, the EBRD also assisted the former Ministry of Energy Infrastructures and Natural Resources to develop a "Sustainable Energy Action Plan", which aimed at developing legislation to promote energy efficiency investments across the economy.

In addition, the government set a primary energy savings target of 37.4% by 2020 compared to 2010 levels. By 2014, 8.6% savings had been achieved, according to an assessment made as part of the development of the second phase of the NEEAP. However, to date no further assessment has been made on progress towards this target, and the figures provided in the assessment also need to be reconciled both with increases in TFC and with declines in energy intensity over the past decade, as discussed previously.

At the time of publication of this report, several parallel efforts were underway to create a comprehensive policy framework for energy efficiency in Armenia. A new National Programme on Energy Saving and Renewable Energy covering the period 2021-2030 was expected to be adopted by the government in 2021 and include the main energy efficiency policies and targets of Armenia until 2030, based on an analysis of data available for the period 2007-2020, and incorporate a revised NEEAP.

Implementation of the CEPA will mean Armenia is aligning to key EU energy efficiency laws, such as the Ecodesign Directive, which covers all end uses and energy-using equipment, and the Energy Performance of Buildings Directive (EPBD),[27] which contains important provisions for both new and existing buildings. Most of the measures relevant to energy efficiency are to be adopted during 2025 to 2030. Implementation of the CEPA is accompanied by a technical assistance package and funds to support energy efficiency retrofits in educational facilities or street lighting, for example.

Meanwhile, as part of its membership of the EAEU, Armenia is required to harmonise directives and technical regulations on energy efficiency according to EAEU treaty obligations. In this context it is important to note that Armenia is only harmonising with EU laws that are not already specified as part of EAEU requirements.[28] More specifically, in cases where measures are already harmonised with EU requirements as part EAEU membership, or conversely if a specific future requirement is already stipulated as part of EAEU membership, then Armenia will align with EAEU requirements.

While not examined in detail in this section, price signals (usually interlinked with energy subsidy and taxation policies) can have a significant impact on the success of energy efficiency policies. While Armenia is one of the few developing countries that does not subsidise fuel prices but rather taxes them, gas represents the largest part of TES, and Armenia receives almost all its gas from Russia at relatively low prices, effectively creating a subsidy that negatively impacts incentives to increase energy efficiency.

[27] https://ec.europa.eu/commission/presscorner/detail/en/IP_21_782.
[28] Official EAEU website: www.eaeunion.org/?lang=en.

Governance, data and institutional capacity

The main body responsible for developing energy efficiency policies in Armenia is the Division for Energy Efficiency and Technical Norms, part of the Energy Department of the MTAI. Since energy efficiency was previously under the purview of a minister, assisted by three deputy ministers, the new arrangement would seem to represent a reduction in administrative capacity devoted to energy efficiency within the government of Armenia. Capacity challenges also impact on, and are impacted by the limited availability of statistical data covering indicators relevant to energy efficiency across economic sectors, population segments, etc. (see also Box 7.1).

The Armenian Renewable Resources and Energy Efficiency (R2E2) Fund was created in 2006 with financial help from the World Bank to facilitate investments in energy efficiency and renewable energy. The R2E2 includes a revolving lending tool that finances projects in the public sector.

Despite capacity and data challenges, technical transposition of EU energy efficiency laws such as the EPBD and the European Endowment for Democracy (EED) is already underway. For example, 50% of relevant secondary laws have already been aligned with corresponding EPBD and EED provisions. However, experts expressed concern during the IDR review mission that, due to capacity challenges, transposed rules are neither effectively implemented nor sufficiently enforced. Moreover, there is limited local capacity in Armenia to transpose fully some of the technical provisions contained in the EPBD, such as those requiring expertise in the area of building physics, for example.

Capacity challenges were also cited with respect to implementing simultaneously the provisions of the EU CEPA and EAEU membership, such as technical regulations and labelling for energy-using equipment. While EU and EAEU rules are aligned from a technical point of view to enable wider cross-border trade, they nonetheless need to be managed separately, requiring additional administrative resources.

Buildings

Buildings constitute Armenia's largest energy-consuming sector, accounting for around 40% of electricity demand and over 25% of gas demand. The residential sector alone (much like the transport sector) accounts for one-third of TFC in Armenia. The Armenian government has identified energy efficiency in buildings as an important part of its overall energy strategy, as evidenced by action plans, strategies and laws developed since the early 2000s. The government has also adopted specific measures for energy efficiency and energy-saving regulations in the construction sector (2013), as well as minimum energy performance requirements for new and renovated buildings (2016). Furthermore, secondary legislation, norms, standards and calculation methods based on international best practice have been adopted for the buildings sector over the past decade to address energy auditing, thermal insulation, building energy performance, and a range of other related topics.

However, work remains in terms of developing and implementing a comprehensive framework for building codes designed to drive energy efficiency improvements for both new and existing buildings in Armenia. While energy performance requirements are in place for new buildings, there are issues in terms of implementing and enforcing the rules. There are also challenges related to capacity in the market to carry out standardised

performance assessments of buildings, as well as individual systems such as heating, ventilation, air conditioning and other core building efficiency technologies.

Several efforts supported by international partners have been made or are underway to boost progress on building efficiency in Armenia. For example, the UNDP has been supporting the development of a code for the thermal protection of buildings, a building "energy passport" and methodologies for performing energy audits in residential and public buildings. In 2020, the IEA published an in-depth roadmap for energy-efficient buildings in Armenia. In early 2019, the EU launched a new high-level initiative to encourage and coordinate international financial institutions support for large-scale energy efficiency measures in buildings. With EU support, a separate roadmap for nearly zero energy buildings is also being developed.

With the implementation of the CEPA, Armenia will have an opportunity to adopt the EU's relatively comprehensive legislative framework on building energy efficiency. Assuming legislation such as the EPBD (which includes requirements on gradually strengthening building codes in new and existing buildings) is fully adopted, Armenia will have filled any gaps in terms of aligning legal provisions on building efficiency with EU norms. Challenges are likely to remain, however, in terms of implementation and enforcement, with nuances across sub-sectors.

Heating

Within the residential sector, heating (for space heating and hot water) is responsible for the main share of consumption, due to the length of the heating season and the severity of winter in Armenia, particularly in certain parts of the country. Improving the efficiency of heating in Armenia's buildings is therefore a key policy consideration, although it is complicated by several barriers, beginning with a lack of data.

Gas boilers are not regulated in Armenia. There is no clear data on how many gas boilers are being used to heat apartments in multi-apartment blocks (MABs), nor are there data on the efficiency of the boilers currently in use. A draft law on heating is being discussed by the government of Armenia, and detailed provisions are scheduled to be adopted as part of a new law by December 2022.

The option to revitalise existing district heating networks in order to improve central heating systems, as an alternative to widespread and largely unregulated residential gas boiler use, has received limited attention in Armenia. Only one such system is currently operational, providing heating for 36 MABs in the capital, Yerevan.

While these approaches offer opportunities for improving heating efficiency, particularly in cases where the pre-existing central heating networks used during the Soviet era can be cost-effectively rehabilitated, non-technological barriers may also need to be addressed. These include challenges relating to the communal governance of MABs, whereby a lack of clarity on ownership and/or management of improvements to common areas (including any central heating systems, main doors, building envelope, etc.) presents a potentially significant obstacle not only for heating system improvements, but for whole building retrofits more generally.

Beyond individual end uses such as heating, improving building efficiency in Armenia will also require the setting and enforcement of stronger construction codes and standards. There are concerns around the extent to which codes and standards are being

implemented in practice, with gaps in terms of the government's capacity to enforce rules and to collect data to monitor implementation. Low consumer demand for available grants to support more energy-efficient construction may also be an indicator that these standards and codes face adoption barriers in the market.

Lighting, appliances and other energy-using equipment

Armenia has made some progress in developing its regulatory framework for lighting, appliances, (e.g. refrigerators, washing machines) and other common energy-using equipment, such as industrial motors and heaters. As part of the CEPA implementation of EU rules and alignment with EAEU technical requirements on standards and labelling, the regulatory framework for appliances will continue to take shape in Armenia.

Similar to the case for buildings, the adoption of laws and standards for appliances will require market enforcement and quality control to ensure consumers have access to the most efficient equipment. In the area of lighting. Armenia made progress in this regard in 2019 by establishing mobile and stationary photometric lighting laboratories to test the quality and efficiency of lamps and street lighting systems. In addition, more than 400 subsidy-backed LED street lighting programmes are currently being deployed with a focus on small communities. Funding for these LED rollouts, which are encouraged to integrate solar PV technologies where possible, is drawn from community and state budgets on a shared basis.

In terms of cooling, energy performance requirements for air conditioners (ACs) and fans are also due to be aligned with EU and international norms as part of the CEPA, although the impact of cooling on energy use in Armenia is still relatively minimal, particularly when compared with heating demand. Only 5% of Armenian households have an AC unit, although the figure is higher in Yerevan at just over 10%. However, cooling is one of the fastest-growing sources of Armenian energy demand, mirroring a global trend resulting from climate change-induced average temperature increases. Policy-makers in Armenia undoubtedly will need to increase their attention to energy use for cooling in the coming years.

Transport

Armenia currently does not have a policy framework for transport energy efficiency outside of tax incentives for the uptake of electric vehicles. Transport fuel economy standards are due to be harmonised with EU rules over the period 2026 to 2030 as part of the CEPA implementation. In addition to the introduction of fuel economy standards and other eventual policy measures related to transport, Armenia faces important strategic choices with respect to transport.

Energy use in Armenia's transport sector is closely linked with the country's wider reliance on natural gas imported primarily from Russia: On average around 60% of the sector's total energy consumption is in the form of CNG. If the sector is to transition towards electrification, this may also lead, effectively, to a reduction in indirect subsidies for road transport.

Given the transport sector's reliance on natural gas, which is imported from Russia at prices below what might be expected, any move to electrification will need to be carefully coordinated in terms of price impact on consumers. In parallel, the development of EV infrastructure will need to be carefully coordinated with existing and planned natural gas

investments to avoid stranded assets and to allocate adequate capital to electrification. At the same, the quality of the transport stock will need to be improved, along with better data collection on vehicle numbers, status, age, etc., as well as controls on imports of vehicles that may not meet standards.

Industry

Armenia does not have a regulatory framework in place per se for energy efficiency in its industrial sector, nor does the government track the energy intensity of its industries against standards or benchmarks. In general terms, industrial policy in Armenia has been based primarily on the principle that market forces and tariffs will incentivise efficient production practices. However, the government of Armenia has indicated it may consider more targeted energy efficiency initiatives for industry in the future.

Currently, use of the ISO 50001 standard for industrial energy management is encouraged by the government, but all industrial efficiency initiatives in Armenia are voluntary, with no mandatory requirements in place for measures such as energy audits. The level of expertise to deliver audits is also considered to be relatively low, suggesting efforts are needed to address capacity barriers to industrial energy efficiency. In addition, data availability and quality pose a challenge, with no central database in place to capture the energy performance of industrial equipment currently in use across Armenia.

Assessment

The government of Armenia has repeatedly affirmed the importance of energy efficiency in its economic development, with legislative provisions in place since the early 2000s. However, progress has largely been put on hold since 2018, due to major political disruptions related to the revolution, armed conflict with Azerbaijan and the COVID-19 pandemic. In addition, the implementation of legal provisions on energy efficiency has been slowed by governance constraints, lack of market capacity and limited availability of statistical data.

The first comprehensive legislation on energy efficiency was adopted in 2004 as part of a law on Energy Saving and Renewable Energy, followed in 2007 by a National Programme on Energy Savings and Renewable Energy. A NEEAP was adopted in 2010 and updated in 2017, with a third revision delayed due to political circumstances. Mandatory energy efficiency requirements for newly constructed MABs, mandatory energy audits for buildings constructed with state funds, and the definition of labelling requirements for energy-saving devices and equipment feature among the rules adopted as part of these policies and measures.

Energy targets have previously been set in Armenia, and one assessment concluded that targets had been achieved. However, there are concerns about the level and quality of available data to verify progress towards targets.

At the time of writing this review, the government of Armenia is developing a new National Programme on Renewable Energy and Energy Efficiency, scheduled for adoption at the end of 2021. The third phase of the NEEAP will form a part of this new programme, which will be based in part on an assessment of the level of implementation of the 2007 National Programme on Energy Efficiency and Renewable Energy.

Armenia has also started to implement the energy efficiency provisions of the EU-Armenia Comprehensive Partnership Agreement (CEPA), which entered into force in February 2021. The CEPA includes requirements to implement key EU laws on energy efficiency, such as the Energy Efficiency Directive (EED) and the Energy Performance of Buildings Directive (EPBD). In parallel, Armenia is due to implement a range of separate standards for energy-using technologies as part of its membership of the EAEU.

Armenia faces constraints in terms of energy efficiency governance. In 2019, as part of a wider administrative reform, the Ministry of Energy was merged into the MTAI, with a significant reduction in administrative staff and capacity to support energy efficiency policies and measures. In parallel, the Ministry of Urban Development, which is responsible for key energy efficiency measures such as building standards and codes, was downgraded to the level of a State Committee, with reduced capacity and staffing levels. Armenia also does not have a dedicated energy agency to coordinate energy efficiency policy development and implementation across ministries and departments. Compounding capacity challenges are energy end-use data quality and availability issues that impact policy formulation, implementation and monitoring.

Governance and related data challenges are compounded by limited technical capacity to implement key legislative provisions. Capacity gaps are evident in building sector codes and norms, where a general lack of specialist expertise in areas such as building physics complicates bottom-up efforts related to standardisation. In the industrial sector, limited expertise exists in implementing energy management systems and other efficiency programmes. Governance and capacity constraints are also expected to create challenges with respect to the simultaneous implementation of the CEPA and alignment with EAEU standards. While these standards are complementary, they constitute two separate reporting regimes and require dedicated resources to administer effectively.

Nonetheless, Armenia has made progress in terms of aligning with EU legislations and norms, having already adopted more than 50% of the provisions of the EPBD, for example, at least in terms of transposing headline provisions of this directive into national law. Progress has also been made in the realm of appliances and equipment, with the adoption of the A-to-G labelling scheme, in line with the EU Ecodesign Directive and Energy Labelling Directive, for a range of energy-using devices, such as refrigerators and washing machines. Based on training sessions and surveys conducted by the UNDP, Armenia is also making steady progress in terms of phasing out the most inefficient technologies, notably with respect to lighting.

Despite progress in the efficiency of individual building technologies, significant potential remains in the buildings sector. As Armenia's largest energy-consuming sector, buildings account for around 40% of electricity demand and over 25% of gas demand. Efficiency potential exists particularly in home heating. Currently, gas boilers and other common home heating technologies are not regulated in Armenia, and scant information exists on the efficiency level of these technologies. These issues will need to be addressed as part of the CEPA implementation. In addition, most of Armenia's MABs, which are home to nearly 40% of Armenia's population, do not have functional central heating. This is due in part to legal uncertainly concerning the communal management of MABs, with associated regulatory reforms delayed.

In the industrial sector, no energy efficiency policies, such as minimum energy performance requirements for industrial motors, or tax breaks to incentivise the adoption

of ISO 50001 or other energy management systems, currently exist in Armenia. The government considers that, due to the energy-intensive nature of industrial activities, market forces are sufficient to drive investments in the most energy-efficient technologies. However, there may also be important barriers to increasing efficiency in industrial facilities, including lack of access to finance for more efficient motors, or lack of awareness about additional cost-effective opportunities for energy performance gains.

In the transport sector, except for the tax breaks for electric vehicles, to date Armenia has not adopted any energy efficiency provisions, such as fuel economy standards for passenger vehicles. However, as part of the CEPA provisions, Armenia is expected to transpose EU standards for transport efficiency between 2026 and 2030.

Recommendations

The government of Armenia should strengthen measures to improve economy-wide energy efficiency. In particular, it should:

- Ensure sufficient capacity to successfully approximate the standards and norms required as part of the EU-Armenia CEPA and applicable EAEU legislation, and to implement the planned new National Programme on Energy Saving and Renewable Energy.
- Develop a detailed strategy, including codes implementation and enforcement mechanisms, to improve the energy efficiency of the building stock, with a particular focus on residential buildings, leveraging work already begun in this area.
- In tandem with efforts to improve building energy efficiency, develop a national strategy on heating, including information and awareness-raising measures, as well as improved data collection on heating technologies used in homes, combined with an assessment of the potential for greater use of district heating networks as an alternative to individual gas boilers.
- Consider basic or early measures to promote energy efficiency in industry, for example through a subsidised energy audit scheme accompanied by information and awareness-raising initiatives.

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8. Renewable energy

Key data

(2020 provisional)

Renewable energy: 0.25 Mtoe (7.1% of TES) and 1.8 TWh (23.3% of total electricity generation)

Hydro: 0.15 Mtoe (4.3% of TES) and 1778 GWh (23.0% of electricity generation)

Bioenergy: 0.08 Mtoe (2.1% of TES) (no electricity generation)

Solar: 0.03 Mtoe (0.7% of TES) and 137 GWh (0.28% of electricity generation)

Wind: <0.001 Mtoe (<0.01% of TES) and 2 GWh (0.02% of electricity generation)

World renewable energy shares (2019): 13.8% of TES and 26.0% of electricity generation

* includes solar PV and solar thermal.

Overview

The contribution of RES to energy consumption in Armenia averaged about 11% during 2015-2020 (measured by the sustainable development goal indicator 7.2). This mostly consists of hydroelectricity.

Most electricity generation from RES comes from two sets of large hydropower plants. The growth of small hydropower plants (SHPPs) has been significant over the past two decades, in response to attractive feed-in tariffs (FiTs) and other support. However, growth in SHPP construction has slowed in recent years, due to stricter siting rules related to growing concern over ecological impacts.

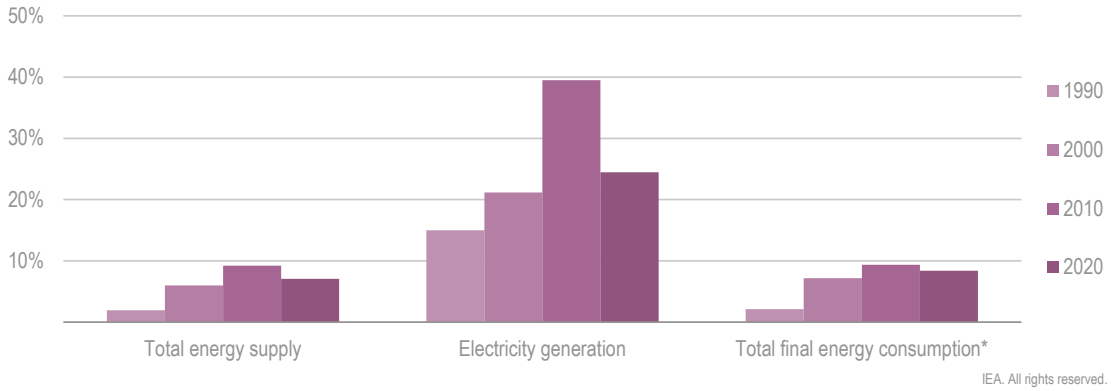
Solar photovoltaic (PV) energy capacity is currently low but expected to become the major source of new RES growth, due to support mechanisms and to falling costs worldwide for solar PV equipment.

Although several prospective sites for wind farms have been identified, most are in remote, high-altitude locations, reducing their cost-competitiveness vis-à-vis other RES, particularly solar.

Government support for RES development includes FiTs, offtake guarantees, net metering, and currency and inflation risk mitigation.

The 2021 Energy Strategy considers maximum use of the country's renewable energy potential to be a key policy priority. However, it will be a challenge to integrate the expected large and rapid increase in grid-connected variable forms of renewable energy (VRE).

Figure 8.1 Share of renewable energy in Armenia's energy system, 1990-2020



Hydropower currently accounts for most RES in Armenia.

* includes direct use in TFC and indirect use through electricity and heat consumption.

Notes: 2020 data are preliminary.

Source: IEA (2022), *World Energy Statistics and Balances* (database), https://www.iea.org/data-and-statistics.

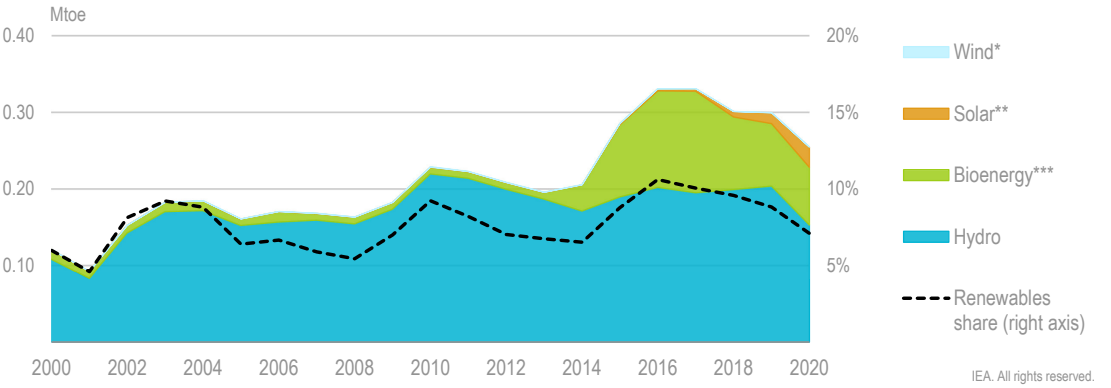
Renewable energy supply and consumption

Renewables in total energy supply

The share of RES in TES has averaged about 9% over the past decade. By far the largest share has been hydroelectricity, followed by biomass, which is mainly wood used for both cooking and heating in rural regions.

Although official figures show a large increase in biomass consumption from 2014, this apparent growth is most likely due to recent improvements in statistical reporting. Actual consumption of biomass probably has been declining over the past two decades, in response to significant expansion of the gas network, which now reaches over 95% of the country's communities.

Figure 8.2 Renewable energy in Armenia's total energy supply, 2000-2020



The annual share of renewables depends significantly on hydrological conditions.

* not visible at this scale

** includes solar PV and directly used solar heat

*** includes solid biofuels. More detailed data is available from 2014; prior to that solid biofuel consumption is likely underestimated.

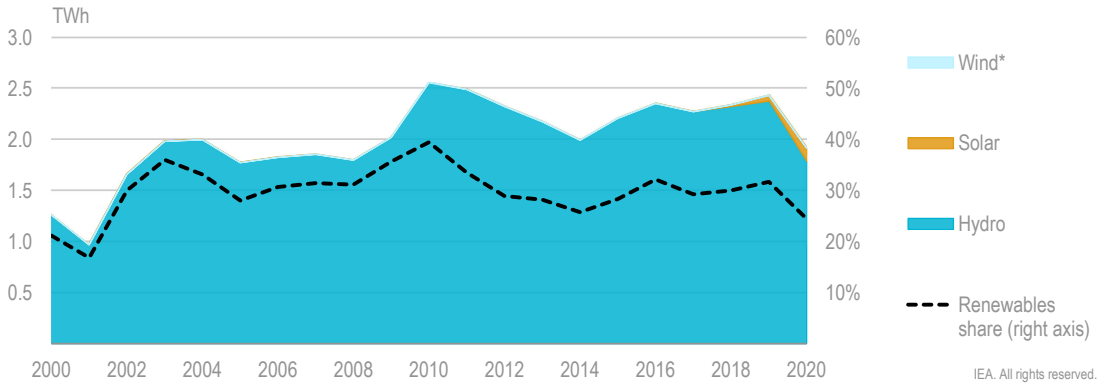
Source: IEA (2022), *World Energy Statistics and Balances* (database), https://www.iea.org/data-and-statistics.

Renewable electricity generation

Renewable energy generating capacity represented 46.7% of Armenia's total available capacity of 2.9 GW in 2020. Most of this (33.5% of total capacity) was accounted for by the country's two sets of large hydropower plants, the Vorotan and Sevan-Hrazdan Cascades, both of which were built during the Soviet era. Most of the remaining grid-connected RES consisted of 188 small (under 30-kW) hydropower plants, most built during the past 15 years, comprising 13.2% of total available capacity. In addition, there was 49.5 MW (1.7%) of grid-connected solar PV capacity, composed of 2 669 PV plants with individual capacities up to 500 kW, as well as four wind plants with a total capacity of 4.2 MW, and one biogas plant based on poultry manure with a generating capacity of 0.8 MW.

The share of RES in electricity generation averaged around 30% during the 2010s, depending primarily on hydrological conditions during a given year. The share of RES in electricity generation also depends in part on the amount of electricity exported under a gas-for-electricity swap arrangement with Iran. Since the additional electricity generated for export is based on gas, increased exports can lead to a reduced share of renewables in Armenia's power mix in practice.

Figure 8.3 Renewable energy in Armenia's electricity generation, 2000-2020



Renewable electricity generation is expected to increase, mostly driven by wind and solar capacity additions.

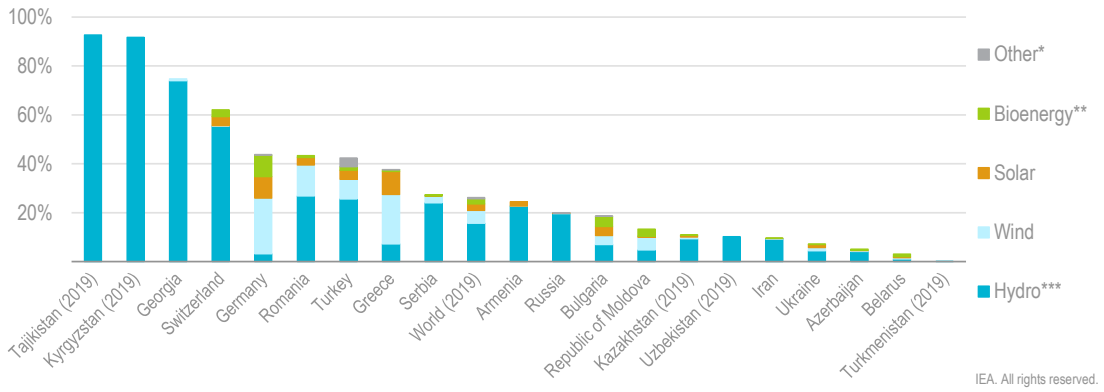
* Not visible on this scale

Note: TWh = terawatt-hour.

Source: IEA (2022), *World Energy Statistics and Balances* (database), https://www.iea.org/data-and-statistics.

The share of RES in Armenia's electricity generation is around the world average. Regionally, it is less than one-third the share in neighbouring Georgia, though more than double that in Iran.

Figure 8.4 Renewable energy share in electricity generation in selected countries, 2020



Armenia's share of renewables in TES is near the world average.

* includes geothermal, primary heat and wave and ocean energy

** includes solid, liquid and gaseous biofuels and renewable waste

*** excludes pumped storage

Source: IEA (2022), *World Energy Statistics and Balances* (database), https://www.iea.org/data-and-statistics.

The 2021 Energy Strategy places increased emphasis on solar PV, the capacity for which is expected to reach 1 000 MW and account for "at least" 15% of total generation by 2030 (GoA, 2021a). This includes plans for about 520 MW of additional utility-scale (above-30 MW) solar PV plants, of which at least two are expected to have individual capacities of 200 MW.

Plans for additional hydropower plants of any size are comparatively modest, limited primarily to 23 SHPPs (50 MW in total) for which licenses already have been issued. New siting restrictions are expected to make issuing new licenses more difficult for SHPPs, while the major prospective sites for large hydropower plants have not been included in the government's most recent development plans.

The government does not expect significant wind power generating capacity to be built in the near future, mainly due to assumptions about high transport and construction costs for the remote, high-altitude locations that are considered the most feasible.

Institutional framework

The following are the main government institutions involved in renewable energy development and policy in Armenia:

The **Ministry of Territorial Administration and Infrastructure (MTAI)** develops and implements policy and strategic programmes in the energy sector.

The **Public Services Regulatory Commission (PSRC)** is the independent regulator in the energy sector (and other network industries), which issues licences and sets tariffs, including for RES.

The **Renewable Resources and Energy Efficiency (R2E2) Fund** was launched by the government in 2005 to help create a favourable environment for investments in renewables

and energy efficiency. It provides funding and co-financing for projects, often working with international donors and local commercial banks.

The state-owned **High Voltage Electric Networks of Armenia (HVEN)** maintains the country's transmission system. Only renewable generators above 30 MW are allowed to connect to the transmission system, while the rest are allowed to connect to the distribution grid, which is operated by the privatised **Electric Networks of Armenia (ENA)**.

The **Ministry of the Environment** is responsible for issuing water-use permits for hydropower projects, as well as approving environmental impact assessments for renewable energy projects above certain thresholds.

Policies and measures

Maximum use of the country's renewable energy potential is one of the key priorities of Armenia's 2021 Energy Strategy. The aim is to "minimise reliance on other imported energy sources and to strengthen Armenia's energy security and competitiveness", as well as to help ensure the lowest-cost generation (GoA, 2021a). The Strategy notes that solar is expected to prevail over other types of RES, not only due to favourable sunlight conditions in the country but also to recent downward cost trends for PV technologies. Secure system integration of variable solar PV is helped by the availability of flexible hydropower.

The current emphasis on renewable energy is not new. The government adopted a Law on Energy Savings and Renewable Energy in 2004 and established the Renewable Resources and Energy Efficiency (R2E2) Fund in 2005. The government produced a National Programme on Energy Savings and Renewable Energy in 2007, elaborated a Renewable Energy Roadmap in 2011 and updated this with a Renewable Energy Investment Plan under the Scaling-up Renewable Energy Program (SREP) in 2014. The Investment Plan included a comprehensive analysis of RES potential and set targets for renewable energy use by 2025.[29] It also highlighted several large-scale solar PV and geothermal projects that the government intended to pursue as demonstration projects.

RES played an important role in the scenarios in the 2019 Armenia Least-Cost Energy Development Plan 2020-2030, which in turn informed the 2021 Energy Strategy. Building on the Energy Strategy, the government is currently developing a National Programme on Energy Saving and Renewable Energy for 2021-2030, which will define new targets.

From the early 2000s until the mid-2010s, the emphasis was on promoting SHPPs, while high investment costs were considered major barriers for the development of most other RES. Falling equipment costs have helped shift the emphasis to solar PV in recent years, while ecological concerns have led to de-emphasising further SHPP development.

FiTs have been a major driver in RES development in Armenia. Based on amendments to the Energy Law, the PSRC set FiTs in 2007 for SHPPs and wind plants with individual capacities up to 30 MW. Such tariffs were set for 15 years in the case of SHPPs and 20 years for other RES, i.e. to 2022 and 2027, adjusted annually in line with changes in

[29] Targets set in 2013 included a 26% share of total energy consumption from renewables by 2025. By that time, 397 MW of small hydro capacity was expected, along with 100 MW each for wind and geothermal, and 80 MW for solar PV.

inflation and the USD/AMD exchange rate. In 2016 the PSRC extended FiTs to small-scale solar PV plants up to 1 MW, and in 2019 raised the threshold for such plants to 5 MW.

Power producers benefiting from FiTs, i.e. those below relevant capacity thresholds, are not subject to licensing. Renewable plants above the thresholds for FiTs are subject to licensing and are expected to go through the same tariff-setting procedures with the PSRC as other power plants. In practice, the development of utility-scale RES power plants has been limited to projects based on competitive tenders that result in long-term power-purchase agreements (PPAs). The main bidding element is the tariff, which is guaranteed for a set period (e.g. 20 years in the case of Masrik-1) and enshrined in a public-private partnership with MTAI and a power-purchase agreement with ENA. Tariffs under public-private partnership agreements are adjusted annually for changes in inflation and the exchange rate.[30] Public-private partnerships and related PPAs are only available through competitive tenders.

The first competitive tender was held for the 55-MW Masrik-1, which was one of six solar PV projects identified in the 2014 Renewable Energy Investment Plan. The R2E2 Fund conducted the tender during 2017-2018, and as of mid-2021 the plant was under construction. The winning bid for the Masrik-1 Project proposed a tariff considerably lower than that expected from the project's original financial model (USAID 2020). A tender for a second solar PV plant, the 200-MW AYG-1, was completed in 2021, with a proposed tariff that was even lower. Tenders for several additional solar PV plants are planned.

No tenders for wind power plants or additional hydropower plants have taken place or are currently planned. Potential investors so far have shown little interest in the country's geothermal resources, following the disappointing results of an exploratory drilling project financed by the World Bank (see below).

In addition to FiTs and tender-based, long-term power-purchase guarantees, support mechanisms for RES electricity developers include assistance in obtaining land use permits, non-discriminatory access and connection conditions, investment aids and loans, and tax and duty exemptions for imported equipment.

In 2015, net metering was introduced for autonomous power producers, i.e. those producing electricity primarily for their own consumption. Originally the capacity threshold for such producers was 150 kW, though this was increased to 500 kW in 2017. Under such a scheme, the autonomous power producer is able to "store" the excess power it produces on the grid and consume an equivalent amount later. At the end of the year, the autonomous power producer pays, or is reimbursed by, ENA for the difference between its production and consumption at regulated prices set by the PSRC. In addition, those with capacities up to 150 kW are not taxed on any income from surpluses. The cost of becoming a net-metering customer is the cost of installing a reverse-flow metre, currently less than USD 100.

New rules will allow "virtual" net metering, meaning that an auto-producing customer will not have to locate its RES at the same point on the network at which it consumes power. This will allow it to site RES in more technically favourable locations and pay the network only the regulated transmission or distribution fee. However, such customers will need to

[30] For those with licences issued after 1 November 2018, changes to the USD/AMD exchange rate are applied to 90% of the tariff and changes to Armenia's consumer price index are applied to the remaining 10%. Prior to this date, the split was 65% /35%.

provide the Market Operator advance schedules (with hourly granularity) of their consumption and generation at the relevant metering points.

The new rules will also enable group net metering, by which groups of consumers located at different points in the network will be able to share a particular autonomous power producer. These changes will help Armenia align more closely with EU electricity directives and international best practices.

The new electricity market model, scheduled for launch in 2022, envisages RES power plants to primarily sell to the Universal Supplier (currently ENA) in the long-term-contract component of the bilateral contracts market at regulated prices. Sales to the non-regulated component of the bilateral contracts market will be open to auto producers and to RES with expired power-purchase guarantees (USAID, 2020).

Hydro

Armenia's two large hydropower cascades account for 965.6 MW or around one-third of the country's total available generating capacity of 2.9 GW. SHPPs accounted for an additional 380 MW or 13.2% of total capacity. As of July 2020, there were 188 small (under 30-kW) SHPPs, up from about 150 (260 MW) in 2014 and around 40 in 2007.

The significant growth in SHPPs has been due in large part to favourable investment incentives, including FiTs set in 2007 for 15 years.

As the number of SHPPs has grown, so has opposition to them, including claims of damage to nature, loss of biodiversity and the loading of rivers with diversion pipes. In April 2021 the government adopted resolution 488-N, "On defining the list of rivers prohibited for the construction of small hydroelectric power plants". This calls for applications for water-use permits to be rejected for areas determined to be spawning sites for Red-Listed fish species and rivers where the load through diversion pipes is 40% or more (ecolur.org). In June 2021, the Environment Ministry further proposed lowering the allowed SHPP capacity threshold to 10 MW from the current 30 MW, meaning that new applications for water-use permits for SHPPs above 10 MW would need to include environmental impact assessments and would not benefit from FiTs.

The main prospective projects for additional large-scale hydropower that have been considered for many years include the proposed Meghri Plant on the Araks River (est. 100-130 MW), the Shnogh Plant on the Debed River (est. 76-102 MW), and the Lori-Berd Plant on the Dzoraget River (est. 60-66 MW). However, no large hydropower projects were included in the 2019 Least-Cost Capacity Development scenarios or appeared as investment priorities in the 2021 Energy Strategy. Nevertheless, the latter document notes that these "remain relevant projects" to be realised "when the construction of such power plants will be needed" (GoA, 2021a).

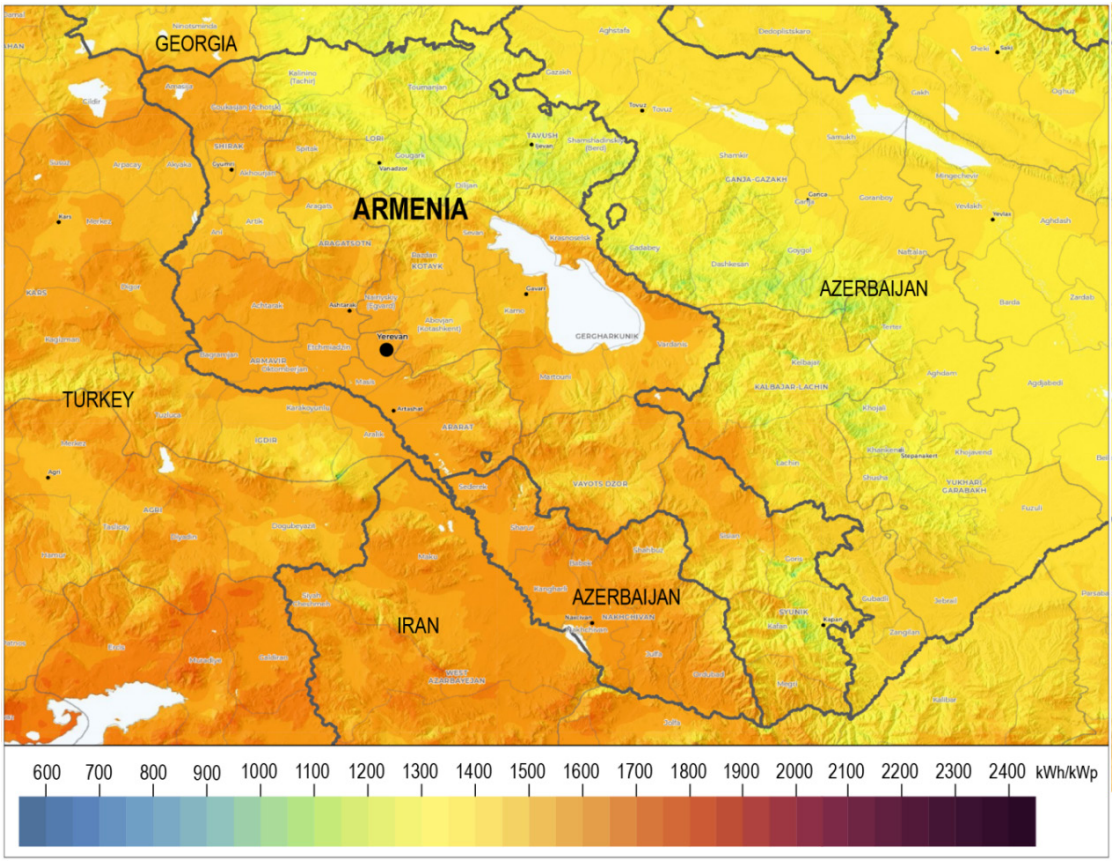
Armenia currently contains three small pumped-storage units, which transport water to reservoirs at higher elevations using electric pumps during off-peak hours, allowing stored water to be released through turbines during peak periods. Pumped storage is useful in helping electrical systems adjust quickly to network fluctuations in response to rapid increases or decreases in production by intermittent RES, e.g. due to changes in sunlight or wind conditions. The need for such rapid reaction is likely to become more important as Armenia's share of VRE increases. Several studies since the 1980s have identified

opportunities for further pumped-storage capacity, including one completed in 2008 that identified 11 sites, of which three were regarded as particularly promising.

Solar PV

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 (World Bank ESMAP 2020). Some two-thirds of this is 4.0- 4.4 kWh/kWp (or 1 460-1 600 kW full load hours per year), which is similar to Spain.

Figure 8.5 Solar energy potential in Armenia



This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

Source: World Bank (2020a), Global Solar Atlas: Armenia, https://globalsolaratlas.info/download/armenia. This map, adapted by the IEA, was obtained from the "Global Solar Atlas 2.0", a free, web-based application, developed and operated by the company Solargis s.r.o. on behalf of the World Bank Group, utilising Solargis data, with funding provided by the Energy Sector Management Assistance Program (ESMAP). For additional information: https://globalsolaratlas.info. The Works are licensed under the Creative Commons 4.0 Attribution International license, CC BY 4.0.

As of mid-2020, Armenia had 49.5 MW of grid-connected solar PV capacity, representing about 1.7% of total available capacity. This consisted of 2 669 PV plants with individual capacities up to 500 kW. In addition, there was an estimated 100 MW of unmetered, non-grid-connected solar PV capacity.

The 2021 Energy Strategy aims for 1 000 MW of solar PV capacity by 2030 and expects this technology to dominate other types of RES, due to in large part to favourable worldwide cost trends (GoA, 2021a).

The 2014 Renewable Energy Investment Plan under the SREP identified several large-scale solar PV projects, which the government planned to pursue as demonstration projects. A tender was held for the first of these, Masrik-1, in 2017, attracting some 70 international bidders in a two-stage process. The winner, a consortium led by Fotowatio Renewable Ventures, part of Abdul Latif Jameel Energy, won the tender to produce the 55-MW power plant by proposing the lowest tariff: 4.19 US cents per kWh. This tariff was subsequently formalised in a 20-year PPA with ENA, as well as in a public-private partnership signed with MTAI in 2018 that included other supports, such as offtake and payment guarantees. The winner is also receiving financing assistance from the International Finance Corporation (IFC), European Bank for Reconstruction and Development (EBRD) and the EU (up to USD 38.4 million). The Masrik-1 Project is currently under construction and is expected to be completed in 2024.

The winning tariff for Masrik-1 turned out to be significantly lower than that suggested by the original financial model, which reportedly was 6.39 US cents, excluding VAT. The lower-than-expected proposed tariff has been attributed to a number of factors, including falling costs for solar panels that were not fully updated in the model, stronger than expected competition among bidders and stronger than expected competition among lenders, including international financial institutions (USAID, 2020).

A tender for a second solar PV plant, the 200-MW AYG-1 Project, was completed in 2021, with an even lower winning bid of 2.9 US cents per kWh by Abu Dhabi Future Energy Company PJSC-Masdar. That plant is expected to be in operation sometime in 2025 (ecolur.org).

Tenders for several additional solar PV plants are planned, including for the 200-MW AYG-2 Project. Solar PV is expected to benefit significantly from the new rules related to virtual net metering and group metering mentioned above.

Solar thermal

In 2020, the estimated utilisation of solar thermal was 167 GWh. There is no systematic support for solar water heaters, though installation of these often takes place under ad hoc government or donor programmes that offer grants, soft loans and tax and import-duty exemptions, with a particular focus on communities that do not have access to gas. For example, between August 2017 and November 2018, commercial banks provided soft loans with funds from the KfW Development Bank for an energy efficiency credit programme that helped install 1 364 solar water heaters. Similarly, drawing on UNDP funding, the R2E2 Fund and National SDG Innovation Lab installed a number of solar thermal systems in communities which do not have gas pipeline connections. In both cases, solar PV systems were provided along with solar thermal units.

Wind

Armenia currently has a small number of windpower plants with a total capacity of 4.2 MW.

According to the Armenian Wind Atlas, developed in 2003 by the US National Renewable Energy Laboratory (NREL), Armenia could potentially support up to 5 000 MW of installed

capacity. Potential sites include the Karakhach, Pushkin and Jajur passes in the Bazum Mountain Range, the Sevan pass in the Areguni Range, and the Sisian Pass in the Zangezur Range (NREL, 2003).

Many of these potential sites have been studied further by Armenia's SRIE, which has noted that the most favourable locations for grid-connected wind power are generally limited to remote mountain passes at altitudes above 2 000 m. The isolated nature of the most prospective locations is expected to lead to high transport and construction costs vis-à-vis other RES options, while diminished air density at high altitudes could be a problem for plant efficiencies.

The 2021 Energy Strategy calls for the development of up to 500 MW of windpower capacity through 2040, though it notes that the use of public-private partnerships for such projects, including guaranteed offtake under PPAs, would need to be based exclusively on competitive tariffs, i.e. determined by auctions (GoA, 2021a).

Geothermal

Geothermal exploration work financed by the GEF in the mid-2010s indicated potential resources at Karkar in the southern province of Syunik, while a potentially smaller site was identified at Grizdor in Gegharkunik province. Based on the results from two narrow exploratory wells drilled with IBRD financing, it was determined that the geothermal reserves at Karkar at 130-135 degrees Celsius were too low to support a flash power plant, though possibly could supply a binary technology plant. The R2E2 Fund subsequently contacted a number of specialised drilling companies, but all reportedly felt the project too risky and the scale too small. The Ministry of Energy Infrastructures and Natural Resources (forerunner to MTAI) also contacted some 50 international geothermal developers. Due to apparent lack of investor interest, the Ministry decided to close the project in 2018, and the 2021 Energy Strategy does not list the development of geothermal energy as a priority.

Bioenergy

According to a report for the World Bank (PROFOR 2020), fuelwood production in Armenia in 2016 was about 848 000 m^3, or around 0.29 m^3 per person, though actual harvesting may be an order of magnitude larger. Almost all demand is met through the informal sector. Only a minority of rural households reportedly collects its own wood.

Whereas in 2004 only 31% of households had access to gas, now almost every community (95%) in the country is connected to the national gas pipeline network. However, a significant number of rural residents reportedly are not always able to afford gas, and when price increase, such households reportedly revert to using fuelwood (PROFOR 2020).

Assessment

While large and small HPPs are currently the main sources of renewable energy in Armenia, solar is expected to account for much of the increase in renewables by 2040. An initial emphasis on SHPPs has given way to increasing concerns about environmental impacts, while solar PV is likely to benefit from declining equipment costs worldwide. In general, RES benefit from a number of favourable government policies, including FiTs and net metering regulation.

The Armenian government expects solar PV capacity to reach 100 MW by 2024 and 1 000 MW by 2030, at which point it is expected to account for at least 15% of total generation. Some increase in wind is also planned. Experience elsewhere has shown that large increases in VRE should be accompanied by measures to ensure their technical and economic integration so that the power system and market are able to efficiently respond to rapid increases and decreases in production. System integration in Armenia is facilitated by the large presence (and potential) of hydropower, which can provide flexible power that quickly responds to solar and wind output variations. However, a balanced portfolio of renewables and a good geographical distribution will also be key for securing cost-effective system integration. Market measures could include taking full advantage of smart metering to institute differentiated tariff levels that recognise the different locational, time and technological value of decentralised renewable power installations. Reinforcements to networks and training of network personnel will also be important.

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 must be imported, as well as the country’s Soviet-era nuclear power plant. There are several potential large hydropower sites in the country that have been studied for several decades. Such plants might not only help reduce dependence on imported gas and nuclear energy but also help integrate the expected large increase in VRE into the system.

Pumped storage has also 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 current pumped-storage capacity is small, but several studies indicate possible significant potential for developing such capacity.

Residential heating is now dominated by small, individual gas boilers. Given the large share of gas consumption currently represented by domestic heating and the lack of information about equipment employed, including possibilities for improving its efficiency, the government may wish to undertake a strategic review of options in this important sector. Such a review should include opportunities to promote the use of RES, either directly or indirectly, including through solar PV and heat pumps.

Armenia is currently promoting the uptake of electric vehicles, particularly through the suspension of VAT for imports. Electric transport can only truly be “clean”, however, if based on electricity from renewable or other low-carbon resources. Given that some 70% of road transport in Armenia currently runs on natural gas, i.e. is already relatively less polluting than transport based on gasoline and diesel, the government should ensure that the electrification of transport is integrated with measures that promote the use of renewable electricity.

Recommendations

The government of Armenia should:

- Building upon its 2021 Energy Strategy, target an enlarged and diversified portfolio of energy technologies, including accelerating deployment of cost-effective solar and considering the further development of large HPP projects that could allow Armenia to take advantage of its significant hydro potential to increase energy security.
- In connection with ambitious plans for the introduction of solar and wind energy, develop and implement mechanisms for technical and economic integration of VRE sources, in order to ensure the power system's secure and cost-effective operation.
- Continue to study the potential of RES for heat supply, including the use of solid waste, biomass, geothermal energy and heat pumps.
- Integrate the planning for electric mobility, including subsidies or tax breaks for electric vehicles and the development of EV charging infrastructure, to the use or expansion of renewable electricity production.

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9. Energy research, development and innovation

Key data

Global Innovation Index ranking: 61 out of 131 (2020)

Annual government spending on research: EUR 25.4 million, or 2% of GDP (2018)

Overview

Armenian researchers in the energy sector, as in other sectors, face a number of challenges, including low levels of state funding, lack of structures for cooperation between research institutes, universities and industry, and requirements for university professors to teach a large number of hours in order to receive a full salary. Despite the challenges, Armenia ranked 61st out of 131 countries in the 2020 Global Innovation Index, above Georgia (63), Belarus (65) and Azerbaijan (82).

The EU's Horizon Europe Policy Support programme undertook a review of Armenia's research sector in 2019. The main findings included a need to increase overall funding while focusing on a smaller number of subjects, based on relevance for the country's social and economic development, among other criteria. While various government policy documents suggest that energy is a priority area for the country's development, tangible support for energy research has yet to materialise.

Institutional basis

The **Ministry of Education, Science, Culture and Sport (MESCS)** is the primary organisation responsible for policy-making related to both higher education and research.

The **Science Committee** is the state's research funding agency and is responsible for the development and implementation of research policy. The Science Committee is part of the MESCS system and manages and distributes the research budget which it receives from the Ministry.

The main bodies engaged in energy-related research include the following:

The **Scientific Research Institute of Energy (SRIE)** was founded in 1948 and is currently under the Ministry of Territorial Administration and Infrastructure (MTAI). The SRIE's main activities include gathering and analysis of statistics on demand for electrical and thermal energy; forecasting demand; developing technical and economic measures for tariff

stabilisation; calculating losses and developing methods to reduce them; assessing energy-saving measures; developing efficiency measures; researching alternative energy; designing engineering networks and systems; and promoting harmonisation with international standards. The SRIE played an active role in developing the 2021 Energy Strategy and energy efficiency regulations under the EAEU and is currently helping produce the new National Programme for Energy Efficiency.

The **Armenian Scientific Research Institute for Nuclear Power Plant Operation CJSC ("Armatom")** provides scientific and technical support for the ANPP. Founded in 1973, it develops and implements measures to enhance security, trains personnel, and develops technical documentation for the plant. Armatom has several international partners, including Russian, American and European.

The **Institute of Energy and Electrical Engineering** is part of the National Polytechnic University of Armenia, the main higher education institution for training specialist in the energy sector. The Institute has several centres of competence, including the "Regional nuclear safety training centre", which was founded with the support of the US Department of Energy.

According to the 2021 Energy Strategy, the government plans to continue supporting these and other scientific institutions but is considering consolidation to reduce overheads. In particular, it has proposed establishing a unified institution for work on projects dealing with climate change, energy and energy efficiency (GoA, 2021a).

Funding

In 2019, around 80 bodies received state funding via the Science Committee in different scientific areas. Half of the recipients were research institutes under the structure of the National Academy of Sciences, while most of the rest were research institutes under the MESCS or other line ministries, or were universities.

Gross state expenditure on all research has been maintained at about 0.2% of GDP over the past decade. In comparison, for example, the research shares for Ukraine and Lithuania are around 0.5% and 0.9%, respectively (EU, 2020). Although the amount of spending on R&D in Armenia has been rising in absolute terms, its real value has declined due to inflation.

The government budgeted AMD 14.3 billion (about USD 29 million) annually for research during the period 2019-2021 (Hovhannisyan, 2019). According to the EU's Horizon Europe programme (formerly Horizon 2020), the amount of research funding provided by the Armenian government is "critically low" relative to the size of the country, while the number of bodies receiving funding is relatively large. The Horizon Europe peer-review team's key recommendations include increasing overall spending on research while consolidating the number of recipients. It also advises further prioritising the number of subject areas supported, based on a review that would help determine the areas in which Armenian scientists have the most capacity to be competitive internationally and those that are most relevant to the country's economic and social development (EU, 2020).

According to various policy documents, the government generally has considered energy to be a key sector for the country's economic and social development, as well as an important research subject. For example, the government's five-year plan for 2015-2019

listed "secure and efficient energy" as one of six priority areas for scientific research (GoA, 2019). More recently, however, energy did not appear among the "leading areas" to receive increased funding in the government's five-year plan for 2021-2026 (GoA, 2021b).[31]

Box 9.1 Main messages of the EU's policy support team for Armenia

- Unless Government R&D funding as a share of GDP is increased, the Armenian Science system's capacity to retain qualified young researchers and produce high-quality research and innovations will decline even further.
- The higher education and research institute landscape is too fragmented. However, an overly-rapid restructuring should be avoided. In particular, a rapid merger of research institutes into universities risks weakening performance given the current lack of strategic agendas and limited R&D management capacities in higher education institutions (HEIs).
- In evaluating research institutes and allocating future funding, a balance should be struck between research that has an international impact and research that is locally relevant and contributes to national social and economic development objectives.

Source: EU (2020).

There are no official statistics on the amounts spent on research pertaining to energy. As is the case for most other research bodies in Armenia, however, most of the funding to those organisations focusing on energy is intended to pay salaries and basic administrative costs. Overall, approximately 73% of the funding distributed through the Science Committee in 2018 was for basic institutional funding, while only 27% was for work on specific research projects. Most of the latter funding was based on requests for proposals by individual researchers or groups and evaluated on a competitive basis by a board or group of experts (EU, 2020).

The average value of a competitive research grant distributed by the Science Committee is currently around USD 34 000 over two years, an amount that the Horizon Europe team feels is "[not] ideal for the medium-term development of research teams under a principal researcher" (EU, 2020). Several interviewees from research institutes told the IEA review team that the sizes of the grants in the energy sector are typically even smaller than this. As one put it, the size of the grants "often makes them more suitable for topping up a university professor's salary" than for funding a team of researchers.

In practice, only about 12% of the state research budget went to universities in 2018. Similar to the case in a number of other former Soviet countries, Armenia inherited a system under which universities have focused primarily on teaching rather than research. In addition to the lack of funding and equipment, an important obstacle for full-time university staff wishing to engage in research reportedly is the requirement to teach a number of hours per semester that leaves little time for research in practice compared to their counterparts in many European countries (EU, 2020).

[31] Priorities listed in the five-year plan for 2021-2026 were: data science, artificial intelligence, quantum technology, intelligent agriculture, biotechnology, materials science, chemistry, physics and mathematics.

The Horizon Europe team also noted that there are currently few incentives for cooperation among universities and research institutes, e.g. for institute-based researchers to teach at universities or for professors to conduct projects at or with research institutes. The team recommended introducing incentives for closer cooperation between the two types of institutions, including for example, the possibility for researchers to hold dual status within both a university and institute, as is common in some European countries such as France. While cooperation could include the integration of some research institutes into universities, the team cautioned against "forced" mergers, noting that the current capacity of most Armenian universities to host research institutes appeared to be weak (EU, 2020).

The Horizon Europe team also noted that low salaries relative to those offered in the private sector and abroad were a major disincentive to continue or begin a research career in Armenia, whether in an institute or university (EU, 2020). The IEA review team heard from a number of interviewees that there was a significant gap between the salaries of senior research staff in Armenian institutes dealing with energy and those of junior staff, causing many of the latter to be lured away to the private sector or abroad after only a short period.

There are no official statistics on R&D in the business sector, though there is nothing to suggest it is significant. According to the Horizon Europe review team, there seems to be little cooperation between research institutes or universities and the business sector, and no innovation support mechanism for the private sector (EU, 2020).

International collaboration

In 2018, the MESCS requested support from the European Commission's Horizon Europe (formerly Horizon 2020) programme to help reform and strengthen the performance of Armenia's research sector. Horizon Europe subsequently conducted a peer review that resulted in 19 recommendations. The government appears to have recognised many of these in the goals it outlined in the Science chapter of its overall five-year plan for 2021-2026, including for example the need to increase the efficiency of public funding for science, attract young staff, bring together small scientific organisations conducting research in related fields into larger scientific centres, introduce support mechanisms for innovation, and increase the research component in higher education (GoA, 2021b).

Since Armenia is an Associate member of the EU's Horizon Europe programme, Armenian researchers are entitled to participate in competitive calls for proposal. As of the end of 2019, Armenian research teams had secured over EUR 2.5 million in Horizon Europe funding (EU, 2020).

Much of the funding for projects at energy-related institutes reportedly comes from donor sources, either directly or indirectly. For example, donor projects often engage international companies as primary contractors, and the latter typically engage Armenian institutions as partners and sub-contractors. Donor funding for researchers in the energy sector has been primarily for technical and economic analysis, scenario development and policy-making.

Assessment

Two of the main findings of the Horizon Europe peer-review team were that Armenia is spending a relatively small amount on scientific research for a country its size while spreading its limited funding across an unsustainable number of institutions and subjects. In addition to increasing spending on scientific research generally, the Horizon Europe team recommended consolidating the country's large number of research bodies and focusing funding on areas in which Armenia could be competitive internationally and/or are particularly important for its social and economic development.

Based on various government policy documents, energy would appear to be an important priority area for receipt of government research funds. However, this prioritisation still needs to be translated into programmes and instruments supporting energy research, development and innovation in the country. There is so far no specific strategy to guide research, development and innovation pertaining to the energy sector.

Given the lack of state funding, the main institutions involved in energy-related research, development and innovation in Armenia are primarily self-financed, with most funding coming from project-based contracts with international organisations. Such funding is helpful for supporting and building local expertise, including attracting young researchers to the field. However, donor support, if significantly greater than the government's own funding contribution, risks research that focuses on donor priorities, which can differ from the government's priorities. Ideally, donor support should supplement a reliable baseload of government funding for research.

The Horizon Europe review team noted a general lack of interface between universities, research institutes and industry, as well as a lack of government support mechanisms for innovation in industry. Interviews conducted by the IEA review team suggest that these are also problems in the energy sector. Regular consultation and involvement of industry in determining research priorities will be important for ensuring that funding is targeted to the most important energy-related challenges faced by the country.

Recommendations

The government of Armenia should:

- Formulate an energy research, development and innovation (RDI) Strategy, including the setting of clear priorities within thematic areas and applied research, to ensure that priorities are linked with those of the national energy strategy adopted in January 2021.
- Building on such a strategy, introduce an energy-specific RDI support scheme with a dedicated budget per specific research area.
- Strengthen the links and cooperation between policy-makers, scientific research institutions and industry, e.g. through establishing working groups and conducting regular roundtables to address the concrete challenges in the energy sector requiring scientific research and innovation.
- Provide incentives for young professionals and researchers to pursue careers in energy RDI within Armenia, including in collaboration with international partners.

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ANNEX A: Organisations visited

Review criteria

The Shared Goals, which were adopted by the IEA Ministers at their 4 June 1993 meeting in Paris, provide the evaluation criteria for the in-depth reviews (IDRs) conducted by the IEA. The Shared Goals are presented in Annex C.

Review team and preparation of the report

The IEA in-depth review team held online meetings with Armenian stakeholders from 26 April to 5 May, 2021. The team met with government officials, energy suppliers, interest groups and other stakeholders.

This report was drafted on the basis of these meetings, the team's preliminary assessment of the country's energy policy, the government response to the IEA energy policy questionnaire, and other information.

The members of the team were:

IEA member countries

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EU4Energy countries

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IEA for EU4Energy programme

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- Armin MAYER, Consultant, Energy Efficiency Expert
- Anna PETRUS, Programme Officer
- Vahan SARGSYAN, Country Expert for Armenia
- Philip SWANSON, Consultant, Key author of the IDR report
- Olga TERENTEVA, Country Expert for Kyrgyzstan
- Furugzod USMONOV, Country Expert for Tajikistan

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Philip Swanson drafted most of the report and Armin Mayer drafted chapter 7. Markus Fager-Pintilä prepared the graphs and drafted the sections related to statistics and energy data. Anna Petrus organised and coordinated the review process.

The review team also would like to thank Rebecca Gaghen, Head of the Europe, Middle East, Africa and Latin America Division for investing her time in reading the report and providing comments. Helpful comments and updates were provided by the review team members and IEA staff, including: Toril Bosoni, Paolo Frankl, Kevin Lane, Stefan Lorenczik, Sara Moarif, Gergely Molnar, Aleksandra Paciorek, and Kristine Petrosyan. Therese Walsh managed the editing process and Elspeth Thomson edited the report. Astrid Dumond managed the production process, Clara Vallois finalised the layout, and Tanya Dyhin prepared the maps and images.

Organisations visited

Asian Development Bank (ADB)

Armatom (Armenian Scientific Research Institute for Nuclear Plant Operation)

Armenian Energy Agency

Countur Global Hydro Cascade

Ecoteam

Electric Networks of Armenia

Electric Power System Operator

Foundation to Save Energy

Gazprom Armenia

High Voltage Electric Networks

International Energy Corporation

Karine Danielyan

Kreditanstalt Für Wiederaufbau (KfW)

Ministry of Economy

Ministry of Environment

Ministry of Territorial Administration and Infrastructure

National Polytechnic University of Armenia

Nuclear and Radiation Safety Centre

Nuclear Safety Regulatory Committee (ANRA)

Public Services Regulatory Commission (PSRC)

Renewable Resources and Energy Efficiency Fund (R2E2)

Scientific Research Institute of Energy

Settlement Centre

Standing Committee on Territorial Administration, Local Self-Government, Agriculture and Environment of the National Assembly of the Republic of Armenia

Statistical Committee of the Republic of Armenia

United Nations Development Programme (UNDP)

UNDP team of GHG emissions register developers

United States Agency for International Development (USAID)

World Bank

ANNEX B: Energy balances and key statistical data

Unit: Mtoe

SUPPLY		1990	2000	2010	2017	2018	2019	2020
TOTAL PRODUCTION		**0.15**	**0.64**	**0.88**	**1.11**	**0.89**	**0.93**	**0.96**
Coal		-	-	-	0.00	0.00	0.00	0.00
Peat		-	-	-	-	-	-	-
Oil		-	-	-	-	-	-	-
Natural gas		-	-	-	-	-	-	-
Biofuels[1]		0.01	0.01	0.01	0.12	0.08	0.07	0.06
Nuclear		-	0.52	0.65	0.78	0.60	0.64	0.72
Hydro		0.13	0.11	0.22	0.20	0.20	0.20	0.15
Wind		-	-	0.00	0.00	0.00	0.00	0.00
Geothermal		-	-	-	-	-	-	-
Solar		-	-	-	0.00	0.01	0.01	0.03
TOTAL NET IMPORTS[2]		**7.56**	**1.37**	**1.69**	**2.22**	**2.25**	**2.48**	**2.67**
Coal	Exports	-	-	-	-	-	-	-
	Imports	0.24	-	0.00	0.00	0.00	0.00	0.01
	Net imports	0.24	-	0.00	0.00	0.00	0.00	0.01
Oil	Exports	-	-	0.00	0.00	0.00	0.00	0.00
	Imports	3.84	0.35	0.43	0.39	0.40	0.50	0.63
	Int'l marine and aviation bunkers	-0.20	-0.06	-0.04	-0.06	-0.07	-0.07	-0.04
	Net imports	3.64	0.29	0.38	0.34	0.33	0.43	0.59
Natural gas	Exports	-	-	-	-	-	-	-
	Imports	3.59	1.12	1.37	1.97	2.03	2.12	2.15
	Net imports	3.59	1.12	1.37	1.97	2.03	2.12	2.15
Electricity	Exports	0.07	0.07	0.09	0.12	0.14	0.11	0.11
	Imports	0.15	0.03	0.02	0.03	0.02	0.03	0.03
	Net imports	0.08	-0.04	-0.07	-0.10	-0.12	-0.08	-0.09
TOTAL STOCK CHANGES		**-**	**-**	**-0.08**	**-0.03**	**0.00**	**-0.01**	**-0.04**
TOTAL SUPPLY (TES)[3]		**7.71**	**2.01**	**2.48**	**3.29**	**3.15**	**3.40**	**3.59**
Coal		0.24	-	0.00	0.00	0.00	0.00	0.01
Peat		-	-	-	-	-	-	-
Oil		3.64	0.29	0.38	0.32	0.32	0.40	0.56
Natural gas		3.59	1.12	1.29	1.95	2.04	2.14	2.14
Biofuels[1]		0.01	0.01	0.01	0.13	0.09	0.08	0.08
Nuclear		-	0.52	0.65	0.78	0.60	0.64	0.72
Hydro		0.13	0.11	0.22	0.20	0.20	0.20	0.15
Wind		-	-	0.00	0.00	0.00	0.00	0.00
Geothermal		-	-	-	-	-	-	-
Solar		-	-	-	0.00	0.01	0.01	0.03
Electricity trade[4]		0.08	-0.04	-0.07	-0.10	-0.12	-0.08	-0.09
Shares in TES (%)								
Coal		*3.2*	*-*	*-*	*-*	*-*	*0.1*	*0.2*
Peat		*-*	*-*	*-*	*-*	*-*	*-*	*-*
Oil		*47.2*	*14.5*	*15.4*	*9.9*	*10.2*	*11.8*	*15.6*
Natural gas		*46.6*	*55.6*	*52.0*	*59.2*	*64.9*	*62.8*	*59.6*
Biofuels[1]		*0.2*	*0.6*	*0.3*	*4.0*	*3.0*	*2.4*	*2.1*
Nuclear		*-*	*25.9*	*26.1*	*23.8*	*19.2*	*18.9*	*20.0*
Hydro		*1.7*	*5.4*	*8.8*	*5.9*	*6.3*	*6.0*	*4.3*
Wind		*-*	*-*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
Geothermal		*-*	*-*	*-*	*-*	*-*	*-*	*-*
Solar		*-*	*-*	*-*	*0.1*	*0.2*	*0.4*	*0.7*
Electricity trade[4]		*..*	*..*	*..*	*..*	*..*	*..*	*..*

0 is negligible, - is nil, .. is not available. Please note: rounding may cause totals to differ from the sum of the elements.

Unit: Mtoe

DEMAND FINAL CONSUMPTION	1990	2000	2010	2017	2018	2019	2020
TFC	**6.48**	**1.11**	**1.83**	**2.24**	**2.19**	**2.46**	**2.61**
Coal	0.24	-	0.00	0.00	0.00	0.00	0.01
Peat	-	-	-	-	-	-	-
Oil	2.36	0.29	0.38	0.32	0.32	0.40	0.56
Natural gas	2.75	0.44	1.02	1.29	1.30	1.46	1.45
Biofuels[1]	0.01	0.01	0.01	0.13	0.09	0.08	0.08
Geothermal	-	-	-	-	-	-	-
Solar	-	-	-	0.00	0.01	0.01	0.01
Electricity	0.78	0.31	0.40	0.48	0.46	0.50	0.51
Heat	0.34	0.06	0.01	0.00	0.00	0.00	0.00
Shares in TFC (%)							
Coal	*3.8*	*-*	*0.0*	*0.0*	*0.0*	*0.1*	*0.3*
Peat	*-*	*-*	*-*	*-*	*-*	*-*	*-*
Oil	*36.4*	*26.3*	*20.9*	*14.5*	*14.6*	*16.3*	*21.4*
Natural gas	*42.4*	*39.6*	*56.0*	*57.8*	*59.5*	*59.5*	*55.5*
Biofuels[1]	*0.2*	*1.1*	*0.5*	*5.9*	*4.3*	*3.3*	*2.9*
Geothermal	*-*	*-*	*-*	*-*	*-*	*-*	*-*
Solar	*-*	*-*	*-*	*0.1*	*0.2*	*0.3*	*0.5*
Electricity	*12.0*	*27.9*	*22.0*	*21.6*	*21.2*	*20.4*	*19.4*
Heat	*5.2*	*5.0*	*0.6*	*0.0*	*0.0*	*0.0*	*0.0*
TOTAL INDUSTRY[5]	**2.10**	**0.42**	**0.36**	**0.36**	**0.37**	**0.36**	**0.39**
Coal	-	-	-	-	0.00	0.00	0.00
Peat	-	-	-	-	-	-	-
Oil	0.74	0.02	0.04	0.05	0.05	0.06	0.08
Natural gas	0.97	0.31	0.22	0.17	0.19	0.16	0.17
Biofuels[1]	-	-	-	0.00	0.00	0.00	0.00
Geothermal	-	-	-	-	-	-	-
Solar	-	-	-	-	-	-	-
Electricity	0.29	0.06	0.09	0.14	0.13	0.13	0.14
Heat	0.10	0.03	0.01	-	-	-	-
Shares in total industry (%)							
Coal	*-*	*-*	*-*	*-*	*0.0*	*0.0*	*0.0*
Peat	*-*	*-*	*-*	*-*	*-*	*-*	*-*
Oil	*35.4*	*5.6*	*11.7*	*14.4*	*14.2*	*17.5*	*19.6*
Natural gas	*46.3*	*73.0*	*61.4*	*46.1*	*50.8*	*45.2*	*44.2*
Biofuels[1]	*-*	*-*	*-*	*0.0*	*0.0*	*0.0*	*0.0*
Geothermal	*-*	*-*	*-*	*-*	*-*	*-*	*-*
Solar	*-*	*-*	*-*	*-*	*-*	*-*	*-*
Electricity	*13.6*	*14.2*	*25.2*	*39.6*	*35.0*	*37.4*	*36.2*
Heat	*4.7*	*7.2*	*1.7*	*-*	*-*	*-*	*-*
TRANSPORT	**1.05**	**0.21**	**0.50**	**0.65**	**0.71**	**0.81**	**0.85**
OTHER[6]	**3.33**	**0.48**	**0.97**	**1.22**	**1.11**	**1.29**	**1.37**
Coal	0.24	-	0.00	0.00	0.00	0.00	0.01
Peat	-	-	-	-	-	-	-
Oil	0.60	0.07	0.14	0.02	0.02	0.02	0.03
Natural gas	1.78	0.13	0.51	0.73	0.66	0.82	0.88
Biofuels[1]	0.01	0.01	0.01	0.13	0.09	0.08	0.08
Geothermal	-	-	-	-	-	-	-
Solar	-	-	-	0.00	0.01	0.01	0.01
Electricity	0.46	0.24	0.30	0.33	0.33	0.36	0.36
Heat	0.24	0.03	0.01	0.00	0.00	0.00	0.00
Shares in other (%)							
Coal	*7.4*	*-*	*0.1*	*0.0*	*0.1*	*0.2*	*0.5*
Peat	*-*	*-*	*-*	*-*	*-*	*-*	*-*
Oil	*17.9*	*14.9*	*14.7*	*1.8*	*1.9*	*1.7*	*2.0*
Natural gas	*53.4*	*27.4*	*52.7*	*59.8*	*59.6*	*63.3*	*64.7*
Biofuels[1]	*0.5*	*2.6*	*0.9*	*10.9*	*8.5*	*6.3*	*5.5*
Geothermal	*-*	*-*	*-*	*-*	*-*	*-*	*-*
Solar	*-*	*-*	*-*	*0.2*	*0.5*	*0.7*	*1.0*
Electricity	*13.7*	*49.8*	*31.1*	*27.2*	*29.5*	*27.8*	*26.1*
Heat	*7.2*	*5.3*	*0.5*	*0.0*	*0.0*	*0.0*	*0.0*

0 is negligible, - is nil, .. is not available. Please note: rounding may cause totals to differ from the sum of the elements.

Unit: Mtoe

DEMAND							
ENERGY TRANSFORMATION AND LOSSES	**1990**	**2000**	**2010**	**2017**	**2018**	**2019**	**2020**
ELECTRICITY GENERATION[7]							
Input (Mtoe)	1.89	1.24	1.13	1.51	1.44	1.43	1.49
Output (Mtoe)	0.89	0.51	0.56	0.67	0.67	0.66	0.67
Output (TWh)	10.36	5.96	6.49	7.77	7.79	7.68	7.84
Output Shares (%)							
Coal	-	-	-	-	-	-	-
Peat	-	-	-	-	-	-	-
Oil	*68.6*	-	-	-	-	-	-
Natural gas	*16.4*	*45.2*	*22.2*	*37.0*	*43.3*	*39.7*	*40.4*
Biofuels[1]	-	-	-	-	-	-	-
Nuclear	-	*33.7*	*38.4*	*33.7*	*26.6*	*28.6*	*35.2*
Hydro	*15.0*	*21.2*	*39.4*	*29.2*	*29.8*	*30.9*	*22.7*
Wind	-	-	*0.1*	*0.0*	*0.0*	*0.0*	*0.0*
Geothermal	-	-	-	-	-	-	-
Solar	-	-	-	*0.0*	*0.2*	*0.8*	*1.7*
TOTAL LOSSES	**1.28**	**0.91**	**0.66**	**1.06**	**0.96**	**0.94**	**0.98**
of which:							
Electricity and heat generation[8]	1.00	0.73	0.57	0.84	0.77	0.77	0.81
Other transformation	-	-	-	-	-	-	-
Own use and transmission/distribution losses	0.28	0.18	0.09	0.22	0.19	0.18	0.17
Statistical differences	**0.05**	**-**	**-0.00**	**0.00**	**-0.00**	**-0.00**	**-0.00**
INDICATORS	**1990**	**2000**	**2010**	**2017**	**2018**	**2019**	**2020**
GDP (billion 2015 USD)	5.84	3.96	8.51	11.37	11.96	12.87	11.89
Population (millions)	3.54	3.07	2.88	2.95	2.95	2.96	2.96
TES/GDP (toe/1000 USD)[9]	1.32	0.51	0.29	0.29	0.26	0.26	0.30
Energy production/TES	0.02	0.32	0.35	0.34	0.28	0.27	0.27
Per capita TES (toe/capita)	2.18	0.66	0.86	1.12	1.07	1.15	1.21
Oil supply/GDP (toe/1000 USD)[9]	0.62	0.07	0.04	0.03	0.03	0.03	0.05
TFC/GDP (toe/1000 USD)[9]	1.11	0.28	0.21	0.20	0.18	0.19	0.22
Per capita TFC (toe/capita)	1.83	0.36	0.63	0.76	0.74	0.83	0.88
CO_2 emissions from fuel combustion ($MtCO_2$)[10]	19.8	3.4	4.0	5.2	5.4	5.9	..
CO_2 emissions from bunkers ($MtCO_2$)[10]	0.6	0.2	0.1	0.2	0.2	0.2	..
GROWTH RATES (% per year)	**90-00**	**00-10**	**10-17**	**17-18**	**18-19**	**19-20**	**00-20**
TES	-12.6	2.1	4.1	-4.4	8.1	5.7	2.9
Coal	-100.0	-	-7.4	209.1	157.0	172.4	-
Peat	-	-	-	-	-	-	-
Oil	-22.3	2.8	-2.3	-1.1	24.9	39.5	3.3
Natural gas	-11.0	1.4	6.1	4.9	4.5	0.2	3.3
Biofuels[1]	-2.0	-3.6	48.2	-28.6	-13.9	-7.5	9.5
Nuclear	-	2.2	2.7	-23.2	6.9	11.5	1.6
Hydro	-2.1	7.3	-1.7	2.2	2.3	-25.0	1.7
Wind	-	-	-15.8	-10.5	71.7	-42.1	-
Geothermal	-	-	-	-	-	-	-
Solar	-	-	-	135.6	101.5	89.4	-
TFC	-16.2	5.1	2.9	-2.0	12.1	6.3	4.4
Electricity consumption	-8.8	2.7	2.7	-3.9	8.1	0.9	2.5
Energy production	15.8	3.2	3.4	-19.3	4.4	2.9	2.0
Net oil imports	-22.3	2.8	-1.8	-0.7	28.9	36.4	3.6
GDP	-3.8	8.0	4.2	5.2	7.6	-7.6	5.7
TES/GDP	-9.1	-5.4	-0.1	-9.1	0.4	14.4	-2.6
TFC/GDP	-12.9	-2.6	-1.2	-6.8	4.2	15.1	-1.2

0 is negligible, - is nil, .. is not available. Please note: rounding may cause totals to differ from the sum of the elements.

Footnotes to energy balances and key statistical data

1. Biofuels and waste comprise solid biofuels. Data are often based on partial surveys and may not be comparable between countries.
2. In addition to coal, oil, natural gas and electricity, total net imports also includes solid biofuels.
3. Excludes international marine bunkers and international aviation bunkers.
4. Total supply of electricity represents net trade. A negative number in the share of TES indicates that exports are greater than imports.
5. Industry includes non-energy use.
6. Other includes residential, commercial and public services, agriculture/forestry, fishing and other non-specified.
7. Inputs to electricity generation include inputs to electricity, CHP and heat plants. Output refers only to electricity generation.
8. Losses arising from electricity and heat production by main activity producers and by auto producers. For non-fossil-fuel electricity generation, theoretical losses are based on plant efficiencies of approximately 33% for nuclear and solar thermal, 10% for geothermal and 100% for hydro, wind and solar photovoltaic.
9. Toe per thousand USD at 2015 prices and exchange rates.
10. CO_2 emissions from fuel combustion were estimated using the IPCC Tier I Sectoral Approach methodology from the 2006 IPCC Guidelines. Emissions from international marine and aviation bunkers are not included in national totals.

ANNEX C: International Energy Agency "Shared Goals"

The member countries* of the International Energy Agency (IEA) seek to create conditions in which the energy sectors of their economies can make the fullest possible contribution to sustainable economic development and to the well-being of their people and of the environment. In formulating energy policies, the establishment of free and open markets is a fundamental point of departure, though energy security and environmental protection need to be given particular emphasis by governments. IEA countries recognise the significance of increasing global interdependence in energy. They therefore seek to promote the effective operation of international energy markets and encourage dialogue with all participants. In order to secure their objectives, member countries therefore aim to create a policy framework consistent with the following goals:

1. Diversity, efficiency and flexibility within the energy sector are basic conditions for longer-term energy security: the fuels used within and across sectors and the sources of those fuels should be as diverse as practicable. Non-fossil fuels, particularly nuclear and hydro power, make a substantial contribution to the energy supply diversity of IEA countries as a group.

2. Energy systems should have **the ability to respond promptly and flexibly to energy emergencies.** In some cases this requires collective mechanisms and action: IEA countries co-operate through the agency in responding jointly to oil supply emergencies.

3. The environmentally sustainable provision and use of energy are central to the achievement of these shared goals. Decision-makers should seek to minimise the adverse environmental impacts of energy activities, just as environmental decisions should take account of the energy consequences. Government interventions should respect the Polluter Pays Principle where practicable.

4. More environmentally acceptable energy sources need to be encouraged and developed. Clean and efficient use of fossil fuels is essential. The development of economic non-fossil sources is also a priority. A number of IEA member countries wish to retain and improve the nuclear option for the future, at the highest available safety standards, because nuclear energy does not emit carbon dioxide. Renewable sources will also have an increasingly important contribution to make.

5. Improved energy efficiency can promote both environmental protection and energy security in a cost-effective manner. There are significant opportunities for greater energy efficiency at all stages of the energy cycle from production to consumption. Strong efforts by governments and all energy users are needed to realise these opportunities.

6. Continued **research, development and market deployment of new and improved energy technologies** make a critical contribution to achieving the objectives outlined above. Energy technology policies should complement broader energy policies. International cooperation in the development and dissemination of energy technologies, including industry participation and cooperation with non-member countries, should be encouraged.

7. Undistorted energy prices enable markets to work efficiently. Energy prices should not be held artificially below the costs of supply to promote social or industrial goals. To the extent necessary and practicable, the environmental costs of energy production and use should be reflected in prices.

8. Free and open trade and a secure framework for investment contribute to efficient energy markets and energy security. Distortions to energy trade and investment should be avoided.

9. Cooperation among all energy market participants helps to improve information and understanding, and encourages the development of efficient, environmentally acceptable and flexible energy systems and markets worldwide. These are needed to help promote the investment, trade and confidence necessary to achieve global energy security and environmental objectives.

(The Shared Goals were adopted by IEA Ministers at the meeting of 4 June 1993 in Paris, France.)

*Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Korea, Lithuania, Luxembourg, Mexico, The Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland, Turkey, United Kingdom, and United States.

ANNEX D: Glossary and list of abbreviations

In this report, abbreviations and acronyms are substituted for a number of terms used within the International Energy Agency. While these terms generally have been written out on first mention, this glossary provides a quick and central reference for the abbreviations used.

Acronyms and abbreviations

ABWR	advanced boiling water reactor
ACOT	avoided cost of transmission
ANPP	Armenian Nuclear Power Plant
APR	advanced pressurised reactor
BAU	business as usual
BEV	battery-electric vehicles
BOF	basic oxygen furnace
C	Centigrade
CCA	capital cost allowance
CCAC	Climate and Clean Air Coalition
CCGT	combined cycle gas turbine
CCS	carbon, capture and storage
CDM	clean development mechanism (under the Kyoto Protocol)
CGE	computable general equilibrium model
CHP	combined production of heat and power
CO_2	carbon dioxide
CSP	concentrated solar power
DHC	district heating and cooling
DNI	direct normal irradiance
DR	demand response
DRI	direct reduced iron
DSO	district system operator
EA	environmental assessment
EAEU	Eurasian Economic Union
EAF	electric arc furnace
EBRD	European Bank for Reconstruction and Development
EET	energy efficiency technology
EIA	environmental impact assessment
EIB	European Investment Bank
EPCO	electric power company
ESCO	energy service company
ETC	early transition country

ETS	emissions trading scheme
FiT	feed-in tariff
FY	financial year
GCF	Green Climate Fund
GDP	gross domestic product
GDP PPP	gross domestic product with purchasing power parity
GHG	greenhouse gas
GHI	global horizontal irradiance
HDV	heavy-duty vehicle
HEI	higher education institution
HFT	heavy-freight truck
HWR	heavy water reactor
ICE	internal combustion engine
ICV	internal combustion engine vehicles
IFC	International Finance Corporation
INDC	Intended Nationally Determined Contribution
ISIC	international standard industrial classification of all economic activities
LCOE	levelised cost of electricity
LED	light-emitting diode
LNG	liquefied natural gas
LPG	liquefied petroleum gas
LULUCF	land use, land-use change, and forestry
LWGR	light water-moderated graphite reactor
LWR	light water reactor
MABs	multi-apartment blocks
MEPS	minimum energy performance standards
MFT	medium-freight truck
MRV	measurement, reporting and verification
MSW	municipal solid waste
NACE	statistical nomenclature of economic activities in the European Union (Fr. Acronym)
NDC	nationally determined contribution
NPP	nuclear power plant
PHEV	plug-in hybrid electric vehicles
PHWR	pressurised heavy water reactor
PPA	power-purchase agreement
PPP	purchasing power parity
PV	photovoltaics
PWR	pressurised water reactor
R&D	research and development
RD&D	research, development and deployment [or demonstration]

RES	renewable energy source(s)
SMEs	small and medium enterprises
	tota ene u
TFC	total final consumption
TPA	third-party access
TPES	total primary energy supply
TSO	transmission system operator
USD	United States dollar
VAT	value-added tax
VRE	variable renewable energy
WACC	weighted average cost of capital
WWER	water-water energetic reactor

Units of measure

bcm	billion cubic metres
b/d	barrels per day
CO_2-eq	carbon dioxide-equivalent
EJ	exajoule
GJ	gigajoule
GJ/t	gigajoules over tonne
GW	gigawatt
GWh	gigawatt-hour
Hz	hertz
kb/d	thousand barrels per day
km	kilometre
km^2	square kilometre
kW	kilowatt
kWh	kilowatt-hour
kWh/m^2	kilowatt hours per square metre
kWh/t	kilowatt hours per tonne
m	metre
m/s	metres per second
m^3	cubic metre
mb	million barrels
mBtu	million British thermal units
mcm	million cubic metres
Mha	million hectares
MJ	megajoule
ML	million litres
Mt	million tonnes

$MtCO_2$	million tonnes of carbon dioxide
$MtCO_2$-eq	million tonnes of carbon dioxide-equivalent
Mtoe	million tonnes of oil-equivalent
MW	megawatt

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Armenia 2022

Energy Policy Review

This International Energy Agency (IEA) in-depth review of the energy policies of Armenia follows the same format as that used for the IEA peer reviews of member countries. This in-depth review of Armenia was conducted under the auspices of the EU4Energy programme, which is being implemented by the IEA and the European Union, along with the Energy Community Secretariat and the Energy Charter Secretariat.

Armenia depends on imports to meet much of its energy needs, particularly natural gas from the Russian Federation. It is one of the few ex-Soviet republics to avoid significant energy subsidies, and it is the only country in the Caucasus region to possess a nuclear power plant.

In January 2021, the government approved a new Energy Sector Development Strategic Programme that sets the path for the sector's transition through 2040. Key government priorities include promoting maximum use of the country's potential for renewable energy and energy efficiency; increasing power transmission links with Armenia's neighbours; gradually liberalising the domestic electricity market; and maintaining and, possibly, increasing the role of nuclear power.

This report assesses the energy sector and related challenges facing Armenia and proposes policy recommendations to improve sector governance, energy efficiency, and security of supply.

International Energy Agency

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