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**ADBI Working Paper Series**

**ENERGY INSECURITY AND  
RENEWABLE ENERGY SOURCES:  
PROSPECTS AND CHALLENGES  
FOR AZERBAIJAN**

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**Abstract**

This study investigates the prospects and challenges of renewable energy source (RES) usage in Azerbaijan within the context of the country's energy security goals. As one of the hydrocarbon producers of the world, Azerbaijan is looking to generate 20% of its electricity from renewable sources by 2020. Aiming to minimize its energy insecurity problems and ensure the country's energy security, Azerbaijan has established its RES policies according to the norms of sustainable development while simultaneously securing an uninterrupted supply of energy. Using oil export revenues and the established legal infrastructure, Azerbaijan has made significant investments for development in the renewable energy sector since the 2000s. Considering that there is a short time to 2020 and energy security is a strategic part of Azerbaijan's national security aims, this paper examines how close the country is to achieving the goal of obtaining 20% of its electricity using RES and what challenges prevent the realization of this target. Starting from a thermal power plant accident in July 2018, which revealed many of the deficiencies in Azerbaijan's energy strategies, this paper considers the country's energy security and insecurity issues in terms of the legal framework, environmental policies, and actual achievements as shown in government data. The study includes an assessment of the prospects for Azerbaijan's transition actions to RES, as well as potential solutions to remove the challenges that the country faces.

**Keywords:** Azerbaijan, development, renewable energy, sustainability

**JEL Classification:** O44, Q42, Q48, Q56

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# 1. INTRODUCTION

As a result of the accident at the Mingachevir Thermal Power Plant on 3 July 2018, electricity was cut off in most of Azerbaijan, including 39 regions of the country, the capital Baku, and the major cities of Ganja and Sumgait. The electricity supply was disrupted for the Baku subway, Azersu (which supplies water and sanitation services), the State Oil Company of Azerbaijan Republic's (SOCAR) large-scale production facilities, industrial enterprises, health care centers, and other facilities with strategic importance. Interruptions in power supply caused disruptions in the movement of trains on the Baku metro and water distribution in the cities, as well as railway schedule delays throughout the country. Serious problems occurred in hospitals, especially in the departments of surgery, intensive care, obstetrics, and premature birth units.

Azerenergy OJSC and the Ministry of Energy of Azerbaijan tried to explain the accident, citing a sharp increase in outdoor temperatures and a resulting 40% increase in energy demand. These statements did not satisfy the public in light of the public programs implemented to strengthen the country's energy security and the funds allocated for that purpose for many years. Official investigations revealed that the causes of the accident were completely different and included high imbalance between the plant's infrastructure and workload; old equipment; false risk assessments; weak security measures; lack of renewable energy source (RES) stations to compensate for power disruption during periods of extreme heat, and the poor performance of the responsible organizations who focused mainly on initiatives rather than acting in accordance with the strategic development plan.

The accident revealed all aspects of energy insecurity in Azerbaijan, including technical shortcomings, poor electricity supply system diversification, and lack of risk elimination for the country's economy, including strategic enterprises. The activities of the organizations responsible for the country's energy security were also not organized systematically and the electricity production and supply systems were not properly integrated. The state funds allocated for the development and strengthening of the electricity supply system were spent inefficiently. One of the significant facts is about alternative energy policy, which has not been coordinated with energy security policy of the country.

However, Azerbaijan is an oil-producing country that is developing and implementing policies in line with the rising trend in RES to achieve sustainable economic growth, ensure energy security, and increase the share of non-oil sectors in the national economy. Renewable energy is one of Azerbaijan's strategic priorities, because the development of renewable energy sector in Azerbaijan are not only in line with environmental goals for the reduction of carbon emissions to reach Paris Agreement targets, but also to diversify the energy basket and increasing energy security (Taghizadeh-Hesary et al. 2019). In other words, as an important part of its national security goals, Azerbaijan aims to use renewable energy sources alongside fossil resources to guarantee energy security and minimize the risk of energy insecurity. It aims to solve the problems that may arise in the country's energy supply with renewable resources, which are attractive due to their environment-friendly features. The aforementioned accident, however, revealed that Azerbaijan must still face serious challenges before achieving its goals.

This paper defines the prospects and challenges for Azerbaijan's use of RES to decrease its energy insecurity. Following consideration of the Mingachevir Thermal Power Plant accident in this first section, the second section of this study presents the research background, emphasizing the increasing importance of RES within the context of energy

security and insecurity. The second section also builds a sustainable development equation and outlines a map of Azerbaijan's current energy security and insecurity. Third section presents the legal framework for the environment and energy issues in Azerbaijan's sustainable development agenda based on policy documents and sources. The fourth section considers the present situation of RES transformation attempts using official statistical data. The achievements, potential, and deficiencies within Azerbaijan's current legal framework in the RES sector are also analyzed. The conclusion includes the research findings and suggestions for future study.

## 2. BACKGROUND OF THE RESEARCH

The International Energy Agency (IEA) defines energy security as “the uninterrupted availability of energy sources at an affordable price” (IEA 2014). Energy insecurity, therefore, is a lack of the ability to provide or ensure the constant accessibility of energy sources at a fair price. The absence of energy security and the existence of energy insecurity lead to negative economic and social effects for national economies. The emergence of the sustainable development concept has, however, emphasized the need to respect environmental concerns when making use of energy resources.

RES is an option both to ensure energy security and for sustainable development. Renewable energy is commonly defined as energy generated from solar, wind, geothermal, tide and wave, wood, waste, and biomass (Yazdi and Shakouri 2017). The energy produced from RES plays an important role in decreasing energy insecurity, contributing to energy security, and diversifying energy consumption. Used principally by the electricity sector to decrease shortages and lack of access, a significant expansion in renewable energy has been encouraged by technological advances and the reduced costs of transportation and communication (Yazdi and Shakouri 2017).

Despite a large and increasing interest in renewable energy, it still faces some challenges. Examining renewable energy development in Malaysia, Mustapa, Peng, and Hashim (2010) found the following four major challenges: financial barriers, technical barriers, institutional/regulatory barriers, and information barriers. The cost of renewable investments—exactly capital costs—is higher due to new technologies, and there is uncertainty about renewable energy because of the novelty of the technologies used and the nature of renewable energy itself (e.g., weather conditions). It is less expensive to operate RES, but the establishment such systems is costly. Financial institutions are therefore reluctant to support the renewable energy sector because the start-up cost is perceived as a risk. Area conditions, infrastructure type, and means of transportation and communication pose technical obstacles for the development of renewable energy. An insufficient legal framework, governmental institutions, and policies, as well as public-private partnerships to encourage renewable energy also prevent progress in the sector. Most services are still not aware of the full value of RES. Energy investors often think about narrow value parameters and miss the big-picture, long-term opportunities that RES promise. Lack of information and awareness about the benefits of RES and poor public opinion on renewable energy usage have had a negative effect on the sector's development. Increased awareness and willingness are needed. While these challenges differ from country to country, in developing countries, generally all of these challenges must be faced simultaneously.

The state is a key stakeholder in the field of energy security in Azerbaijan, and there are numerous institutional mechanisms to manage and control the domestic energy market and oil and gas exports. The Ministry of Energy is the main executive body responsible for implementing state policy and regulations in the energy sector and providing for the

energy security of the country. It should be noted, however, that SOCAR is the prime organization representing the government in conducting international oil policy and has been directly involved in major oil and gas contracts as a shareholder. SOCAR plays a central role in Azerbaijan's strategic sector and the many international oil and gas exploration projects and extraction fields. The Ministry of Energy plays a more symbolic role in the energy sector, while major energy projects are under SOCAR's control.

Azerbaijan's electricity sector is controlled by Azenergy OJSC, an independent state-owned company, and is a vertically integrated monopoly system. This institution manages the production, transmission, and distribution of electricity, and is responsible for domestic electricity supply to the country's electricity system. The main fuel used for domestic energy consumption is natural gas, both for the population as a whole and for industry. The transportation system, meanwhile, uses oil products, so natural gas and oil are the basis of internal energy consumption, as well as the country's energy security.

Up to 2005, the main power plants were insufficient to produce the electricity needed in the country. The lack of sufficient electricity, gas, and heat caused regional imbalances in the country, with the supply of electricity lasting only a few hours a day, along with frequent interruptions in supply and periodic malfunctions in the system. The low quality and intermittent power supply hindered industrial, agricultural, and commercial activities, as well as economic growth and employment opportunities.

The State Program on the Development of the Fuel-Energy Complex (2005–2015) of the Republic of Azerbaijan and the Additional Measures to Improve the Electricity Supply in the Republic of Azerbaijan were a turning point in reliable energy access, energy security, and the creation of new energy sources for the country. In addition to the implementation of the State Program, with the support of the Asian Development Bank (ADB) within the framework of an Improvement of Energy Transmission project, measures were taken to improve the quality of the electricity supply and restore the electricity network, to develop alternative and renewable energy sources, and to maximize energy efficiency and energy conservation. Recent trends towards decreasing energy insecurity have included preventing energy losses in the domestic market, increasing energy savings, enhancing customer service, and providing reliable energy.

When oil prices were higher and there were, accordingly, higher fiscal revenues, the infrastructure costs of the Azenergy OJSC were also high. The state budget was one of the main financial sources of the organization. To subsidize the losses related to SOCAR's sale of natural gas to Azenergy OJSC at a price lower than the contract value, 300 million manat was allocated from the state budget (Hasanov 2018). The decline in oil prices has forced the government to accelerate reforms in the domestic electricity sector. Achieving productivity in the domestic electricity market would increase Azerbaijan's potential to sell more energy to neighboring countries such as the Russian Federation, Iran, Turkey, and Georgia, which could compensate for losses related to falling oil prices.

It has not, however, been possible to achieve serious quality changes in the electricity supply system, which is the key component of energy security in the country. Most of the domestic energy infrastructure has deteriorated, which has caused frequent short circuits, energy cuts, and energy losses. Out-of-date technologies and electrical equipment have decreased the reliability and efficiency of energy system operation, while the lack of a reliable energy supply in the country is one of the main energy security concerns for the government. Recent structural reforms have aimed to reduce this internal energy security problem.



The general population and the commercial and public sectors are the main consumers of electricity in Azerbaijan. The change in tariffs for electricity and gas has always had a significant impact on consumers. Electricity tariffs were raised three times in 2007 for the first time since 1997, which has forced many consumers to use natural gas, which has led to electricity savings and exports (Aliyeva and Veliyev 2016). Fossil fuels therefore retain their importance for energy consumption in Azerbaijan. Ensuring the country's energy security will, however, require using RES. Rovnag Abdullayev, president of SOCAR, noted "the diversification and security of energy supplies, the deepening of energy market reforms, the development and modernization of energy infrastructures, energy efficiency, energy savings and the use of renewable energy sources are key concerns" of Azerbaijan's energy security (SOCAR 2014). More has been improved and accomplished for the concerns related to fossil fuels, their export, and transportation within the country's energy security than for RES issues.

New achievements have been made in the energy sector since 2003. Azerbaijan's electricity system and power generation infrastructure have been reconstructed, trunk lines have been renewed within the country and in connection to other countries, and a number of large and small power stations have been built in cities and districts. Although the national electricity system has been reinstalled to meet European Union (EU) standards, to reduce the demand for domestic energy and to sell electrical energy to neighboring countries, the July 2018 accident showed that Azerbaijan still faces serious challenges in terms of energy insecurity. That the country cannot reach the desired renewable energy use, along with the failure to obtain power from RES in case of necessity, has led to the question energy security and insecurity in Azerbaijan. The accident revealed the need to revise alternative energy policies from the context of energy security and diversify access to electricity through several sources, including RES, for strategically important public organizations.

### **3. ENVIRONMENT – ENERGY ISSUES IN AZERBAIJAN'S SUSTAINABLE DEVELOPMENT AGENDA**

#### **3.1 Environmental Policy**

Environmental issues in Azerbaijan have appeared in several official documents. The country's environmental policy has mainly focused on three aspects shaped by existing environmental circumstances and socio-economic conditions. As the security of environment is of primary importance, policy first of all focuses on reducing the human impact on the environment and coordinating environmental protection using best practices for sustainable development. Considering the demands of present and future generations, the second focus of the policy is towards an effective use of natural resources, including RES. Evaluation of the country's needs for global environmental matters, producing solutions for them, and acting on solutions through cooperation with international organizations is the third aspect of Azerbaijan's environmental policy (Zoï Environment Network 2011).

Some obligations and principles are defined for the achievement of environmental policy goals, including improving the environment through support of successful experiences of human resource management, as well as encouragement of the economic models and technologies needed for the safety of present and future generations (Zoï Environment Network 2011). The Constitution of Azerbaijan has defined “living in a healthy and clean environment as a right of the country’s citizens” (Zoï Environment Network 2011). This right forms a basis for environmental legislation. At the beginning of the 1990s, the State Committee for the Environment developed the Ecological Concept of the Republic of Azerbaijan, specifying the foundation for Azerbaijan’s state policy on environmental protection. As a part of Agenda 21 of the Rio de Janeiro Conference, ecological security norms have focused on environmental security and progression in ecological situation in Azerbaijan. To take precautions to improve the environment, special emphasis and general provisions have been defined including the “protection of the biosphere, continuous utilization of natural resources, decrease and disposal of waste, rational use of energy and reduction of risk associated with human activity” (Ministry of Ecology and Natural Resources [MENR] 2019).

To achieve these goals, the first National Environmental Action Plan (NEAP) of Azerbaijan was developed between 1995 and 1998 with World Bank assistance, in parallel with the first wave of NEAPs in Eastern Europe, the Caucasus, and Central Asia after the dissolution of the Soviet Union. Both the Law on Environmental Protection and the Law on Environmental Safety were adopted in 1999. These two laws defined “the rights and responsibilities of government, citizens, public associations and local authorities; use of natural resources; state registry of natural resources of the environment, monitoring, standardization and certification on environmental protection and safety” (Zoï Environment Network 2011). These legal documents involve “economical regulation of environmental protection and ecological terms required for implementation of economic activities.” The laws aim “to promote education, research, statistics and information on environment; environmental emergency response situations and zones of ecological disasters; control on environmental protection, impact assessment; inspection and audit; responsibility for the violation of environmental legislation and international cooperation” (Zoï Environment Network 2011). The Law on Environmental Protection concerns “all means (water, soil, air), waste management, protection of fauna, protected areas and ecological expertise”, stating “the order for the protection of atmospheric air, water objects, and soils, organization of waste collection and disposal, animal world protection, operation of specially protected areas” (Zoï Environment Network 2011).

Following the passage of these laws, strategic documents such as the 2003 and 2008 State Program on Poverty and Economic Development (SPPRED) and the 2003 State Program for Environmentally Sustainable Economic Development (SPESEC) restated and added to Azerbaijan’s environmental priorities (ADB 2005). During the country’s transition period, international, regional, and intergovernmental collaborations were developed, and Azerbaijan has joined twenty concerned conventions, like the United Nations Framework Convention on Climate Change and the Kyoto Protocol. The State Commission on Climate Change was established in 1997 (ADB 2010: 11). In 2012 the government of Azerbaijan accepted the development plan “Azerbaijan 2020: Look into the Future,” through which it aimed to set higher development goals parallel to modern global challenges, including environmental concerns. Azerbaijan 2020 stresses the probable effects of climate change on the country’s society and economy, underlining the need for preparation in policy measures. The plan argues that the quantity of energy consumed and CO<sub>2</sub> released for the production of one unit of GDP must be analogous with the matching OECD member country norms by 2020.

Since 1990 industrial activity in Azerbaijan has slowed, and the rate of greenhouse gas emissions has decreased correspondingly. Difficult economic conditions have also limited the government's abilities to take measures in the same period. Thus, the pollution rate accounted for 71.1 MTOE of CO<sub>2</sub> in the 1990s, which has calculated at more than an average of 50.0 MTOE of CO<sub>2</sub> in the 2000s (The State Statistical Committee of the Republic of Azerbaijan [SSCRA] 2017). Energy and total land use and corresponding changes (both including and excluding forestry) are the main sectors in Azerbaijan that emit greenhouse gasses into the atmosphere. Depending on economic growth, especially with the start of the Baku–Tbilisi–Ceyhan pipeline, significant increases have been observed in the amount of funding allocated for environmental protection by the government. However, economic constriction due to oil prices has once again reduced governmental expenditures for environmental issues.

### 3.2 Energy Policy

Due to its historic oil industry, which dates from the 1840s, rather than the quantity of its oil reserves, Azerbaijan is well known as one of the world's energy producing countries. As oil and natural gas exports are the main income source for the national budget, the energy sector is a mirror of as well as a driving force for economic development in Azerbaijan (Flegel 2016). Azerbaijan's energy policy therefore mainly focuses on the production, export, and transportation strategies for fossil energy resources, as well as regulation of the electricity sector, management of energy revenues, and energy sustainability, including environmental issues and RES. The four laws on the Utilization of Energy Resources, Energy, Electric Energy, and Electric and Heat Power Plants, respectively, created the early legal framework for the country's energy development and RES. The law on the Utilization of Energy Resources, No. 94-IQ, dated 30 May 1996, defined the legal, economic, and social framework of governmental policy on the use of energy resources, as well as the main directions for the law's implementation, and regulation relations between the state and legal and physical persons (The Ministry of Energy of Azerbaijan Republic [ME] 2018). The state's energy policy is clearly defined in article 3 of the law on Energy of Azerbaijan, No. 541, dated 24 November 1998, which runs as follows:

1. Effective production, transportation, distribution, storage, use and safety of energy products.
2. Creation of infrastructure that will provide efficient energy supply to all consumers and to create new workplaces; establishment of competition and minimal monopoly conditions in energy sector; organization of activities in the energy sector on the basis of various types of ownership, long-term contracts and special permits; creation of favorable conditions for local businesses producing high quality products; creation of favorable conditions for the application of efficient and environmentally safe technologies.
3. Conservation of energy resources, reduction of waste amounts, efficient use of energy and use of RES.
4. Reduction of negative impact on the environment.
5. In case of energy shortage, to provide subsidies to producers and consumers to increase energy efficiency.
6. To create favorable legal and economic conditions for investments.
7. Development of state energy programs (ME 2018).

The law on Electric Energy, No. 459-IQ, dated 3 April 1998, sets out the legal basis for the production, transportation, distribution, purchase, and sale of electricity and heat energy. The main purpose of this law is to use energy resources efficiently by including environmental care in the energy market in a socially sound manner, in the interest of energy production and consumption (ME 2018). The law on Electric Power and Heat Stations, No. 784-IQ, dated 28 December 1999, determines the legal basis for the design, construction, and operation of permanent facilities producing electric and thermal energy in accordance with the legislation of the Republic of Azerbaijan (ME 2018).

These laws are the country's initial energy legislation, which were enacted in the first years of independence and involve the fundamental urgent issues of that period based on the primary energy resource—fossil fuels. None of these legal documents explicitly includes renewable energy. Thus, the 1990s can be considered the first stage of the formation of Azerbaijan's energy policy, focusing mainly on environmental and ecological concerns rather than renewability. This situation can be accepted as usual for a country going through a transition period and focusing on the recovery of its economy; under the existing conditions of that period, sustainability could only be considered at a future stage.

The State Program on the Use of Alternative and RES in the Republic of Azerbaijan was approved by Presidential Order No. 462, dated 21 October 2004, and was a new pillar for Azerbaijan's energy policy. The objective of the State Program was to promote power generation from renewable and environmentally sound sources and to utilize hydrocarbon energy sources more efficiently. The major tasks of the State Program included defining “potential of alternative (renewable) energy sources for electric power generation” and raising “efficiency of utilization of country's energy sources by developing RES” and “to ensure the opening of additional jobs with creation of new energy production sites; and given the existing total capacity of traditional energy sources in Azerbaijan, to increase the energy capacities at the expense of RES and therefore, achieve the country's energy security” (State Agency for Alternative and Renewable Sources (SAARES) 2019).

Some of the goals of the Memorandum of Understanding of 2006 signed between the EU and Azerbaijan overlap with the objectives of the State Program, including “modernization of the electric grid, enhance the security and reliability of the energy infrastructure; preparation of programs and regulations for the development of renewable energy sector and achievement the efficient use of energy.” Within the framework of State Program, SAARES was established under the auspices of the Ministry of Industry and Energy of the Republic of Azerbaijan in 2009. In December 2011 a second long-term government strategy for the development of alternative and RES for the years 2012–2020 was accepted in line with the EU's 2006 climate and energy policy for worldwide 20/20/20 targets (Caspian Information Centre 2013). While energy efficiency, renewable energy, security of supply, ecologic security, and cost effectiveness were the main concepts of the strategy, stabilizing the final energy consumption was the key function of the strategy's structure. The Strategy aims to reduce 20% greenhouse gas emission from 1990 levels, to scale up the rate of renewable energy by up to 20% in using electricity as well as to increase energy efficiency by 20% by 2020 (Caspian Information Centre 2013: 4). To improve management in this sector, SAARES and the agency's AzAlternativEnerji LLC were established in 2013. SAARES is the central executive authority that implements state policy on and regulatory control over alternative and renewable energy and its sound management, and the agency ensures the effective organization of activities concerning alternative and RES, as well as coordination and state control in this field.

The agency participates in the development of a unified state policy for its areas of authority and ensures implementation of that policy. It also oversees progress in the alternative and renewable energy field, establishing the required infrastructure, and ensuring the application of alternative and renewable energy in the economic and social fields. SAARES is also responsible for the implementation of measures related to power generation, energy consumption, and energy efficiency using alternative and RES, as well as conducting relevant state registration and inventory. The Republic of Azerbaijan has been a member of the International Renewable Energy Agency (IRENA) since 2014. In 2014 the state program for the development of industry in Azerbaijan for 2015–2020 was accepted, which strategically supports the progress of RES. The drafts of the Law on the use of alternative and RES and on Energy Efficiency are currently being reviewed by Azerbaijan’s Cabinet of Ministers. In the post-independence period, energy policy has transformed in parallel with the development of Azerbaijan’s economy. As mentioned earlier, while the energy policy of the country focused on recovery-oriented activities in the 1990s, it evolved towards sustainability in the 2000s thanks to the opportunities provided by economic development. As a result, the issues of RES have become integrated into the country’s energy and environment policies.

#### 4. AZERBAIJAN’S ATTEMPTS AT RENEWABLE ENERGY TRANSFORMATION: ACHIEVEMENTS AND POTENTIAL

The geographic conditions of Azerbaijan create a favorable environment for progress in the country’s renewable energy sector. The technical potential of RES in Azerbaijan is accounted to be approximately 130,000 MW/year (Table 1).

**Table 1: Azerbaijan’s Technical RES Potential**

Type of RES	Capacity, MW/billion kW
Solar	>115,200
Wind	>15,000
Bioenergy	>900
Geothermal	>200
Small hydropower	>650
<b>Total</b>	<b>&gt;130,000</b>

Source: IREA, <https://irena.org/-/media/Files/IRENA/Agency/Events/2018/May/Azerbaijan-RRA-workshop/2--Mr-Jabir-Yusifov-SAARES--Overview-of-the-energy-sector-and-renewa.pdf?la=en&hash=EF0FFCB2B8F1CB61B92F5528C5A22B54E1B0D16C>.

The yearly duration of sunlight in the Absheron peninsula and the coastal areas of the Caspian Sea is approximately 2,500 hours and, in Nakhichevan Autonomous Republic (AR), it is about 2,900 hours (Sevil 2011). The annual amount of solar energy for each m<sup>2</sup> in the country ranges between 1,300 kW/h to 1,750 kW/h (AREA 2017). The solar energy potential of the country is estimated to be 115,200 MW/year. There are five 2.8 MW–capacity solar power plants (SPP) established in the Samukh, Sumgait, Pirallahy, Surakhany, and Karadakh regions. A sixth plant has been established in Nakhichevan with a 20 MW capacity (SAARES 2018).

For wind energy, the Absheron Peninsula and Caspian Sea coastal zones receive heavy winds for more than 270 days a year (Sevil 2011). Because the wind enters the territory of Azerbaijan from a narrow strip at the shoreline of the Caspian Sea and from the valley between the Great and Small Caucasus Mountains, wind intensification is a recurring weather phenomenon in the surrounding territories. According to SAARES's research study (2017), the average annual wind speed ranges between 7.0–8.5 m/s at 80 m above the land surface there, which is categorized as highly favorable in IREA's energy potential classification. In 2007, according to the decision of the Council of Tariff of Azerbaijan, a selling price of 4.5 Qapik<sup>1</sup> for wind energy was determined to promote the operation of wind energy plants (WPP), particularly at Yeni Yashma (1.7 MW), Shurabad (48 MW), Sitalchay (3.6 MW), Hokmali (8MW), Wind Island Offshore (200 MW) Wind Farms, and Yeni Yashma Wind Power Station (50 MW; SAARES History 2018).

There are approximately 2.7 million large-horned animals, 9 million small-horned animals, and 30.5 million poultry birds in Azerbaijan (SSCRA Agriculture 2019), with a total annual discharge of 25 million tons (SAARES 2017). The country's annual volume of solid and production waste is more than 2 million tons. Burnable manufacturing contaminants, woods and carpentry waste, agrarian organic compounds, household waste, and oil or petroleum product-based wastes are the most widely available biosubstances in Azerbaijan. Developments in several industrial sectors as well as agriculture and social services increase the opportunities for bioenergy generation (Huseynova 2014). In 2012, Balakhani Waste-to-Energy Plant was opened, with a total capacity of 37 MW and a production capacity of 231.5 million kW/year using urban inert waste with a 500,000 ton/year operation capacity.

The geothermal energy potential of Azerbaijan is quite high. Existing thermal sources are mainly in the Great and Small Caucasus, the Absheron Peninsula, Talish Mountains, Kur-Araz plain, Nakhichevan, and on the northwest part of the Caspian Sea (Table 2). However, the extreme expense of the excavation of geothermal wells is a serious obstacle for electricity generation from thermal waters. Azerbaijan has many thermal water sources with relatively low temperatures (<80°C), and technologies using low potential geothermal energy have only recently been developed (Mukhtarov et al. 2015).

**Table 2: Thermal Waters of Azerbaijan**

<b>Hydro-geological Areas</b>	<b>Water Temperature, °C</b>	<b>Water Flow Rate, m<sup>3</sup>/day</b>	<b>Energy Potential, MW</b>
Absheron Peninsula	20–90	20,000	up to 504
Kur depression	22–95	172,466	up to 47·10 <sup>3</sup>
Great Caucasus	30–50	2,000	up to 168
Small Caucasus	30–74	4,171	up to 771
Gusar foothill lowlands	30–97	21,654	up to 609
Nakhchivan	40–53	3,000	126–290
Talysh	31–64	14,405	605–778
Lyankaran	42–84	7,908	399–1,129
<b>Total</b>		245,604	Up to 51·10 <sup>3</sup>

Source: Mukhtarov et al. (2015).

There are 1,100 rivers of different lengths in Azerbaijan (Caspian Information Centre 2013), so there is great potential for hydropower, which is the most widely used and most

<sup>1</sup> A unit of currency equivalent to a hundredth of an Azerbaijani Manat.

developed RES in Azerbaijan. A hydropower plant was built in 1883 in Galakend village of Gedebei region to provide electricity for the copper melting factory there, as well as local people. The full potential of hydropower remains underexploited. The capacity of hydroelectric plants in Azerbaijan is approximately 1,106.4 MW/year, which is the highest capacity in comparison to other RES types. The capacities of the existing hydropower plants in Azerbaijan are shown in Table 3. Mingachevir Hydropower Plant (HP) is the oldest hydropower station with the highest capacity; built in 1955, its power has increased from 284 MW to 424 MW after renovations in the 2000s.

**Table 3: Hydropower Plants of Azerbaijan**

<b>Hydropower Plants</b>	<b>Small Hydropower Plants (SHP)</b>
Mingachevir HP – 424 MW	Goychay SHP – 3.1 MW
Shemkir HP – 380 MW	Ismaili – 1 SHP – 1.6 MW
Yenikend HP – 150 MW	Ismaili – 2 SHP – 1.6 MW
Fuzuli HP – 25 MW	Balakan – 1 SHP – 1.5 MW
Tahtakopru HP – 25 MW	Kusar SHP – 1.0 MW
Shemkirchay HP – 25 MW	Astara – 1 SHP – 1.7 MW
Varvara HP – 18 MW	
<b>Nakhichevan AR</b>	
Aras HP – 22 MW	Vayhir SHP – 5 MW
Bilev HP – 22 MW	
Arpacay – 1 HP – 20,5 MW	
Arpacay – 2 HP – 1.4 MW	
Ordubad HP – 36 MW	

Source: Azerenerji ASC, <http://www.azerenerji.gov.az/index/page/13>.

There are two hybrid power plants in Azerbaijan. The first is Gobustan Experimental Polygon and Training Center with a total capacity of 5.5 MW including WPP (2.7 MW), SPP (1.8 MW), and a Biogas Power Plant (1MW). The second is the Samukh Agro-Energy Residential Complex, with a total capacity of 31 MW electric and 48 MW thermal energy. Samukh SPP is part of this complex.

**Table 4: Azerbaijan's RES Plants Capacities**

<b>Capacity</b>	<b>Proven</b>	<b>Metrics</b>
Hydroelectric Plants Capacity	1,106.4	MW/year
Wind Plant Capacity	15.7	MW/year
Solid Domestic Waste Plants Capacity	42.0	MW/year
Biogas Electric Plants Capacity	1.0	MW/year
Solar Plants Capacity	28.4	MW/year

Source: SSCRA, [https://www.stat.gov.az/source/balance\\_fuel/?lang=en](https://www.stat.gov.az/source/balance_fuel/?lang=en).

Table 4 shows the total capacities of Azerbaijan's existing RES plants. Table 5 shows the main energy indicators for the country and the share of RES in total energy production, consumption, and the share of electricity generated from RES and share of total RES supply.

**Table 5: Main Energy Indicators for Azerbaijan and Share of RES**

Indicators	2010	2011	2012	2013
Total energy supply (TTOE <sup>a</sup> )	12,566.5	13,594.9	14,390.0	14,630.6
Primary production of all energy products (TTOE)	68,254.6	62,541.5	60,973.9	61,699.5
Share of RES in primary production of all energy products	386.5	326.9	254.3	285.7
Energy final consumption (TTOE)	7,247.6	7,910.1	8,125.2	8,549.6
Share of electricity generated from RES in total production of electricity. %	18.4	13.2	7.9	7.0
Share of total RES supply in total energy consumption. %	3.1	2.4	1.8	2.0
Indicators	2014	2015	2016	2017
Total energy supply (TTOE <sup>a</sup> )	15,085.5	15,569.4	15,393.5	15,471.9
Primary production of all energy products (TTOE)	61,132.0	61,084.2	59,977.6	57,036.0
Share of RES in primary production of all energy products	271.0	301.4	273.2	258.0
Energy final consumption (TTOE)	8,992.9	9,108.0	9,424.6	9,265.5
Share of electricity generated from RES in total production of electricity. %	6.0	7.4	8.8	8.1
Share of total RES supply in total energy consumption. %	1.8	1.9	1.8	1.7

<sup>a</sup> Thousand tonnes of oil equivalent.

Source: Author's own elaboration based on SSCRA Energy 2019 data.

**Table 6: Production of Electricity (million kWt/hour)**

Years	Production of Electricity	Hydroelectric Power Plants	Wind Power Station	Solar (Photovoltaic) Station	Electricity Generated from Wastes Incineration	Electricity Generated from Biomass Incineration
2010	18,710	3,446	0.5	—	—	—
2011	20,294	2,676	—	—	—	—
2012	22,988	1,821	—	—	—	—
2013	23,354.4	1,489.1	0.8	0.8	134.1	—
2014	24,727.7	1,299.7	2.3	2.9	173.5	—
2015	24,688.4	1,637.5	4.6	4.6	181.8	0.0
2016	24,952.9	1,959.3	22.8	35.3	174.5	0.0
2017	24,320.9	1,746.4	22.1	37.2	170.3	0.0

Source: SSCRA, [https://www.stat.gov.az/source/balance\\_fuel/?lang=en](https://www.stat.gov.az/source/balance_fuel/?lang=en).

**Table 7: Renewable Energy Supply by Types (TTOE)**

Indicators	2010	2011	2012	2013	2014	2015	2016	2017
Renewable energy supply in total	386.5	326.9	254.3	285.7	271.0	301.4	273.2	258.0
Hydropower	296.4	230.1	156.6	128.1	111.8	140.8	168.5	150.2
Biomass and waste	90.2	96.6	98.4	157.1	158.9	160.7	100.8	102.4



Wind power	—	—	—	0.1	0.2	0.4	2.0	1.9
Solar (photovoltaic) Power	—	—	—	0.1	0.2	0.4	3.0	3.2

Source: Author's own elaboration based on SSCRA Energy 2019 data.

Table 6 and Table 7 show the data for the production and share of RES by type in the total energy production of the country. The reason for the decreased shares of RES in total electricity production after 2011 was the establishment of new heat power stations (HPS) using fossil fuels. For example, the Janub HPS was opened in 2013 with a 780 MW capacity. Its capacity is more than half of the total capacity of existing HPs and SHPs (including in Nakhichevan AR; see Table 3), which is 1,174.4 MW. Total electricity production has increased due to these plants, so the share of electricity generated from RES in total electricity production accordingly decreased.

In light of the existing outlook for RES in Azerbaijan, the strategic goal of the country for the future is to increase the share of RES in total energy production, to diversify its energy portfolio, and, as a result of these actions, to supply the remaining natural gas to Europe. Table 8 shows the current status of RES and the Strategic Road Map goals in determined capacities up to 2030.

**Table 8: Power Installation up to 2030**

RES Type	2018	2020	2025	2030
Wind PP	311 MW	350 MW	440 MW	465 MW
Solar PP	35 MW	50 MW	150 MW	190 MW
Hydro PP	—	10 MW	220 MW	220 MW
Bioenergy PP	37 MW	20 MW	30 MW	50 MW
<b>Total (MW)</b>	<b>383 MW</b>	<b>430 MW</b>	<b>840 MW</b>	<b>925 MW</b>
<b>Total (RES %)</b>	<b>8.1%</b>	<b>20%</b>	<b>25%–30%</b>	<b>35%–40%</b>

Source: IREA, <https://irena.org/-/media/Files/IRENA/Agency/Events/2018/May/Azerbaijan-RRA-workshop/2--Mr-Jabir-Yusifov-SAARES--Overview-of-the-energy-sector-and-renewa.pdf?la=en&hash=EF0FFCB2B8F1CB61B92F5528C5A22B54E1B0D16C>.

Considering that RES is relatively new and unconventional sector in Azerbaijan, the country has nonetheless made significant progress. Importantly, the government has clearly expressed a political will for the development of RES. There are still some challenges facing RES development in Azerbaijan. First are the legal challenges for both production and usage of RES. Fundamental laws should be enacted to draw legal framework. Investments in RES in Azerbaijan are mainly made by the government and international organizations, and a draft law is still under discussion. Significant technical, legal, and regulatory infrastructure is far from satisfactory for the business environment. Existing conditions make it unfavorable for private bodies to invest and do not guarantee effectiveness. Similarly, optimal regulations for the promotion of the RES sector—such as production, transfer, distribution, and delivery of energy—should be established.

Second are the technical challenges primarily related to technology transfer. RES technologies are expensive investments and, considering that Azerbaijan imports them from other countries, technical procedures need to be facilitated and simplified. Azerbaijan's electricity has long been dominated by oil and natural gas. The country is experienced in such methods, so these are well developed and substantially known. This situation, particularly the well-established nature of oil and gas related technologies, poses a serious disadvantage for RES.

A lack of financial resources and high interest rates also create financial challenges, which are the third important obstacle. Azerbaijan's economy was seriously affected by the fall in oil prices beginning from mid-2014. The effects of economic constriction were strongly perceived in the RES sector, as almost all RES projects were completed before the oil crisis.

The fourth challenge is low awareness. There is a lack of support from international organizations and local authorities to increase public awareness about RES in Azerbaijan. During the literature search for the current paper, it appeared that most research studies and projects focusing on the development of RES and awareness raising about RES in Azerbaijan were made between 2009 and 2015 both by national and international organizations. Consequently, the achievement of a relatively stable economic order following the unexpected oil price shock has created an environment for the revitalization of the development of RES in Azerbaijan. As a result of recent government announcements about a restructuring legal basis to develop the use of RES in the country, BP and ME signed "a Memorandum of Understanding" at the end of December 2018 (Azernews 2019). BP has played a significant role in Azerbaijan's energy sector for a long time, so the signed memorandum can be accepted as a precursor to significant revivals of the country's RES policies and actions. SAARES is working on 23 projects with a total budget of 13 million Azerbaijani manat within the context of the Strategic Road Map 2018–2020 to improve public services. The projects seek to construct wind, water, and biofuel power plants at a 420 MW capacity. WPP capacity is 350 MW, SPP are designed for 50 MW, and biofuel power plants are planned at 20 MW. SAARES has also been negotiating with several foreign investors to provide financing for WPPs in the Caspian Sea that will increase the renewable energy supply (Azernews 2019). The country's aim is to develop RES by attracting private sector investment and forming a legal framework that can stimulate the private sector. For this purpose, negotiations are ongoing with companies, international organizations, and financial institutions interested in investment in the RES sector in Azerbaijan to discuss suggestions about the drafts law, as the laws that will be accepted will determine the future development of RES in Azerbaijan.

## 5. CONCLUSION

Azerbaijan is known as an oil country and one of the traditional world hydrocarbon producers. While some hydropower stations have been established, there was no state policy for the development of RES until the 2000s. Environmental protection and natural resources issues have, however, attracted attention in recent years. Azerbaijan aims to gain economic growth in accordance with the UN's sustainable development goals and is looking to generate 20% of its electricity from renewable sources by 2020. Although RES is a new policy area for Azerbaijan, significant progress has been made in the short time since the first laws created an early legal framework for the development of RES in the country at the end of the 1990s. The State Program on the use of alternative and RES can be considered a new step in Azerbaijan's energy policy towards the use of RES. The establishment of SAARES and the coordination of related actions under a centralized institution have shown positive effects in a short period of time. The share of RES in Azerbaijan's total electricity production has reached 8.1% as of 2018.

Azerbaijan applies tax incentives to support the use of RES. Receiving investment promotion documents in accordance with the procedure established by the relevant executive authority, legal entities and individual entrepreneurs are free from paying import customs duties and VAT for technical equipment and facilities for a period of seven years from the date of receipt of the mentioned document. They are also free from

paying taxes for 50% of their total income, 50% of their total profit, property tax, and land tax.

The planned steps have increased the use of RES in Azerbaijan, as well as improving the technology used in this field. The Azguntex Solar Panels Plant with a 50 MW annual production capacity and the Solar Collector Factory were established in Sumgait Technology Park. Despite all these steps, the expensive investments in RES have mainly been made by the state, and the capacities of the country's RES and the share of total RES electricity production is lower than expected. The lack of development of the renewable energy sector in Azerbaijan is similar to the rest of the world, and is mainly due to low interest from the private sector in long-term investment. The main reason that the private sector is not interested in entering the long-term financing of infrastructure projects, including green energy projects, is the low rate of return and the associated risks (Yoshino, Taghizadeh-Hesary, and Nakahigashi 2019).

If Azerbaijan plans to achieve the UN's sustainable development goals and the Paris agreement goals, it needs to scale up the financing of investments that provide environmental benefits through new financial instruments and new policies, such as green bonds, green banks, carbon market instruments, fiscal policy, green central banking, fintech, community-based green funds, and other measures collectively known as "green finance" (Sachs et al. 2019).

Given that the geographic conditions of Azerbaijan create favorable conditions for the progress of the renewable energy sector, there is important RES potential in the country. The fall of oil prices has limited the amount of state investment and operation in RES. This situation has shown that it is unsustainable to develop the RES sector only with public capital and involvement. The sector must be developed with private investments, and the government must create attractive conditions for investors under competitive market opportunities. The recent technical potential of RES in Azerbaijan is estimated to be approximately 130,000 MW/year. To achieve the goal of 20% RES use by 2020 and future objectives in subsequent periods, the legal, financial, and technical challenges must be removed rapidly and awareness of the RES sector must be increased. This will be helpful in reaching the full capacities of RES in Azerbaijan. There is no other realistic way to increase the rate of RES usage from 8.1% in 2018 to 20% in 2020.

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