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PROMOTING SUSTAINABILITY IN AZERBAIJAN'S ENERGY SECTOR: A GREEN POLICY EVALUATION AND FUTURE OUTLOOK

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Abstract. This paper provides an analysis of the current status, policies, and future prospects of Azerbaijan's green energy sector. Azerbaijan accounts for a mere 0.15% of global greenhouse gas (GHG) emissions, with the majority of CO_2 emissions resulting from energy production activities, as is the case worldwide. The energy sector is a vital component of the economy, and energy supply and security are critical issues for modern states. As a significant energy producer and exporter, Azerbaijan recognizes the importance of these issues. They are incorporated into its strategic road maps to ensure long-term energy security, sustainability, and economic growth. In order to achieve a sustainable future, Azerbaijan must transition to green strategies, particularly given the dominance of natural gas and liquid fuel in the country's energy supply. Over the last decade, Azerbaijan has launched practical initiatives to transform its energy resources, which have the potential to revolutionize the sector. Proposed projects aimed at increasing the share of renewable energy sources, improving energy efficiency, promoting sustainable transportation, and reducing carbon emissions demonstrate promising prospects for a green energy future in Azerbaijan.

Keywords: *Green economics, energy, renewable energy sources, sustainability, energy policies of Azerbaijan.*

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1. Introduction

The abundant oil and gas reserves of Azerbaijan have been a crucial driver of its economy and position in the global energy market. The production and export of these resources have significantly contributed to the country's GDP and government revenue. The energy sector of Azerbaijan has a long-standing history dating back to the late 19th century when the Nobel brothers established the first power plant with a capacity of 550 kW in Baku in 1897. Over the years, Azerbaijan has become the primary energy producer in the region, with hydrocarbons, mainly oil and natural gas, dominating the country's energy mix.

Azerbaijan's energy supply is currently heavily reliant on fuel-fired power plants, with thermal power plants contributing the majority of electricity production. In 2022, the total electricity production in the country was 29,004.3 million kWh, out of which 27,059.1 million kWh came from thermal power plants, 1,595.7 million kWh from hydro power plants, and 349.5 million kWh from other renewable sources (Minenergy, 2023). Coal and oil-based power plants are widely considered as the most undesirable sources of energy for transitioning towards a green economy, mainly due to their high carbon intensity. Coal, for instance, has a carbon intensity of approximately 1,000g CO2/kWh, while oil has a carbon intensity of 800g CO2/kWh, and natural gas has a carbon intensity

of about 500g CO2/kWh. In contrast, renewable energy sources such as nuclear, hydro, wind, and solar have much lower carbon intensities, with less than 50g CO2/kWh (Lindsay, 2013). Globally, the combustion of fossil fuels results in carbon dioxide (CO2) emissions totaling around 34 billion tonnes (Gt) annually, with coal accounting for approximately 45% of this, oil for about 35%, and gas for approximately 20% (World-Nuclear, 2022). To provide an instance, coal contributed to around 12% of the United States' energy consumption and accounted for approximately 21% of the overall yearly CO2 emissions resulting from energy-related activities (EIA, 2022). Solid fuels are not utilized for energy production in Azerbaijan, and in 2021, natural gas was the primary fuel source for 69% of the country's electricity generation (Stat, 2022).

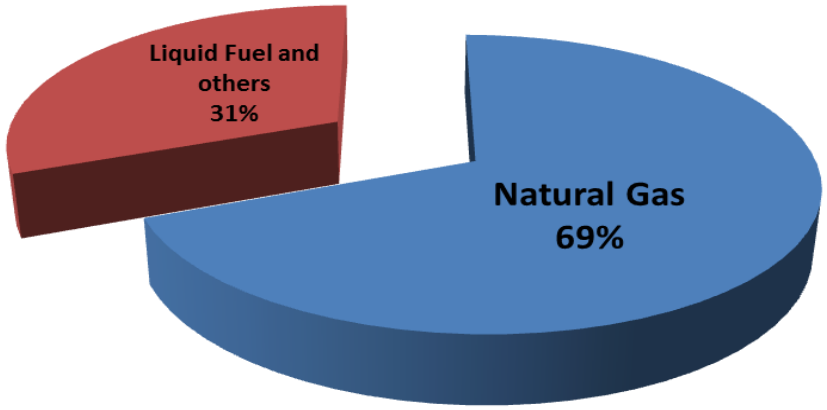

Figure 1. Specific weight of fuel types in energy supply of Azerbaijan in percentage (2021)

Azerbaijan's energy sector can be considered relatively environmentally friendly, particularly when compared to other countries that rely heavily on coal-based power plants. As such, the country's power plants using natural gas and nuclear energy, as well as alternative energy sources, have been deemed acceptable according to the latest green standards (Abnett, 2022). The above statement highlights the increasing priority given to renewable resources over natural gas, which is considered a relatively cleaner energy source compared to other fossil fuels. Despite natural gas producing fewer greenhouse gas emissions, it still contributes to climate change, leading to the shift towards renewable resources such as solar, wind, and hydropower that have gained global momentum. This transition is attributed to various factors, including technological advancements that make renewable energy sources more affordable and accessible, and growing awareness of the environmental and social impacts of fossil fuel use. Azerbaijan has vast renewable energy resources such as wind, solar, geothermal, and hydropower that can be utilized to reduce carbon footprint, improve air quality, and support sustainable economic development. Investing in renewable energy infrastructure and reducing reliance on fossil fuels can generate economic benefits such as creating new jobs, increased energy security, and a more sustainable and resilient economy.

2. Methodology

This study was conducted using a qualitative research methodology to explore the green opportunities available in Azerbaijan's energy sector, while also gaining insights into the sector's sustainability, with a specific focus on its green perspective. The research

involved a thorough investigation of the current state of the sector and ongoing projects in the field, which provided valuable information on the principles of sustainability. The methodology utilized in this article entailed analyzing data from primary sources, including reports, books, and academic journals, to complement and validate the information collected during the research. By combining data from multiple sources, the research team was able to triangulate their findings and ensure the accuracy and reliability of their conclusions. This study offers a comprehensive and nuanced analysis of the sustainability of Azerbaijan's energy sector, thereby making a significant contribution to the existing body of knowledge on this crucial topic.

To conduct a thorough analysis of Azerbaijan's energy sector, it is necessary to consult with the primary authorities responsible for the country's energy issues. The Ministry of Energy of the Republic of Azerbaijan (minenergy.gov.az) and the State Statistics Committee (stat.gov.az) are the two main government institutions to obtain data. The Azerenerji (azerenerji.gov.az) and Azerishiq (azerishiq.az) platforms are valuable sources of information on electricity supply and consumption in Azerbaijan. To gather information on green energy sector and upcoming projects in Azerbaijan, the newly established State Agency for Renewable Energy Sources under the Ministry of Energy of the Republic of Azerbaijan (area.gov.az) is a credible source. The agency is responsible for promoting and developing renewable energy sources in Azerbaijan and supervising the execution of related projects. In addition, the statements of official spheres can provide essential sources of information.

Numerous scholars have produced scientific literature on Azerbaijan's green energy sector, consistent with the prevailing global trend towards sustainable energy. The book authored by Gasimli et al. (2022) is a highly valuable piece of work that offers a detailed analysis of Azerbaijan's green economy. The book provides a comprehensive examination of the country's efforts to promote sustainable development, with a particular focus on its green initiatives. The academic article authored by Vidadili et al. (2017) provided a scholarly discourse on Azerbaijan's transition to sustainable energy and renewable resources. The scholars underscore the imperative of mitigating Azerbaijan's excessive reliance on non-renewable energy sources and propose the adoption of alternative sources, including solar, wind, and hydropower, as crucial steps towards sustainable energy development. Mustafayev et al. (2022) offer a comprehensive analysis of the current state of renewable energy in Azerbaijan, with a specific focus on the potential for future development of solar and wind energy. Hamidova et al. (2022) scrutinize the challenges that Azerbaijan confronts when attempting to implement renewable energy sources. Rzayeva et al. (2021) analyze the natural and economic effects of renewable energy sources in Azerbaijan, which is classified as a developing country. Other than these, Mukhtarov et al. (2017) conduct an academic inquiry into the correlation between energy consumption and economic growth in Azerbaijan.

3. Research Findings

Azerbaijan has a significant potential for renewable energy sources, which is among the highest of any country. The country's total power generation capacity is 7542.2 MW, with renewable energy sources accounting for 1304.5 MW, or 17.3% of the total capacity, including large hydroelectric power plants. However, Azerbaijan's potential for renewable energy sources is much greater, with a total untapped potential of 27,000 MW,

including 3,000 MW of wind energy, 23,000 MW of solar energy, 380 MW of bioenergy potential, and 520 MW of mountain river potential (Minenergy, 2022).

In the realm of alternative energy, hydropower plants are currently the dominant sources of energy production in Azerbaijan, accounting for approximately 6% of the country's total energy output in 2022. The two largest hydropower plants in Azerbaijan are the Mingachevir HPP, which has a capacity of 424 MW, and the Shamkir HPP, which has a capacity of 380 MW, and both of which are located on the Kura River. These plants play a significant role in the country's energy mix and contribute to reducing Azerbaijan's reliance on non-renewable energy sources. The total potential capacity of HPPs in Azerbaijan is over 1150 MW.

Hydroelectric Power Stations in Azerbaijan (2022)

1. Mingachevir	424 MW	16. Sugovushan-2	3 MW
2. Shamkir	380 MW	17. Chichakly	3 MW
3. Yenikend	150 MW	18. Ismailli-1	1.6 MW
4. Fuzuli	25 MW	19. Ismailli-2	1.6 MW
5. Tachtakorpu	24 MW	20. Balaken	1.5 MW
6. Shamkirchay	24 MW	21. Arpachay-2	1.4 MW
7. Araz	22 MW	22. Oghuz-1	1.3 MW
8. Bilav	22 MW	23. Oghuz-2	1.3 MW
9. Arpachay	20.5 MW	24. Sheki-1	1.3 MW
10. Varvara	17 MW	25. Qusar-1	1 MW
11. Gulabird	8 MW	26. Oghuz-3	0.9 MW
12. Vaychir	5 MW	27. Nugadi	0.83 MW
13. Sugovushan-1	4.8 MW	28. Sheki-2	0.6 MW
14. Mughan	4 MW	29. Masalli	0.3 MW
15. Goychay	3.1 MW	30. Astara	0.26 MW

Total 1155 MW

Figure 2. All hydroelectric plants and existing potentials. Data source: www.area.gov.az

HPPs with a capacity of less than 10 MW can be considered “small hydropower plants”. The construction of hydroelectric power stations in the small mountain rivers of Azerbaijan is providing local energy security, and there are plans to create more of such stations in the future. The use of small hydropower plants has been recognized as an effective means of providing electricity and promoting sustainability in rural and inland regions.

The plan is to construct hydroelectric power stations in the recently liberated Karabakh region and its surroundings in Azerbaijan. One of the upcoming projects is the building of the “Khudafarin” and “Giz Galasi” hydroelectric power stations with a combined capacity of 140 MW on the Araz River in the Jabrayil region, which will be operational soon. Azerbaijan has the potential to develop a variety of renewable energy sources beyond traditional hydropower. The country has promising prospects for the majority of types of sustainable energy. The utilization of renewable energy sources is a crucial topic in Azerbaijan, as it holds enormous potential for various types of energy generation. Solar energy is a promising alternative in flat regions with high sunlight exposure throughout the year. Wind energy can be effectively produced by installing turbines in and around Baku, which is commonly referred to as the City of Winds. Bioenergy can be sourced from industrial and household waste or from unusable biomass found in nature. The installation of devices on the shores of the Caspian Sea presents a viable option for wave energy. Geothermal energy can be generated from active

geothermal areas in the Karabakh zone, Kalbajar, and Lachin territories. These potential renewable energy sources offer opportunities for sustainable energy development in Azerbaijan.

The region of Nakhchivan, in Azerbaijan, is an ideal location for harnessing solar energy, as it receives the highest solar radiation in the country. Other suitable areas for solar energy are the Aran and Eastern Zangezur regions. Meanwhile, there is potential for wind energy in newly explored areas in the Karabakh zone. It is worth noting that there is a great potential for renewable energy sources in the recently liberated areas of Azerbaijan, particularly with solar, wind, and geothermal energy sources. It is estimated that the total potential capacity of these sources could reach up to 10,000 MW.

The implementation of the "State Program on the Use of Alternative and Renewable Energy Sources in the Republic of Azerbaijan" in 2004 marked a crucial milestone in the utilization of renewable energy resources in the country (E-qanun, 2004). This program proposed an action plan to establish green energy infrastructure in Azerbaijan (Eco, 2004). In recent years, the country has made significant progress towards achieving this goal, with the establishment of three new green energy fields since 2013. These fields have been successfully operating, contributing to the country's efforts to promote sustainable energy sources.

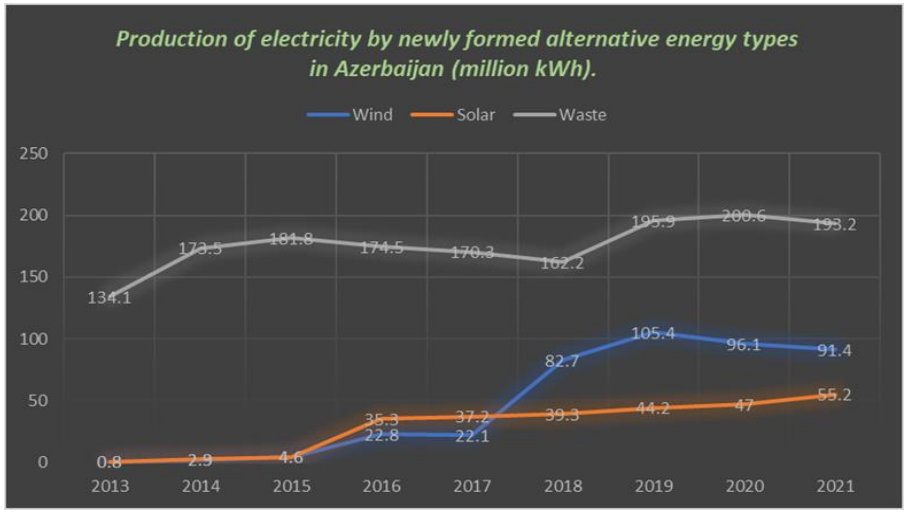

Figure 3. Newborn green energy fields in Azerbaijan.
Data source: State Statistics Committee of the Republic of Azerbaijan

As society progresses towards more ecologically conscious and sustainable energy sources, it is imperative to evaluate the potential capacity for installed renewable electricity. According to UNDP Renewable Energy Snapshot (2014) Azerbaijan boasts a noteworthy technical potential for renewable electricity capacity. This includes an impressive potential for installed solar PV capacity, which stands at a staggering 115,200 MW. This significant figure demonstrates the ample solar resources that can be utilized in the region. Furthermore, Azerbaijan has the potential to generate up to 4,500 MW of installed wind capacity, highlighting the opportunity to exploit wind resources in coastal areas. The research also estimates that Azerbaijan's technical potential for installed biomass capacity is around 1,500 MW.

Wind and Solar Power Stations in Azerbaijan (2022)

1.	Yeni Yashma	50 MW	
2.	Hokmali	8 MW	
3.	Yashma Baghlari	3.6 MW	
4.	Gobustan	2.7 MW	
5.	Shurabad	1.7 MW	
6.	Culfa	0.11 MW	

Total Wind Energy: 66 MW

Total Solar Energy: 45 MW

1.	Babak	22 MW
2.	Kangarli	5 MW
3.	Sharur	5 MW
4.	Gobustan	2.9 MW
5.	Samux	2.8 MW
6.	Sumgayit	2 MW
7.	Sahil	1.9 MW
8.	Suraxani	1.6 MW
9.	Pirallahi	1.1 MW
10.	Culfa	1 MW

Figure 4. Renewable energy plants and existing energy potentials. Data source: www.area.gov.az

Azerbaijan is aligned with global energy policies that promote sustainable progress. The Republic of Azerbaijan has pledged to the Convention Secretariat its Nationally Determined Contributions in accordance with the Paris Agreement ratified during the 21st Conference of the Parties on December 12, 2015. To combat the detrimental consequences of global climate change, Azerbaijan has committed itself to a goal of reducing its greenhouse gas emissions by 35% by 2030, based on the emissions levels in 1990 (EU4Climate, 2022). In November 2021, at the COP26 Conference held in Glasgow, Azerbaijan committed to reducing emissions by 40% by 2050 and creating a "net zero emission" zone in territories that have been liberated from occupation (SOCAR, 2021). The primary goal by 2030 is to raise the proportion of renewable energy in the country's total energy mix to 30%. To achieve this, a total of 1,500 MW of new generation capacity will be developed, exclusively using renewable energy sources. This new capacity will be composed of 440 MW by 2023, 460 MW between 2023-2025, and 600 MW from 2026-2030 (Hasanov, 2023). On December 29, 2020, an agreement was signed between the Ministry of Energy, "Azerenergy" Joint Stock Company, and the "ACWA Power" company of the Kingdom of Saudi Arabia to build a wind power plant with a 240 MW installed capacity. The agreement consisted of three components: "Investment Agreement", "Energy Purchase Agreement", and "Transmission Network Connection Agreement". The "ACWA Power" company is presently executing a 240 MW wind farm project in Azerbaijan, which is part of a large-scale green energy initiative established through mutual cooperation. Upon completion, the project is projected to generate about one billion kilowatt-hours of electricity each year, conserve around 220 million cubic meters of natural gas, and decrease carbon emissions by over 400,000 tons per year (ACWA, 2023). On April 6, 2021, the Ministry of Energy, "Azerenergy" OJSC, and the "Masdar" company of the United Arab Emirates signed an "Investment Agreement," "Energy Purchase Agreement," and "Transmission Network Connection Agreement" for the 230 MW solar power plant project (Wood, 2022). According to Area (2023), there are four additional large green energy projects underway in Azerbaijan that are worth mentioning:

– "Khizi-Absheron" Wind Power Plant - 240 MW.
– "Karadagh" Solar Power Station - 230 MW.
– "Shafaq" Solar Power Station.

– “Khudafarin” and “Giz Galasi” Hydroelectric Power Stations.

It is conceivable that in the foreseeable or remote future, the aforementioned initiatives may elevate the proportion of renewable energy sources in Azerbaijan's energy equilibrium.

4. Conclusion

Azerbaijan, historically renowned for its oil and gas industry, has recently developed new green strategies to promote a sustainable future. The country's green energy sector was initially established based on hydroelectric power plants, but it has since expanded to include a range of renewable sources. This study assesses Azerbaijan's current energy system from a green perspective and presents important findings. The analysis demonstrates that while over 80% of energy is still obtained from water, Azerbaijan is rapidly shifting towards alternative energy sources. In the fight against global climate change, Azerbaijan has made important commitments and created a roadmap for a sustainable future using innovative strategies. The research results indicate that the potential for green energy production will play a crucial role in achieving economic and environmental efficiency in Azerbaijan's future.

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