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Repositioning oil exporters for the Green Energy Transition: the case of Azerbaijan

Abstract: Azerbaijan is currently an exporter of oil and gas, but its goal is to sustain its status as an energy exporter by investing in green energy projects for the future. The aim of this paper is to establish a conceptual framework that explores how Azerbaijan, an oil-rich country, can transform into a green energy exporter. This study compares various green energy export scenarios.

Findings show that (1) transitioning from fossil fuel exports to green energy generally reduces exporter vulnerability and enhances domestic energy security, despite increasing exposure to international market forces; (2) Azerbaijan could increase its green energy exports to comprise as much as 14% of its exports in the coming years; (3) through these green energy initiatives, Azerbaijan can sustain its role as an energy exporter well beyond 2050; (4) the results of the I-O model show that achieving green energy export targets could lead to a 6.7% increase in Azerbaijan's total output; (5) this shift would also play a crucial role in diversifying the country's export base and formation of net-zero energy systems; (6) it would allow Europe to diversify its energy supply and reduce its dependence on a single country. By combining two different

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approaches, Azerbaijan has the potential to transition its exports from oil and gas to green energy, thereby positioning itself as a model for other oil-rich nations pursuing sustainable energy development.

Keywords: green energy exporter, energy security, net-zero energy systems, wind energy, solar energy

Introduction

The Republic of Azerbaijan has established a goal: that of becoming an exporter of green energy, an achievement that is difficult for many countries rich in oil and gas. However, work is underway to achieve it. Note that this goal was not determined haphazardly, given other large energy projects it implemented since becoming independent. Beginning in its first years of independence, Azerbaijan invited international oil companies to its sector of the Caspian Sea, and, in 1994, concluded the "Deal of the Century" to bring about a major increase in oil production and exports. Its oil production was 9.6 million tons in 1994, but reached 50.8 million tons in 2010 (SSC 2025), gradually decreasing in the following years to 29,1 million tons in 2024 (See appendix). During the period when oil production was decreasing, natural gas production increased and reached 50.3 billion cubic meters in 2024, compared to 26.3 billion cubic meters in 2010 (SSC 2025).

The increase in oil and gas production has also affected the structure of exports in Azerbaijan; in 1994, petroleum products accounted for 35.5 percent of exports, and, in 2024, oil and gas exports amounted to 87 percent of total exports. Although the share of oil in Azerbaijan's exports has decreased in recent years, this gap has been filled by exports of gas. While gas exports were 1.7 billion cubic meters in 2003, they were 25.2 billion cubic meters in 2024. Of this, 12.9 billion cubic meters went to Europe, 9.9 billion cubic meters to Turkey, and 2.4 billion cubic meters to Georgia (MoE 2025a). While Azerbaijan supplied Europe with 8 billion cubic meters of gas in 2021, this amount increased to 12.9 billion cubic meters in 2024 and is projected to reach 20 billion cubic meters in 2027.

Azerbaijan generates 0.7% of global oil production and 0.9% of global gas production. However, increasing non-oil and gas exports is important for Azerbaijan. Therefore, Azerbaijan has begun to implement a number of major projects to become a green energy exporter and has included the use of wind and solar energy potential in its export targets for the near future. The WEF (2023) report indicates that Azerbaijan has significant potential for an effective energy transition. The country's green energy sector was initially based on hydroelectric power plants, but later expanded to include a number of renewable sources (Hasanov 2023). Although small hydroelectric power plants continue to be built, efforts are currently focused mainly on the production of solar and wind energy. For example, Azerbaijan is implementing a project to increase renewable energy production to 5 GW by the end of 2030 (PoA 2024b). This will create the potential for Azerbaijan's green energy exports to Europe post-2030, utilizing the cable to be laid under the Black Sea. Since this green energy will be obtained from wind and solar power stations, this article does not evaluate Azerbaijan's potential from other renewable energy sources (hydropower, bioenergy, geothermal, etc.). This article also examines the challenges and opportunities for an oil and gas exporting country to become a green energy exporter. In addition, this paper analyzes the hypothesis of the possibility of green energy replacing oil and natural gas in exports. Its major objective is to develop a conceptual framework for becoming a large-scale green energy exporter within Azerbaijan's energy system.

Section 2 reviews the literature covering the research in the field. Methodology and data sources are covered in Section 3, whereas the next section discusses the results and findings. Conclusions are contained in Section 5, and Limitations and Future Research in Section 6.

1. Literature review

Articles on green energy exports have focused mainly on zero CO_2 hydrogen production and export. For example, Wang et al. (2023) and Curtis and McLellan (2023) examined the cost profile of different hydrogen carrier methods for export from Australia; Galván et al. (2022) discussed scenarios for green hydrogen exports from South America; and Burdack et al. (2023) from Colombia. Khan and Al-Ghamdi (2023) examined the potential benefits and challenges for hydrogen exports from Gulf Cooperation Council member states. Hjeij et al. (2023) researched hydrogen export competitiveness, focusing on top-ranking countries in the hydrogen market. Raouf (2023) analyzed a sample of 67 hydrogen-exporting nations during the period from 2000 to 2021.

Zholdayakova et al. (2022) and Tleubergenova et al. (2023) studied the establishment of the hydrogen economy in Kazakhstan. Zholdayakova et al. (2022) concluded that hydrogen transport and storage infrastructure for exports should be developed in the near future. For a landlocked country like Kazakhstan, nearby hydrogen markets are available via pipeline and rail. The financial burdens of infrastructure development for hydrogen export could be shared among interested stakeholders.

Tleubergenova et al. (2023) stressed that the export of green hydrogen to world hydrogen markets requires developing a new set of natural resources that fundamentally differ from those underpinning the current hydrocarbon economy.

Islam and Ali (2024) examined oil-rich Saudi Arabia's sustainable green energy transition, highlighting the country's ambition to become a global leader in clean hydrogen production and exports. Comparable studies on the United Arab Emirates reveal a similar trajectory (Said et al. 2018). In contrast, Azerbaijan distinguishes itself through its strategic focus on initiating green electricity exports in the near term, followed by the phased development and export of green hydrogen.

Although many articles examine the production of wind and solar energy, the same cannot be said about export. In fact, this is normal. Exporting wind and solar energy has received little attention so far, as it is seen as an expensive project. However, the increase in efficiency in producing wind and solar energy, as well as the decrease in cost (IEA 2024), has made the issue of export more urgent. In this regard, Gallardo et al. (2021) have provided a techno-economic analysis of the case for exporting low-cost solar electricity from the Atacama Desert region in Chile, and Downie (2022) has developed a sophisticated framework for the geopolitical leverage of states exporting renewable electricity.

The experience of Singapore, which plans to import green energy, is also interesting. Six countries – Australia, Cambodia, Indonesia, Laos, Malaysia, and Thailand – will export solar, wind, hydropower, and geothermal energy to Singapore. Singapore plans to import 1.0 GW of renewable energy yearly from Cambodia (via new undersea high-voltage transmission cables that can transmit the electricity over more than 1,000 km.) The Republic has a target of 4 GW of low-carbon electricity imports by 2035 (Tan 2023).

This confirms the gap that exists in work on the topic of wind and solar energy exports and the importance of this paper in explaining the need for developing a framework for domestic energy security through the implementation of large-scale green energy exports.

Azerbaijan's transition to green energy has garnered significant attention among researchers (Alakbarov 2024), with extensive studies conducted since 2010. Notably, Aydin (2019) explored the feasibility of Azerbaijan achieving its green energy objectives by 2020. Hajizadeh (2023) covered Azerbaijan's green energy strategy. In addition, research by Gasimli et al. (2024) thoroughly analyzed Azerbaijan's green energy potential, the prospects for its realization by 2030, and the subsequent social, economic, and ecological benefits of increasing green energy production. Additionally, the research conducted by Aliyev et al. (2024) has established a significant causal link between the consumption of renewable energy and economic growth in Azerbaijan. Furthermore, other scholars, like Hasanov (2023, 2024), emphasize that the potential for green energy production is pivotal for realizing economic and environmental efficiency in Azerbaijan's future. His research indicates that if the current trajectory continues, Azerbaijan's solar energy production will exceed 120 million kilowatt hours by 2030 (Hasanov 2023, 2024).

Rzayeva (2023) pointed out that exporting green energy could sustain Azerbaijan's status as a significant energy exporter beyond 2040. Moreover, this strategy could enable Azerbaijan to align its energy exports with the timeline by which many European countries aim to achieve their net-zero emissions targets (2050). Nuriyev and McFerren (2025) conducted a PESTEL and SWOT analysis of Azerbaijan's renewable energy sector, concluding that the country's experience illustrates how a clear strategic vision, robust policy support, and strong international partnerships can enable a successful transition from black to green energy.

However, the prospect of transforming Azerbaijan from an oil and gas exporter to a green energy exporter in a relatively short time frame is a novel topic, explored in depth for the first time in this study.

2. Data and methodology

2.1. Data

The data was obtained from the statistical data of the State Statistics Committee of Azerbaijan (SSC), in the Ministry of Energy of Azerbaijan. In particular, the Intersectoral Balance Tables for Production and Distribution of Products and Services of 2021 (SSC 2021) was used. Also, two focus groups in the Center for Analysis of Economic Reforms and Communication (the largest economic think tank in Azerbaijan) studied the problems of exporting green energy in 2024. In July 2025, the author participated in a three-week training program at the Gansu Natural Energy Research Institute (GNERI) / UNIDO Solar Energy Center in China. During this program, the author engaged in further discussions on the issues addressed in the article with green energy experts from ten countries. In addition, the reviewers' comments were reviewed in detail with experts, and appropriate revisions were incorporated into the manuscript.

2.2. Methods

a) **Calculating the expected value of green energy to be exported.**

Azerbaijan is planning two major projects for the exportation of green energy through the Caspian-Black Sea-European Green Energy Corridor (4 GW) and the Turkey-European Green Energy Corridor (1 GW). HVDC (High Voltage Direct Current) cable with an efficiency typically ranging from 90 to 95% will be utilized. HVDC power transmission losses can be less than 0.3% per 100 km – approximately 30% to 40% lower than comparable HVAC losses at the same voltage level – due to several technical advantages (Brunt 2025). Moreover, high-capacity (2–5 GW) long-distance HVDC systems, whether overhead, underground, or submarine, can efficiently transmit power both between and within synchronous grids and balancing areas (The Brattle Group & DNV 2023). However, we have applied a more conservative efficiency factor of 80% in our calculations to account for various factors, such as seasonal fluctuations and energy losses. This adjustment allows us to estimate the potential annual capacity of electricity exports using the 4 GW Caspian-Black Sea-European Green Energy Corridor.

- **Within a year:** 96 GWh · 365 days = 35,040 GWh or 35.04 TWh

  Taking into account 80% efficiency:

- 35.04 TWh · 0.80 = 28.032 TWh

The figures show that approximately 28.03 terawatt-hours (or 28 billion kilowatt-hours) of electricity can be exported annually through the Caspian-Black Sea-European Green Energy Corridor. Based on this calculation, an additional 7 billion kilowatt-hours of energy per year can be exported through the 1.0 GW Turkey-European Green Energy Corridor. The formula to calculate the annual energy export potential for 5 GW using HVDC cables is as follows:

$$\text{Exported energy (GWh)} = 1 \text{ Power (GW)} \cdot \text{Efficiency} \cdot \text{Time (hours)}/1$$

Here:
- Power: 5 GW
- Efficiency: 80% (i.e., 0.80)
- Time: 1 year = 365 days · 24 hours = 8,760 hours

The formula is as follows:

$$\text{Exported energy (GWh)} = 5 \cdot 0.80 \cdot 8760 = 35{,}040 \text{ GWh}$$

The estimate for the total amount of energy to be exported through both corridors in a year 35,040 GWh, or 35.04 billion kilowatt-hours (kWh). Considering that the wholesale price of electricity in Europe (especially in Romania) in 2024 has ranged between 0.10 and 0.15 euros per kWh (Statista 2025; Lazar 2025; Euenergy 2025), the wholesale value of 35 billion kilowatt-hours of electricity is at least 3.5 billion euros.

$$35{,}040{,}000{,}000 \text{ kWh} \cdot 0.10 \text{ €} = 3{,}504{,}000{,}000 \text{ €}$$

At the average exchange rate in 2024, 3.5 billion euros is approximately 6.5 billion manats (AZN). An input-output (I-O) model for Azerbaijan was built based on this figure.

b) **Input-output (I-O) model.**

Research has developed an input-output (I-O) model for the Azerbaijani economy. The export of goods and services is a key component of this output, so increasing the export of green energy will boost the total output of the corresponding economic sector. Naturally, this increase will impact not only the total output of that sector, but also, in a multiplicative manner, the output of all other sectors within the economy. These effects are analyzed through the input-output (I-O) model, a widely used tool in economic analysis. I-O models enable the evaluation of direct, indirect, and induced effects from occurrences in one or more sectors, allowing us to understand their impact on individual sectors as well as on the overall economy (Leontief 1990; Duchin 2004).

The intersectoral balance sheets for the production and distribution of products and services, which are provided by the State Statistics Committee, are organized into 96 categories. However, given the international components of I-O models, these are typically grouped into 19 broader economic activity areas (SNA 2008). To align with this practice, the intersectoral balance sheets for 2021 from the SSC have been reorganized into 19 economic activity areas, forming the foundation for the I-O model. Note that the SSC compiles these intersectoral balance sheets every five years (SSC 2021).

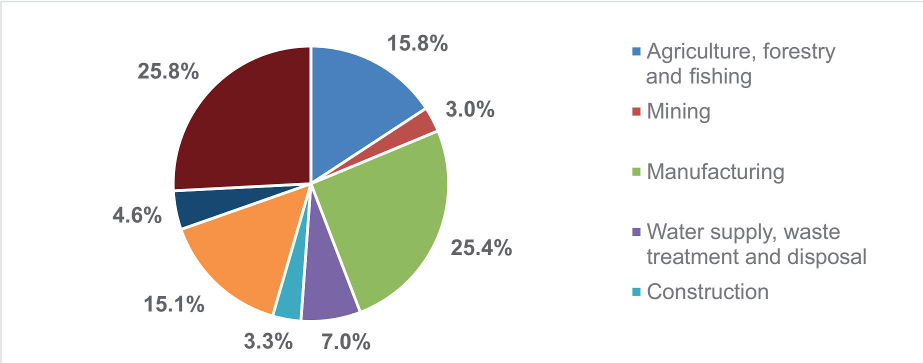


Fig. 1. Structure of intermediate consumption by economic activity sector: production, distribution and Supply of electricity, gas and steam (SSC 2021)

Rys. 1. Struktura zużycia pośredniego według sektorów działalności gospodarczej: wytwarzanie, dystrybucja i zaopatrywanie w energię elektryczną, gaz i parę wodną

Electricity production, consumption, and export are classified under the broader category of Production, Distribution, and Supply of Electricity, Gas, and Steam.

The primary components of the intermediate products in the Production, Distribution, and Supply of Electricity, Gas, and Steam sector are derived from the following economic activities: the Processing Industry (25.8%), Agriculture, Forestry, and Fishing (15.8%), and Trade and Vehicle Repair (15.1%).

3. Results and discussion

3.1. Green energy potential and production

Research efforts to evaluate Azerbaijan's onshore and offshore green energy potential have recently intensified. The country has established collaborations with numerous international organizations, such as the World Bank (2022), to advance knowledge in this area. The technical potential of Azerbaijan's sector of the Caspian Sea for wind energy is estimated at 157 GW (including 35 GW in shallow water basins and 122 GW in deep water basins) (World Bank 2022). At the same time, Azerbaijan's technical potential onshore is estimated at more than 135 GW. Azerbaijan expects to use this potential gradually by turning it into green energy (Fig. 2).

Onshore, Azerbaijan has an economic potential of 3 GW for wind energy and 23 GW for solar energy. Also, research by Ismayilov et al. (2025) has demonstrated that Azerbaijan's coastal

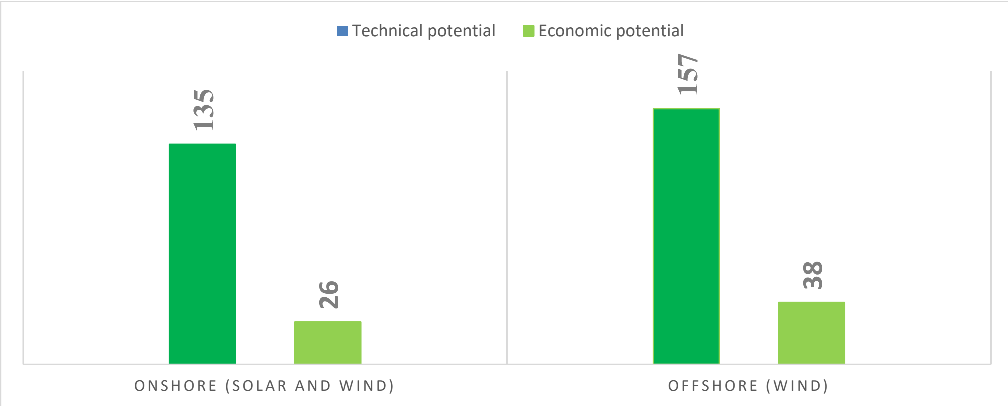


Fig. 2. Technical and economic potential of solar and wind energy of Azerbaijan [GW] (MoE 2024; World Bank 2022)

Rys. 2. Potencjał techniczny i ekonomiczny energii słonecznej i wiatrowej w Azerbejdżanie [GW]

regions, particularly Baku, Sumgait, and Gobustan, possess the highest wind energy potential in the country. The high Weibull scale parameters and favorable shape factors in these regions further confirm their suitability for wind energy exploitation. For example, Baku's average wind speed of 8.01 m/s and wind power density of 628.5 W/m^2 at 100 m above ground level (AGL) significantly exceed the 300 W/m^2 threshold required for large-scale wind energy development (Ismayilov et al. 2025).

To effectively harness this potential, the country has entered into agreements to implement projects totaling 6 GW with Masdar (United Arab Emirates), 10 GW with Fortescue Future Industries (FFI), and 1.5 GW with ACWA Power (Saudi Arabia). Azerbaijan has also established a successful energy partnership with BP (Great Britain), ADNOC, and China Gezhouba Group Overseas Investment to implement renewable energy projects. The total electricity generation capacity of Azerbaijan was 8,415.6 MW in 2024.

Table 1. Total power produced by the power system in Azerbaijan (2024)

Tabela 1. Całkowita energia wytworzona przez system energetyczny Azerbejdżanu (2024)

No	Type	Number	Power [MW]
1	Thermal power plant – TPPs	22	6,623
2	Hydropower plant – HPPs	58	1,406.6
3	Solar power plant – SPPs	9	278.1
4	Wind power plant – WPPs	5	63.7
5	Solid waste power plant	1	37
6	Hybrid power plant	3	7.3

Source: Shahbazov 2024.

Using 2024 as a base, the total capacity to generate power from renewable energy sources, including hydroelectric power plants, stands at 1,792.6 MW, representing 21% of overall energy generation capacity.

Masdar is involved in efforts to accelerate the transition to renewable energy; it has already laid the foundation for three large-scale renewable energy plants, with a total capacity of 1,000 MW. These include two solar power plants, with capacities of 315 MW and 445 MW, as well as one wind power plant with a capacity of 240 MW. The total investment for these projects is approximately $1 billion.

Azerbaijan estimates that the share of green energy in its electricity generation capacity will rise to 33% by 2027, and to 35% by 2031 (Shahbazov, 2024). To achieve this, there are plans for the construction of eight solar and wind power plants, with a combined capacity of 2 GW, by 2027.

3.2. Green energy corridors

The Republic of Azerbaijan is not only pursuing initiatives to increase green energy production, but also the establishment of green energy corridors, including the Caspian-Black Sea-Europe Green Energy Corridor, which involves laying a 4 GW cable beneath the Black Sea[1] (the development of this green corridor is anticipated to span three to five years and will require an investment of approximately 2 billion euros), and the Azerbaijan-Turkey-Europe corridor, designed to export one GW of renewable energy.

In July 2022, the EU and Azerbaijan signed a *Memorandum of Understanding on a Strategic Partnership in the Field of Energy*, which supports further cooperation in the field of energy efficiency and renewable energy sources.

Azerbaijan plans to export green energy through these corridors to Hungary and Romania in the initial phase, with plans to extend exports to Bulgaria and Serbia thereafter. In addition, the parties have agreed on the path for Bulgaria's accession to the *Intergovernmental Agreement* (MoE 2025c).

Azerbaijan is also discussing the possibility of connecting the Central Asian countries to this cable (Caspian Green Energy Corridor). Because investment projects related to renewable energy resources are increasing in Kazakhstan and Uzbekistan, after a period of time, there may

[1] The World Bank (2024) estimates indicate that the first phase of the Black Sea Submarine Cable (BSSC) Project – which constitutes the segment of this corridor between Georgia and Romania – is expected to cost between US$3.1 billion and US $3.7 billion. This phase involves the construction of the HVDC transmission line with a planned capacity of up to 1.3 GW. The proposed interconnection will extend approximately 1,155 kilometers, of which about 1,115 kilometers will consist of a submarine cable system reaching depths of up to 2,200 meters, making it one of the longest and deepest submarine cable systems in the world. In parallel, according to calculations by private companies, the development of the first phase of this green corridor is anticipated to span three to five years and will require an investment of approximately 2.3 billion euros (APA 2025).

be a surplus of electricity in these countries, and exporting it via Azerbaijan to Europe may be on the agenda.

In addition, a proposal to construct an energy cable across the Caspian Sea is under consideration. It would connect the energy markets of Kazakhstan and Uzbekistan with Azerbaijan; these nations are conducting preliminary discussions.

In parallel with the green energy production projects, the green cable project extending from the Caspian Sea to the Black Sea, and from there to Europe, is now in the final stage of its feasibility study. The cable under the Black Sea will connect the South Caucasus region with southeastern Europe, linking the electricity systems of these countries with those of continental Europe (Hajiyev 2024).

Plans are for a joint venture among the four countries operating transmission systems, which will play a significant role in rapidly implementing the project, which has its headquarters in Bucharest, the capital of Romania.

In addition to planning for electricity, discussions are also underway regarding the export of green hydrogen from Azerbaijan to Europe.

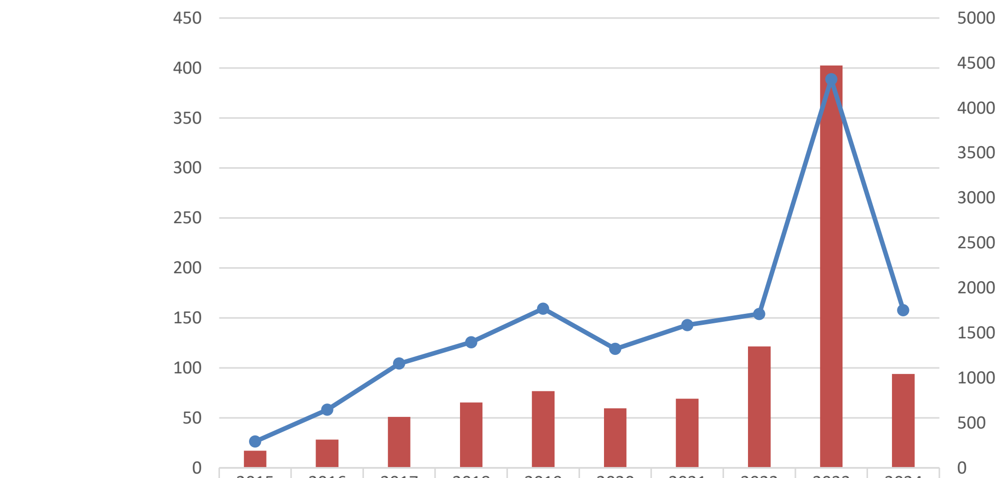
3.3. The impact of green energy projects on exports

In 2023, oil and gas accounted for 90% of Azerbaijan's exports; in 2024, this share is expected to be 87%. Forecasts suggest that the share of oil in exports will stabilize in the coming years, while gas exports are projected to increase. In 2024, Azerbaijan produced 29.1 million tons of oil (including condensate) and exported 24.4 million tons (MoE 2025a). It produced 50.3 billion cubic meters of natural gas in 2024, with 25.2 billion cubic meters being exported. Of this, 12.9 billion cubic meters were exported to Europe (10 countries), 9.9 billion cubic meters to Turkey, and 2.4 billion cubic meters to Georgia. Looking ahead, Azerbaijan also plans to become a major exporter of green energy. But what capabilities will allow the country to achieve this goal?

Data for 2024 indicate that total electricity production in Azerbaijan amounted to 28,394.1 million kWh. Electricity production at TPPs accounted for 24,543.2 million kWh, at HPPs for 3,011.0 million kWh, and 839.9 million kWh from other sources. WPPs generated 51.1 million kWh of electricity, SPPs produced 556.3 million kWh, and the solid household waste incineration plant generated 232.5 million kWh (MoE 2025). Just 13.3% of the energy produced in the country in 2024 came from renewable sources.

In 2024, compared to 2015, electricity exports from Azerbaijan increased by 5.5 (value) and 6 (volume) times, respectively. Currently, Azerbaijan exports electricity to Georgia, Turkey, Russia, and Iran; it is now aiming to export electricity generated from renewable sources to new markets.

In line with these aims, Azerbaijan expects to develop 7 GW of green energy capacity by the early 2030s, with plans to export more than 70% of the electricity generated. With the



	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
million US dollars	17	28	51	66	77	60	69	122	403	94
million kWh	294	647	1160	1397	1771	1324	1588	1711	4320	1753

Fig. 3. Electricity exports (HS code 271600) from Azerbaijan (2015–2024) (SSC 2024, 2025)

Rys. 3. Eksport energii elektrycznej (kod HS 271600) z Azerbejdżanu (2015–2024)

establishment of the green energy corridors, Azerbaijan's potential for the export of green energy to Europe will rise to 35 billion kWh. The growth of green energy production and the concomitant exports will have a positive effect on various sectors of the economy. The Input-Output (I-O) model demonstrates this.

3.4. The Input-Output model

The Input-Output (I-O) model shows that an income of 6.5 billion manats from green energy exports allocated to the sector Production, Distribution, and Supply of Electricity, Gas, and Steam will lead to an overall increase in the final output of that sector.

Using the established cost-output model, a simulation was conducted by increasing the final output of the Production, Distribution, and Supply of Electricity, Gas, and Steam sector by 6.5 billion manats.

The results show that the largest impacts on total output occur in the following economic sectors: Transport and Storage (5.0%), Mining (4.5%), and Construction (4.1%). In addition, the total output of nearly all economic sectors increases as a result of the multiplier effect. Overall, the increase in these sectors leads to a 6.7% increase in total output for the economy (Fig. 4).

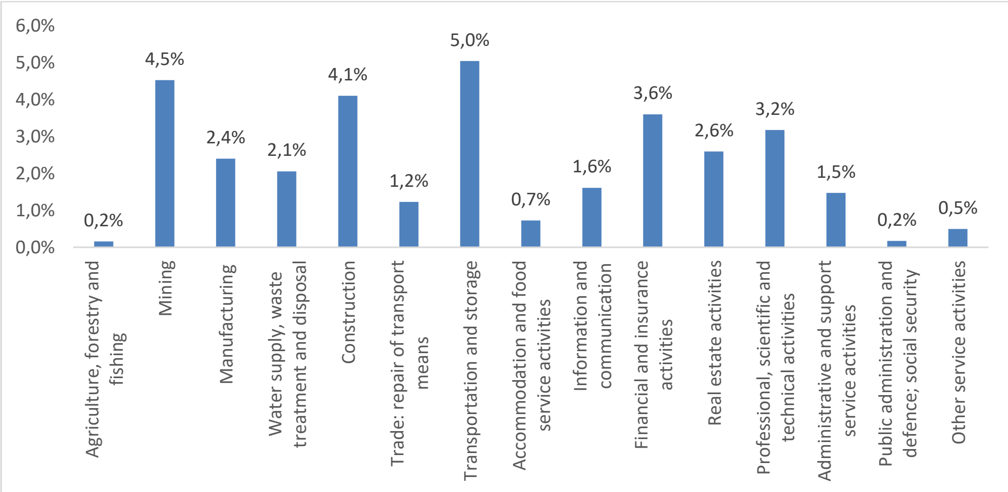


Fig. 4. Impact of a 6.5 billion manat increase in green energy exports on total output by economic activity [%] (authors' calculation)

Rys. 4. Wpływ wzrostu eksportu zielonej energii o 6,5 mld manatów azerbejdżańskich (AZN) na całkowitą produkcję według działalności gospodarczej [%]

3.5. Discussion

Discussions are currently ongoing to support the development of three key green energy corridors in Azerbaijan: the Caspian-Black Sea-Europe Corridor, the Azerbaijan-Turkey-Europe Corridor, and the Azerbaijan-Central Asia-Europe Corridor. These initiatives will enhance regional energy cooperation to promote sustainable energy solutions. Internationally, it is evident that energy corridors have become a key focus; undersea electrical cables are being laid to facilitate efficient energy transmission across regions. For example, the Viking Link Interconnector is a 760-km-long 1.4 GW HVDC cable being developed to connect the transmission systems of Denmark and Great Britain. The marine part of the project includes two 620-kilometer submarine HVDC cables, while the underground cables run a total of 120 kilometers in both directions (NS Energy 2024b).

The EuroAsia Interconnector is a 400-kV HVDC submarine cable system designed to connect the power grids of Israel, Cyprus, and Greece (Crete and Attica) to the European transmission network. Its total length is 1,518 kilometers, and it will be the longest communication cable in the world, connecting Europe and Asia. The cost of the first phase of the interconnection project is estimated at 3.5 billion euros ($3.9 billion), with a transmission capacity of one GW, which is planned to be increased to 2 GW in the next phase. The EuroAsia Interconnector line starts in Hadera, Israel, and runs 310 kilometers under the sea to connect to Kofinou, Cyprus. From there, it goes west and takes a submarine route again to connect with Korakia Point on Crete, the largest Greek island. The length of the Cyprus-Crete section is 879 kilometers. From Crete, the link continues for 329 kilometers to connect to Attica in mainland Greece. The lowest point of the cable is 3,000 meters below sea level in the Mediterranean Basin, making it the world's deepest submarine cable (NS Energy 2024a).

The Xlinks Morocco-UK Power Project is a new power generation facility that runs entirely on solar and wind power with battery storage. It is located in the renewable energy-rich Guelmim Oued Noun region of Morocco and will be linked exclusively to the UK by 4,000 km (2,485 miles) of HVDC submarine cables.

This first project will generate 11.5 GW of carbon-free electricity from solar and wind energy, supplying an average of 3.6 GW of reliable power for 19 hours a day. This is enough to provide affordable clean electricity to more than 7 million UK homes and, once the project is complete, will be able to meet 8% of the UK's electricity needs.

In addition to continuous power from solar panels and wind turbines, the on-site 22.5 GWh/5GW battery facility has enough storage to provide the UK with a near-continuous source of flexible and predictable clean energy every day, designed to complement the renewable energy already produced in the UK (Xlinks 2024).

A $22 billion infrastructure project will send Australian sunshine more than 5,000 kilometers to Singapore via high-voltage undersea cables. Due to open in 2027, it will be the largest solar power plant and battery storage facility in existence. The electricity will travel north to the coast via overhead cables and then northwest via Singapore's long-voltage continuous submarine cable along the seabed, some 4,200 km (2,600 mi). It will deliver up to 3.2 GW of transferable clean energy, which Sun Cable says will provide up to 15 percent of Singapore's electricity, with sufficient power for up to three million homes (Blain 2021).

The discussion brought out the fact that all the countries have green energy sources in one form or another. In the near future, the number of countries producing green energy using solar, wind, bioenergy, or other resources will increase. Given such a case, it may be possible to claim that countries will not need to import green energy.

On the other hand, it is important to point out that the transmission of green energy over long distances with the current technology can be a very expensive project. Based on this, there are those who doubt that the export of green energy will be efficient. Some reports claim that it is too early to implement projects related to the export of green energy. However, experts who disagree with this argument say that the natural climate conditions of all countries are not the same. It is also true that the demand for energy increases during certain seasons.

Singapore is clear proof that, in the near future, as now, there will be countries that need energy imports, and importing green energy can be an excellent option for them. For example, connecting the energy systems of Azerbaijan, Kazakhstan, and Uzbekistan will affect the energy security of all three countries. Also, the initiatives aimed at the export of green energy to Europe through Azerbaijan will contribute to improving Europe's energy security.

The *Business Europe* (2024) report states, "…energy prices could remain substantially higher in Europe compared to our international competitors". In summary, by 2050, projections are for residents of European Union countries to face higher electricity costs in comparison to those of the USA and China. These projections are based on forecasts for electricity production costs in the EU, which are expected to be at least 50% higher than those in the US and China by that year. This significant cost disparity suggests a strong potential demand within Europe for the green energy that Azerbaijan aims to export. Furthermore, Azerbaijan could capitalize on this opportunity by offering the European market its green energy exports at competitive prices.

Conclusions

Azerbaijan's transition to green energy serves as a pivotal example for oil- and gas-rich countries, demonstrating that the shift towards sustainable energy sources can generate opportunities rather than economic challenges.

This shift would also make a significant contribution to the diversification of Azerbaijan's exports and would contribute to the formation of net-zero energy systems. Our calculations indicate that if Azerbaijan were to export 35 billion kilowatt-hours (kWh) of electricity, the income from these exports would equal approximately 14% of the country's total revenue from its 2024 exports. As a result, the share of oil and gas in Azerbaijan's exports would decrease to around 70%. Also, according to the I-O model, achieving green energy export targets could lead to a 6.7% increase in Azerbaijan's total output. This growth is crucial for Azerbaijan as it supports economic diversification and strengthens the development of the non-oil sector.

By leading this transition, Azerbaijan pioneers a critical movement and acts as a model for other countries with substantial oil and gas reserves, demonstrating that they should not hinder this progress; rather, they should embrace it. This shift has already commenced and is gaining further importance through regional collaborations. These green energy projects present additional prospects for landlocked nations such as Kazakhstan, and Uzbekistan, enhancing their access to sustainable energy resources and economic opportunities.

The joint implementation of the project to connect the energy systems of Azerbaijan, Kazakhstan and Uzbekistan (the Green Corridor) will contribute to the stability of this region. The corridor will start from Central Asia, pass through the Caspian and Black Seas, and extend to Europe. Therefore, the geo-economic importance of this project will be exceptional. The establishment of the Caspian-Black Sea-European Green Energy Corridor will strengthen the energy security of the participating countries and strengthen the links between energy systems and economies. Also, the development of green energy corridors will enable Azerbaijan to attract increased investment in the renewable energy sector.

If we look at the issue from another angle, the implementation of green energy projects will be useful for countries that want to import gas from Azerbaijan. So, obtaining Azerbaijan's energy from renewable sources will lead to the saving of natural gas used for energy production. This gas will either be exported or used as a raw material in the chemical industry.

These mega projects, in which Azerbaijan plays a key role, will significantly enhance Europe's energy security by diversifying its energy sources, reducing reliance on any single country, accelerating the transition to green energy, and boosting stability in the energy market.

Finally, through its green energy initiatives, Azerbaijan can maintain its position as an energy exporter well beyond 2050. Although this will not entirely replace the revenue from oil, it offers a substantial potential source of export income for the country.

Limitations and future research

Despite the contributions of this study, several limitations should be noted. As green energy export is an emerging field, existing research in this area is limited. Efforts are currently underway to transform the concept of green energy corridors from theoretical to a tangible reality. Our study emphasizes that many projects related to green energy export are still in the early stages of development. Obtaining sufficient data in this domain remains a significant challenge.

We encourage future research in this area and offer several recommendations. Researchers could explore alternative methods to assess the efficiency of Azerbaijan's wind and solar energy exports to Europe. In addition, the export potential of Azerbaijan's green hydrogen to Europe presents another avenue for investigation. Research into the feasibility of Kazakhstan exporting green hydrogen to Europe via Azerbaijan would also be relevant.

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Zmiana pozycji eksporterów ropy naftowej w kontekście przejścia na zieloną energię: przypadek Azerbejdżanu

Streszczenie

Azerbejdżan jest obecnie eksporterem ropy naftowej i gazu, ale jego celem jest utrzymanie statusu eksportera energii poprzez inwestowanie w przyszłości w projekty związane z zieloną energią. Celem niniejszego artykułu jest stworzenie koncepcyjnych ram, które pozwolą zbadać, w jaki sposób Azerbejdżan, kraj bogaty w ropę naftową, może przekształcić się w eksportera zielonej energii. W niniejszym badaniu porównano różne scenariusze eksportu zielonej energii.

Wyniki pokazują, że (1) przejście od eksportu paliw kopalnych do zielonej energii ogólnie rzecz biorąc, zmniejsza podatność eksportera na zagrożenia i zwiększa bezpieczeństwo energetyczne kraju, mimo zwiększenia ekspozycji na siły rynku międzynarodowego; (2) Azerbejdżan mógłby zwiększyć eksport zielonej energii do poziomu 14% całkowitego eksportu w nadchodzących latach; (3) dzięki tym inicjatywom w zakresie zielonej energii Azerbejdżan może utrzymać swoją rolę eksportera energii znacznie dłużej niż do 2050 r.; (4) wyniki modelu I-O pokazują, że osiągnięcie celów w zakresie eksportu zielonej energii może doprowadzić do wzrostu całkowitej produkcji Azerbejdżanu o 6,7%; (5) zmiana ta odegrałaby również kluczową rolę w dywersyfikacji bazy eksportowej kraju i tworzeniu systemów energetycznych o zerowym bilansie emisji; (6) pozwoliłoby to Europie zdywersyfikować dostawy energii i zmniejszyć zależność od jednego kraju. Łącząc dwa różne podejścia, Azerbejdżan ma potencjał, aby przekształcić swój eksport z ropy i gazu w zieloną energię, stając się tym samym wzorem dla innych bogatych w ropę krajów, dążących do zrównoważonego rozwoju energetycznego.

Słowa kluczowe: eksporter zielonej energii, bezpieczeństwo energetyczne, systemy energetyczne o zerowym bilansie energetycznym, energia wiatrowa, energia słoneczna

Appendix

Crude oil (including gas condensate) extraction and export in Azerbaijan

Wydobycie i eksport ropy naftowej (w tym kondensatu gazowego) w Azerbejdżanie

	1995	2000	2005	2010	2015	2020	2024
Crude oil (including gas condensate) extraction [thsd. tons]	9,161	14,017	22,214	50,838	41,628	34,532	29,100
Export crude petroleum [thsd. ton]	–	5,512	6,345	31,916.8	21,960.3	29,023.1	23,596.1
Export crude petroleum, value [thous. US dollars]	–	985,436.9	2,218,812	18,489,553.8	8,866,158.6	9,363,570.7	14,437,356

Source: SSC 2025; MoE 2025a.