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Mahabbat Mammadov[1], Fidan Mammadova[2], Shahla Alizada[3], Turkan Hasanova[4], Said Alekperov[5]

Comprehensive analysis and evaluation of Azerbaijan's National Energy Complex: current status and future prospects

Abstract: The scientific article considers the first and second energy sectors included in the classification of industries, shows the need to take into account the realities of the electric power sector when studying the historical stages of development of the infrastructure complex of the oil and gas sector, and conducts research in this direction. The processes of construction and commissioning of power plants (HPPs, TPPs) in Azerbaijan since the end of the 19th century and the transformation of this industry into the main elements of economic development have been analyzed. At the same time, the paper analyzes the infrastructural indicators of the current state of the gas and energy

✉ Corresponding Author: Mahabbat Mammadov; e-mail: prof.mammadov@yahoo.com

[1] Economics, Azerbaijan University of Architecture and Construction, Baku, Azerbaijan; ORCID iD: 0000-0002-5327-2507; e-mail: prof.mammadov@yahoo.com

[2] Economics, Azerbaijan University of Architecture and Construction, Baku, Azerbaijan; ORCID iD: 0000-0002-1284-7562; e-mail: fidan.mammadova@azmiu.edu.az

[3] Economics, Azerbaijan University of Architecture and Construction, Baku, Azerbaijan; ORCID iD: 0000-0001-8079-3255; e-mail: shahla.alizada@azmiu.edu.az

[4] Economics, Azerbaijan University of Architecture and Construction, Baku, Azerbaijan; ORCID iD: 0000-0001-8382-3675; e-mail: turkan.hasanova@azmiu.edu.az

[5] Economics, Azerbaijan University of Architecture and Construction, Baku, Azerbaijan; ORCID iD: 0009-0008-5271-6330; e-mail: Saidalekperov1@gmail.com

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infrastructure of the country, which is an integral structure in the development of the energy sector, and also compiles a SWOT analysis matrix of quantitative and qualitative indicators of energy security of the country.

Keywords: energy, infrastructure, integrated analysis, power plants, SWOT, matrix, energy security

Introduction

When analyzing the current state of the national oil and gas sector and infrastructure complex of Azerbaijan, its structural structure, resource base, potential, technological format, and integration unity, as well as retrospective and prospective activities, it is necessary to take into account the strategy of economic and energy policy reforms implemented in the republic and the mechanism of its implementation. The structural structure of the national oil and gas sector of the country and its infrastructure complex does not differ much from the paradigms existing in other countries.

In the statistical classification of the country, the first energy sector includes the mining (oil and gas), processing (Fuel and Energy Complex, oil and gas chemical) industry and the oil and gas supply system (upstream + midstream + downstream), while the second energy sector includes the structures of production, distribution and supply of electricity, gas and steam (electric power industry). In terms of ownership, the energy sector and its infrastructure complex consist of public and private sectors. The study of the retrospective situation of the national oil and gas sector and its infrastructural complex shows that the main factor in the formation of the country's energy sector and its infrastructural complex is the fact that the country has centuries-old hydrocarbon reserves and is the source of the world oil civilization in terms of the tradition of oil production and consumption. In all periods of history, these resources have played an important role in social and political life along with trade, agriculture, construction, industry, transportation, and logistics, and play an important role at present.

1. Literature review

Oil production in Azerbaijan is a cornerstone of the country's economy. The Caspian Sea region, rich in oil reserves, positions Azerbaijan as one of the world's leading oil producers. Over the years, the country has attracted numerous international companies to develop its oil fields. Since 2005, with the onset of a new mining boom, revenues from oil sales have become a crucial source of funding for Azerbaijan's economic and social development (Khalilov and Huseyn

2021). Azerbaijan has strategically leveraged these oil revenues to improve the well-being of its population while modernizing its economy. The country remains focused on advancing its energy sector and expanding its oil exports.

Azerbaijan, known for its substantial oil and gas reserves, is actively working to enhance the role of renewable energy within its energy framework. The nation has already made notable progress in this area (Gasimli et al. 2024a). Specifically, Azerbaijan's goal is to boost its renewable energy capacity to 2,250 MW and increase the share of renewable energy to 34.7% by 2030 by developing additional power stations (Shahbazov 2024). Furthermore, Azerbaijan is developing green energy corridors such as "Caspian–Black Sea–Europe", "Azerbaijan–Turkey–Europe", and "Azerbaijan–Central Asia–Europe" to support this transition (Gasimli et al. 2024b).

Azerbaijan continues to focus on modernizing its energy sector and expanding its oil exports. Azerbaijan's State Oil Company (SOCAR) remains one of the central pillars of the country's oil and gas industry. According to SOCAR (2025), the company is responsible for managing large-scale oil production and export, which is vital for the national economy. SOCAR's contributions to both local and international markets provide insights into Azerbaijan's economic reliance on energy exports. In a significant move, SOCAR, the national oil company, has engaged in green energy initiatives, establishing SOCAR Green LLC and forming strategic partnerships with Masdar and ACWA Power to advance green energy projects.

The economic potential of oil and gas industry enterprises is vast, as they contribute significantly to national revenues and economic growth. The oil and gas sector is a driving force behind Azerbaijan's industrial development and export capacity (Aliyev et al. 2003). The enterprises in this sector not only generate substantial income from the extraction and sale of hydrocarbons but also create jobs and stimulate related industries. Aliyev highlights the importance of investment in modern technologies and infrastructure to enhance productivity and efficiency. The sector's economic impact extends to both domestic and international markets, strengthening Azerbaijan's role in the global energy market. Through strategic management, the oil and gas industry continues to play a key role in the country's overall economic potential.

The development of industry and the fuel and energy complex in Azerbaijan is focused on modernization, diversification, and sustainability. The country aims to reduce its dependency on oil and gas by investing in alternative energy sources, such as renewable energy, while continuing to develop its hydrocarbon resources. The fuel and energy complex remains a key driver of Azerbaijan's economy, contributing significantly to national revenues through exports of oil and gas (Mammadov et al. 2012). Efforts are being made to modernize infrastructure, enhance energy efficiency, and implement advanced technologies in both the oil and gas sectors. Furthermore, the government is working on expanding the use of renewable energy, such as solar and wind power, to ensure long-term energy security. Strategic investments and international partnerships are seen as vital to supporting the growth of the industry and maintaining the country's position as a key energy supplier.

The fuel and energy complex of Azerbaijan has developed in several key stages, each contributing to the country's growth as an energy producer and exporter. Initially, the industry began with the discovery of oil reserves in the Caspian Sea, marking the foundation of Azerbaijan's

energy sector. In the Soviet era, the sector expanded significantly with the establishment of infrastructure for large-scale oil and gas production. After gaining independence, Azerbaijan focused on modernizing its energy infrastructure and attracting international investments, leading to the construction of major pipelines like the Baku-Tbilisi-Ceyhan (BTC) pipeline (Mammadov et al. 2007; MoE 2024).

Looking ahead, the prospects of Azerbaijan's fuel and energy complex include diversifying energy sources, with an emphasis on renewable energy such as wind and solar power. The government is also focused on improving energy efficiency, strengthening energy security, and continuing to expand its role in global energy markets. The sector's future development is linked to strategic partnerships, technological advancements, and sustainable energy policies (Tagiyev et al. 2024).

The transformation of our country from an energy-importing country to an energy-exporting country is a clear result of the economic policy pursued in the energy industry. Recent years have been rich in successes in increasing the stability of our electric power system and its development in a new context. With the commissioning of new power plants, the total installed capacity of our country has reached 8,320.8 MW, which is 22 thermal power plants with a total capacity of 6,633.0 MW, 46 hydro power plants with a total capacity of 1,301.8 MW, 5 wind power plants with a total capacity of 66.5 MW, 9 solar power plants with a total capacity of 281.8, a bioenergy power plant with a capacity of 37 MW, 3 hybrid power plants with a total capacity of 0.7 MW. The capacity of power plants on renewable energy sources, including hydropower plants, is 1,687.8 MW, which is about 20.3% of the total installed capacity (MoE 2024).

In Azerbaijan, fuel transportation through pipelines plays a crucial role in the country's energy infrastructure. The country is strategically located between oil-rich regions, making pipeline networks essential for the export of crude oil and natural gas. Azerbaijan has an extensive network of pipelines, including the Baku–Tbilisi–Ceyhan (BTC) pipeline, which is a key route for transporting oil to global markets. These pipelines also help deliver natural gas to neighboring countries and Europe, enhancing regional energy connectivity (MoDDT 2024). The development of pipeline infrastructure has significantly contributed to Azerbaijan's economic growth, providing a steady income from energy exports. However, the management and maintenance of these pipelines are critical to ensure the continuous and safe transport of fuel. Azerbaijan continues to invest in pipeline projects to meet growing demand and strengthen its position as a major energy supplier.

Renewable energy is energy obtained from natural sources that are replenished faster than they are used. Azerbaijan is one of the countries with high potential for renewable energy sources. Renewable energy is becoming increasingly important in Azerbaijan as the country seeks to diversify its energy sources. The government is focusing on expanding solar, wind, and hydropower capacities to reduce dependency on fossil fuels. This shift towards renewable energy is vital for sustainable development and reducing the environmental impact of traditional energy sources. Azerbaijan's favorable climate conditions provide an excellent opportunity for harnessing solar and wind power. Investing in renewable energy also helps improve energy security and reduce carbon emissions. As a result, Azerbaijan is making significant strides toward

a greener and more sustainable energy future. Thus, the technical potential of our country's onshore renewable energy sources is 135 GW, and offshore is 157 GW (Gasimli et al. 2024b). The economic potential of renewable energy sources is estimated at 27 GW, including 3,000 MW of wind energy, 23,000 MW of solar energy, 380 MW of bioenergy potential, and 520 MW of mountain rivers. Although it is rich in energy resources and recognized as an energy exporter in the world, the use of renewable energy sources is paid special attention in the Republic of Azerbaijan (MoE 2024). As worries about climate change rise and energy demand is projected to increase by almost 50% by 2050, greater focus is being placed on renewable energy rather than fossil fuels. Advancements in technology are reducing the costs of renewable energy, while the prices of fossil fuels continue to rise as they become more limited.

Economic reforms and development strategies play a crucial role in ensuring sustainable development by creating a balanced and resilient economy. These reforms focus on diversifying industries, improving infrastructure, and promoting innovation to reduce dependency on traditional sectors, such as oil and gas. By implementing policies that encourage investments in renewable energy, technology, and human capital, countries can foster long-term growth. Moreover, reforms aimed at enhancing economic efficiency, transparency, and governance contribute to sustainable economic development (Mammadova et al. 2022). Development strategies also prioritize environmental protection, social welfare, and reducing inequality, ensuring that growth benefits all segments of society. Overall, these efforts support a sustainable future by addressing both economic and environmental challenges.

Economic and mathematical modeling for risk assessment in innovative activities within the oil and gas industry involves using quantitative techniques to evaluate potential risks and uncertainties associated with new projects (Kariuk et al. 2022; Mammadov et al. 2024). These models help identify and measure various risks, such as market volatility, technological failures, environmental impacts, and regulatory changes. By applying statistical methods and simulations, enterprises can forecast outcomes and make informed decisions to minimize financial losses and maximize returns. The goal is to create a systematic approach that integrates both economic factors and mathematical tools to assess the viability and risks of innovative investments. This type of modeling aids in optimizing resource allocation, ensuring project success, and improving overall strategic planning in the oil and gas sector.

2. Material and methods

When conducting research on the historical path of development of Azerbaijan's oil and gas sector and its infrastructure complex, it is necessary to take into account the realities of its energy sector. Power plants were operating in Azerbaijan at a time when most European countries, where the industrial revolution was born, had no production or supply of electricity. It should be noted that the first hydroelectric power plant was built in the village of Gedabek Galakand

in Azerbaijan by the German firm "Siemens" in 1880–1883. However, in industrial terms, the first production of electricity in Azerbaijan was realized in the late 19th century. In 1887, the first thermal power plant with a capacity of 550 kilowatts was built in Baku by the Nobel brothers' firm, and a few years later, in 1895, the first thermal power plants (TPP) were installed and put into operation in Baku. As a result of these works, the electric power industry has become a key element of Azerbaijan's economic development since the beginning of the 20th century (MoE 2020; Aliyev 2003).

The realization of targeted measures in this direction continued, namely, in 1953 the first giant hydroelectric power plant – Mingachevir HPP with a design capacity of 424.6 MW was put into operation, in 1954 – Shimal HPP with a capacity of 330 MW, in 1957 – Varvarinsk HPP with a capacity of 18 MW, in 1981– the largest HPP in the Caucasus with a capacity of 2400 MW – Azerbaijan TPP, and in 1982 – Shamkir HPP with a capacity of 380 MW (MoE 2020; Aliyev 2003).

The "Contract of the Century" signed on September 20, 1994, within the framework of which Azerbaijan signed 38 production sharing agreements and 3 risk service agreements on joint development of fields with more than 50 companies from more than 20 countries of the world, was of special importance in the creation of new important infrastructure that ensured the development of the oil and gas industry of the country. The main elements of this infrastructure system are the infrastructure complex of oil and gas fields ("Azeri-Chirag-Guneshli", "Shahdeniz", "Umid–Babek", "Absheron", "Karabakh", "Nakhchivan", etc.), the Heydar Aliyev "Baku–Tbilisi–Ceyhan" oil export pipeline; Western Export Pipeline – WEP (Baku–Supsa oil pipeline); Baku–Novorossiysk oil pipeline; South Caucasus Gas Pipeline-SCGP (Baku–Tbilisi–Erzurum pipeline); Sangachal Oil Terminal; Dubandi Oil Terminal (reconstructed); Floating Deep Drilling Rigs ("Heydar Aliyev", "Istiglal", "Dede Korkut", "Kurtulush", "Leader", etc.); Oil depots and autobuses (Heydar Aliyev, "Istiglal", "Dede Korkut", "Kurtulush", "Leader", etc.); Oil depots and gas stations; It includes transportation and logistics infrastructure facilities, as well as other oil and gas infrastructure facilities (SOCAR 2025).

The provided study employs several research methodologies to analyze and assess the energy infrastructure and the oil and gas sector of Azerbaijan.

Historical analysis: the study examines the historical development of Azerbaijan's oil, gas, and electricity infrastructure. This includes reviewing the early establishment of power plants, the evolution of energy sources, and significant infrastructure milestones in the energy sector.

Data analysis: quantitative data on oil and gas production, energy consumption, and export/import statistics are analyzed. Key indicators like oil and gas production, electricity generation, and energy security factors are assessed using various data points from government reports and official statistics. The study presents tables with production and consumption metrics for oil, gas, and electricity.

Modeling: the research also incorporates mathematical models to calculate energy security indicators (ESFOR, ESFGR, EESF), which assess the security of oil, gas, and electricity resources. These models help quantify the adequacy of energy production in comparison to consumption, using real-time data.

SWOT analysis: a SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis is employed to evaluate the quantitative and qualitative aspects of Azerbaijan's energy security. This method is used to assess internal and external factors affecting energy production, infrastructure, and market dynamics.

Comparative analysis: the study compares Azerbaijan's energy infrastructure with that of other regions and tracks its historical evolution. It also benchmarks the country's energy capacity against other nations in the region.

Strategic planning: the study proposes strategic measures, focusing on infrastructure modernization, the introduction of new energy resources, and technological advancements in the energy sector. The findings lead to recommendations for policy improvement and long-term energy sustainability.

In summary, the study uses a combination of historical research, quantitative data analysis, mathematical modeling, SWOT analysis, and strategic planning to evaluate and forecast the energy security and infrastructure development in Azerbaijan's oil and gas sector. These methods help inform decision-making for future energy policies and infrastructure projects.

3. Results

In order to assess the current state of the infrastructure complex of the energy sector of Azerbaijan related to the oil and gas industry, it is also advisable to analyze the works carried out in this area. It should be noted that there are 81 oil and gas fields in the country, 61 of which are currently being developed, including 42 onshore and 19 offshore. The geological reserves of these fields amount to 3–5 billion tons of oil and 3 trillion m^3 of gas. The probable area of hydrocarbon fields is 43–45 thousand km^2 onshore and 21.4 thousand km^2 offshore. In 2022, the country produced 32.6 million tons of oil and 47.3 billion m^3 of gas. In 2023, oil production was 30.2 million tons, 2.4 million tons less than in the previous year. In total, more than 800 million tons of oil and 1 trillion cubic meters of gas were produced from 1991 to 2023. According to calculations, it is planned to produce 3 billion tons of oil in Azerbaijan in 2060 and 2 trillion m^3 of gas in 2055 (SSC 2025; MoE 2024c).

In the first years of state independence, purposeful and effective work on the reconstruction of the gas infrastructure of the energy sector began. Since those years, activities under the state program, development concept, and strategy aimed at the development of the fuel and energy complex have been implemented. At the same time, export gas pipelines were reconstructed, gas storage facilities were modernized, and their active volume was doubled. Currently, a significant part of Azerbaijan's gas potential is associated with the Shahdeniz field. The field's reserves amount to 1.2 trillion m^3 of gas and more than 240 million tons of condensate. In addition to meeting the country's domestic needs, gas resources are transported through the South Caucasus section of the Southern Gas Corridor via the Trans-Anatolian Pipeline – TANAP, passing

through Georgia to Turkey, and from there to Europe via the Trans-Adriatic Pipeline – TAP. At the same time, Azerbaijan has the necessary infrastructure of main gas pipelines, through which it exchanges gas with Russia and Iran, as well as supplies gas to Georgia. Previously, Armenia also used these gas pipelines, but as a result of its reactionary and hateful occupation policy, it found itself outside these gas pipelines (Kariuk et al. 2022). Considering the risk factor, the actual returns of investments in innovation projects within the oil and gas industry should exceed the standard returns. Also, the optimal investment limit for the purchase of machinery and equipment for innovative activity, the installation of purchased fixed assets (funds) and the construction of fixed assets (funds) based on innovative technologies, using real results and according to the model proposed for "Oil and Gas Construction" of SOCAR the enterprise is defined (Mammadov et al. 2024).

In 2022, Azerbaijan exported a total of 21 billion m^3 of natural gas through the "Southern Gas Corridor", including 8.4 billion m^3 to Turkey, 8.7 billion m^3 to Italy, and 3.8 billion m^3 each to Georgia, Greece, and Bulgaria. It should be noted that Azerbaijan provides 80% of gas consumption for some of these countries and 15–20% for others, and every year there is an increase in these indicators (MoE 2023). It should also be noted that Azerbaijan is developing new fields, mainly with its own resources, in order to expand its gas potential and increase its reliability. These include "Umid" with recoverable reserves of 200 billion m^3 of gas and 40 million tons of condensate, "Babek" with 400 billion m^3 of gas and 80 million tons of condensate in the same reserves, "Absheron" with 350 billion m^3 of gas and 45 million tons of condensate, "Shafag-Asiman" with forecast reserves of 500 billion m^3 of gas and 65 million tons of condensate and other similar fields. Produced natural gas resources in large volumes (4.2–4.7 billion m^3 per year) are sent to the gas processing plant for purification and processing (MoE 2024c).

Another direction related to gas infrastructure is gas chemistry. These are "Azerikimya" PA (Production Association), "Karbamid" and "SOCAR Polymer" plants located in Sumgayit city, as well as "SOCAR Methanol" plants in Baku. The largest infrastructure complex in the gas sector belongs to "Azerigaz" PA, and "Gas Export" Department, which are SOCAR structures. The structure of "Azerigaz" PA, whose main activity is the receipt, distribution and sale of natural gas from supply points throughout the country (2.2 million subscribers), includes the entire territory of the country. With a gasification rate of 96.3%, this production association includes pipelines of various infrastructure diameters with a total length of 72 thousand kilometers, 50 gas regulating points, and Garadagh (2.0 billion m^3) and Galmaz (1.5 billion m^3) gas storages with a total usable capacity of 3.5 billion m^3. The "Gas Export" Department functionally receives gas produced by Shahdeniz and "Azeri–Chirag–Guneshli" fields, as well as by the Operating Companies, and sells it on foreign markets. In total, the main gas pipelines of Azerbaijan have an infrastructure of 2.4 thousand kilometers in 4 directions through 4 countries (MoE 2023). The main gas pipeline infrastructure of the country in 2022 has been analyzed and is presented in the following table.

Table 1. Infrastructure complex of main gas pipelines of the Republic of Azerbaijan (2022)

Tabela 1. Kompleks infrastruktury głównych gazociągów Republiki Azerbejdżanu (2022)

Route	Countries	Main stations	Operator	Length [km]	Capacity [bcm/year]	Date of commissioning [year]
Hajigabul–Astara–Astara–	Azerbaijan, Iran	Hajigabul–Astara–Astara (Iran)	SOCAR, National Gas Company of Iran	210	4.0	2006
Hajigabul–Gazakh–Saguramo	Azerbaijan, Georgia	Hajigabul–Gazakh–Saguramo	SOCAR, Georgian Gas Company	478	8.7	2007
Hajigabul–Shirvanovka–Mozdok	Azerbaijan, Russia	Hajigabul–Shirvanovka–Novo-Filya–Makhachkala–Mozdok	SOCAR, Gazprom	680	10.0	2007
Baku–Tbilisi–Erzurum	Azerbaijan, Georgia, Turkey	Baku–Tbilisi–Erzurum	SOCAR, BP, BOTASH	980	7.4	2006

Source: SOCAR 2025.

4. Discussion

The analysis of the indicators presented in the table above shows that the main gas pipeline infrastructure of Azerbaijan is multidirectional and covers most of the country's territory. In addition, the gas infrastructure includes "Domestic Liquid Gas" CJSC engaged in the production and sale of gas fuel, "Pure Gas" CJSC providing technical services to the gas supply system, and various other infrastructure facilities.

Thus, based on the conducted analyses and assessments, the structural classification of the gas infrastructure of the republic is as follows: Gas and oil and gas fields; Institutional bodies: PA "Azerigaz", "Gas Export" Department, Gas Processing Plant, Carbamide Plant, Methanol Plant, "Domestic Liquid Gas" CJSC, "Pure Gas" CJSC; Gas storage facilities (total volume 3.5 billion m^3); Gas distribution stations and gas regulator stations (total 256 facilities); Trunk and distribution gas pipelines (total 75 thousand kilometers); It can be systematized as regional gas operation offices and LPG and compressed gas refueling stations.

The study of the current state of the energy infrastructure and power sector of Azerbaijan shows that there is a constant development dynamic in this sphere. It should be noted that since the first years of independence, important measures aimed at reconstruction and development of the

energy sector have been implemented within the framework of state programs and development strategies, and these works were regularly carried out during the period of their implementation. During these periods, about 3,500 MW of generating capacities have been commissioned across the country, electricity production has doubled, and the currently implemented energy policy in the power sector has been successfully continued. Studies show that in the period 2003–2022, about 40 power plants with an installed capacity of more than 3,000 MW of various energy sources were put into operation, more than 1,000 MW of additional generating capacity was restored, and the capacity of the power system exceeded 7,000 MW. The construction of a new RES (renewable energy source) system in the country has also entered a new active phase, with the capacity of WFs (wind farms) and SPPs (solar power plants) increased to 100 MW (MoE 2024b; "Azerenerji" OJSC 2024).

Based on the analysis of infrastructure indicators characterizing the state of the structures of the national energy infrastructure complex of the country, the dynamics of the state of implementation of works carried out in this direction is determined, which is presented in the following table.

Table 2. Infrastructure indicators of the current state of the energy sector of the Republic of Azerbaijan

Tabela 2. Wskaźniki infrastrukturalne dotyczące aktualnego stanu sektora energetycznego Republiki Azerbejdżanu

No	Indicators	Unit of measurement	Volume	No	Indicators	Unit of measurement	Volume
1	Oil production	million tons	32.6	5	Gas exports	billion m^3	22.3
1.1	SOCAR	million tons	7.8	5.1	SOCAR	billion m^3	2.8
1.2	Consortiums	million tons	24.8	5.2	Consortiums	billion m^3	19.5
2	Oil exports	million tons	26.3	6	Gas consumption	billion m^3	13.5
2.1	SOCAR	million tons	1.4	7	Electricity generation	billion kWh	28.9
2.2	Consortiums	million tons	24.9	7.1	TPPs	billion kWh	27.0
3	Oil refining (SOCAR)	million tons	6.2	7.2	HPPs	billion kWh	1.6
4	Gas production	billion m^3	46.7	7.3	RES	billion kWh	0.3
4.1.	SOCAR	billion m^3	8.1	8	Electricity consumption	billion kWh	23.1
4.2	Consortiums	billion m^3	38.6	9	Electricity export	billion kWh	3.0

Analysis of the indicators presented in the table above shows that the energy potential of the country has an increasing dynamic. Strengthening the energy security of the country is of particular importance in ensuring the sustainable and progressive development of the country's economy. For this purpose, it is necessary to combine all alternatives, continue reforms, and form a dynamic modern system ahead of the needs (MoE 2024a).

Continuous institutional reforms and improvement of the regulatory and legal framework in this area are necessary to ensure the excellence of the energy sector (Kariuk et al. 2022).

Based on the analysis carried out in the above-mentioned areas, the electric power infrastructure of the republic for 2022 can be classified in the following format:

- PPs – 81 (TPPs – 27, HPPs – 37, RES – 17);
- GSs – 33,236 (500 kW – 2, 330/220 kW – 21, 110/35 kW – 803, 10/6/0.4 kW – 32,410);
- PLs – 1,838,636 (500 kW – 3, 330/220 kW – 54, 110/10/6/0.4 kW – 1,838,579);
- Dispatch stations, Regional Power Grids – RPGs, Sales Offices of District Energy Supply – SODESs, electric vehicle charging stations and likewise.

Based on the analysis and research conducted, the result is a schematic classification of the energy infrastructure of Azerbaijan. The presented classification can also serve as an important basis for determining the elements of energy infrastructure, which are the subject of technical regulation when conducting research in this direction. At the same time, there is a significant need for the formation and optimization of this infrastructure complex. All these qualities ultimately contribute to the energy security of the country. Generalization of the conducted analyses and assessments shows that the energy security of the country is sufficient in both cycles of energy production. To obtain such a designation, the following formula composition should be used:

$$E_{SFER} = \{E_{SFOR} + E_{SFGR} + E_{ESF}\} = \{E_{Production} = E_{OProduction} + E_{GProduction} + E_{EProduction}\} : \{E_{Consumption} = E_{OConsumption} + E_{GConsumption} + E_{EConsumption}\}$$

where:

E_{SFER} – the security factor of energy resources,
E_{SFOR} – the security factor of oil resources,
E_{SFGR} – the security factor of gas resources,
E_{ESF} – the energy security factor,
$E_{Production}$ – the energy production in the republic,
$E_{OProduction}$ – the energy production from oil resources,
$E_{GProduction}$ – the energy production from gas resources,
$E_{EProduction}$ – the electricity production,
$E_{Consumption}$ – the energy consumption in the republic,
$E_{OConsumption}$ – the energy consumption from oil resources,
$E_{GConsumption}$ – the energy consumption from gas resources,
$E_{EConsumption}$ – the electricity consumption.

To calculate all three elements of energy security of the republic (oil, gas, and electricity), the data of the following table are used.

It should be noted that if the coefficient of energy resource security is greater than one, the country's energy security is considered secured; if it is less than one, it is considered insufficient.

As noted above, Azerbaijan will produce 32.6 million tons of oil in 2022 and 30.2 million tons of oil (including condensate) in 2023, which is 2.4 million tons or 7.4% less than in 2022 (SOCAR 2025).

Table 3. Oil, gas and electricity production and consumption indicators in the Republic of Azerbaijan (2022)

Tabela 3. Wskaźniki produkcji i zużycia ropy naftowej, gazu i energii elektrycznej w Republice Azerbejdżanu (2022)

Types of energy resources	Unit of measurement	Production	Consumption
Oil	million tons	32,6	6,2
Gas	billion m^3	46,7	13,5
Electricity	billion kWh	28,9	23,1

Source: Aliyev 2003; Mammadov et al. 2024; Mammadova et al. 2024.

It should be noted that in 2023, 17.8 million tons of oil production in the country came from "Azeri–Chirag–Guneshli" fields, 4.3 million tons from "Shahdeniz" field, and 0.3 million tons from "Absheron" field. SOCAR's oil production (including condensate) this year amounted to 7.8 million tons. At the same time, 629.2 million tons of oil has been produced since the commissioning of "Azeri–Chirag–Guneshli" and "Shahdeniz" fields as of January 1, 2024. Thus, during this period, 584.7 million tons of oil were produced from the "Azeri–Chirag–Guneshli" field, and 44.5 million tons of condensate were produced from the "Shahdeniz" field (SOCAR 2023).

In 2023, from the "Azeri–Chirag–Guneshli" field, this indicator amounted to 12,897.2 thousand cubic meters, from the "Shahdeniz" field – 26,254.1 thousand cubic meters.

When calculating the indicators mentioned in the table, using the formula above, the energy security indicators for oil, gas, and electricity in the country will be:

- E_{SFOR} the security factor of oil resources = 5.3;
- E_{SFGR} the security factor of gas resources = 3.5;
- E_{ESF} the energy security factor = 1.3.

The results of the coefficients of energy resources provision show that Azerbaijan has fully ensured energy security for the main energy carriers. At the same time, it should be taken into account that in accordance with modern requirements, the energy security of any country is assessed not only in quantitative terms, but also in terms of numerous qualitative indicators that are among the basic conditions. First of all, energy security is broader than these three components (Shirinov and Mahas 2023). Thus, there are many energy products for daily use and general use, and the security indicator for them covers this range. This primarily includes fuel supplies. Azerbaijan's oil and gas refining capacities provide the republic with a confident position in these indicators as well. Energy security is also reliably guaranteed in terms of production, transportation, and logistics infrastructure. In the section of the PS of Apsheron region, oil fractionation by specific gravity and composition is noted, which is most contrasting between the suites of the Lower and Upper divisions of this stratigraphic unit (Tagiyev et al. 2024).

Ensuring full-fledged qualitative energy security will be further strengthened by increasing innovation in this infrastructure complex, broad institutionalization of energy efficiency, and

effective implementation of the institution of technical regulation. The perfection of quantitative and qualitative indicators of energy security of the Republic of Azerbaijan can be further confirmed by constructing a matrix using the SWOT analysis method (Mammadova et al. 2022). It should be noted that SWOT analysis is a method of strategic planning, which determines the factors of internal and external environment of the organization, dividing them into four categories (S – strengths, W – weaknesses, O – opportunities, T – threats) (Mammadov et al. 2012). Based on this method, the following SWOT-analysis matrix of quantitative and qualitative indicators of energy security of the Republic of Azerbaijan is compiled (Mammadov and Aliyev 2007).

Table 4. SWOT analysis matrix of quantitative and qualitative indicators of energy security of the Republic of Azerbaijan

Tabela 4. Macierz analizy SWOT zawierająca ilościowe i jakościowe wskaźniki bezpieczeństwa energetycznego Republiki Azerbejdżanu

Strengths – advantages	Weaknesses – disadvantages
Political-economic-social stability	Attribution of a significant part of gas resources to external liabilities
Potential of domestic natural energy resources	Mismatch between the capacity of gas treatment facilities and the volume of gas produced
Domestic infrastructure for energy production, transmission, and maintenance	Lack of domestic production of high-octane gasoline
High gasification and its growth rate	Limited competitive private infrastructure
Improved institutional and legal framework	Incomplete formation of a liberalized energy market
Government priorities – reform strategy	Foreign dependence on a range of high-quality energy products
Opportunities – prospects	**Threats – danger**
Expanding the scope of technical regulation	Risks to the sustainability of investments in infrastructure reconstruction
Increasing energy efficiency	Outsourcing of certain segments of secondary production supplies
Development of new gas fields using domestic resources	Lag in modernization and reconstruction
Continuous innovation and technological progress	Global economic crises and other force majeure events

Diversification of the economy, development of innovative solutions, and infrastructure modernisation are the key factors contributing to Azerbaijan's sustainable economic growth in the long term (Abdullayev et al. 2024).

Conclusion

This SWOT analysis shows that energy security risks in Azerbaijan are at a very low level. All this also allows us to state with confidence once again that the energy policy pursued in the country is flexibly regulated and constantly improved within a strategic and conceptual framework. As a result, this updated infrastructural system constantly provides a basis for reforms in this field. It is also considered important to find cardinal solutions to a number of issues in order to increase the rationality of these reforms, their effectiveness in achieving their objectives, and make them sustainable. To this end, it is advisable to realize a set of reforms implemented through activities in the following areas:

- search and development of new sources of natural and artificial energy resources, their gradual introduction into circulation in both rings of the energy infrastructure in accordance with the needs of economic development;
- formation of a more optimal system of management of energy resources utilization and energy security;
- improving the competitive environment in the energy sector and expanding free market relations;
- preparation of program documents to improve energy, environmental efficiency, and cost-effectiveness, bringing the share of renewable energy sources in the energy system up to 30 percent;
- development of new strategies and state programs expanding the application of Industry 4 achievements in the energy sector and increasing energy efficiency;
- increasing energy exports, especially electricity, and enhancing the integration of regional infrastructures on the basis of mutual benefits.

In addition, optimizing the energy sector and its infrastructure mix, increasing its resilience, improving it, and ensuring continuous and sustainable investment through strategic plans are essential.

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Mahabbat Mammadov, Fidan Mammadova, Shahla Alizada, Turkan Hasanova, Said Alekperov

Kompleksowa analiza i ocena krajowego kompleksu energetycznego Azerbejdżanu: aktualny stan i perspektywy na przyszłość

W artykule naukowym poddano rozważaniom pierwszy i drugi sektor energetyczny uwzględnione w klasyfikacji branż. Wskazano na konieczność uwzględnienia realiów sektora energetycznego podczas badania historycznych etapów rozwoju kompleksu infrastrukturalnego sektorów naftowego i gazowego oraz przedstawiono badania w tym kierunku. Przeanalizowano procesy budowy i uruchamiania elektrowni (elektrownie wodne, elektrownie cieplne) w Azerbejdżanie od końca XIX wieku oraz transformację tej branży w główny element rozwoju gospodarczego kraju. Jednocześnie w artykule przeanalizowano wskaźniki infrastrukturalne aktualnego stanu infrastruktury gazowej i energetycznej kraju, która stanowi integralną strukturę w rozwoju sektora energetycznego, a także opracowano matrycę analizy SWOT ilościowych i jakościowych wskaźników bezpieczeństwa energetycznego kraju.

Słowa kluczowe: energia, infrastruktura, analiza zintegrowana, elektrownie, SWOT, macierz, bezpieczeństwo energetyczne