



THE CURRENT STATE OF THE GAS INDUSTRY AND THE EMERGING GREEN ENERGY SECTOR IN AZERBAIJAN

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ABSTRACT

Azerbaijan is at the crossroads of its energy development, weighing its traditional position as a leading gas exporter against the increasing trend towards renewable energy. This article examines the interaction between Azerbaijan's fossil fuel industry and its nascent green energy sector, looking at its contribution to European energy security and the shift towards sustainability. This research evaluates the importance of the Southern Gas Corridor in providing EU gas diversification, especially during geopolitical transformations, and measures the renewable energy potential of Azerbaijan. Based on PESTEL and SWOT assessments, the article analyzes Azerbaijan's renewable and gas industries with implications of strength, weaknesses, challenges, and opportunities. The analysis indicates that although gas exports are crucial for Europe's immediate energy security, Azerbaijan is also investing in wind power and solar energy to become a green energy hub. Its participation in the EU–Black Sea–Caspian Sea Green Energy Corridor is particularly significant as an indicative change towards renewable electricity exports. The research determines that natural gas will be the central pillar of Azerbaijan's economy in the near future, but the nation is preparing the ground for a future based on renewable energy. Breaking through the infrastructure issues, attracting investment, and coordinating policies with international decarbonization targets will be decisive. If well managed, Azerbaijan can not only become a stable source of energy but also a regional clean energy leader, achieving long-term economic and environmental stability.

Keywords: Southern Gas Corridor; renewable energy transition; Azerbaijan-EU energy relations; green energy corridor.

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1. Introduction

The global energy market is at a revolutionary stage that entails the intense interaction between traditional fossil fuels, dominated by natural gas, and the recently emerging renewable resources. This transition process is dictated in the nature by geopolitical factors, technological development, economic stress, and environmental-related policy realignments across diverse regions. Everywhere across the globe, over 150 countries, covering 90% of humanity, have committed to being net-zero emitters by 2050 [1].

The EU itself is also making a stunning energy revolution towards climate neutrality by 2050. The transition is from fossil fuels to renewable energy sources such as wind, sun, and hydroelectric power for reducing carbon footprint. Decarbonization is the most important priority, which requires enormous investments and policy changes to limit greenhouse gas emissions and enhance sustainability [2]. Outside Europe, other large economies are also sorting out the puzzle of energy transformation in a geopolitics context. As an example, the United States has introduced the Inflation Reduction Act (IRA) in 2022, which is a landmark climate law

that provides large-scale green subsidies, aims to accelerate the clean energy transition by subsidizing renewable energy, and hydrogen production [3]. The IRA is expected to reduce US greenhouse gas emissions significantly, closing two-thirds of the emissions gap to meet the 2030 climate targets. However, Donald Trump has been outspoken opponent of renewable energy, which was strongly advocated by former President Joseph R. Biden Jr. as a key strategy for tackling climate change. The energy secretary, along with Trump and Republican lawmakers in Congress, has committed to reversing many of Biden's climate and energy initiatives [4]. At the same time, Meidan, Hove, and Andrews-Speed, [5], state that China is further expanding its influence across international energy markets by investing massive renewable energy projects in Africa, Latin America, and Southeast Asia, further complicating the international energy landscape.

Azerbaijan has a rich and long oil and gas industry history. Ever since as early as the 13th century, visitors like Marco Polo saw the «stream of oil in such abundance» in the Baku surroundings [6]. As of the early and late 19th and 20th centuries, the country was an oil-producing global leader that fueled the Soviet Union's World War II campaigns [7]. Natural gas, though surpassed by oil in the past, has grown more and more central to Azerbaijan in recent decades. The start of

production at the giant Shah Deniz gas field in 2006 marked a turning point, making Azerbaijan a net exporter of gas by the mid-2000s. The gas boom has enhanced Azerbaijan's strategic position in regional energy geopolitics. In particular, the country emerged as a major player in European energy security. The reliance of Europe on Russian gas had been an Achilles' heel for long, one starkly highlighted in the aftermath of the Russian-Ukraine war. As a reaction to the resulting energy crisis, the European Union (EU) hastened its quest for alternative providers.

2. Azerbaijan's production and exports of gas

Azerbaijan, being a country with vast gas reserves and strong pipeline connections to Europe, became an immediate focal point of EU diversification efforts shortly thereafter. The EU and Azerbaijan signed a memorandum of understanding in July 2022 to double the supply of gas to a minimum of 20 billion cubic meters (bcm) per year by 2027 [8]. European Commission President Ursula von der Leyen was hailing Azerbaijan as a key partner in our effort to leave Russian

fossil fuels [8], and the geopolitical significance of Azeri gas was emphasized for Europe.

Azerbaijan possesses extensive natural gas reserves beneath its rising export potential. The International Energy Agency estimates that Azerbaijan's proven gas reserves amount to approximately 2.5 trillion cubic meters (tcm), with the majority of these reserves located in offshore fields within the Caspian Sea [9].

Annual gas production in the republic has risen rapidly in recent years. According to the analysis of the above figure 1, in 2024, output reached a record 50.4 bcm of gas, a 4.1% jump from the prior year. It should be noted that production volumes are reported at different temperature standards. Volumes for the Shah Deniz, ACG, and Absheron fields are measured at 15 °C, while production volumes for SOCAR are measured at 20 °C. As the analysis shows, the reason for this is new projects. The giant Shah Deniz field alone contributed about 27.8 bcm of gas to this total, with another 13.4 bcm of gas coming from associated gas at the Azeri-Chirag-Gunashli (ACG) oil field and 1.5 bcm of gas from the newly developed Absheron field. Moreover, small fields and onshore operation of the state oil company SOCAR supplied around 7.7 bcm of gas for domestic needs.

The analysis demonstrates that the export infrastructure for this gas centers on the Southern Gas Corridor (SGC), a 3500 km pipeline network that transports Azerbaijani gas from the Caspian Sea to Europe via Georgia and Turkey. The SGC is composed of three linked pipelines: the South Caucasus Pipeline (Baku-Tbilisi-Erzurum) transporting gas from Azerbaijan via Georgia; the Trans-Anatolian Pipeline (TANAP) across Turkey; and the Trans-Adriatic Pipeline (TAP) from Greece via Albania to Italy. The detailed pipeline network is illustrated in figure 2.

Constructed in 2020, this corridor has an initial capacity of around 16 bcm of gas per year, providing around 10 bcm of gas to the EU market and 6 bcm of gas to Turkey, with the potential for future expansion by adding compressor stations.

According to the analysis of figure 3, Azerbaijani gas exports have illustrated a consistent growth from 18.9 bcm of gas in 2021 to 25.2 bcm of gas in 2024. Azerbaijan's gas exports totaled 25.2 bcm of gas, of which 12.9 bcm were supplied to Europe via Italy, Greece, and Bulgaria, and 9.9 bcm to Turkey, with 2.4 bcm supplied to neighboring Georgia. This export route has been instrumental in directly linking Caspian gas to EU consumers for the first time, enhancing Europe's supply diversity.

3. Azerbaijan's role in EU energy security

The completion of the Southern Gas Corridor has given the EU a new source of pipeline gas at a critical time. According to Aitken and Ersoy, the European Union is in vulnerable situation due to its reliance on Russian gas supplies [15]. Azerbaijani gas is now flowing directly into Europe, offering a measure of relief from the continent's dependence on Russian supplies. Since the situation encourages the EU to diversify energy supplies [16]. Although the volumes are relatively modest on the EU scale, they are strategically important. Based on the analysis of figure 3 and the chronology of the conflict in Ukraine, it is determined that, in 2021, before the Ukraine crisis, Azerbaijan supplied about 8.2 bcm of gas to the Europe, whereas a year after, this had grown to 11.4 bcm, and in 2024 reached 12.9 bcm. This growth in

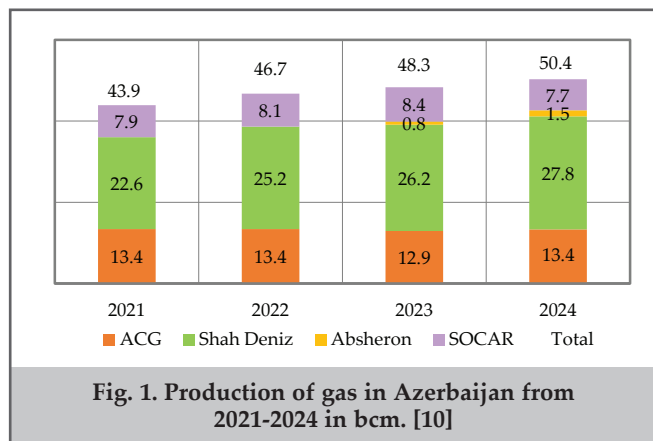


Fig. 1. Production of gas in Azerbaijan from 2021-2024 in bcm. [10]

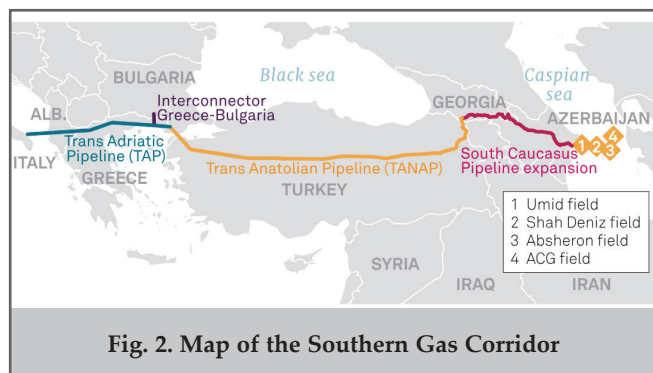


Fig. 2. Map of the Southern Gas Corridor

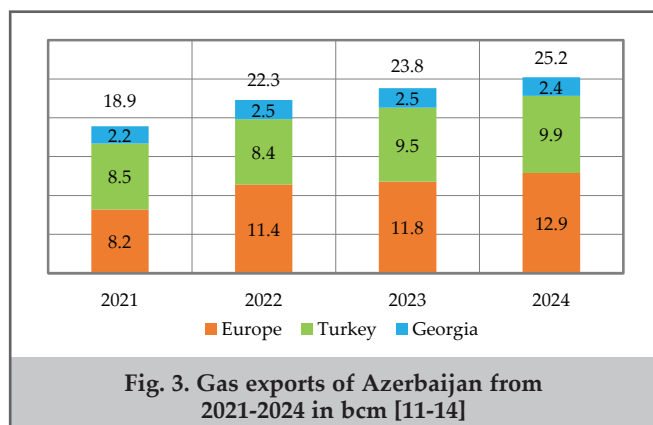


Fig. 3. Gas exports of Azerbaijan from 2021-2024 in bcm [11-14]

exports was driven by the addition of new development wells, which expanded Azerbaijan’s production capacity. The crisis in Ukraine has resulted in a slightly more than doubling of gas imports to the EU from Azerbaijan, namely by 57.3% when comparing 2021 to 2024. This increase coincided with Russia’s cutback of gas exports to Europe and helped countries like Italy, Greece, and Bulgaria offset a portion of the lost Russian volumes. At the inauguration of the Southern Gas Corridor in 2018, President of Azerbaijan Mr. Ilham Aliyev noted that with this project, Azerbaijan is creating a new energy map of Europe [17]. This is a bold claim that underscored Azerbaijan’s potential to alter Europe’s energy supply picture.

To formalize this collaboration, the EU and Azerbaijan signed a strategic energy partnership in July 2022 that provided a roadmap to expand Azerbaijani gas exports to Europe. The memorandum of understanding committed to raising the Southern Gas Corridor’s capacity to around 20 bcm per year from its current level of around 12 bcm per year by 2027 [18]. Pipeline expansion and new upstream investment will be required to achieve this objective. On the supply side, Azerbaijan is developing fields like non-associated gas of Azer-Chirag-Gunashli, Absheron, and Umid and working with international partners to ensure sufficient gas to meet the higher export volumes. Baku has made it clear that it needs long-term purchase guarantees and financing to realize these projects, given the considerable costs and Europe’s broader shift toward green energy [19].

Azerbaijani gas is playing an increasingly noticeable role in the supply diversification of some European nations. Initially, Italy, Greece, and Bulgaria were the primary EU recipients via the TAP pipeline. In 2021, the Greece-Bulgaria Interconnector (IGB) was completed, extending Azerbaijani gas to Bulgaria, a country that had depended almost entirely on Gazprom and faced a supply cut-off in 2022 [20]. By replacing a sizable portion of Bulgaria’s gas needs, the SGC helped blunt the impact of Russia’s energy pressure. Other countries have since sought access to Azerbaijan’s gas as well. In 2023, Hungary and Romania negotiated to receive modest volumes of Azeri gas through existing pipeline links with neighbors. Slovakia has announced plans to import Azerbaijani gas as a means to reduce its reliance on Russia, and the Czech

Republic and Austria have explored the same possibilities [21]. Notably, Azerbaijan started supplying Slovenia with gas under a new contract in August 2024, marking the first instance of Caspian gas flowing to the nation. These trends suggest the potential that the Southern Gas Corridor presence could extend from its initial termini, branching into Southeast and Central Europe through interconnectors and swap deals. Every new connection further reduces the share of Russian gas in the European basket, whether by building more pipelines or utilizing the EU’s integrated gas system.

3.1. PESTEL analysis of Azerbaijan’s gas industry

A PESTEL framework including Political, Economic, Social, Technological, Environmental, and Legal factor analysis gives a structured overview of the drivers and restraints behind Azerbaijan’s gas industry. Table 1 illustrates the summary of PESTEL analysis.

Political factors

Azerbaijan’s government is very supportive of hydrocarbon development and has maintained friendly relations with transit states, Turkey and Georgia, to allow for export lines. Politically, Azerbaijan’s gas industry has reaped a lot from robust local government support and diplomatic relationships. Nevertheless, a key political challenge is the European Union’s reluctance to make long-term fossil fuel commitments in the midst of its climate and energy policy transition. While the EU has been keen to diversify away from Russian gas, so Azerbaijan is an attractive near-term partner, long-term deals have been held up by climate-focused policies and ambitions under the European Green Deal.

Economic factors

Azerbaijan’s fortunes are closely tied to oil and gas revenues, which account for roughly 90% of export earnings and two-thirds of government revenue [22]. These earnings have endowed Azerbaijan with a strong sovereign balance sheet, including a sizeable sovereign wealth fund, and sustained public spending. However, this hydrocarbon dependence makes the economy vulnerable to commodity price fluctuations and external demand shifts. With oil output plateauing, gas exports are considered a key driver of future growth and investment, but global decarbonization trends pose a long-term risk to this gas-centric development model.

PESTEL Analysis of Azerbaijan’s gas industry

Table 1

Political	Economical	Social	Technological	Environmental	Legal
Strong government support for gas development.	Fossil fuels contribute 90% of exports.	Fossil fuel revenues improve living standards.	Modern offshore drilling.	Immediate support to reduce coal emissions in the EU.	Long-term Product Share Agreements.
Stable diplomatic relations with Turkey and Georgia.	Two-thirds of government revenue.	Growth of middle class supported.	Reliant on pipeline exports.	Fossil fuel account for 97.5% of domestic energy in 2019.	Contract of the Century.
EU Hesitant on long-term agreements.	Economic vulnerability to price fluctuations.	Gas sector creates employment.	Interest in hydrogen.	Conflict with climate goals.	Transit agreements.
EU Green deal	90% of electricity generated powered by gas.	Affordable domestic energy.			Evolving EU regulations.
		90% of electricity generated powered by gas.			

Social factors

The hydrocarbon sector has had a revolutionary effect on Azerbaijani society and development. Energy revenues fund public spending and infrastructure, and they fuel living standards and build a middle class [9]. The funds from the State Oil Fund of the Republic of Azerbaijan were invested in programs such as AZN 9585.8 million were transferred to the «2019-2023 State Program on Increasing the International Competitiveness of the Higher Education System of Azerbaijan»; AZN 10.8 million were financed for the «State Program for the Education of Youth at Prestigious Universities of Foreign Countries for 2022-2026»; AZN 770.6 million were allocated for the Oguz–Qabala–Baku water supply system; AZN 748.6 million were allocated for the Baku–Tbilisi–Kars railway; and AZN 1469.6 million were transferred for the reconstruction of the Samur-Absheron irrigation system [23]. The gas sector also creates employment, directly and in ancillary industries, and assists energy affordability domestically as natural gas fuels 90% of electricity generation in Azerbaijan, producing round-the-clock power [9].

Technological factors

The gas sector of Azerbaijan has benefited from modern technology introduced to a large degree by foreign partners. The development of offshore fields like Shah Deniz has employed sophisticated drilling and production techniques contributed by companies such as BP. The SGC export pipeline system is modern and built to current standards for efficiency and safety. As a landlocked country, Azerbaijan has not invested in LNG export terminals and to date relies on pipeline technology only for gas transport. Azerbaijan is actively exploring new energy technologies, ranging from advanced extraction methods to potential hydrogen or renewable gas capabilities, to maintain its competitiveness in the evolving energy market.

Environmental factors

As an oil and gas producer, Azerbaijan also shares the environmental issues typical of oil and gas. Azerbaijani gas can reduce Europe's emissions by substituting for coal. EU officials have noted that Azeri gas is being used as a cleaner «transition fuel» to reduce reliance on coal power in the short term [7]. As of 2019, domestic energy consumption was entirely fueled by fossil fuels, at 97.5% [24]. They are thus significant emitters of greenhouse gases. As experts note, the path aimed at increasing production of gas is incompatible

with global climate goals. Balancing the country's role as a gas producer with environmental sustainability is an ongoing policy dilemma. The government has started investing in renewable energy projects, such as wind and solar farms, and discussing «green energy» export ideas, but these are still in their infancy compared to the magnitude of the fossil fuel sector.

Legal factors

Azerbaijan's oil and gas sector is regulated by a privileged legal regime of long-term production-sharing agreements. The government initially introduced investor-friendly PSAs in the 1990s; notably, on the 20th of September 1994, the «Contract of the Century» was signed, which provided foreign oil majors with secure rights to develop ACG and later Shah Deniz fields. These parliament-approved contracts are effective above ordinary law and have ensured stability and legal certainty for investors for decades. In the export sector, international treaties favor the pipelines. Azerbaijan has transit deals with Turkey and Georgia to guarantee gas exports to Europe. Being landlocked and dependent on neighbors for export routes means Azerbaijan must maintain sound legal relations with transit countries. Thus far, that cooperation has been strong; for example, the TANAP and TAP pipelines were facilitated by intergovernmental agreements. Another legal dimension is the evolving EU regulatory environment. European climate regulations or greenhouse gas rules may in the future impose further demands on gas imports, which could affect Azerbaijan's exports. Overall, Azerbaijan has used legal tools quite effectively to obtain long-term export agreements, but it will need to be able to react to any legal developments in its most significant markets and to maintain the contractual confidence it has built with partners.

3.2. SWOT analysis of Azerbaijan's gas exports to the EU

A SWOT analysis determines the Strengths, Weaknesses, Opportunities, and Threats of Azerbaijan's gas exports to the EU (table 2).

Strengths

Azerbaijan possesses huge gas reserves of around 2.5 tcm proven and a geography that makes direct pipeline access to Europe possible. It has established infrastructure and supply routes, and the Southern Gas Corridor is already delivering gas to several EU markets such as Croatia, Slovenia, Italy, Greece, Bulgaria, Romania, Hungary, and Slovakia.

SWOT Analysis of Azerbaijan's gas exports to the EU

Table 2

Strengths	Weaknesses
<ol style="list-style-type: none"> 1. Proven gas reserves of 2.5 tcm 2. Strategic geography 3. Established infrastructure 4. Full government support 5. Strong partnership with international companies 6. Reputation as a reliable partner 	<ol style="list-style-type: none"> 1. No LNG exports capabilities 2. Dependence on single exports corridor
Opportunities	Threats
<ol style="list-style-type: none"> 1. EU demand for non-Russian gas 2. MOU signed to double gas supplies 	<ol style="list-style-type: none"> 1. Aggressive EU Climate policies 2. Global competition 3. EU's reluctance for long-term contracts

Azerbaijan has the full government support for developing gas and has enticed large international energy companies to partner with it, bringing technical expertise and investment. Azerbaijan's record of stability in exports and the existence of long-term contracts have created a reputation for being a reliable supplier to Europe.

Weaknesses

Azerbaijan's exports are limited, as a country without LNG capability, and therefore wholly dependent on pipelines through Turkey and Georgia. This inflexibility diminishes its flexibility because it depends on a single corridor and a few large purchasers. The very high dependence of the economy on hydrocarbons also means that Azerbaijan has relatively low diversification, which may weaken its negotiating position if the market context changes. Additionally, any future production increases will require significant new investment; Azerbaijan has had to import gas at times to meet domestic demand while honoring export commitments, indicating capacity limits.

Opportunities

The conducted analysis provides grounds to assume that in the medium term, European demand for non-Russian gas should remain robust, and this is an opportunity for Azerbaijan to expand its market share. The EU proposal to increase imports from Azerbaijan to 20 bcm by 2027 provides a clear growth trajectory. There is also scope to extend Azerbaijan's reach into new markets in South-Eastern and Central Europe, recent agreements with countries like Romania, Hungary, and others to access Azerbaijani gas illustrate this potential. Further pipeline network expansion, such as expanding TAP's capacity or building new Balkan interconnectors, would potentially unlock further volumes for export. In the future, Azerbaijan may diversify exports by participating in future energy trends such as when Europe gets greener. Azerbaijan can investigate exporting hydrogen or renewable-sourced gases via its pipelines, benefiting from its already established corridor for future green exports.

Threats

Azerbaijan's gas export strategy faces several external threats. Chief among them are the prospects of declining gas demand in Europe, as the EU is pursuing an aggressive climate policy. Thus, the EU's energy strategy REPowerEU, initiated in May 2022, envisions reducing gas consumption by approximately half by 2030, which could sharply reduce the need for imports.

As analyzed in figure 4, gas consumption in the EU has been steadily decreasing from 2021 to 2024. The consumption of gas in the EU has already decreased by 8.2%, comparing the 2022 value to 2024. EU energy experts note that if Europe stays on track with its renewables transition, it will not need any additional gas from Azerbaijan beyond current levels. In addition, Azerbaijan competes with other suppliers such as LNG from the United States and Qatar, or pipeline gas from North Africa, an oversupply in global markets or lower prices could erode its market share. There is also the risk of European consumers, conscious of climate targets, being reluctant to sign long-term gas contracts into the 2030s, which could make it difficult for Azerbaijan to secure funding for new field development. Finally, regulatory changes, like stricter EU regulations on methane emissions or carbon levies on gas, could involve higher compliance costs and make Azerbaijan's access to the EU market difficult. These elements

may all cumulatively jeopardize the ambitious expansion strategy unless they are alleviated by strategic planning and global collaboration.

4. Unfounded criticism of Azerbaijan's path

Criticism directed at Azerbaijan regarding gas exports and the hosting of the 29th Conference of the Parties to the United Nations Framework Convention on Climate Change (COP29) is largely unfounded and overlooks the important context of current energy and climate agendas.

Above all else, it is necessary to consider the realities of European energy security. After the restriction of Russian gas supplies, the European Union faced a pressing need for diversifying sources of energy. In these situations, Azerbaijan proved to be one of the key partners, delivering stable volumes of gas through the Southern Gas Corridor. Furthermore, natural gas is also a transitional fuel that is needed for ensuring the energy security of Europe until the time of complete decarbonization. Azerbaijani gas exports criticism ignores this key fact, forgetting the fact that a rejection of Azerbaijani gas could lead to energy shortages and increased prices. This addresses the nation's strategy for a phased transition within a low-carbon economy, in which natural gas is viewed as a transitional component in the energy mix. Moreover, COP29, held in Baku in November 2024, serves as an opportunity for substantive engagement. This event provided an opportunity for developing economies to play an active role in the global climate agenda.

Additionally, criticism ignores the regional context. For Azerbaijan, gas export is not only a strategic element of foreign trade but also one of the principal sources of funding for social programs of the republic and sustainable development policies. Ignoring this specificity leads to one-sided assessments of the country's policy. Moreover, cooperation with the EU in the energy field strengthens regional stability and diversification of Europe's energy market, which is in the interest of all parties.

Finally, Azerbaijan is already taking steps to combat climate change. It has set a goal of being carbon neutral by 2050 and is actively decreasing greenhouse gas emissions. These efforts should be welcomed and supported; therefore, an objective approach should be adopted when assessing the situation.

Thus, the fault-finding of Azerbaijan regarding gas exports and COP29 hosting is not considerate of the complexity of current energy facts and the country's commitment to sustainable development. Meaningful engagement

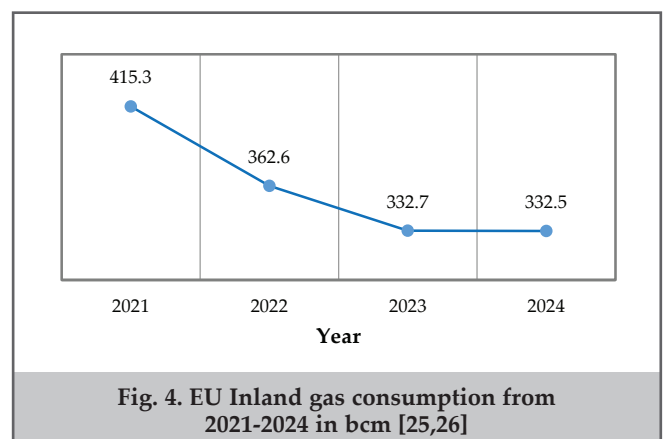


Fig. 4. EU Inland gas consumption from 2021-2024 in bcm [25,26]

requires paying attention to both the current challenges as well as the efforts being made to balance energy security and climate obligations.

5. Green energy in Azerbaijan

Azerbaijan, a hydrocarbons powerhouse for decades, finds itself at a pivotal point in its energy history. The petroleum and gas sector is still the driver of the economy – contributing to the GDP of around half and over 90% of export earnings [27, 28] but is now also trying to leverage its rich renewable energy resources. More recently, the Baku government has set ambitious green energy targets, with renewables to generate around 30% of its electricity by 2030 [29]. The initiative is a conscious U-turn for a nation that was once powered by offshore oil wells and Caspian Sea gas fields. Azerbaijan's government went as far as to make the country a climate leader by hosting the COP29 climate conference in 2024, showing how serious it is about a greener energy future.

The geography and politics of Azerbaijan also place it at the center of emerging regional energy systems. Azerbaijan's physical location between Asia and Europe positioned it as a green energy bridge between the EU and the Caspian Sea basin. The idea behind the EU-Black Sea–Caspian Sea Green Energy Corridor is to export renewable electricity from Azerbaijan and its neighboring countries through the Black Sea to the European market. The motivation for this corridor has grown in the wake of Europe's efforts to reduce dependence on Russian fossil fuels, especially after the Ukraine crisis in 2022. European officials view Azerbaijan as a «reliable energy partner» in this context [30], not only for natural gas in the short term but increasingly for renewable power in the long term. Azerbaijan, Georgia, Romania, and Hungary signed a landmark agreement in December 2022 to connect a 1195-kilometer-long submarine cable transmission line over the Black Sea [31]. The initiative will introduce Azerbaijan's green energy into the EU power grid, marking Azerbaijan's strategic position in the green transition of Europe. As the following sections shall witness, Azerbaijan is gradually transforming its energy economy, making use of its renewable resources and geographical position to become an integral component of the region's green energy belt.

5.1. Current state of renewable energy in Azerbaijan

Azerbaijan is endowed with rich renewable energy resources in the form of solar, wind, hydro, and bioenergy. It receives high solar irradiance in the plains and semi-arid

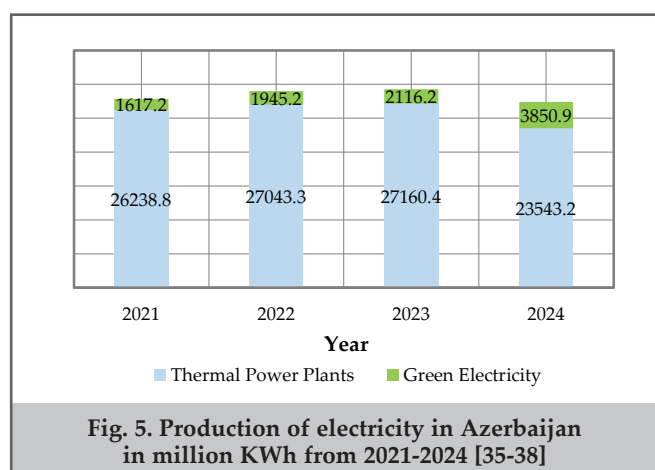
lowlands and strong winds along the Caspian Sea coastline and in some mountain passes. According to World Bank and Ministry of Energy analysis, the economically viable renewable energy potential of Azerbaijan is around 27 gigawatts (GW) [32, 33]. It includes around 23 GW of solar photovoltaic potential and 3 GW of developable wind power, with lesser quantities of bioenergy, around 380 MW, and hydropower on mountain rivers around 520 MW.

It is also worth noting that the technical potential is even larger on the order of 135 GW onshore and 157 GW offshore, when considering all favorable sites and future technologies [34]. In particular, the winds over the Caspian Sea are considered an attractive resource. According to a World Bank study, the Azerbaijani sector of the Caspian alone could generate up to 7000 MW of wind power with current technology. Despite this huge potential, renewable energy, excluding old hydropower, is currently a relatively modest part of Azerbaijan's energy mix. According to the analysis of figure 5, as of 2024, thermal power plants continue to produce around 86% of electricity in the country, while renewables accounted for 13.5%.

In 2024, Azerbaijan produced 28.3 billion kWh of electricity, of which only 3850.9 mn kWh came from green sources. Solar farms generated 556.3 million kWh and wind farms a mere 51.1 million kWh in that period [35], reflecting the fact that large solar and wind projects are just beginning to come online. This situation, however, is rapidly changing as new projects are commissioned.

Azerbaijan initiated several big renewable energy projects on international collaborations within the past two years. The country's first independent solar power project – 230 MW Garadagh Solar Plant developed by Masdar (Abu Dhabi clean energy firm) – has gone on stream in 2023[39]. This success was followed by Masdar and Azerbaijan pledging to develop an additional 1 GW of onshore wind and solar projects on various sites and even outlined plans for as much as 4 GW in a second phase with offshore wind and green hydrogen production [29]. Another key participant is Saudi Arabia's ACWA Power, constructing the 240 MW Khizi-Absheron wind farm to be commissioned in late 2025. They are one of a broader sweep of foreign investments: contracts or memoranda for some 10 GW of clean capacity have been awarded to companies from the UAE, Saudi Arabia, Europe, China, and elsewhere [40]. Even traditional oil and gas majors are now intervening; for instance, BP signed a deal in 2024 to develop a 240 MW solar farm in Azerbaijan [41].

The Azerbaijan government has also made efforts to establish a favorable policy environment to attract such investments. In 2021, the Parliament approved a new Law on Renewable Energy that set up feed-in tariffs, long-term power purchase contracts, and competitive auctions for renewable energy [42]. The legislation also provides investor incentives in the form of priority grid connection and land lease guarantees for renewables. The government targets have now been adjusted to accommodate its own. Initially, Azerbaijan aimed to achieve 1500 W of new renewable capacities by 2030. However, as noted by the President, Mr. Ilham Aliyev, at COP29, this figure is expected to reach 6000 MW by 2030. Achieving 6 GW of capacity would mean roughly one-third of Azerbaijan's installed power capacity would be green by the end of this decade – a big leap from today. The Deputy Energy Minister has projected that,



given current momentum, over 32% of the country’s power capacity could be renewable by 2027 [34]. If these goals are met, Azerbaijan will not only meet more of its electricity demand with clean energy but also position itself to export surplus green power.

5.2. Azerbaijan’s role in the EU–Black Sea–Caspian Sea green energy corridor

Azerbaijan’s strategic importance goes beyond its borders: it is the linchpin of the envisioned EU – Black Sea – Caspian Sea Green Energy Corridor, which aims to link the renewable energy resources of the Caspian region to European markets. This corridor concept has gained traction as Europe seeks new energy supplies in a decarbonizing world. By virtue of geography, Azerbaijan can serve as the collection and transit point for green electricity, much as it already does for oil and gas via pipelines.

The centerpiece of Azerbaijan’s role is the Black Sea Submarine Cable project – a bold plan to connect Azerbaijan to the EU grid. In December 2022, Azerbaijan joined Georgia, Romania, and Hungary in signing a Memorandum of Understanding to build this undersea power line [43]. The proposed high-voltage direct current (HVDC) cable will run around 1,100 km through the Black Sea from Romania to Georgia, plus additional overhead cables via Azerbaijan and Georgia, ensuring a continuous link from the Caspian coast to the continent of Europe. With an estimated transmission capacity of 1000 MW, the cable would supply sufficient clean electricity to supply 1 million European homes. European Commission President Ursula von der Leyen has greeted the Black Sea cable as a flagship project to introduce renewables into the grid, calling it «so important» for enabling more green energy to be integrated into the grid [30]. The EU has backed this vision with serious intent. The construction of the cable will receive EUR 2.3 billion in funding, according to Hungary’s foreign minister [44].

5.3. PESTEL analysis of Azerbaijan’s renewable energy sector

A PESTEL framework, including Political, Economic, Social, Technological, Environmental, and Legal factor anal-

ysis gives a structured overview of the drivers and restraints behind Azerbaijan’s renewable energy market. All of these refer to the rate and extent to which the country can get greener and achieve its corridor ambitions (table 3).

Political factors

Politically, there has been enthusiastic vocal government commitment to developing renewables in Azerbaijan. The topic commands high-level political support: President Ilham Aliyev spoke frequently about renewables in public statements and set tangible targets, for example, 30% renewables by 2030. Being the host nation for COP29 in Baku in 2024 was also a clear indicator of Azerbaijan wanting to emerge as a green leadership country. This senior-level support comes in concrete policy – the government, for instance, created the specialized Ministry of Energy Agency for renewables and made «green energy zones» a reality in politically favored areas like the liberated Karabakh region. The nation’s foreign policy has also utilized energy cooperation in building relations with both Eastern and Western partners.

The political relations with the EU, for instance, have been promoted by collaborative efforts on the Green Energy Corridor, which positions Azerbaijan in sync with Europe’s climate agenda. Globally, Azerbaijan is also interacting with entities such as IRENA to demonstrate its commitment. According to IRENA Director-General Francesco La Camera, «Central Asia’s ample renewable energy endowments and efforts to construct a green energy corridor release significant opportunities», implicitly praising Azerbaijan’s regional leadership [45].

Economic factors

Economically, diversification of renewable energy is a challenge and opportunity for Azerbaijan. The country’s hydrocarbon wealth has provided it with huge economic resources – oil and gas alone contributed over 92% to export revenues in the past, which filled up the sovereign wealth fund. The funds can be utilized to co-finance the renewable projects and improve the grid. At the same time, excessive dependence on oil revenues makes Azerbaijan’s economy vulnerable to fluctuations in fossil fuel prices and long-term decline in world demand for oil. Investment in renewables is a way of future-proofing the economy and creating new

PESTEL Analysis for Renewables prospects in Azerbaijan

Table 3

Political	Economical	Social	Technological	Environmental	Legal
The government targets 30% renewables by 2030.	Renewable energy diversifies the economy.	Job creation and skill-building opportunities.	Grid modernization.	Aim to cut emissions by 40% by 2050.	Renewable Energy Law (2021) establishes clear rules.
COP29 host (2024), highlighting green leadership ambitions.	Oil revenue funds renewable infrastructure projects.	Positive public health impacts from cleaner energy.	Partnerships for advanced grid technology.	Renewable energy reduces pollution and water usage.	Financial incentives attract renewable investment.
Creation of green energy zones in Karabakh.	Major Foreign Investments.		Potential development of green hydrogen technologies.	Sustainable redevelopment plans in liberated territories.	The electricity market is gradually becoming competitive.
Renewable energy strengthening EU foreign relations.	Potential renewable exports to Europe.			Prevents historical environmental damage from fossil fuels.	
Cooperation with international renewable organizations.	High initial investment costs and grid challenges.				

industries. Economically, diversification into renewable energy presents opportunities and challenges for Azerbaijan. The hydrocarbon wealth of the nation has provided humongous fiscal assets, oil and gas have covered over 92% of traditional export receipts, which swelled the sovereign wealth fund. The capital may be used to provide co-finance for renewable developments and reinforce the grid.

Meanwhile, dependence on oil revenues is burdensome, which makes the economy of Azerbaijan susceptible to fluctuating prices for fossil fuels as well as longer-term reductions in world demand for oil. Renewable investment is one way of future-proofing the economy and setting up new sectors. The investment climate for renewables in Azerbaijan is improving, as evidenced by multi-billion-dollar agreements with foreign firms such as Masdar, ACWA POWER, BP, and TotalEnergies. These deals suggest that international investors see Azerbaijan as an attractive market for green energy, thanks to its resource potential and government guarantees. The promise of exporting electricity or green hydrogen to Europe further sweetens the economic rationale – Europe represents a large, creditworthy market willing to pay for clean energy, especially in the context of energy security post-2022. The planned Black Sea cable, supported by EU funding, is essentially a new export pipeline for electricity that could generate steady revenue for decades. Azerbaijan can also save money domestically by using renewables since every megawatt of solar or wind used at home frees up natural gas that can be exported or used in petrochemical industries.

On the flip side, the economic challenge is the high upfront cost of renewable infrastructure. Solar panels, wind turbines, and transmission lines require significant capital [46]. While foreign direct investment is flowing in, Azerbaijan must continue to provide incentives and a stable environment to attract the tens of billions of dollars needed to realize its 6 GW by 2030 plan. Additionally, integrating variable renewables might require investments in energy storage or peaking power plants to ensure reliability, which come at a cost. Finally, the broader push to decarbonize could eventually impact Azerbaijan's oil and gas revenues – if electric vehicles and heat pumps cut oil and gas demand, Azerbaijan's state budget might tighten, potentially affecting its ability to invest in or subsidize renewables. Managing this economic transition will require careful planning so that the boom-and-bust cycles of oil are not replicated in the nascent green sector.

Social factors

The move toward green energy in Azerbaijan has multifaceted social consequences. On the positive side, the growth of renewable energy holds the potential for job creation and the training of skills among Azerbaijani workers. Solar farm building and operation, wind park construction, and new transmission line construction will create thousands of short-term construction jobs and technical jobs in the long run. The government frequently emphasizes employment opportunities from renewables, especially in rural regions where many projects are located. For instance, establishing solar plants in communities in Karabakh or Nakhchivan could provide local employment and support the resettlement of displaced populations with improved infrastructure. There is also a public health issue: shifting away from fossil fuels will reduce pollution from power plants, resulting in cleaner air and potentially healthier conditions for residents. Therefore, there is likely public sup-

port for clean energy, as seen in the updating of the country and the reduction of pollution.

Potential social issues are the retraining of employees from the oil industry to service in the renewables industry. Oil and gas companies are major employers, and jobs some of the time over long periods can drop; having a means of managing this shift in the workforce by education and vocational schemes will be critical. Another consideration is energy equity. The benefits of renewables accrue to the broader population. Generally, socially, the green transition offers Azerbaijan the chance to boost employment, improve public health, and inspire its citizens with a vision for the future – provided any possible disruption to established industries is properly managed.

Technological factors

Technically, Azerbaijan needs to upgrade and overhaul its energy grid to incorporate renewable energy. Among the main issues is grid readiness: the national grid system will have to deal with the intermittency of solar and wind energies. Interconnection of new renewable plants can require sophisticated load management systems, intelligent grid technology, and possibly energy storage units in order to coordinate supply and demand. The government has started working on these issues with government and international experts; for example, the World Bank and other agencies have provided technical expertise on integrating renewables into the grid. The HVDC Black Sea cable itself, as proposed, is a major technological undertaking, with advanced engineering in deepwater cable-laying and converter station technology. Successful project delivery will demonstrate considerable tech capability.

In addition to that, Azerbaijan is also exploring state-of-the-art renewable technologies like offshore wind and green hydrogen. Offshore wind in the Caspian Sea has the potential to exploit world-class quality wind resources of approximately 157 GW offshore, although a new technology frontier in the country requires experience with offshore platforms and turbine foundations. Green hydrogen is another technological opportunity: excess renewable electricity could be used to produce hydrogen fuel, via electrolysis, for export or domestic use. Azerbaijan's existing pipeline infrastructure and port facilities might, with modifications, be used to transport hydrogen or its derivatives like ammonia.

In fact, the EU-Azerbaijan energy MoU includes green hydrogen transit cooperation, which is evidence of mutual interest in this technology [47]. Simply put, technologically, Azerbaijan must renovate its grid, embrace novel energy technology like offshore wind power, and accumulate know-how. Its willingness to embrace and invest in high-level solutions, along with the accompaniment of international partners, bodes well with the triumph over the tech challenge of green transition.

Environmental factors

Environmental issues are at the heart of Azerbaijan's pursuit of renewable energy. Climate change poses real risks to Azerbaijan – from rising temperatures and droughts that could affect water resources and thereby hydropower and agriculture, to potential Caspian Sea level changes. Through expanding renewables, Azerbaijan aims to cut its greenhouse gas emissions and assist global climate mitigation efforts. At the COP26 summit in 2021, Azerbaijan made a pledge to reduce emissions by 40% by 2050 [48]. Every solar plant and

wind farm helps displace electricity that would otherwise come from burning natural gas, thereby lowering CO₂ output. Replacing aging oil- or diesel-burning power plants in remote areas with solar/wind will reduce their local pollution. Further, renewables use much less water than thermal power plants – a big bonus since Azerbaijan is water stressed [49].

Locally, on the environmental front, growing renewables must be done without adverse impacts on the environment. Big solar farms occupy a great deal of land; care should be exercised not to place them on fertile or disturbed land so as to have little effect on ecosystems or agriculture. Wind farms, especially those in the Caspian Sea, have to consider bird migration patterns and fishery impact. The government’s Green Energy Zone proposal for liberated territories is specifically crafted for sustainability, with the use of clean technology and energy efficiency in rehabilitating the area [50]. Adequate application would turn it into a template for eco-friendly rehabilitation, transforming destroyed regions into carbon-neutral energy hubs.

Another environmental factor is the cleanup of legacy oil pollution – while not directly related to renewables, Azerbaijan has also long grappled with the remediation of oil-soiled soil around Baku. Such a successful shift to renewables can also be seen as preventing such environmental damage in the future.

Lastly, as part of the international environmental community, Azerbaijan’s greening of its energy supply contributes to its reputation and soft power. Balancing energy development with the protection of the environment will require robust environmental impact assessments and enforcement of regulations. So far, Azerbaijan appears to be cognizant of this balance, boasting the tale that green energy will render the nation more sustainable and enable it to preserve its natural beauty for future generations.

Legal factors

Legally and regulatorily, Azerbaijan has made significant strides in establishing a framework amenable to the growth of renewable energy. The basis is the Renewable Energy Law of 2021, which was the country’s first dedicated comprehensive legislation focused solely on renewables. The legislation and regulation decrees were supplemented by transparent rules for private investment into the production of renewable power. Key legal provisions are mainly the use of auctions to select renewable project developers ensuring that they are transparent, competitive prices, and direct negotiation in case of strategic or pilot schemes [42]. The legislation provides guarantees such as long-term power purchase agreements under a fixed tariff to auction winners, priority dispatching of renewable electricity into the grid, and guaranteed grid

connection to approved projects. These steps reduce market risk for investors.

In addition, Azerbaijan’s regulatory framework offers tax relief or incentives for renewable energy under the umbrella of investment promotion regimes [51]. Another regulatory aspect is the liberalization and unbundling of the power industry. Historically, generation and transmission were under the control of state-owned utility Azerenerji. Those changes to modernize this system are underway; as an example, an electricity act, passed in 2020, paves the way for a more market-oriented electricity sector [52]. When renewables go online from independent power producers, having a level playing field grid access system and maybe eventually an electricity market will be important. The country is a member of the Energy Charter Treaty, which provides protections to foreign energy investors, and it has been working with the EU on harmonizing technical standards for the Black Sea interconnector. The prospective export of electricity to the EU also means compliance with EU regulations, for example, guarantees of origin for renewable electricity, and possibly the EU’s Carbon Border Adjustment mechanisms in the future. In terms of environmental law, implementing regulations to meet climate pledges such as MRV – monitoring, reporting, and verification of emissions – will increasingly come into play as renewables expand.

One challenge on the legal side is ensuring consistent regulatory enforcement and reducing bureaucratic hurdles. While the laws are in place, investors will be looking for clarity in land acquisition processes, permit issuing, and grid interconnection procedures. Any delays or non-transparent practices could dampen enthusiasm. Fortunately, Azerbaijan’s early renewable projects have largely been facilitated by one-stop agreements at the government level, indicating that high-priority projects get the needed support. Moving forward, as the sector scales up, the legal framework may need further refinement, for example, by introducing provisions for energy storage, or creating a legal basis for offshore wind development in the Caspian.

5.4. SWOT analysis of Azerbaijan’s green energy prospects

A SWOT analysis determines the Strengths, Weaknesses, Opportunities, and Threats of Azerbaijan’s renewable energy ambitions and its vision to be a green energy hub (table 4).

Strengths

Azerbaijan is strategically the link between Europe and Central Asia. It is already an energy transit country, through oil and gas pipelines to Georgia, Turkey, and the Black Sea. Such pre-existing energy infrastructure and know-how

SWOT Analysis of Green Energy prospects in Azerbaijan		Table 4
Strengths		Weaknesses
1. Strategic geographic location 2. Strong political commitment		1. Aging grid infrastructure 2. Reliance on foreign technologies and equipment
Opportunities		Threats
1. EU demand for renewable energy imports 2. Increased interest of EU for investments		1. Regional geopolitics 2. Dependence on partners’ political stability 3. Increased global competition

can be reused or added to for electricity transmission. The suggested Black Sea cable and existing regional grid intensify this potential. Strong political will by the government towards renewables is a key strength. Clear targets as 30% market share through renewables by 2030, capacity of 6 GW by 2030. Azerbaijan succeeded in attracting major foreign energy players to its renewable market. Joint ventures with experienced developers such as Masdar, ACWA Power, BP, and TotalEnergies do not only attract funding but also technical expertise and credibility as well.

Weaknesses

While the grid is extensive, there are certain infrastructure vulnerabilities. Renewable-rich areas like certain areas of Karabakh or offshore areas require the necessary high-capacity transmission lines to feed electricity to load centers or export points. The aging grid infrastructure can cause losses or reliability issues if not upgraded, and intermittent solar or wind integration will require sophisticated control systems that are not yet extensively deployed. The Black Sea cable project is likewise a record effort for Azerbaijan – even domestic delays in building converter stations or interconnection lines are bottlenecks. Azerbaijan is currently reliant on foreign technology for renewables. Solar cells, wind turbines, and ancillary equipment are not domestically manufactured in large volumes. Such production can be costly and dependent upon foreign providers. There is also limited local research and development work in renewables, although the volume is slowly increasing. Without local manufacturing, Azerbaijan might miss part of the economic multipliers of the renewables boom. Operation and maintenance of the high-tech installations might also necessitate perpetual foreign technical support until local capacity is built.

Opportunities

European Energy Diversification: The EU's effort to diversify away from Russia and decarbonize its supply presents Azerbaijan with a huge chance. Europe targets ambitious renewable import levels and invests in interconnections. Azerbaijan can provide a new niche for emerging exports as a top leader of green electricity and possibly green hydrogen to Europe.

Threats

The sustainability of Azerbaijan's renewable export vision is dependent upon stability in the region. Re-emergence of conflict within the Caucasus or political upheaval would imperil infrastructure or discourage investors. The involvement of multiple countries in corridor projects means the venture is only as strong as its weakest link – political changes in partner countries could delay or derail projects. Additionally, while unlikely, cyber or physical sabotage threats to large infrastructure like the submarine cable or major wind farms have to be considered in an era of heightened global tensions. With other countries emerging to develop more with renewables, Azerbaijan will be tested by others to export clean energy. North Africans and Middle Eastern countries are equally queuing to provide Europe with clean energy or hydrogen, tending to enjoy great solar weather and being geographically close. Within Europe, there may be a massive build-out of offshore wind in the North Sea and solar in Southern Europe, which could meet a lot of EU demand internally. If Europe becomes oversupplied with renewables or if prices of renewables drop further, the economics of exporting from Azerbaijan might become less attractive. There is a scenario where the Black Sea cable transmits power that struggles to compete on price in the European market unless subsidized.

Conclusions

1. Azerbaijan's gas sector has evolved from a long-term role as an «oil anomaly» to a key player in Europe's energy security. The development of the Southern Gas Corridor and production from major gas fields such as Shah Deniz has given Azerbaijan a new geopolitical status as a natural gas supplier to the EU. This role was reinforced in the context of the Ukraine crisis, when Azerbaijani gas became a substitute for part of Russian supplies to Europe and facilitated important agreements to further increase supplies. The study confirms that Azerbaijan can offer the EU a valuable source of diversification. Large reserves and strategic pipeline routes provide Europe with gas free from Russian influence and increase the sustainability of supply.
2. Azerbaijan's experience can serve as an example for other hydrocarbon-dependent economies seeking a green transition. Azerbaijan shows that the availability of oil and gas is not an obstacle to leadership in renewable energy in the future. However, the realization of this green leadership will depend on the successful and timely implementation of current renewable energy initiatives and measurable progress toward decarbonization goals. It is not an effortless path, but as Azerbaijan's experience demonstrates, with a clear vision, policy support, and international partnerships, the transition from black to green energy is possible. Integration into the EU-Black Sea-Black Sea-Caspian Sea Green Energy Corridor is not just an infrastructure project but a stage of Azerbaijan's maturation into the era of sustainable energy. The coming decade will show the full picture of the country's success in the renewable energy sector, but we can already be optimistic about the prospects of its green path.
3. Azerbaijan's contribution to the EU's energy security in the future will remain but will undergo changes. In the short and medium term, as the European strategy to diversify gas imports strengthens, Azerbaijan will be able to increase exports to the EU. In the long term, as decarbonization progresses in the European market, Azerbaijan will have to adapt to new requirements. The country's active renewable energy policy and commitment to developing hydrogen exports show that it is ready for these changes. If successfully implemented, Azerbaijan will be able to successfully ramp up gas capacity in the 2020s and, at the same time, prepare the basis for a clean energy future. It will not only be able to maintain its current position in Europe's energy mix but also remain an important partner in the decades to come.

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