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ВОЗОБНОВЛЯЕМАЯ ЭНЕРГЕТИКА В АЗЕРБАЙДЖАНЕ: СТРАТЕГИИ РАЗВИТИЯ И ПЕРСПЕКТИВЫ МЕЖДУНАРОДНОГО СОТРУДНИЧЕСТВА

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Аннотация
В статьях подробно рассматриваются стратегии развития возобновляемых источников энергии в Азербайджане, инициативы, представленные на COP29, и возможности для международного сотрудничества. Анализ подчеркивает важность максимального использования потенциала солнечной и ветровой энергии страны, обеспечения экономической безопасности и поддержания экологической устойчивости.
Проекты, представленные на COP29, укрепили позиции Азербайджана на мировом энергетическом рынке, привлекая новые инвестиции. В частности, Гобустанская солнечная электростанция и проект Восточный Зангезур выделяются как важные шаги на пути к продвижению использования солнечной энергии. Исследования показывают, что международное сотрудничество играет решающую роль в эффективном развитии возобновляемых источников энергии, содействуя обмену знаниями и финансовой поддержке.
Эти достижения открывают двери для цифровизации энергетического сектора, позволяя применять передовые технологии, такие как интеллектуальные сети и системы управления энергией на основе искусственного интеллекта. Интеграция современных технологий повышает эффективность, сокращает потери энергии и ускоряет переход к более зеленой экономике.
Предлагаемые стратегии соответствуют долгосрочным целям энергетической политики Азербайджана, обеспечивая успешную реализацию зеленого перехода. Отдавая приоритет развитию возобновляемых источников энергии, Азербайджан укрепляет свою энергетическую независимость, снижает зависимость от ископаемого топлива и вносит вклад в глобальные усилия по обеспечению устойчивости.
Кроме того, участие Азербайджана в международных соглашениях по возобновляемым источникам энергии и сотрудничество с мировыми лидерами в области энергетики усиливают роль страны в формировании будущего устойчивой энергетики. Инициативы COP29 служат основой для

долгосрочного партнерства и инвестиционных возможностей, еще больше усиливая амбиции Азербайджана в области возобновляемых источников энергии.

В заключение следует отметить, что приверженность Азербайджана развитию возобновляемых источников энергии, стратегическим проектам и международному сотрудничеству укрепляет его позицию как ключевого игрока в глобальном переходе к зеленой энергетике. Эти усилия прокладывают путь к устойчивому и технологически продвинутому энергетическому сектору, обеспечивая экономический рост и экологическую устойчивость.

Ключевые слова: возобновляемая энергетика, COP29, солнечная энергия, инвестиционные стратегии, международное сотрудничество.

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RENEWABLE ENERGY IN AZERBAIJAN: DEVELOPMENT STRATEGIES AND PROSPECTS FOR INTERNATIONAL COOPERATION

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Abstract

The articles comprehensively discuss Azerbaijan's renewable energy development strategies, the initiatives presented at COP29, and opportunities for international collaboration. Analyses emphasize the importance of maximizing the country's solar and wind energy potential, ensuring economic security, and maintaining environmental sustainability.

Projects introduced at COP29 have strengthened Azerbaijan’s position in the global energy market while attracting new investments. Notably, the Gobustan Solar Power Plant and the East Zangezur project are highlighted as significant steps toward advancing solar energy utilization. Research indicates that international cooperation plays a crucial role in the effective development of renewable energy sources, fostering knowledge exchange and financial support.

These advancements open doors for the digitalization of the energy sector, enabling the application of cutting-edge technologies such as smart grids and AI-driven energy management systems. The integration of modern technology enhances efficiency, reduces energy waste, and accelerates the transition to a greener economy.

The proposed strategies align with Azerbaijan's long-term energy policy goals, ensuring the successful implementation of the green transition. By prioritizing renewable energy development, Azerbaijan strengthens its energy independence, reduces reliance on fossil fuels, and contributes to global sustainability efforts.
Furthermore, Azerbaijan's participation in international renewable energy agreements and collaboration with global energy leaders enhance the country's role in shaping the future of sustainable energy. The COP29 initiatives serve as a foundation for long-term partnerships and investment opportunities, further boosting Azerbaijan's renewable energy ambitions.
In conclusion, Azerbaijan's commitment to renewable energy development, strategic projects, and international cooperation reinforce its position as a key player in the global green energy transition. These efforts pave the way for a sustainable and technologically advanced energy sector, ensuring economic growth and environmental resilience.

Key words: renewable energy; COP29; solar energy; investment strategies; international cooperation.

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Introduction

The energy sector is one of the strategic areas of great importance in the economic development of Azerbaijan and strengthening its position in the regional energy market. This sector plays an indispensable role in ensuring the country's economic stability, expanding export opportunities and attracting foreign investments. However, the existing energy infrastructure, in particular the technological level of energy production and network stability, does not fully meet modern requirements, and this situation limits the development prospects of the sector. The application of technologies related to the use of renewable energy sources not only ensures the efficient use of energy resources, but is also of great importance for protecting the environment and increasing energy security.

The main purpose of the article is to identify existing problems in the energy sector of Azerbaijan, to propose optimal approaches to solving these problems and to analyze the impact of investment strategies on the development of the sector. The use of renewable energy sources, especially in terms of solar, wind and hydropower potential, is of particular importance for increasing the competitiveness of Azerbaijan in international energy markets. However, legal and financial difficulties arising in the process of attracting local and foreign investments in this direction can be noted as the main problems hindering the development of the sector. Therefore, the article aims to provide recommendations on improving the investment climate and introducing modern technologies in energy production.

To ensure sustainable development in the energy sector of Azerbaijan, it is strategically important to use international experience, take into account the economic and environmental advantages of renewable energy sources, and stimulate the application of modern technologies. One of the main priorities currently in the focus of attention in the current energy policy is the diversification of energy exports and increasing domestic production potential, which can ensure a stronger position of the sector in international markets. This approach is also important in terms of strengthening national and

international efforts aimed at strengthening the country's energy security and environmental protection. This study will demonstrate how the application of modern approaches in the energy sector will contribute to the country's long-term sustainable development.

Literature review

The energy sector of Azerbaijan plays an important role in the country's economic development and increasing its competitiveness in international energy markets, which further increases the strategic importance of the sector. Within the framework of the literature review, an extensive analysis of research conducted by local and foreign authors in this field will be conducted, issues of energy resource management, application of renewable energy sources and formation of investment strategies will be examined. Research by various authors allows us to deeply understand the existing problems and potential of this field and determine the development prospects of the sector.

Badalov and Farazade (2020) devoted extensive space to the issues of energy security of Azerbaijan and the role of energy resources in economic development in their research. The authors noted that ensuring energy security is a decisive factor for maintaining the country's economic stability, and the state programs implemented in this direction have had a significant impact. In their opinion, the application of management models in accordance with international standards is necessary for the sustainable development of the current energy policy [Badalov and Farazade, 2020].

Aliyeva (2023) deeply analyzed the role of Heydar Aliyev in the development of the Azerbaijani gas sector and the importance of the Shah Deniz project. The author emphasized that this project, in addition to increasing the country's influence in international energy markets, contributed to strengthening energy security. Aliyeva also noted the successes of Azerbaijan's gas export strategy, especially the implementation of gas projects within the framework of cooperation with Europe. In her opinion, these projects are of strategic importance both from an economic point of view and in the context of regional security. As a result, the Azerbaijani gas sector acts not only as an energy producer, but also as an important energy transit country [Aliyeva, 2023]. Hajiyev (2021) studied the development of alternative energy sources in the liberated territories of Karabakh and the energy potential of these regions. The author noted that the widespread use of solar and wind energy can contribute to sustainable energy production in these areas. At the same time, Hajiyev emphasized that the use of these sources has a positive impact on environmental protection and economic diversification. As a result of implementing these approaches, significant improvements in energy supply in the regions can be achieved in terms of both quality and scale [Hajiyev, 2021].

Karimli and Aghayev (2020) analyzed Azerbaijan’s policy of transition to renewable energy sources and potential problems in this area. The authors noted that the transition from traditional energy sources to renewable energy sources is important not only in terms of economic efficiency, but also for environmental protection. In their opinion, state support, as well as the participation of the private sector, play a key role in this transition process. Karimli and Aghayev also emphasized that the application of new technologies in this direction, especially in the field of wind and solar energy, can ensure that Azerbaijan has a higher position in the energy market. In addition, the digitalization of energy production is also one of the main steps for the modernization of the sector [Karimli and Aghayev, 2020]. Tahirli (2023) paid extensive attention to the role of foreign investments in the energy sector and the efficient use of these investments. According to the author, international investments are a decisive factor for the application of modern

technologies in the energy sector of Azerbaijan and the financing of new projects. Tahirli also notes that transparency and legal guarantees for foreign investors increase their interest in Azerbaijan. At the same time, the author emphasized that, along with attracting foreign investments, directing local capital to the energy sector is also one of the main priorities [Tahirli, 2023].

Shafaqatov (2014) examined the prospects for the application of alternative energy sources in Azerbaijan and proposed appropriate strategies for the country based on world experience in this area. The author showed that the application of alternative energy sources can make a significant contribution to economic development [Shafaqatov, 2014].

Veliyev et al. (2024) analyzed the impact of state policy on the development of renewable energy sources and the economic effect of projects in this area. The authors showed that Azerbaijan's solar and wind energy projects are important steps to ensure the country's energy security and increase export opportunities. They noted that expanding the state's incentive programs in this area and making the investment climate more favorable will ensure faster development of renewable energy sources. The authors also emphasized that international cooperation and exchange of experience in this area further increases the competitiveness of the country's energy sector [Valiyev et al., 2024].

The literature review shows that the harmonious application of traditional and renewable energy sources in the development of the energy sector of Azerbaijan provides a sound approach to ensuring the economic and environmental sustainability of the country. The authors' research covers important aspects such as the formulation of energy strategies, the promotion of international investments, and the application of renewable energy sources. These studies emphasize the importance of applying modern approaches in Azerbaijan's energy policy and the need to take concrete steps to solve existing problems in this area.

Renewable energy prospects in Azerbaijan

The widespread use of renewable energy sources in Azerbaijan is of particular importance in terms of strategic goals for sustainable energy supply in the near future, since this approach can not only meet the rapidly growing energy demand of cities, but also reduce the amount of harmful emissions emitted into the atmosphere. The expected progress in the development of technologies will ensure a higher level of efficiency in the application of renewable energy sources, increase the accessibility of these sources to the general public, make their use more convenient, and at the same time create advantages in terms of economy, ensuring long-term sustainability.

In addition, the approval of the "State Program on the Use of Alternative and Renewable Energy Sources in the Republic of Azerbaijan" by the decree signed by the President of the Republic of Azerbaijan Mr. Ilham Aliyev on October 21, 2004, has created a serious basis for the development of this area in the country. This order has given impetus to the formation of a legal framework for the implementation of strategies aimed at the development of alternative and renewable energy sectors in the country and the implementation of relevant measures on a large scale.

The inclusion of energy factors in macroeconomic assessment models is a global trend observed in the development of the world economy and is becoming increasingly widespread. This approach ensures the prioritization of the role of energy resources in the planning and management of economic processes. It is noteworthy that in recent times the concept of sustainable development has interacted with the ideology of the "green" economy, since the main goals of this approach include achieving high energy efficiency and minimizing the impact on ecological systems.

Solar energy has a number of important advantages compared to other types of energy, such as biomass energy, hydropower or nuclear energy. The most striking of these advantages is that there is no need for water in the process of generating solar energy, which prevents any problems that may arise in the future related to the depletion of water resources, as well as water shortages. This aspect makes solar energy a more attractive alternative, especially in regions with limited water resources.

In recent years, there has been a remarkable development in the field of solar energy use, especially concentrated solar power technologies and increasing the economic feasibility of energy production through photovoltaic panels. The significant decrease in the production costs of these technologies has made them an energy source that can compete with fossil fuels not only in temperate climate zones, but also in subpolar latitudes.

The current climatic conditions in Azerbaijan also provide very favorable opportunities for the development of solar energy. Thus, the country has an average of 300 sunny and 270 windy days per year, which further increases the prospects for the application and development of solar energy in these areas. Such favorable natural conditions provide broad opportunities for the long-term development of solar energy in the Azerbaijani region and allow for significant achievements in the field of renewable energy.

Since 2017, the European Union has been supporting Azerbaijan in the field of more efficient use of energy resources and the establishment of a regulatory framework in the field of energy efficiency within the framework of the "EU4 Energy" initiative. Within the framework of this project, the preparation of the first draft law on energy efficiency was ensured, thereby taking important steps towards the implementation of relevant policies in the country. As a result of the preparatory work related to the adoption of this law, the Law "On Efficient Use of Energy Resources and Energy Efficiency" was approved on July 9, 2021 under the leadership of the President of the Republic of Azerbaijan Mr. Ilham Aliyev. Following the adoption of this important law, the European Union, as a continuation of the activities initiated in 2021, provided support for the financing of projects implemented in Azerbaijan in 2022 to bring energy efficiency to a higher level and expand the application of modern technologies. This support has created the basis for increasing the culture of using energy resources, as well as developing a strategic approach that ensures more economical and effective management of resources. Thus, this law and the measures taken in connection with it were a significant turning point in the field of improving energy efficiency in Azerbaijan.

The 29th Conference of the Parties to the UN Framework Convention on Climate Change (COP29) held in Baku in 2024 created the conditions for Azerbaijan to make significant progress in the field of renewable energy. Within the framework of this event, an auction was held and the winner was announced with the support of the European Bank for Reconstruction and Development (EBRD) for the construction of the 100 MW "Gobustan" Solar Power Plant.

The winner of the auction was the company "Universal International Holdings Limited", which submitted the lowest bid per kilowatt-hour of electricity. The plant is planned to be commissioned in 2027 and is expected to produce approximately 260 million kilowatt-hours of electricity annually. This will save 57 million cubic meters of natural gas per year, as well as reduce carbon emissions into the atmosphere by 124 thousand tons.

According to Energy Minister Parviz Shahbazov, COP29 was marked by significant achievements that reflect Azerbaijan’s commitment to a green energy transition. He cited the groundbreaking ceremony of a 240 MW solar power project in

East Zangezur, jointly implemented with BP, and the 9th ministerial meeting on the Caspian-Europe Green Energy Corridor as examples of these achievements.

In addition, an Intergovernmental Agreement on Strategic Partnership in the Development and Transmission of Green Energy was signed between Azerbaijan, Kazakhstan, and Uzbekistan, and documents were adopted to ensure that Saudi Arabia joins this trilateral project as a key partner. Six contracts were signed with six Chinese companies, Azerbaijan announced its hydrogen strategy, and a Memorandum of Understanding on Cooperation in Energy Planning in the Context of the Paris Agreement was signed with the International Atomic Energy Agency.

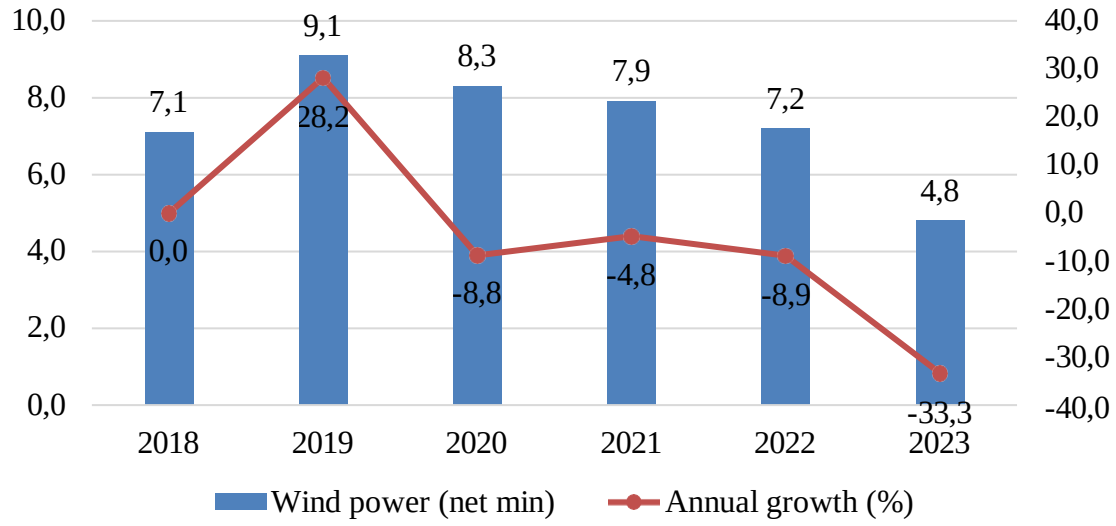

Рис. 1. Поставки ветроэнергии в Азербайджан
Fig. 1. Wind energy supplies in Azerbaijan
Source: [Bərpa olunan mənbələrdən enerji təchizatı]

Wind power generation in Azerbaijan fluctuated between 2018 and 2023, indicating that annual production is far from steady growth or stabilization. The data shows that while there was a significant increase in 2019, there have been successive declines in subsequent years. These declines are particularly pronounced with a 33.3 percent decline in 2023, which may indicate a recent decline in production capacity or technical problems. The fluctuation in annual growth rates highlights the need for a more stable and sustainable development strategy for wind power in the country. The declines from 2020 onwards may indicate delays in infrastructure development or the impact of external factors. The overall decline in production figures, with the exception of the increase in 2019, increases the need for long-term investment and policy support in this area. It is clear that Azerbaijan needs appropriate technological and financial resources for the development of wind power. This trend highlights the need for additional measures to ensure that wind power plays a more sustainable role in the country's overall energy balance.

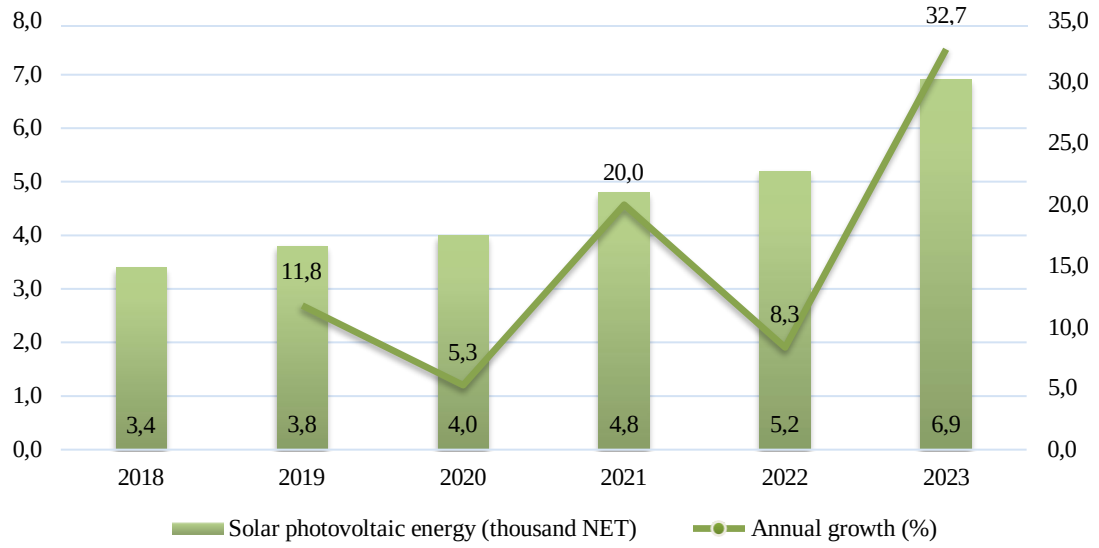

Рис. 2. Выработка солнечной энергии в Азербайджане
Fig. 1. Solar power generation supply in Azerbaijan
Source: [Bərpa olunan mənbələrdən enerji təchizatı]

Solar photovoltaic power generation has increased continuously between 2018 and 2023, with annual growth rates at different levels. Starting from 2018, production figures have increased every year, reaching 6.9 million kWh in 2023. The highest annual growth rate was recorded in 2023, which was 32.7 percent. A faster development was observed in 2021, with an increase of 20 percent, which indicates an increase in investments or technological improvements in solar energy during that period. Accordingly, the growth in 2019 and 2020 was more moderate, at 11.8 and 5.3 percent, respectively. This continuous increase in production shows that Azerbaijan has given solar energy a special place in its renewable energy strategy. The high growth rate in 2023 may be the result of the application of stronger resources and technologies to fully realize the potential of this sector. This trend also indicates that solar energy will play a larger role in the country's energy balance in the future and contribute to reducing carbon emissions. The growth rate of solar photovoltaic energy confirms that the sector has strong prospects for sustainable development.

Таблица 1

Состояние выработки электроэнергии: январь-июнь 2023 г. и январь-июнь 2024 г.

Table 1

Status of electricity generation: January-June 2023 and January-June 2024

Indicator	January-June 2023	January-June 2023
Total electricity generation (mln kWh)	13,907.9	13,557.4
HPP (mln kWh)	891.0	1,581.1
Wind power plants (mln kWh)	31.7	29.7
Solar photovoltaic power (mln kWh)	32.3	286.6
Solid waste plant (mln kWh)	126.8	135.0
Share of renewable energy sources (%)	8.0	15.0
Share of thermal power plants (%)	92.0	85.0

Source: [Renewable energy in Azerbaijan …]

Some significant changes were observed in electricity production in Azerbaijan in 2024 compared to the January-June period of 2023. Total electricity production decreased slightly from 13,907.9 million kWh to 13,557.4 million kWh. Although this indicates the stability of the overall trend in energy production, sharp changes were recorded in some energy sources.

Hydroelectric power (HPP) production showed a significant increase in 2024, reaching 1,581.1 million kWh from 891.0 million kWh. This increase indicates an increased focus on renewable energy sources in the country with a 1.7-fold expansion. Solar photovoltaic energy showed a larger increase, increasing from 32.3 million kWh to 286.6 million kWh, which is an 8.8-fold increase and reflects the rapid implementation of solar energy technologies.

A decrease was recorded in wind power; production decreased from 31.7 million kWh to 29.7 million kWh, which indicates that the potential of wind energy is not fully utilized. At the same time, production at the solid waste plant increased from 126.8 million kWh to 135.0 million kWh, demonstrating continued growth.

The share of renewable energy sources in total electricity production increased from 8 percent to 15 percent, which indicates an increase in interest and investments in the development of green energy in the country. At the same time, the share of thermal power plants decreased from 92 percent to 85 percent, which emphasizes the decrease in dependence on traditional energy sources and the transition to more sustainable energy strategies.

These trends indicate an increased focus on renewable sources in Azerbaijan's energy policy and confirm that the country is acting in accordance with its goal of reducing carbon emissions and strengthening energy security. Accelerating technological development and the introduction of new energy sources in energy production can lead to even greater positive results in the future.

Таблица 2

Потенциал возобновляемой энергии Азербайджана

Table 2

Renewable energy potential of Azerbaijan

Potential type	Total potential (GW)	Solar energy (GW)	Wind energy (GW)	Hydropower (GW)	Special regions (GW)
Technical potential (onshore)	135 GW	115 GW	15 GW	5 GW	Karabakh and East Zangezur – 10 GW, Nakhchivan – 5 GW
Technical potential (offshore)	157 GW	-	-	-	-
Economic potential (onshore)	27 GW	23 GW	3 GW	1 GW	Karabakh and East Zangezur – 2.5 GW, Nakhchivan – 1.5 GW
Economic potential (offshore)	Under evaluation	-	-	-	-

Source: [Renewable energy in Azerbaijan …]

Renewable energy potential in Azerbaijan shows significant differences in technical and economic dimensions. The technical potential is 135 GW onshore and 157 GW offshore, with very high overall indicators. Solar energy has the largest share of the technical potential with 115 GW, which indicates the high efficiency of the country's solar resources. The technical potential for wind energy is set at 15 GW, and for hydropower at 5 GW, which emphasizes that wind and hydropower resources are smaller but significant compared to solar.

The economic potential is estimated at 27 GW overall. Solar energy is ranked at 23 GW, wind energy at 3 GW, and hydropower at 1 GW in the economic potential. These indicators demonstrate that economic application is more limited compared to the technical potential, but there are great development opportunities in these areas.

The Karabakh and East Zangezur regions play an important role in both technical and economic potential: 10 GW in technical potential and 2.5 GW in economic potential. Nakhchivan has 5 GW technical and 1.5 GW economic potential, respectively. The special mention of these regions indicates their strategic importance.

These data highlight the great potential of Azerbaijan in the field of renewable energy and the importance of infrastructure, financial and technological support to use this potential more effectively. The realization of such high potential requires the development and implementation of sustainable development strategies.

Development strategies and prospects of international cooperation within COP29

The events held within the framework of COP29 opened up wide opportunities for presenting Azerbaijan's renewable energy potential to the world. According to the research of the State Agency for Renewable Energy Sources under the Ministry of Energy, there is a favorable potential for solar energy projects in the Gubadli, Zangilan, Jabrayil and Fuzuli regions, and this technical potential is estimated at more than 7200 MW. At the same time, it was determined that there is a technical potential of wind energy in the mountainous areas of Lachin and Kalbajar in the amount of 2000 MW. This information was presented to the international community during COP29, and Azerbaijan's opportunities in the field of renewable energy were widely discussed.

COP29 also created the basis for the start of real cooperation between governments and companies. Ahmed Aldusari, an employee of the Kuwait Center for Renewable Energy, noted that COP29 creates the basis for concrete discussions for the start of real cooperation between companies and governments. Within this partnership, important steps have been taken to implement new projects and accelerate the energy transition.

On the fifth day of COP29, an event was held on the theme "Energy Transformation in 2030 and Beyond". The event noted that more than 40 partners and global utilities, collectively serving nearly 300 million customers, have come together with a shared commitment to advance electrification, renewable energy-ready grids and clean energy deployment, in line with the 2030 progress targets and the goal of net zero emissions by 2050. This will play a significant role in the transformation of Azerbaijan's energy sector.

As a result, COP29 has enabled Azerbaijan to make significant progress in the field of renewable energy and strengthen international cooperation. The projects implemented and agreements signed within the framework of this event will make a significant contribution to ensuring the country's energy security, increasing environmental sustainability and accelerating economic development. These steps taken towards realizing Azerbaijan's renewable energy potential will strengthen the country's position in global energy markets and support

the achievement of sustainable development goals.

Conclusion

The development of Azerbaijan's renewable energy sector is of strategic importance in terms of strengthening its position in global energy markets, ensuring environmental sustainability and increasing energy security. The projects implemented within the framework of COP29 have shown that the large-scale application of solar and wind energy opens a new era in the energy sector of Azerbaijan, and benefiting from international experiences in this area is of particular importance for the country. The effective implementation of the projects, in particular the construction of the "Gobustan" Solar Power Plant and the groundbreaking ceremonies of new energy projects in East Zangezur, confirm the successful implementation of Azerbaijan's energy strategy. The establishment of international partnerships in this area supports the full realization of the renewable energy potential. Increasing energy efficiency and reducing carbon emissions using technological innovations helps to achieve long-term goals. The study shows that cooperation between the public and private sectors is a key factor in achieving new achievements in the field of renewable energy.

The following steps are proposed for the development of renewable energy sources:

1. Special legislative initiatives should be implemented to create a more favorable legal and economic environment for the expansion of renewable energy sources.

2. Appropriate incentive mechanisms should be developed to strengthen international partnerships and attract investments for new projects.

3. Implementation of modern solutions in energy production through the application of digital technologies and automated systems should be ensured.

4. Special technoparks should be created in the regions for the development of solar and wind energy and support programs should be developed for entrepreneurs operating in this field.

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