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## INNOVATION IS A KEY FACTOR IN THE DEVELOPMENT OF THE ENERGY INDUSTRY

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**Abstract:** The article examines the key achievements of Uzbekistan's energy sector development in 2024. It highlights the measures implemented to modernize the energy system, expand generation capacity, introduce renewable energy sources, and further improve the legal and regulatory framework of the sector. Special attention is given to the implementation of major investment projects in thermal, solar, wind, and hydropower, as well as to the deployment of energy storage systems and the development of grid infrastructure.

The role of "green" energy in promoting sustainable economic growth, increasing energy efficiency, improving environmental performance, and strengthening consumer protection is emphasized. In addition, the article outlines the strategic directions for the development of the energy sector through 2030, including the expansion of public-private partnerships and the continued digitalization of the energy system.

**Key words:** energy sector, energy system modernization, green energy, energy storage systems, energy efficiency, energy infrastructure, public-private partnership, sustainable development, environmental sustainability.

**Annotatsiya:** Maqolada 2024-yilda O'zbekiston energetika sohasining rivojlanishida erishilgan asosiy natijalar tahlil qilingan. Energetika tizimini modernizatsiya qilish, ishlab chiqarish quvvatlarini kengaytirish, qayta tiklanuvchi energiya manbalarini joriy etish hamda sohaning huquqiy-me'yoriy bazasini yanada takomillashtirish bo'yicha amalga oshirilgan chora-tadbirlar yoritilgan. Issiqlik, quyosh, shamol va gidroenergetika yo'nalishlarida yirik investitsiya loyihalarini amalga oshirish, energiyani saqlash tizimlarini joriy etish hamda tarmoq infratuzilmasini rivojlantirish masalalariga alohida e'tibor qaratilgan.

Shuningdek, "yashil" energetikaning barqaror iqtisodiy o'sishni ta'minlash, energiya samaradorligini oshirish, ekologik muhitni yaxshilash hamda iste'molchilar manfaatlarini himoya qilishdagi o'rni ochib berilgan. Bundan tashqari, davlat-xususiy sheriklikni kengaytirish va energetika tizimini raqamlashtirishni o'z ichiga olgan holda, 2030-yilgacha bo'lgan davrda energetika sohasini rivojlantirishning strategik yo'nalishlari bayon etilgan.

**Kalit so'zlar:** energetika, energetika tizimini modernizatsiya qilish, yashil energetika, energiyani saqlash tizimlari, energiya samaradorligi, energetika infratuzilmasi, davlat-xususiy sheriklik, barqaror rivojlanish, ekologik barqarorlik.

**Аннотация:** В статье рассматриваются ключевые результаты развития энергетической отрасли Узбекистана в 2024 году. Освещаются меры по модернизации энергосистемы, расширению генерирующих мощностей, внедрению возобновляемых источников энергии и дальнейшему совершенствованию нормативно-правовой базы отрасли. Особое внимание уделено реализации крупных инвестиционных проектов в сфере тепловой, солнечной, ветровой и гидроэнергетики, а также внедрению систем накопления энергии и развитию сетевой инфраструктуры.

Показана роль «зелёной» энергетики в обеспечении устойчивого экономического роста, повышении энергоэффективности, улучшении экологической обстановки и укреплении защиты интересов потребителей. Также раскрыты стратегические направления развития энергетической отрасли до 2030 года, включая расширение государственно-частного партнёрства и цифровизацию энергосистемы.

**Ключевые слова:** энергетика, модернизация энергосистемы, «зелёная» энергетика, системы накопления энергии, энергоэффективность, энергетическая инфраструктура, государственно-частное партнёрство, устойчивое развитие, экологическая устойчивость.

## INTRODUCTION

The energy sector represents one of the key pillars of the national economy, and its stable and sustainable operation directly influences socio-economic development, industrial growth, and the overall quality of life of the population. In the context of steadily increasing energy demand, global climate commitments, and the need for efficient use of natural resources, the modernization of the energy system and the introduction of advanced technologies have become particularly important priorities.

In recent years, the Republic of Uzbekistan has consistently implemented a comprehensive state policy aimed at reforming the energy sector, diversifying power generation sources, and accelerating the development of renewable energy. According to official plans, “by 2026, electricity generation is expected to increase by an additional 30 billion kWh, bringing total output to 100 billion kWh. By raising the share of renewable energy sources to 25 percent by 2026, it is projected that approximately 3 billion cubic meters of natural gas will be saved” [2].

At the same time, significant efforts are being directed toward improving energy efficiency, strengthening the regulatory and legal framework, attracting domestic and foreign investment, and enhancing the protection of consumer interests. These measures collectively contribute to building a modern, resilient, and environmentally sustainable energy system aligned with long-term national development goals.

## LITERATURE REVIEW

A substantial contribution to the development of theoretical approaches to the functioning and reform of enterprises in the electric power industry has been made by A.G. Aganbegyan, A.L. Vershinin, M.G. Delyagin, V.V. Ivanter, N.P. Laverov, D.S. Lvov, A.A. Makarov, and V.E. Fortov. Their research laid the methodological foundations for analyzing structural transformations, investment policy, and the strategic development of the energy sector under conditions of economic modernization.

Issues related to economic modernization, including energy conservation and the improvement of energy efficiency, have been comprehensively examined in the works of L.Yu. Bogachkova, A.I. Gromov, I.S. Kozhukhovskiy, T.A. Mitrova, D.B. Ponarovkin, and V.V. Trufanov. These studies emphasize the importance of technological upgrading, rational resource use, and the integration of innovative solutions to ensure sustainable development of the energy system.

Significant attention to the development and implementation of state energy policy has also been reflected in the works of Uzbek scholars such as M.A. Ikramov, A.M. Kadyrov, G.A. Samatov, G.Zh. Allaeva, G.A. Khamdamova, and M. Saitkomolov. Their research focuses on the modernization of the national energy sector, strengthening regulatory mechanisms, expanding renewable energy sources, and enhancing the role of the energy sector in ensuring long-term economic growth and environmental sustainability.

## RESEARCH METHODOLOGY

The methodological foundation of this study is based on the works of domestic and foreign scholars devoted to the application of innovative solutions aimed at improving energy efficiency and strengthening the competitive performance of enterprises in the energy sector. These theoretical and empirical sources provided the basis for assessing modernization processes and evaluating strategic development directions.

During the research, current regulatory and legal documents, official statistical materials, and findings presented at scientific and practical conferences were comprehensively analyzed. Particular attention was given to policy documents and sectoral development programs that define the priorities of energy sector reform.

The study is grounded in a systemic approach, which allows the energy sector to be examined as an interconnected and dynamically developing system. To achieve the research objectives, methods of logical analysis, comparative assessment, and statistical analysis were applied. This combination of methods ensured the reliability, consistency, and practical relevance of the conclusions drawn.

## ANALYSIS AND RESULTS

The energy sector plays a key role in ensuring the sustainable development of the state and remains one of the most important drivers of economic growth. In recent years, Uzbekistan has given priority attention to the modernization of energy infrastructure, the wider adoption of environmentally friendly technologies, and the strengthening of consumer rights protection. Over the past seven years, substantial new generating capacities have been commissioned within the national energy system, enabling a significant increase in electricity production volumes. At the same time, the renewable energy sector has steadily developed and entered a qualitatively new stage. In this context, it is particularly relevant to analyze the results achieved in the energy sector in 2024, including the growth dynamics of installed capacity and electricity generation based on green energy sources.

In recent years, the transformation of the energy sector has been the focus of sustained attention from both the state and society. Installed capacity and electricity generation volumes demonstrate stable positive dynamics. While large-scale reforms may involve complex implementation processes, industry specialists consistently continue to implement new initiatives and investment projects. Therefore, when summarizing the results of 2024, particular attention is given to identifying the most significant achievements in this field. In recent years, work has been carried out on major and strategically important projects, some of which are currently at the stages of construction and commissioning. The presence of certain operational challenges is a natural component of any масштаб modernization process; however, the defining factor remains the consistent implementation of effective solutions and steady forward progress [12].

It should also be emphasized that the development of the energy sector receives priority attention at the highest level of state leadership. In accordance with long-term plans, by 2030 the share of renewable energy sources is expected to increase to 40 percent. Within this framework, solar and wind power plants are being actively developed, and their total installed capacity has already reached 2.7 GW. In addition, a project for the construction of the first nuclear power plant is being implemented, with commissioning anticipated between 2029 and 2035 [2].

At the same time, improvements in energy efficiency have been observed. Alongside growth in macroeconomic indicators, energy intensity per unit of gross domestic product decreased by 7.4 percent over the period from 2017 to 2024, reflecting the effectiveness of modernization measures.

An important area of reform has been the introduction of market-based mechanisms and the expansion of participation by independent power producers. Overall, the development of the energy sector is aimed at meeting the needs of a rapidly growing economy, including achieving the target GDP level of USD 240 billion by 2030 [4], as well as fulfilling international commitments to reduce greenhouse gas emissions by 35 percent by that year.

Focusing on the key results achieved in the energy sector in 2024, it should be noted that considerable progress was recorded, primarily due to improvements in the regulatory and legal framework of the industry. New laws, Presidential decrees, and resolutions of the Cabinet of Ministers were adopted to enhance energy efficiency, strengthen consumer protection, and create more favorable conditions for attracting investment. These measures contribute to the sustainable and balanced development of the national energy system (Table 1).

Table 1. Key Indicators of Uzbekistan's Energy Sector (2024).<sup>1</sup>

No	Indicator	Value
1	New generating capacity commissioned	2,787.9 MW
	Including: solar energy	<b>1,000 MW</b>
	Including: wind energy	<b>800 MW</b>
	Including: thermal power	<b>965.2 MW</b>
	Including: hydropower	<b>22.7 MW</b>
2	Energy storage systems	<b>2 facilities (300 MW)</b>
3	Solar and wind power generation	<b>4.9 billion kWh</b>
4	Natural gas savings	<b>1.47 billion m<sup>3</sup></b>
5	Reduction in emissions	<b>2.04 million tons</b>
6	Households supplied	<b>more than 2 million</b>
7	Power grids repaired	<b>29495 km</b>
8	New power grids constructed	<b>2896 km</b>
9	Subsidies under the "Solar Home" program	<b>10.56 billion soums</b>

<sup>1</sup> Compiled by the author based on data from the National Statistics Committee of the Republic of Uzbekistan

At the same time, new generation facilities with a total installed capacity of 2,787.9 MW were commissioned. Their structure is dominated by solar power plants with a capacity of 1,000 MW and wind power plants totaling 800 MW, as well as thermal power plants with a combined capacity of 965.2 MW and hydropower plants with a capacity of 22.7 MW. In addition, in December 2024, two energy storage systems with a capacity of 150 MW each were commissioned in the Fergana and Andijan regions, amounting to a total of 300 MW [13]. The implementation of these projects is of strategic importance, as it ensures the stable operation of the power system and the creation of additional electricity reserves during peak demand periods.

Special attention should be paid to the projects implemented in the field of thermal power generation, their technological characteristics, and their significance for the national energy system. Of particular importance is the assessment of their contribution to economic development and the enhancement of reliability in electricity supply across the regions. In 2024, as part of expanding the country's energy potential, several large-scale projects were successfully implemented. In particular, the Saudi company ACWA Power completed the commissioning of the remaining 500 MW of a thermal power plant with a total installed capacity of 1,500 MW, located in the city of Shirin and the Bayaut district of the Syrdarya region. The first stage of this facility, with a capacity of 1,000 MW, had been launched a year earlier. The operation of the plant plays a substantial role in ensuring stable electricity supply both for the region and for the country as a whole.

In addition, during the year, two highly efficient gas turbine units with a combined capacity of 64 MW were commissioned at the Tashkent Thermal Energy Center, thereby enhancing the reliability of power supply to the capital and surrounding areas. Furthermore, a 1.2 MW cogeneration unit began operation in the Almazar district of Tashkent, marking another important stage in the development of microgeneration [13].

In the Kashkadarya region, a gas engine power unit with an installed capacity of 400 MW was commissioned by the Turkish company Aksa Enerji. Owing to its high efficiency, reliability, and multifunctionality, this facility occupies a significant position in the structure of the modern energy system. Gas engine units are capable of operating on natural gas, biogas, and other gaseous fuels. They are also characterized by rapid start-up and quick attainment of rated capacity, which makes them especially valuable during periods of sharp increases in electricity consumption. Moreover, such units play an important role in compensating for the variability of electricity generation from solar and wind sources.

The implementation of these projects is aimed at improving the balance of the country's energy system, ensuring reliable electricity supply to industrial enterprises and households, and contributing to the expansion of production capacity and the creation of new jobs. Improving the quality of energy supply enables various industrial sectors to increase output volumes, which positively influences the growth of the country's gross domestic product.

In 2024, the use of solar and wind energy made it possible to generate 4.9 billion kilowatt-hours of electricity, resulting in savings of 1.47 billion cubic meters of natural gas and a reduction of pollutant emissions into the atmosphere by 2.04 million tons [13]. Current volumes of renewable energy generation make it possible to meet the needs of more than two million households, demonstrating substantial progress in the development of green energy.

During the reporting year, several renewable energy generation facilities were commissioned. In May, solar photovoltaic power plants with a total capacity of 200 MW began operating in the Yukorichirchik district of the Tashkent region and reached their design capacity by August. By the end of the year, several significant wind energy projects were implemented. A 400 MW wind power plant was commissioned in the Tamdyn district of the Navoi region, while two wind power plants with a capacity of 200 MW each began operating in the Peshkun and Gijduvan districts of the Bukhara region. In the future, a phased increase in their installed capacity to 1,000 MW is planned. In addition, a 200 MW solar power plant was launched in the Pap district of the Namangan region, with plans for subsequent expansion to 500 MW. In the Buka district of the Tashkent region, a 50 MW solar generation facility was commissioned, and the project предусматривает expansion of installed capacity to 263 MW [13].

Electricity generated by hydropower plants is classified as environmentally friendly energy. Accordingly, Uzbekistan has set ambitious objectives for the development of small hydropower. Detailed programs have been developed for the deployment of more than one thousand micro-hydropower plants on irrigation canals, rivers, reservoirs, and major drainage facilities across the country. The implementation of these initiatives strengthens the resilience of the energy system while simultaneously contributing to economic development. The use of renewable energy sources reduces the consumption of natural gas and petroleum products, creating additional opportunities for export or deeper processing. Furthermore, the development of green energy plays a crucial role in maintaining ecological balance and addressing climate change challenges [12].

To stimulate the installation of solar panels under the "Solar Home" program, the state allocated more than 10 billion soums in subsidies [3]. This measure is aimed at increasing public participation in solar energy adoption and reducing overall electricity consumption from centralized sources. The state purchases each

kilowatt-hour of electricity generated at a fixed tariff of 1,000 soums, thereby supporting energy efficiency and strengthening environmental sustainability. The total volume of subsidies amounted to 10 billion 563 million soums, transferred directly to citizens' bank cards through the "Solik" mobile application. Payments are made monthly by tax authorities, starting from the reporting period and no later than the 25th day of the following month. For example, compensation for October is paid by November 25. The implementation of this program expands opportunities for households to utilize solar energy and stimulates the development of decentralized generation.

In 2024, considerable attention was devoted to improving the reliability and quality of electricity supply throughout the republic. As part of these efforts, 29,495 kilometers of distribution power grids and 10,221 transformer substations underwent major overhaul, ensuring a more stable and uninterrupted electricity supply to consumers. Simultaneously, new energy infrastructure facilities were constructed. A total of 2,896 kilometers of power transmission lines and 649 new transformer substations were commissioned, contributing to the resolution of existing supply constraints and enhancing the resilience of regional networks.

In the city of Tashkent, construction and installation works were completed at the 110 kV substations "Tashkent City," "New Uzbekistan," "Yunusabad City," and "Yangi Hayot." In the capital, 15.5 kilometers of new power grids were laid, more than 20 kilometers of transmission lines were constructed, and networks with voltages of 35–110 kV were modernized. In addition, 69 high-capacity power transformers supplied from the People's Republic of China were installed in various regions of the country as part of the modernization of 110 kV substations.

A substantial volume of work was also carried out in the gas sector: 168.2 kilometers of high- and medium-pressure gas pipelines were modernized and upgraded, and 455 gas distribution points were repaired. These measures significantly expanded the production and operational capabilities of the gas supply system and strengthened overall energy security [13].

Below is your text edited with high linguistic accuracy, improved academic style, and a consistently positive, forward-looking tone, while fully preserving the original meaning and structure.

Transformations and the introduction of innovations in the energy sector are primarily aimed at ensuring sustainable economic development and maintaining the country's environmental balance. In this context, identifying strategic directions for the further development of the industry and defining effective mechanisms for their practical implementation in the medium term is of particular importance.

A key priority remains the continued expansion of renewable energy potential, primarily through increasing the capacity of solar and wind power plants. Through 2030, several agreements have already been concluded providing for the commissioning of new generation facilities. At the current stage, one of the most important tasks is the development of a modern, reliable, and flexible grid infrastructure capable of ensuring the efficient integration and operation of newly commissioned capacities.

Among the main directions for strengthening the resilience of the energy supply system are the integration of renewable energy sources into the unified power system, the expansion of energy storage systems, the introduction of digital technologies for automated grid management, the modernization of distribution networks, and the enhancement of electricity export potential.

The application of innovative solutions in solar and wind power generation, together with the deployment of advanced energy storage systems, plays a decisive role in the formation of a modern and sustainable energy infrastructure. In this process, expanding international cooperation and actively engaging the private sector are of particular importance. Within this framework, part of the distribution networks and thermal power plants is planned to be transferred to private management under transparent and competitive mechanisms [8]. Such measures are aimed at increasing operational efficiency and attracting additional investment into the sector.

At present, a tender has been announced for transferring the distribution networks of the Samarkand region into management under a public–private partnership framework, with the selection of an investor planned by the end of the year. It is expected that this initiative will contribute to reducing network losses, improving operational efficiency, and enhancing the quality of services provided to consumers.

Overall, 2024 can be characterized as a period of active implementation of innovative approaches in the energy sector. The strengthening of the regulatory and legal framework, the commissioning of new generation capacities, and the dynamic development of green technologies have created a solid foundation for reinforcing the country's energy independence and environmental sustainability.

Thus, 2024 became a significant milestone in the development of Uzbekistan's energy sector. The large-scale measures undertaken to enhance the regulatory environment, expand generation capacity, modernize grid infrastructure, and actively introduce renewable energy sources have substantially strengthened the resilience and reliability of the national power system. The development of green energy not only contributes to reducing dependence on traditional fuel resources and lowering emissions, but also creates favorable conditions for long-term economic growth, increased investment attractiveness, and improved quality of life for the population. The

consistent implementation of strategic initiatives focused on innovation, digital transformation, and expanded private sector participation is forming a strong foundation for Uzbekistan's sustainable energy development and environmental stability in the years ahead.

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## CONCLUSIONS AND RECOMMENDATIONS

Uzbekistan's energy sector in 2024 demonstrated stable and progressive development, supported by a consistent state policy focused on infrastructure modernization and the expansion of generation capacity.

The commissioning of new thermal, solar, wind, and hydropower plants, along with energy storage systems, significantly enhanced the reliability and resilience of the energy supply system while reducing the load on existing facilities.

The dynamic development of green energy substantially increased electricity generation from renewable sources, contributed to the rational use of natural gas resources, and supported efforts to improve environmental sustainability.

Further strengthening of the regulatory and legal framework, together with the implementation of state support programs—including incentives for households to install solar panels—played an important role in improving energy efficiency and reinforcing consumer protection mechanisms.

The modernization and expansion of electricity and gas networks enhanced the quality and stability of energy supply across the regions, created favorable conditions for the uninterrupted operation of industrial enterprises, and stimulated broader economic activity.

The strategic priorities defined through 2030—such as the continued development of grid infrastructure, the introduction of advanced digital technologies, the expansion of energy storage systems, and the active engagement of the private sector—constitute a strong foundation for the sustainable, innovative, and competitive development of Uzbekistan's energy sector in the long term.

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