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ENERGY EFFICIENCY: BENEFITS FOR THE ECONOMY AND THE ENVIRONMENT

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Abstract

The article examines energy efficiency as one of the key factors of sustainable economic development and the reduction of negative environmental impacts. Particular attention is paid to environmental effects manifested in the reduction of pollutant emissions and the rational use of natural resources. The main directions for the implementation of energy-efficient technologies across economic sectors are analyzed, as well as the role of public policy in stimulating these processes. The study concludes that energy efficiency is a significant instrument for achieving a balance between economic growth and environmental safety.

Keywords: Energy efficiency, energy conservation, sustainable development, environmental safety, emission reduction, rational use of resources, “green” technologies.

Introduction

In the context of increasing global globalization and intensifying competitive pressures, a priority area of research is improving the energy efficiency of industrial enterprises, implementing environmentally friendly, energy-saving, and “green” technologies in production, ensuring uninterrupted electricity supply

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to the economy and the population, and strengthening the scientific foundations for the development of the sector. “By 2026, it is planned to increase electricity generation by an additional 30 billion kWh, bringing the total to 100 billion kWh. By increasing the share of renewable energy sources to 25% by 2026, it is expected to save approximately 3 billion cubic meters of natural gas.”[2] In pursuing these objectives, it is advisable to further deepen research in areas such as reducing harmful emissions, improving algorithms for evaluating the efficiency of energy resource use and energy-saving technologies, developing strategies for electricity production with reduced CO2 emissions, and increasing the efficiency of thermal power plants.

Methodology

The methodological foundation of the study was formed by the works of both domestic and foreign authors devoted to the application of innovative solutions in improving energy efficiency and strengthening the competitive positions of enterprises. During the research, current regulatory and legal documents were analyzed, as well as materials from scientific and practical conferences addressing these issues. A systems approach underpinned the study, while logical, comparative, and statistical analysis methods were employed to achieve the research objectives.

Result and Discussion

Amid growing global energy consumption and escalating environmental challenges, improving energy efficiency has become particularly urgent. Energy efficiency involves the rational use of energy resources while maintaining or enhancing productivity and quality of life. This approach not only reduces energy costs for enterprises, governments, and the population but also significantly mitigates the negative impact on the environment. Today, enhancing energy efficiency is recognized as a key instrument of sustainable development. The

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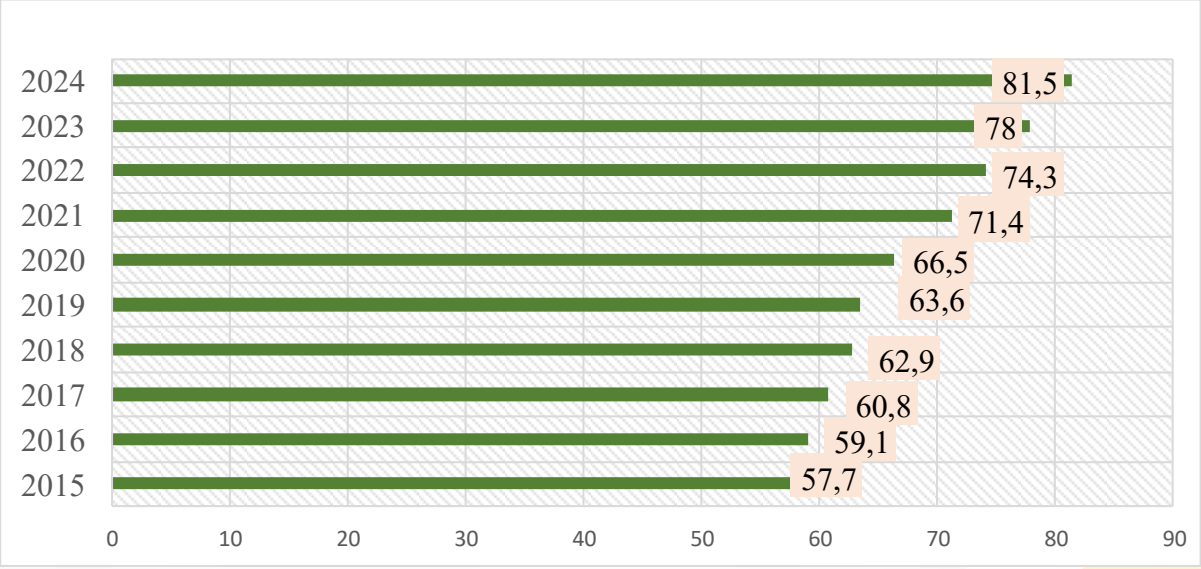
economic benefits include lower operating costs, increased competitiveness, and reduced dependence on finite natural resources. At the same time, it leads to a reduction in greenhouse gas emissions and pollutants, contributing to the improvement of environmental conditions and the preservation of natural ecosystems for future generations.

Uzbekistan's energy sector is currently undergoing active modernization, with a gradual move away from the dominant role of natural gas, which presently accounts for approximately 82–83% of electricity generation. A strategic priority is the diversification of the generation mix through various energy sources. According to long-term plans, the share of renewable energy is expected to reach 40% by 2030. Within this framework, solar and wind power plants are being actively developed, with a total installed capacity already reaching 2.7 GW, and a project for the construction of the first nuclear power plant is underway, with commissioning anticipated between 2029 and 2035. [2]



The volume of electricity generation, in billion kWh.[1]

[1] Prepared by the author

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In 2024, Uzbekistan's energy sector demonstrated stable positive growth: electricity production increased by 4%, exceeding 81.5 billion kWh. A key priority was the accelerated development of renewable energy sources. During the year, 14 solar and 3 wind power plants with a total installed capacity of 4.1 GW were commissioned. As a result, the share of renewable energy in the country's overall energy balance exceeded 16%. The implementation of these projects was significantly supported by foreign investors, including companies such as ACWA Power and Voltalia.

Among the main achievements and trends of 2024, several stand out. Large-scale "green" energy facilities with a total capacity of 2.4 GW were launched in various regions, substantially increasing the potential for renewable generation. As part of infrastructure modernization, more than 54.8 thousand km of distribution networks and 17.2 thousand transformer substations were upgraded, improving electricity supply quality for approximately 8 thousand settlements.

Investment cooperation continued to expand, including financing from international institutions such as the IFC, whose contributions amounted to approximately USD 240 million.[4]

At the same time, the energy efficiency of the economy improved: despite macroeconomic growth, energy consumption per unit of GDP decreased by 7.4% between 2017 and 2024. A key focus of the reforms was the introduction of market mechanisms and the expansion of participation by independent electricity producers.

Overall, the development of the energy sector is aimed at meeting the needs of a rapidly growing economy, including achieving a targeted GDP of USD 240 billion by 2030,[3] as well as fulfilling international commitments to reduce greenhouse gas emissions by 35% by that time.

In the energy sector, which was previously entirely under state control, active participation by the private sector has begun, with 24 independent electricity producers entering the industry. Significant changes have also occurred in the

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renewable energy segment, with large-scale solar and wind power plants commissioned, having a total installed capacity of 3,500 MW, corresponding to an annual generation of approximately 10 billion kWh. This has increased the share of "green" energy in the energy system to 16%.

The Head of State has outlined the key priorities for the further development of the energy sector. First and foremost, by 2030, it is planned to create an additional 19,000 MW of renewable energy capacity, which will increase the share of renewables to 54%. In 2025, 18 solar and wind power plants with a total capacity of 3,400 MW, as well as energy storage systems with a capacity of 1,800 MW, were commissioned. The implementation of these projects will enable annual "green" electricity generation to reach 12 billion kWh. Additionally, over the next two years, a large-scale program will be carried out in cooperation with private investors to construct more than 2,000 small and micro-hydropower plants.

The second priority is the further deepening of electricity market liberalization. By the end of next year, the establishment of a competitive wholesale market is planned, while public-private partnership mechanisms will be extended to the electricity distribution sector. Approximately USD 4 billion is expected to be attracted for the modernization of the network infrastructure. In the Samarkand region, a pilot project has already been developed to transfer the management of regional power grids to a private operator, with an international tender announced for this purpose.

The third priority is the expansion of international cooperation in the field of renewable energy. Within the framework of the COP-29 conference, agreements were signed with Kazakhstan, Azerbaijan, and Saudi Arabia aimed at the joint export of "green" electricity to European markets. In addition, a unified platform has been launched together with neighboring countries to ensure the stability and balance of the regional energy system.

The fourth priority focuses on developing renewable energy as a new growth driver for related industries and improving the quality of life for the population.

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Currently, solar panels with a total capacity of 1,000 MW have been installed, generating approximately 1.5 billion kWh of electricity annually. Further support for environmental initiatives is planned, including through the implementation of a dual education system to train qualified personnel.[4]

It has been noted that the ongoing projects mark a new stage in the development of the national energy sector, contributing not only to economic growth but also to the creation of an environmentally sustainable future for the country.

Against the backdrop of accelerated economic development, Uzbekistan has managed to reduce energy intensity in the production of goods and services. Between 2017 and 2024, the country's GDP increased by 55%, while energy consumption per unit of output decreased by 7.4%. This indicates a shift in the economy toward a more rational model of energy use. Significant changes have affected key sectors—including industry, services, and agriculture—where more efficient approaches to energy consumption have been implemented.

This trend reflects an overall increase in production efficiency, manifested in higher added value with lower energy expenditures. Currently, energy consumption stands at 56.8 kWh per 1 million soms of produced goods.

A key factor in improving the reliability of energy supply has been the large-scale modernization of infrastructure. Over 54.8 thousand km of distribution networks and 17.2 thousand transformer substations have been upgraded, enhancing electricity supply quality in more than 8,000 settlements across the country. For comparison, between 1991 and 2016, only 9.3 thousand km of power lines and 4.8 thousand transformers were updated.

Special attention has also been given to expanding the use of renewable energy sources. By the end of 2024, 14 solar and 3 wind power plants with a total installed capacity of 4,100 MW were commissioned in ten regions of Uzbekistan. During 2024, the production of "green" electricity reached 4.9 billion kWh.

The next stage of reforms in the energy sector involved the gradual liberalization of tariff policies, aimed at creating stable market conditions and increasing the

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investment attractiveness of the industry amid growing demand. To assess the impact of these changes, the Center for Economic Research and Reforms conducted an analytical study examining household behavior following the introduction of a new tariff system based on a social consumption norm, implemented in May 2024.

The study involved 3,516 households representing various regions of the country. Additionally, data on the actual consumption of 3.5 million natural gas subscribers and approximately 8 million electricity consumers were analyzed, allowing for a comprehensive assessment of changes in energy consumption patterns and the population's response to tariff adjustments.

The results indicate a 10.6% reduction in electricity consumption from May to December 2024 compared to the same period in 2023, corresponding to savings of approximately 1.3 billion kWh. The most significant changes were observed among high-consumption households: in 2023, around 80,000 consumers used more than 10,000 kWh per month, whereas in 2024 their number decreased to 15,000.

At the same time, the majority of the population continued to consume electricity within usual limits. The share of subscribers with monthly consumption up to 200 kWh remained nearly unchanged, accounting for 71% in 2023 and 72% in 2024. Similar trends were observed in natural gas consumption: in 2024, 58% of subscribers used up to 500 cubic meters of gas, compared to 54% the previous year, indicating that there were no sharp changes in baseline demand despite the tariff increase.

The most significant reductions in energy consumption were observed in regions with initially high energy usage, including Samarkand, Tashkent, Andijan, and Namangan. The marked decrease in the number of households with excessive electricity consumption indicates the emergence of more efficient energy-use behavior.

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At the same time, improvements in energy supply quality were recorded. According to the survey, nearly half of respondents noted positive changes in electricity provision as well as in access to natural and liquefied gas. Improvements in electricity supply were reported by 47% of households, particularly in Surkhandarya (78%), Syrdarya (70%), and Namangan (67%) regions. Enhanced gas supply was observed by 39% of respondents, with the highest ratings in Khorezm and Surkhandarya regions (68% each) and Jizzakh region (60%).

According to World Bank estimates, a comparable potential for improving energy efficiency exists in social infrastructure facilities, including educational and healthcare institutions. Targeted investments in the thermal modernization of such buildings can reduce energy consumption by 20–50%, creating conditions for annual electricity savings of up to 7.1 billion kWh.

In addition to direct economic benefits, implementing these measures significantly reduces greenhouse gas emissions—by up to 780 thousand tons of CO_2 per year. The country already operates a carbon trading system, under which surplus quotas are successfully sold on international markets. Expanding the scale of energy-saving projects creates additional opportunities to increase the volume of such transactions, potentially generating up to USD 50 million in annual revenue.[5]

Overall, the ongoing reforms are laying the foundation for a gradual transition to a sustainable and highly efficient energy system, based on modernization, increased energy efficiency, and the introduction of market mechanisms.

To improve the regulatory framework, protect consumer rights, and advance the energy sector to a new stage of development, a significant package of regulatory documents was adopted in 2024. This included two laws of the Republic of Uzbekistan, two presidential decrees, 27 presidential resolutions, as well as 18 Cabinet of Ministers resolutions and 16 orders.

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During 2024, generating capacities with a total installed capacity of 2,787.9 MW were commissioned. Of this total, 1,000 MW came from solar photovoltaic plants, 800 MW from wind power plants, 965.2 MW from thermal power plants, and 22.7 MW from hydropower facilities.

The development of "green" generation has become one of the sector's key priorities. Between May and August 2024, solar photovoltaic plants with a total capacity of 200 MW were commissioned in the Yukorichirchik district of the Tashkent region. In December 2024, a 400 MW wind power plant was commissioned in the Tomdi district of the Navoiy region, along with two 200 MW wind power plants in the Peshkun and Gijduvan districts of the Bukhara region. In addition, projects for the construction of solar power plants are underway in the Pap district of Namangan region and the Bukin district of Tashkent region.

A significant milestone in the development of the sector was the introduction of energy storage systems. In December 2024, two energy storage systems, each with a capacity of 150 MW, were commissioned in the Fergana region and the Asakinsky district of Andijan region. These projects are the first of their kind in the country's energy sector and play a crucial role in ensuring grid stability, balancing loads, and providing reserve capacity during peak consumption periods.[4]

Modernization of thermal generation continued as well. The Saudi company ACWA Power completed the commissioning of the remaining part of the thermal power plant in Shirin city and the Bayavut district of Syrdarya region with a capacity of 500 MW, bringing the total capacity of the facility to 1,500 MW (the first phase of 1,000 MW was commissioned in 2023). In addition, in 2024, two gas turbine units with a combined capacity of 64 MW were commissioned at the Tashkent thermal power plant, a 1.2 MW cogeneration unit was installed in the Almazar district of Tashkent city, and a 400 MW gas-piston power plant was

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launched by the Turkish company Aksa Enerji in the Nishan district of Kashkadarya region.

By the end of 2024, the volume of electricity produced by renewable energy facilities reached 4.9 billion kWh. As of January 1, 2025, the cumulative generation from solar and wind power plants since the beginning of 2024 totaled 4,860.5 million kWh, including 4,061.3 million kWh from solar plants and 799.2 million kWh from wind plants. This achievement allowed for the saving of approximately 1,470 million cubic meters of natural gas and prevented the emission of 2,040,000 tons of pollutants into the atmosphere. For comparison, this amount of electricity is equivalent to the annual social consumption norm for over 2 million households.[13]

Conclusion

The analysis demonstrates that improving energy efficiency is one of the key factors for sustainable socio-economic development and environmental security in the Republic of Uzbekistan. In the context of rising energy consumption and tightening environmental constraints, energy efficiency serves as an effective tool for simultaneously reducing costs, enhancing economic competitiveness, and mitigating negative environmental impacts.

The study's results indicate that between 2017 and 2024, the country achieved accelerated GDP growth while simultaneously reducing the energy intensity of the economy. The decrease in energy consumption per unit of GDP confirms a shift toward a more rational model of energy use and reflects an overall improvement in production efficiency across industry, services, and agriculture.

A significant contribution to achieving these results was made by the large-scale modernization of energy infrastructure, the active development of renewable energy sources, and the introduction of market mechanisms in the electricity sector. The growth in installed capacity of solar and wind power plants, along with the implementation of energy storage systems, has strengthened the

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resilience of the energy system and increased the share of "green" generation in the country's overall energy balance.

An important outcome of these reforms has been the establishment of more efficient energy consumption patterns at the household level. The liberalization of tariff policies and the introduction of a social consumption norm have helped reduce excessive energy use without lowering basic demand, reflecting an improvement in energy discipline and awareness among the population.

Additional prospects for improving energy efficiency are linked to the modernization of social infrastructure buildings and the residential sector. Implementing thermal modernization programs allows for significant energy savings while simultaneously reducing greenhouse gas emissions, creating conditions for the development of the carbon credit market and attracting additional financial resources.

Overall, the study's results confirm that the reforms being implemented in Uzbekistan are laying the foundation for a gradual transition to a sustainable, energy-efficient, and environmentally oriented energy system. Such a system is capable of supporting long-term economic growth, fulfilling international climate commitments, and improving the quality of life for the population.

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