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# An Analysis of The Current State and Development of Green Energy in The Republic of Uzbekistan

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**Abstract:** The article analyzes Uzbekistan's energy sector, which is undergoing significant transformation aimed at increasing the share of renewable energy sources (RES) and reducing dependence on natural gas. Green energy is considered as a system for generating energy based on renewable natural resources, including solar, wind, hydropower, geothermal, and bioenergy. The purpose of this study is to analyze the dynamics of renewable energy sources development in Uzbekistan.

**Keywords:** Renewable energy, Uzbekistan, solar energy, wind energy, energy balance, dynamics of electric power development, limited energy infrastructure, high capital intensity of projects, insufficient development of local equipment production, low level of energy efficiency, instability of generation.

**Introduction:** In the context of global climate change, increased energy consumption, and the depletion of traditional energy resources, the development of renewable energy sources (RES) is becoming one of the key directions of countries' energy policy. International organizations, including the International Energy Agency (IEA) and the International Renewable Energy Agency (IRENA), note the rapid growth of investments in solar and wind energy.

The main advantages of renewable energy sources are: environmental safety; reduced greenhouse gas emissions; energy system stability; reduced dependence on fossil fuels; and energy balance diversification.

Energy security is one of the key factors for sustainable economic development. For countries with rapidly growing economies, diversifying energy resources and reducing dependence on fossil fuels are of particular importance.

Uzbekistan traditionally relies on natural gas as the main source of electricity production. However, in recent years, the country has been actively developing renewable energy, including solar, wind, and hydroelectric power plants.

## LITERATURE REVIEW

In world scientific literature, technological, economic, and environmental aspects of implementing renewable energy sources are considered. According to research, the transition to 100% renewable energy in individual countries allows for a reduction in CO2 emissions to zero and ensures energy independence. The authors emphasize the importance of investing in solar and wind energy and the need to integrate renewable energy sources into national energy systems [1].

IRENA's research analyzes the dynamics of renewable energy development at the global level. According to the agency, in 2021-2022, the increase in the installed capacity of solar and wind power plants was more than 8%, and the cost of installing solar panels decreased by 20-25% compared to 2018 [2]. This indicates a reduction in barriers to the implementation of renewable energy sources in developing countries, including Uzbekistan.

Numerous works address the economic aspects of renewable energy development. Bhattacharyya, S.C. analyzes the relationship between investments in renewable energy sources, electricity costs, and economic growth [3]. The research results confirm the presence of a positive correlation between the share of

renewable energy sources in the energy balance and GDP growth. A similar conclusion is presented in the work of Twidell & Weir, where the need for state support and financial incentives for the accelerated implementation of solar and wind power plants is emphasized [4].

A separate group of studies is devoted to the environmental aspects of implementing renewable energy sources. Sadorsky, P. demonstrates that the increase in the share of renewable energy sources contributes to the reduction of CO2 emissions, improvement of air quality, and sustainable economic development. The work emphasizes that the combination of economic and environmental indicators allows for the formation of comprehensive strategies for the development of renewable energy sources at the state level [7].

At the national level, in the context of Uzbekistan, researchers note the high potential of solar energy and the need to scale up renewable energy projects. The World Bank [8] and ADB [9] emphasize that government investments, private capital support, and international cooperation are capable of accelerating the implementation of green energy in the republic.

Despite the significant volume of research, a number of issues remain insufficiently studied. Among them are: the integration of renewable energy sources into the country's energy system, taking into account seasonal and geographical features, the long-term impact of investments on economic growth, as well as the development of optimal models for assessing economic efficiency and environmental benefits. This determines the relevance of further research, including using econometric analysis and modeling of renewable energy sources development scenarios in Uzbekistan.

The literature pays special attention to regional context. In studies on Central Asian countries, the potential of renewable energy sources in conditions of high solar and wind resources is analyzed [5]. The authors note that the countries of the region, including Uzbekistan, have significant opportunities for the development of solar energy, and state support for investments and improvement of the regulatory framework is a key factor in the successful implementation of renewable energy sources.

**METHODOLOGY**

The methodological basis of the research is the methods of analysis and synthesis, statistical and comparative analysis, economic and mathematical methods, as well as methods of graphical interpretation of data.

The information base of the study was the data of the Ministry of Energy of the Republic of Uzbekistan, the Statistics Agency, reports of international organizations (IRENA, World Bank, UNDP), as well as scientific publications of domestic and foreign authors.

**DISCUSSION AND RESULTS**

In recent years, many countries have been actively transitioning to "green" energy, increasing the share of renewable energy sources in the electricity production structure.

The Republic of Uzbekistan, possessing significant potential for solar and wind energy, is actively implementing the strategy for transitioning to "green" energy.

The state is implementing large-scale projects to build solar and wind power plants, modernize energy infrastructure, and attract foreign investment. This is due to the need to diversify the energy balance, reduce natural gas consumption, and reduce greenhouse gas emissions.

The energy system of Uzbekistan is traditionally based on the use of fossil fuels, primarily natural gas. However, in recent years, there has been a gradual transition to a more stable energy supply model.

According to the Ministry of Energy of the Republic of Uzbekistan, the installed capacity of the country's electric power system in 2024 amounted to about 20 GW. At the same time, more than 80% of electricity production comes from thermal power plants operating on the basis of natural gas and coal. The share of hydropower is about 10-12%, while renewable energy sources (solar and wind energy) currently occupy less than 10% of the total electricity production structure [15].

Population growth, the development of industry and agriculture, and urbanization are leading to a steady increase in electricity demand. On average, the annual increase in electricity consumption in Uzbekistan is 6-7%. This increases the load on existing capacities and exacerbates the problem of energy security, especially in regions with high population density.

**Table 1**

**Structure of electricity production in Uzbekistan (2020-2024), % [15]**

| Energy source | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|
| Thermal Power Plant | 87 | 86 | 85 | 83 | 81 |

| | | | | | |
|---|---|---|---|---|---|
| Hydroelectric power plant | 12 | 12 | 11 | 11 | 10 |
| SEP and WEP | 1 | 2 | 4 | 6 | 9 |

Thus, the current structure of the energy sector requires diversification and the active implementation of green technologies.

Thermal power plants occupy a dominant position in the structure of electricity generation.

Currently, the country's energy system includes: thermal power plants (TPP); hydroelectric power plants (HPP); solar power plants; wind power plants.

**Table -2.**

**Structure of the installed capacity of the energy system in 2025 [15]**

| Station type | Installed capacity |
|---|---|
| TPP | 17,551 MWh |
| HPP | 2, 441 MWh |
| Solar power plants | 3, 930 MWh |
| Wind power plants | 1, 652 MWh |

From the table data, it can be noted that the share of renewable energy sources is gradually increasing.

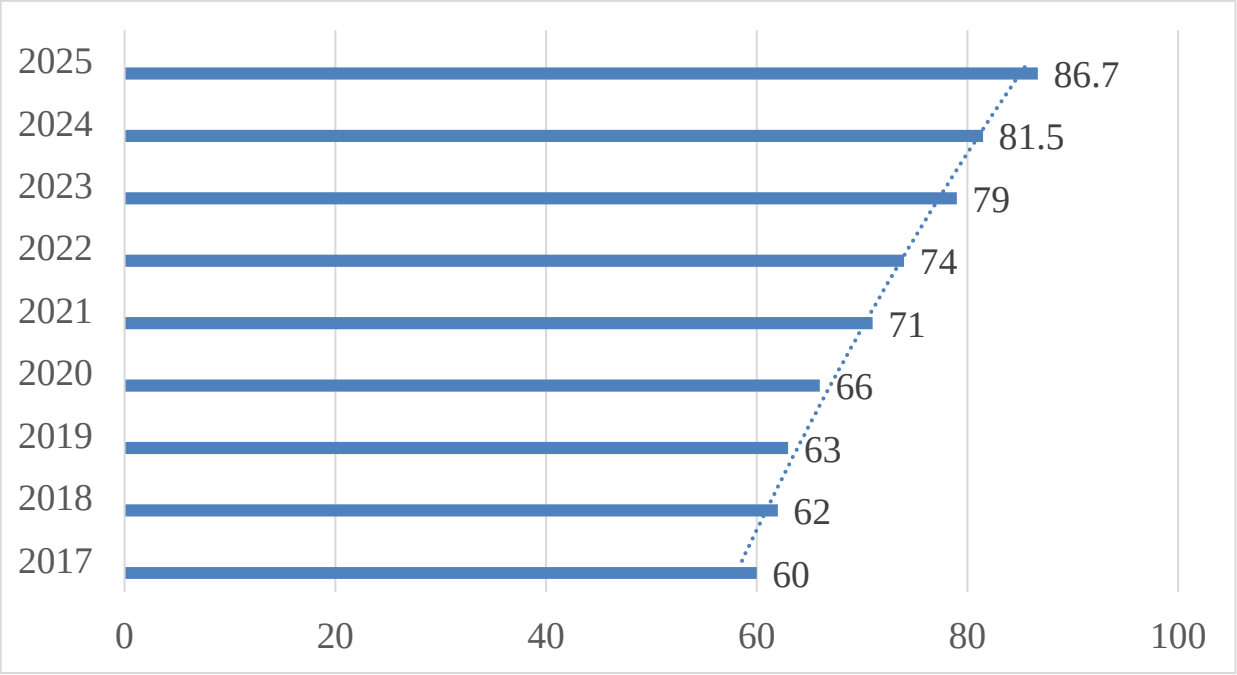


**Fig. - 1. Electricity production for 2017-2025**

In 2025, the total volume of electricity production in the country reached approximately 86.7 billion kWh, which is 30% more than in previous years [11].

Основными источниками электроэнергии остаются: тепловые электростанции (газовые); гидроэлектростанции; солнечные электростанции; ветровые электростанции.

**Table - 3.**

**Solar and wind energy production [12]**

| Year | Solar + wind energy |
|---|---|
| 2022 | 0.43 млрд kWh |
| 2023 | 0.57 млрд kWh |

| | |
|---|---|
| 2024 | 4.86 млрд kWh |
| 2025 | 10.5 млрд kWh |

The increase in electricity consumption is linked to the growth of industry, population growth, urbanization, and the development of the digital economy.

According to forecasts, by 2035, the demand for electricity may reach 121 billion kWh, which will require a significant increase in energy capacities [11].

Uzbekistan has one of the highest solar energy potential in Central Asia.

The main types of renewable energy in Uzbekistan include:

1. Solar energy. The country is located in a zone of high solar activity. The average duration of sunshine is: 300-320 days a year. Most promising regions: Navoi region, Samarkand region, Bukhara region, Kashkadarya region. The technical potential of solar energy is estimated at 525-760 billion kWh per year, which is several times higher than the current electricity consumption.

2. Wind energy. The wind potential is especially high in the following regions: Republic of Karakalpakstan, Navoi region, Jizzakh region. According to experts, the potential volume of wind energy generation exceeds 1 trillion kWh per year.

3. Hydropower. The potential of hydropower is estimated at approximately 25-27 billion kWh per year. The main hydropower resources are concentrated in the Fergana Valley, Tashkent region, and Surkhandarya region.

In Uzbekistan, a number of large investment projects in the field of renewable energy are being implemented with the participation of international companies and financial institutions. Solar power plants with a capacity of 100-500 MW, as well as the first wind power plants of industrial scale, have been commissioned.

In 2025, the volume of green energy amounted to 16.8 billion kWh, and the share of green energy reached approximately 20-23% of total electricity production [13].

Solar and wind power plants produced about 10.5 billion kWh, which is more than twice as much as the previous year's figures [13].

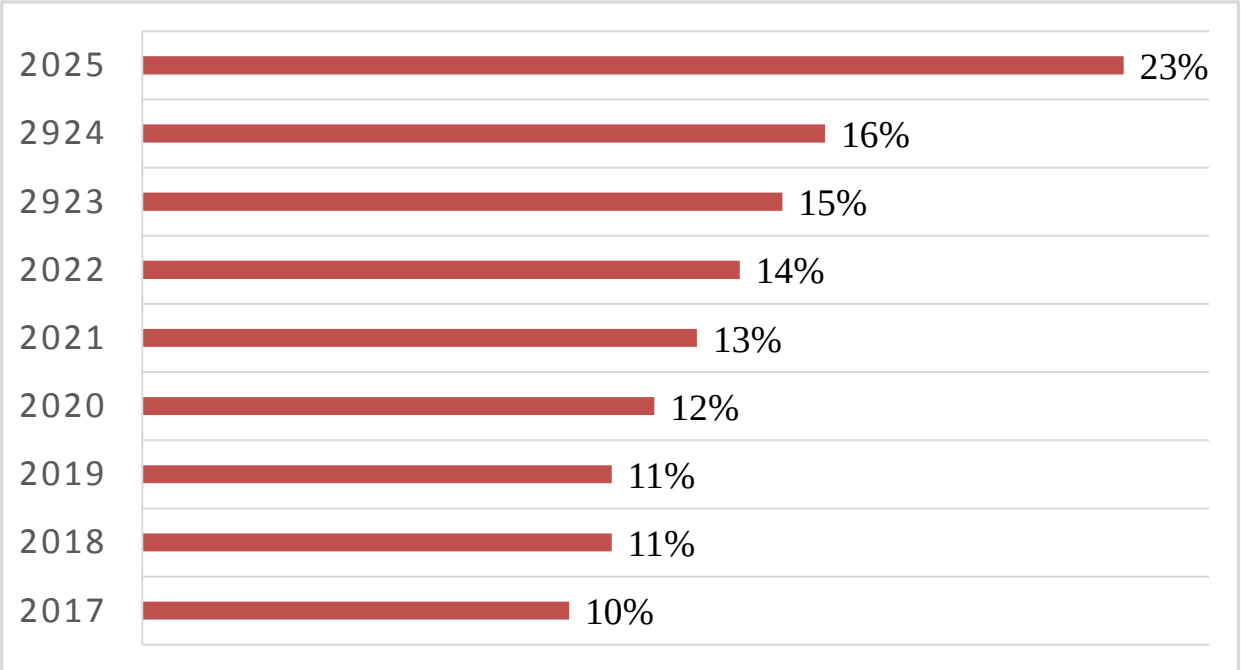


**Fig. - 2. Share of green energy in total electricity production**

**Table - 4.**

**Production of green energy in Uzbekistan (2017-2025) [15]**

| Year | Green energy (billion kWh) | Share (%) |
|---|---|---|
| 2017 | 6.5 | 10 |

| | | |
|---|---|---|
| 2018 | 7 | 11 |
| 2019 | 7.3 | 11 |
| 2020 | 8 | 12 |
| 2021 | 9.5 | 13 |
| 2022 | 10.5 | 14 |
| 2023 | 11.5 | 15 |
| 2024 | 13 | 16 |
| 2025 | 16.8 | 20 –23 |

A total of 12 solar power plants and 5 wind power plants with a total capacity of 4682 MW are operating in the country [14].

The use of renewable energy sources allowed saving 3.2 billion m3 of natural gas, preventing the emission of 4.7 million tons of harmful substances [13].

**Table - 5**

**Main indicators of renewable energy production for 2017-2025 [15]**

| Year | Total electricity (billion kWh) | Renewable (billion kWh) | Solar (billion kWh) | Wind (billion KWh) | Hydro (billion kWh) | RES (share, %) | $CO_2$ (reduction, mln. t.) | Gaz (Saved_bcm) | Investment (bn.USD) |
|---|---|---|---|---|---|---|---|---|---|
| 2017 | 60 | 6,5 | 0,001 | 0 | 6,49 | 10 | 1,2 | 0,4 | 0,3 |
| 2018 | 62 | 7 | 0,002 | 0 | 6,98 | 11 | 1,3 | 0,45 | 0,35 |
| 2019 | 63 | 7,3 | 0,003 | 0 | 7,27 | 11 | 1,35 | 0,48 | 0,4 |
| 2020 | 66 | 8 | 0,005 | 0 | 7,95 | 12 | 1,5 | 0,5 | 0,6 |
| 2021 | 71 | 9,5 | 0,1 | 0 | 9,4 | 13 | 1,8 | 0,7 | 1,1 |
| 2022 | 74 | 10,5 | 0,25 | 0,18 | 10,07 | 14 | 2,1 | 0,9 | 1,8 |
| 2023 | 79 | 11,5 | 0,4 | 0,17 | 10,93 | 15 | 2,4 | 1,1 | 2,4 |
| 2024 | 81,5 | 13 | 3,5 | 1,36 | 8,14 | 18 | 3,2 | 2,1 | 3,5 |
| 2025 | 86,7 | 16,8 | 6,2 | 4,3 | 6,3 | 20 | 4,7 | 3,2 | 4,8 |

From 2017 to 2025, electricity production increased from 60 billion kWh to 86.7 billion kWh. The share of renewable energy sources increased from 10% to 20-23%. A decrease in HPP electricity production is observed (from 6.49 to 6.3 billion kWh). A sharp decline is observed in 2024-2025). Solar energy has significant growth indicators in electricity production (growth from 0.001 to 6.2 billion kWh). Wind energy has been yielding results since 2022 and is experiencing stable growth, with production indicators reaching 4.3 billion kWh, with a sharp increase observed in 2024-2025.

Due to the introduction of green energy, emissions of CO2 - carbon dioxide into the atmosphere decreased significantly from 1.2 million tons to 4.7 tons. The volume of investments in renewable energy sources amounted to 4.8 billion US dollars, which is 16 times more than at the beginning of the period under review.

The state implements a number of strategic programs in the energy system, the main goals of which are:

1. Increasing the share of renewable energy sources.
2. Attracting foreign investment.
3. Reducing dependence on natural gas.
4. Reducing greenhouse gas emissions.

The strategic task is to increase the share of green energy to 50% by 2030 [11].

In addition, the following are planned: construction of 28 solar and wind power plants; commissioning of 8 GW of new capacity; creation of 18 energy storage systems [14].

Despite significant progress, the development of renewable energy faces a number of challenges.

1. Limited energy infrastructure. The country's energy system requires modernization and expansion, especially in terms of high-voltage lines, distribution

networks, and energy storage systems.

2. High capital intensity of projects. The construction of solar and wind power plants requires significant investments.

Despite the decrease in the cost of solar panels, investment costs remain significant.

3. Insufficient development of local equipment production. Most of the renewable energy equipment is imported.

Low level of energy efficiency. Many industrial enterprises use outdated technologies.

5. Generation instability. Solar and wind energy depend on weather conditions.

But despite existing limitations in the development of renewable energy sources in Uzbekistan, by 2030 it is planned to: increase the share of green energy to 40-50%; build new solar and wind power plants; introduce energy storage systems; modernize power grids.

The main directions of development are: 1. expansion of solar generation; 2. construction of wind power plants; 3. development of hydropower; 4. introduction of hydrogen energy.

**CONCLUSION**

To increase the efficiency of green energy development in Uzbekistan, the following measures can be proposed.

1. Development of distributed generation. It is necessary to encourage:

• installation of solar panels on the roofs of houses;

• creation of local microelectric power plants;

• development of autonomous energy supply systems.

2. Development of energy storage facilities. It is important to develop:

• battery energy storage systems;

• hydraulic accumulation stations;

• hydrogen energy technologies.

3. Development of local equipment production. The following should be encouraged:

• production of solar panels;

• production of wind turbines;

• battery production.

This will reduce the cost of projects and create new jobs.

4. Attracting foreign investment. International financial institutions such as the World Bank, the Asian Development Bank, and the European Bank for Reconstruction and Development play a significant role.

5. Development of scientific research. Develop the following:

• scientific centers on renewable energy;

• university laboratories;

• innovative startups.

6. Development of "green" financing. It is necessary to implement:

• green bonds;

• Climate funds;

• tax benefits for investors.

In the coming years, the share of renewable energy sources is expected to grow significantly.

The main directions of development:

- large-scale construction of solar power plants;
- development of wind parks;
- modernization of hydropower;
- development of hydrogen energy.

By 2030, Uzbekistan could become one of the leaders in green energy development in Central Asia.

Thus, the development of green energy is one of the key directions of the energy policy of the Republic of Uzbekistan. In recent years, the country has achieved significant results in this area, including increasing the share of renewable energy sources in the electricity production structure to 23%. Analysis of the current state of the energy sector showed the country's high dependence on traditional energy sources and the need to diversify the energy balance. However, further development requires infrastructure modernization, attracting investments, and implementing innovative technologies.

The comprehensive implementation of the state strategy will ensure the country's energy security, increase the sustainability of the economy, and reduce the negative impact on the environment.

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