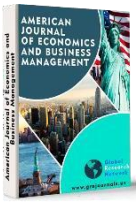

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Article

Construction on the Basis of Green Economy, Development of Hydropower, Electric Power and Alternative Energy Sources

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Abstract: This article systematically studies the development trends of the hydropower, electric power, and alternative energy sources sectors in Uzbekistan in the context of the transition to a green economy. The inextricable link between these sectors and the concept of a green economy, their role in the national economy, and their contribution to the green transformation are analyzed. The role of energy efficiency, carbon emissions reduction, the introduction of alternative energy technologies, infrastructure modernization, and public-private partnership mechanisms is assessed. Scientific proposals are developed for the sustainable development of the sectors based on international experience, national reforms, and regional statistical data.

Keywords: Green Economy, Construction Industry, Hydropower, Electric Power, Alternative Energy, Solar Energy, Wind Energy, Energy Efficiency, Sustainable Development, Carbon Neutrality, Green Innovation, Public-Private Partnership

1. Introduction

Today, the world economy is forced to choose a fundamentally new path of development in the face of global climate change, limited energy resources, and increasing environmental problems. Green economy is a progressive development concept aimed at harmonizing economic activity with the principles of environmental sustainability, efficient use of resources, and social justice, without rejecting the traditional model of economic growth [1].

The construction, hydropower, electricity and alternative energy sectors are strategically important sectors in the transition to a green economy. On the one hand, these sectors play a crucial role in shaping the basic infrastructure of the national economy, and on the other hand, they are sectors that consume a large amount of energy and leave an ecological footprint. Therefore, implementing a green transformation in these sectors should become the central core of the national sustainability strategy.

The Republic of Uzbekistan has also set clear goals for developing its economy on a green basis, increasing the share of alternative energy in the total energy balance to 25 percent, and significantly reducing carbon emissions by 2030 [2]. These strategic objectives require fundamental reforms in the construction and energy sectors, the rapid introduction of innovative technologies, and the widespread use of international experience.

Literature review

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The concept of a green economy was actively introduced into scientific circulation by the United Nations Environment Programme (UNEP) during the global financial crisis of 2008-2009, and this concept implies the need to combine economic growth with environmental sustainability [3]. According to the UNEP definition, a green economy is an economic model that serves to increase human well-being and ensure social equity, while significantly reducing environmental damage, environmental risks and resource scarcity.

The International Energy Agency (IEA) noted in its 2023 report that global investments in alternative energy sources have doubled in the past five years and exceeded US$1.7 trillion in 2022 [4]. This growth trend is also associated with a sharp decrease in the prices of solar, wind and hydropower technologies, which are becoming more economically attractive.

The European Union's "European Green Deal" strategy focuses on the construction sector, aiming to radically improve the energy efficiency of buildings, use green building materials, and widely introduce the concept of "smart buildings" [5]. Within the framework of this strategy, it is planned to reduce the energy consumption of buildings by at least 14 percent by 2030.

The "New Uzbekistan" strategy and the Innovative Development Strategy for 2022-2026, approved in the Republic of Uzbekistan in 2021, provide for the implementation of systemic changes in the energy sector [6]. At the same time, the Presidential Decree "On Measures for the Widespread Introduction of Alternative Energy Sources" of March 1, 2023 set the goals of installing solar panels on more than 29 thousand objects by 2030 and achieving a 25 percent share of "green energy". Comparative analyses show that countries such as China, Germany, Denmark, and India have made significant progress in implementing green transformations in the construction and energy sectors. In particular, in Denmark, more than 50 percent of its electricity is currently generated from wind power plants [7]. This experience can serve as an important learning source for Uzbekistan.

2. Material and Methods

This study used a multi-stage analytical methodology to comprehensively assess the development status of the construction, hydropower, electric power, and alternative energy sectors in the context of the transition to a green economy.

The primary data were the annual reports of the Ministry of Energy of the Republic of Uzbekistan, the Ministry of Ecology and Environmental Protection, as well as the National Statistics Committee of Uzbekistan for 2020-2025. In particular, data on the share of business entities that have implemented green energy facilities by region, installed capacity indicators, energy saving efficiency, and investment attraction dynamics were analyzed. Secondary data were obtained from reports of UNEP, the International Energy Agency (IEA), the World Bank, the Asian Development Bank (ADB), and the European Union's Green Deal documents. In addition, relevant legislative and regulatory documents of the Republic of Uzbekistan, presidential decrees, and government resolutions were analyzed. The following methods were used in the data processing process: systematic analysis, comparative analysis, dynamic series study, interregional comparative analysis, and expert assessment method. Based on the results obtained, decisive factors in the sector were identified and scientifically based practical recommendations were developed.Tahlil va natijalar

The construction sector is one of the largest energy-consuming and CO2-emitting sectors in the global economy. Globally, buildings account for approximately 40 percent of total energy consumption and 36 percent of carbon emissions [8]. Therefore, green transformation in this sector is of paramount importance in achieving climate goals. The green building concept includes several key areas. First, ensuring energy efficiency throughout the entire life cycle of a building, from design to construction and operation, second, using environmentally friendly and recycled building materials, third, equipping

buildings with solar panels, heat pumps and ground-source heating systems, and fourth, optimal use of resources through intelligent management systems.[9]

New building codes in Uzbekistan, which began to be implemented in 2022, set minimum energy efficiency requirements for buildings. More than 1,200 new buildings were built or reconstructed using energy-efficient technologies across the country in 2023-2025. Currently, 600 MW of solar panels are being installed in settlements as part of state target programs. However, the main problems in the sector include: insufficient production of green building materials, a shortage of qualified specialists, high initial capital costs, and the need for information about environmental standards among the population and construction companies. Removing these obstacles will create the necessary conditions for the rapid development of the green construction sector.

Hydropower is a strategically important energy source for Uzbekistan, and the country currently has 36 hydroelectric power plants with a total installed capacity of 1,966.7 MW. Hydropower accounts for approximately 11-12 percent of the country's total electricity generation.

At the regional level, the Rogun HPP in Tajikistan (3,600 MW) and Kambarata HPP in Kyrgyzstan have the potential to radically transform the energy landscape of Central Asia. Uzbekistan has the opportunity to reduce its dependence on energy imports and increase the share of sustainable energy sources by actively participating in these regional projects.[10]

3. Results and Discussion

From a green economy perspective, the advantages of hydropower include: virtually zero carbon emissions, long-term service life (50-100 years), capacity to adapt to demand growth, and energy storage. However, large hydropower projects are also associated with environmental and social risks - they can impact water bodies, reduce biodiversity, and lead to population displacement. Therefore, in the development of modern hydropower, special attention is paid to small hydropower plants (up to 10 MW) and mini-hydropower plants. In Uzbekistan, there is a potential for the construction of dozens of small hydropower plants on local rivers and irrigation canals, which will provide energy to the regions in a decentralized manner.

Uzbekistan's power system is largely composed of gas-fired thermal power plants (TPPs), which account for more than 85 percent of total generation. This makes the country extremely sensitive to fluctuations in natural gas prices and keeps its carbon footprint high.[11]

The main directions for modernizing the power system in terms of transition to a green economy are: the first direction is to convert existing TPPs from natural gas to less gas-intensive technologies and, ultimately, to a hydrogen economy; the second direction is to reconstruct power transmission networks based on modern "Smart Grid" technologies; the third direction is to develop decentralized energy systems and increase energy efficiency at the consumer level.

Uzbekistan's electricity sector development program for 2023-2030 envisages the installation of more than 8,000 MW of new capacity, including 4,000 MW of solar and 3,000 MW of wind power plants. To achieve these goals, it is necessary to attract more than 15 billion US dollars in investment, and active cooperation is being established with the Asian Development Bank, the World Bank, and private investors.[12]

In addition, reducing network losses is also an important strategic task. Currently, electricity transmission losses in Uzbekistan are about 12-14 percent, while in developed countries this figure is around 5-7 percent. Reducing losses by 6-8 percent through modernization will save more than 1 billion kWh of energy.

Uzbekistan has very favorable geographical conditions for the development of alternative energy sources. Alternative energy sources include solar, wind and other

technologies. The annual duration of sunlight in the country is 2700-3000 hours, which is 1.5 times higher than the European average. In addition, there is great potential for the development of wind energy in the Karakum and Kyzylkum deserts.

The total installed capacity of solar energy in Uzbekistan by 2023 exceeded 2,000 MW. The 1,000 MW solar power plant in Navoi region, large projects in Samarkand and Jizzakh regions are vivid examples of the rapid development in this area. Foreign investors, including the Abu Dhabi-based Masdar Company, are making significant investments in Uzbekistan's solar energy.[13]

Work is also underway on wind energy. The total capacity of installed and under construction wind power plants in the Navigation and Kashkadarya regions is expected to exceed 1,500 MW by 2025. World experience shows that the joint development of solar and wind power plants significantly increases the sustainability of energy production.

The development of biomass energy based on biodiversity and organic waste also holds great potential. Uzbekistan has the potential to produce 15-20 million tons of biomass annually from agricultural waste and the livestock sector, which will allow creating approximately 2000-2500 MW of power.

Also, the study of geothermal energy sources in the Aral Sea basin and the development of mini-hydroelectric power plants on small rivers are also promising areas. The integrated development of these sectors will ensure energy independence for Uzbekistan and increase the share of "green energy" to 40 percent by 2030.

The Table 1. below shows the dynamics of the introduction of green energy facilities by region. The dynamics of the share of business and industrial entities that have introduced green energy technologies by regions of Uzbekistan for 2020–2025 are reflected.

Table 1. Share of entities that have introduced green energy technologies by regions of Uzbekistan (%), 2020–2025

№	Province	2020 y	2021 y	2022 y	2023 y	2024 y	2025 y
1.	Tashkent region	6.2	8.1	10.4	13.2	16.1	19.3
2.	Tashkent city	7.5	9.4	12.0	15.3	18.7	22.1
3.	Samarkand region	4.1	5.6	7.3	9.5	12.0	14.8
4.	Fergana region	3.8	5.2	6.9	8.8	11.2	13.7
5.	Surkhandarya region	2.9	3.8	5.1	6.7	8.6	10.9
6.	Kashkadarya region	3.3	4.5	6.0	7.9	10.1	12.6
7.	Navoi region	5.1	6.8	8.7	11.0	13.8	16.9
8.	Khorezm region	2.5	3.4	4.6	6.0	7.8	9.8
9.	Karakalpakstan	2.1	2.9	3.9	5.2	6.9	8.7
10.	Jizzakh region	2.7	3.7	4.9	6.5	8.4	10.6
11.	Syrdarya region	3.0	4.1	5.5	7.2	9.2	11.5
12.	Andijan region	3.6	4.9	6.5	8.4	10.7	13.2
13.	Namangan region	3.2	4.4	5.8	7.6	9.7	12.0
14.	Bukhara region	4.4	5.9	7.7	9.9	12.5	15.3

Source: Compiled by the author based on reports from the Ministry of Energy of the Republic of Uzbekistan and the National Statistics Committee of Uzbekistan (2020–2025).

Analysis of the table shows that throughout 2020–2025, a consistent positive dynamics is observed in the share of entities that have implemented green energy technologies in all regions. This growth trend confirms the practical effectiveness of state policy and the growing environmental awareness in the business environment.

Tashkent city and Tashkent region maintain their leading positions in terms of indicators - reaching 22.1% and 19.3%, respectively. The developed technological

infrastructure in these regions, the availability of qualified personnel, and the relatively easy availability of financial resources are the main factors that ensured such results.[14]

Navoi region (16.9%) and Bukhara region (15.3%) also have high indicators, and the development of the mining and chemical industries in these regions has accelerated energy modernization. The growth rate is also stable in Kashkadarya region (12.6%), and work is underway to develop alternative energy infrastructure along with gas fields.

Relatively low indicators are observed in Karakalpakstan (8.7%) and Khorezm region (9.8%). However, these regions have great potential for the development of alternative energy, especially wind and solar energy, geographically. It is determined that special infrastructure programs and targeted investment support measures should be implemented in these regions.[15]

4. Conclusion

Based on the analysis conducted, the following conclusions were drawn: In Uzbekistan, the construction, hydropower, electric power, and alternative energy sectors are increasingly important as key change agents in the transition to a green economy. Positive dynamics are observed in the introduction of green energy technologies in all regions, but differences between regions remain significant.

Based on the results of the study, the following scientifically sound proposals were developed:

It is recommended to introduce a national "green building" certification system in the construction sector and strictly regulate mandatory energy efficiency standards. The government should provide building owners with subsidies and tax incentives to transition to green building standards.

In the hydropower sector, it is necessary to establish special grant programs for the construction of small and mini hydropower plants and provide local communities with the opportunity to participate in these projects. At the same time, it is necessary to introduce systematic monitoring of the compliance of existing hydropower plants with environmental standards.

It is recommended to activate the public-private partnership model in the modernization of the power system and improve mechanisms for supporting the transfer of foreign technologies. The implementation of smart grid technologies should be a priority to reduce energy losses and increase system reliability.

It is necessary to develop a targeted investment map in the alternative energy sector that takes into account regional characteristics and introduce separate incentive programs in regions with low indicators. It is recommended to actively participate in international projects for the development of wind energy in regions such as Karakalpakstan and Khorezm.

A comprehensive "Green Energy Atlas of Uzbekistan" combining four areas should be developed, which should present potential resources, existing infrastructure and economic opportunities for all regions in a unified manner. This will significantly facilitate decision-making for investors and government agencies.

In general, Uzbekistan has great potential for transition to a green economy in the construction, hydropower, electric power and alternative energy sectors. Through targeted state policies, expanded international cooperation and rapid introduction of innovative technologies, the country can achieve a significant green transformation in the energy sector by 2030.

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