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Article

Development of Renewable Energy Sources in the Process of Transition to a Green Economy in Uzbekistan

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Abstract: The article explores the development and the outlook for renewable energy sources in the wake of Uzbekistan's green economy transition. Statistics on the energy industry, development of wind energy, and economic and ecological efficiency are analyzed during the research. Solar and wind power plant construction, technologies implementation, and foreign investment attraction have gradually expanded electricity generation over the last years. At the same time, renewable energy sources reduce natural gas consumption and play an important role in ensuring ecological sustainability by decreasing the amount of harmful gases released into the atmosphere. The paper further points out that the increasing power generation benefits the entire population's energy supplies, creates new jobs and supports economic development. Moreover, the results of studies reveal that the policy implications are scientific as well as practical, which will also improve green energy policy in Uzbekistan.

Keywords: Green economy, renewable energy, solar energy, wind energy, ecological sustainability, investment, solar panels.

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Introduction

The challenges of achieving the principles of sustainable development in the contemporary world economy — principles that promote sustainable development in global economy, reduction of environmental crises, and rational use of natural resources in recent years have become very recent and pressing issues. Hence, from this perspective, a green economy constitutes a model for new development to ensure economic prosperity, environmental protection and ecological sustainability along with development of the economic growth. The green economy aims for sustainable development where natural resources are used properly in economic activities, energy-saving technologies are implemented, and energy sources are widely used from renewable sources. According to experts' predictions, a green economy is expected to represent roughly 30 percent of the global economy by 2030. It indicates this pathway is becoming strategically relevant globally. Uzbekistan is currently working to transition to a green economy to sustain economic development and alleviate environmental concerns. Various factors contribute towards such a direction in the country [1]. Firstly, the shortage of natural resources and the need to manage them better is turning out to be one of the most pressing problems. At the same time problems such as global climate change, air pollution and the disruption of

ecological balance need to be ensured in terms ecological sustainability. Also, this is one of the fundamental reasons for a green economy to be a priority, as also need to strengthen energy security and provide economic sectors stable energy sources [2]. The strategic initiatives proposed by President of the Republic of Uzbekistan Shavkat Mirziyoyev also demonstrate that great attention is being paid to the development of the green economy and renewable energy sources in the country. In particular, the head of state has set the modernization of the energy sector, the use of environmentally friendly technologies, and the expansion of renewable sources as critical tasks [3].

Literature review

Recent years have witnessed the emergence of a new focus area in both economic and ecological research: the pathway to a green economy and development of renewable energy sources. Scientific study carried out in the same vein suggests that theoretical and practical means of implementing the energy system's diversification will provide it a sustainable basis for development as well as provide greater efficiency as a result. The theoretical basis of the notion of the green economy has been extensively analysed by foreign scholars and international organizations. This particular paradigm describes the green economy as a development model that can integrate economic growth with ecological sustainability, as reflected in the UNEP reports. And more than the immediate impacts on the environment, renewable energy resources create new jobs, technologies and economic stability in an economy that was already highly developed based on UNEP studies. It illustrates the strong link between the green economy and economic efficiency. Of all researchers working on the development of theories from the perspective of the green economy, the one who was one of the most important is Edward B. Barbier. The link between economic growth and ecological balance is thoroughly elucidated in his work "The Green Economy." According to the scholar, investment in renewable energy encourages an economic increase and is consistent with the long-term stability of the economy as well the increase in renewable energy investment stimulates economic growth. But sustainable development of the system is sustainable, Barbier stresses, given that it can be made possible by keeping energy policy consistent with ecological concerns. Nicholas Stern has also extensively studied the question of the economic efficiency of renewable energy sources. The introduction of low-carbon technologies to the energy system is one mechanism that is integral to the maintenance of global economic balance, which is the main issue highlighted by the economic study to combat climate change. Stern observes that the initial high investments required to develop renewable energy sources would ultimately allow economic efficiency and mitigate some of the economic risks arising from climate change in the decades and decades to come. Another relevant real-world area of green energy development also was extensively researched using few national examples. Germany's energy policy in particular is regarded as one of its most successful instances of renewable energy development. In Germany, the "Energiewende" strategy involves policies that aim to develop solar and wind energy, increase energy efficiency, and gradually abandon nuclear energy. Researchers assess Germany's experience as an effective model for transforming the energy system. Beyond that, Sweden has been a leader in green energy development. Sweden's energy policy relies predominantly on renewable energy sources; hydropower and bioenergy. It has been suggested by studies and other related literature that an ecological tax policy established by the Swedish government, as well as by state support systems, played a key role in the early development of green power. In addition, China is among the top nations in developing renewable energy sources worldwide. In the past few years, there have been significant investments in solar and wind energy in China. The study demonstrated that active investment policy on the part of the government and the industrial modernization processes opened opportunities for the quick development of renewable energy resources. As for the development of sources of renewable energy under the conditions of

Uzbekistan, experts and scholars have studied and underlined this issue. Research highlights that the country's natural and climate conditions offer plenty of potential for solar and wind power production. Based on state energy policy, it is expected that by 2025 capacity of energy supply from renewable sources will reach 7.5 GW in the economy and the total capacity of energy of the country will be in the country. Based on the literature review, it was concluded that foreign research primarily examines the global economic efficiency of renewable energy systems and the associated climate change impact, but a lot of local research emphasizes the opportunities for pursuing such energy resources in relation to those provided under Uzbekistan's conditions, the potential of resources and energy policy. From this perspective, this study, through the extension of existing scientific theories, will analyze the economic aspects of developing renewable energy sources during Uzbekistan's transition towards a green economy [4].

Methodology

An integrated system of scientific research methods is applied in this study in order to provide a deeper analysis of the state of development of renewable energy sources from the transition of Uzbekistan to a green economy. The methodology for research incorporates the steps of data collection, systematization, and analysis based on quantitative and qualitative methods commonly used in modern economic research practice. Primary and secondary data sources were utilized in the establishment of the empirical basis of the research. Especially, the official statistical data of the energy industry, and reports of state entities, analytical materials of international organizations, scientific studies obtained as the base documents. Statistical data also provided indicators for the main energy sector development indicators, including the size of energy production, the energy consumption structure and the share of renewable energy in the total energy balance. The role and development of renewable sources for the energy system of the country were also established based on the country's energy balance indicators. Quantitative analysis techniques were commonly employed to analyze the data throughout the research process. Based on statistical data the dynamics of energy production and consumption indicators were analysed within the framework of this approach, while economic analyses were carried out regarding the share of renewable sources of energy. Using a quantitative analysis approach, it was possible to establish energy sector growth rates, changes in energy production volumes, and structural transformation in energy systems. The economic efficiency of development and the future development of green energy were also examined by employing statistical analysis. In addition, qualitative analysis methods have been employed in the analysis. The opinions of experts in the energy sector, the theoretical perspectives presented in scientific literature, and analysis within sectors were gathered through this method. Conducting interviews and conducting expert assessments helped explain institutional factors, economic mechanisms and existing issues associated with renewable sources of energy. This methodology supported the exploration of both barriers and potentials when trying to move the industry from a passive, traditional to a modern renewable energy integration mode. Analysis, comparison and generalization methods were used in the research methodology as well. The development level of renewable energy sources in Uzbekistan's energy system was compared under the comparative method by comparison with the experience of other countries. Systematization of results with the generalization method allowed the scientific conclusions to be drawn.

Results

Based on the research findings, the source of renewable energy in Uzbekistan is playing an essential role in ensuring the stability of energy systems and transition to a green economy. In recent years, large investment projects developed to develop solar and

wind energy under the energy policy of the country have been implemented into various fields in order to decrease dependence on traditional fuel materials and to diversify energy production sources for ecological security. The review of the data demonstrates that generation volume from renewable energy is steadily expanding year by year. Note, that in 2023, 576.9 million kWh of electricity was generated by solar power, while 604 million kWh is produced by wind power. From these signs, we see the percentage of renewable energy input in national power system gradually rising. In particular projects set in place for the building of solar power plants in areas with high solar radiation increase the rate of development of this direction. Based on geographic view, Uzbekistan has been among the countries which have a great potential to utilize the solar energy. There, solar radiation is seen daily for more than 300 days a year—meaning there is a conducive context for solar energy development in the territory of the country. Over the past few years, numerous solar electricity plants have been built in different parts of the nation. One such example is the Nur Navoi Solar Power Plant project, which is one of the biggest solar power projects in Central Asia. In this project, they are creating electricity for hundreds of thousands of households, the gas emission into the atmosphere of the carbon dioxide is less, a huge reduction process. Furthermore, the wind power development is also one of the significant directions of our energy policy. The Zarafshan Wind Farm plant is considered one of the largest wind power projects in Central Asia. Launch of this project also generated millions kilowatt-hours of electricity every year [5]. Wind energy is being developed for use as an effective source energy, including in deserts and wind intensive regions of the country. Predictions suggest that by 2026, renewable sources will bring the total electricity generation in the country to 10 billion kWh. This will be accompanied by a high increase of the share of renewable energy in the total generation volume of the energy system. It will also increase these indicators more with the commissioning of new solar and wind power plants, introduction of modern energy storage technologies, and the attraction of foreign capital. The results of the research also clearly shows the ecological efficiency of renewable energy sources. These calculations show, by 2026, that using renewable energy sources, will open the opportunity for saving an average of 3.2 billion cubic meters of natural gas. This could improve use of the country's energy and provide opportunities to deploy natural gas toward other industrial sectors. The large scale application of renewables will also assist minimize environmental issues. "It's estimated that by 2026, the amount of toxic gas that the energy projects cause will have dropped by some 4.4 million tonnes," explains the latest intelligence released. This is vital to combatting the deleterious impacts of climate change, enhancing air quality and promoting ecological sustainable development [6].

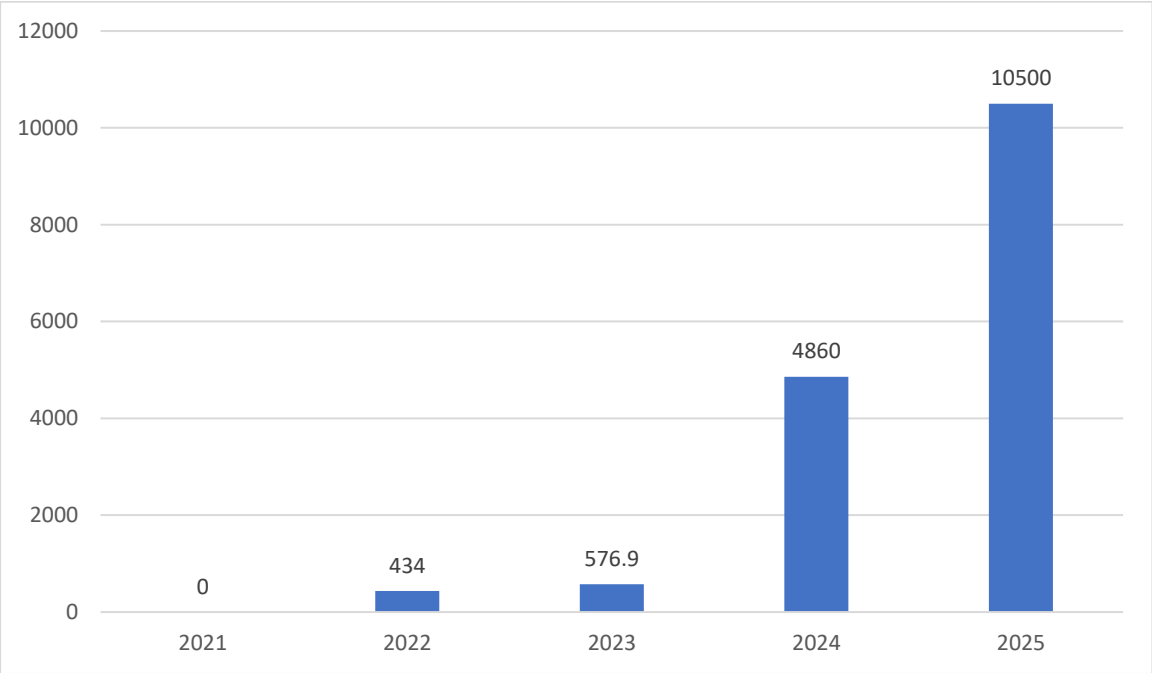

Figure 1. Electricity generated from solar and wind energy in Uzbekistan.

The above work depicts the dynamics of the increasing of electricity from renewable sources from recent years in Uzbekistan. It can be seen that in 2019-2021, the volume of renewable electricity production was relatively low, since in this stage most of the planning in the production of new projects and in the development of infrastructure in the energy sector was realized. In that period, traditional energy sources were the majority of the country's energy system. Beginning in 2022, the energy production volumes for renewable energies increased by leaps and bounds. 2022 production volume was 434 million kWh, and then to 1.18 billion kWh in 2023, it reached 1.18 billion kWh or nearly doubled this level. This surge indicates that investment projects to set up solar and wind power stations to start in the country have met the targets for this, and is reflected by the increase in the amount in production capacity. From 2024–2025, the renewable energy production enters a stage of rapid growth. Production stood at 4.86 billion kWh in 2024 to surpass 7 billion kWh in 2025. Such surging growth rates can be accounted for by increase in investment in green energy, new solar and wind-powered plants entering service, and modernization of the energy system. This trend shows the gradual progress of Uzbekistan’s green economic development. The rise of renewable energy production is crucial not only to stabilize the energy system, but to decrease its dependency on conventional fuel resources such as natural gas, which can also negatively impact the environment. Furthermore, this process encourages better efficiency of energy, new technology and a new area of economy. Renewable energy project development generates also significant economic gains. These projects enable them to generate new jobs, deploy a new era of technologies and upgrade existing power infrastructure [7].

Particular to the production, installation and operation of wind and solar energy-related energy facilities in general, new sectors are being formed. The diversification of the national economy is positively affected by this. For Uzbekistan, developing renewable energy sources results in significant outcomes in enhancing the operational efficiency of the energy system, reinforcing energy security, and guaranteeing environmental sustainability. This steps the country’s strategy to move towards a green economy and is a very important step to take [8].

Discussion

The study finds that not only does making a transition to green economy of Uzbekistan modernizes the energy system but also significantly contributes to enhance socio-economic development of the country. The large scale deployment of renewable energy sources is an important cause of energy supply stability, improvement of environmental conditions, and good quality of life for the people. First, development of alternative energy sources contributes to significant social success. The successful execution of those energy projects is anticipated to provide around 4.9 million households with sustainable electricity power in the future. Therefore, this reduces energy supply disruptions to the population on one hand and builds the stability of the energy system on the other. Solar and wind energy projects are particularly important to improve the energy supply from electricity in remote and rural areas [9].

Development of energy infrastructure is important in overcoming and bridging the socio-economic disparities between the different regions of the country. This in itself also plays a large part in arousing the green economy mentality of society. Renewable energy products, use of energy-saving devices, an array of technologies and green production systems provide tools for the green world. This process is of particular import to the younger generation in terms of raising the awareness of the environment. In addition to these initiatives, the promotion of an environmental culture by schools, higher education institutions, and assorted public organizations encourages the rapid spread of green economy concepts throughout society [10].

Table 1. Renewable Energy Production in Uzbekistan (2022–2025).

Year	Solar (million kWh)	Wind (million kWh)	Total (million kWh)	Gas Saved (billion m^3)	CO_2 Reduction
2022	434	-	434	0.15	0.25
2023	576.9	604	1180.9	0.45	0.7
2024	3000	1860	4860	1.8	3.0
2025	4360	2640	7000	2.7	4.4

Uzbekistan is moving the development of renewable sources of energy in the field rapidly. It is found in the table that total electricity produced from these sources in 2022 reached 434 million kWh in 2022, and 1,180.9 million kWh in 2023. At scale, in volume, production will increase drastically in the months 2024–2025, reaching 7 billion kWh in 2025, and that is projected to increase sharply to 7 billion kWh in 2024 and 2025. On the other hand, only a small increase from the 1.24-km area of Saudi Arabia in 2020 (in the energy consumption, to 3.4-miles of energy) is growing at present, but it is planned for increased production volumes in 2030. This growth can be attributed to a number of reasons. First, between 2022 and 2025, extensive solar and wind plant build-outs on a national scale are being commissioned. The Nur Navoi Solar Power Plant and Zarafshan Wind Farm, for instance, enabled thousands of millions of kWh/year electricity production [11]. The solar and wind power industries have expanded significantly through these facilities, with larger plants that provide higher output. Second, higher investments and foreign collaboration were factors in the sector. In 2022, renewable energy investments were $1.1 billion USD, increased to $1.5 billion dollars in 2023 and predicted to grow to $3.5 billion dollars by 2026 . These investments go toward new plant construction, newer technology, and new energy infrastructure development. Third, technology change and efficiency of energy have also been major contributors to growth. In a recent era, solar panels, wind turbines, storage of energy systems have been deployed to increase production efficiency and decrease reliance on conventional fuel systems. Fourth, both environmental efficiency and natural gas savings have been vital results. Due to energy

produced from renewable energies, 2.7 billion cubic meters of the natural gas are anticipated to be saved by 2026, and CO_2 emissions to be decreased by 4.4 million tons [12].

This reflects Uzbekistan's strategy for achieving a green economy and its goals of environmental sustainability. Socio-economic effects are substantial as well. The increased generation of electricity will allow stable supply of energy for 4.9 million households. In addition, jobs are created and the local economy is developed, environmental consciousness becomes higher among the people, all within the new energy projects context. Introducing energy-saving technologies and systems saves energy and thus supports economic effectiveness of the energy resources as we use them rationally. For example, the introduction of solar panels, low powered lighting, and technologies that save energy can lead to a drastic decrease in electricity consumption. This in turn helps reduce the costs of energy production in relation to producing energy and lessens the load on non-renewable resources. One part of this process is to attract investment to the green energy industry. This growth in the investments for renewable energy projects has been substantial in recent years. For example, $1.1 billion USD in renewable energy expenditure increased from 2022 to 1.5 billion USD, as a result of which the same figure had increased by 2023 to $1.5 billion USD in 2023. That proves Uzbekistan's ability to draw investment from the country's energy sector, and that the state's energy policy is supported by international financial institutions and investors. The increase in investment volumes helps in building solar and wind power plants, upgrading existing energy infrastructure, and deploying new technologies. As a result, the national energy system is diversified further and the share of renewable energy sources is also increased [13].

Meanwhile, there is a positive effect of these projects on the local economy which generates jobs and technological development. It is evident from these analyses, that the process of transitioning to a green economy of Uzbekistan is currently in its early stage, but substantial positive achievements have already transpired in this regard. To further expedite the process there are a few key considerations. It can focus on localization techniques (localizing renewable energy technologies), developing the scientific field, science, energy storage and raising public perception of the environmental concern. According to these aforementioned reviews, the vast available resource potentials in the natural and climatic environment of Uzbekistan (especially in terms of solar radiation, etc. The country's potential for sustainable use of these resources is good and if well leveraged, the country will be well placed to not only sustainably meet its domestic energy demands, but also become central to the regional energy markets later in life. Hence, to develop for the sustainable economic development of Uzbekistan, expanding investments into green energy, modern technologies and developing international cooperation is paramount [14-15].

Conclusion

In conclusion, Uzbekistan's transition toward a green economy represents an important step in ensuring sustainable economic growth, strengthening energy security, and protecting the environment. The findings of this study show that renewable energy sources, particularly solar and wind power, are gradually becoming a vital part of the country's energy system. In recent years, the implementation of large-scale renewable energy projects, technological modernization, and the attraction of foreign investments have significantly increased the production of electricity from renewable sources.

The analysis of statistical data indicates a steady growth in renewable energy generation, which reflects the effectiveness of Uzbekistan's current energy policies and reforms. The development of solar and wind power plants, including major projects such as the Navoi solar power station and the Zarafshan wind farm, has expanded electricity production while reducing dependence on traditional fossil fuels. As a result, renewable energy not only helps diversify the national energy balance but also contributes to

lowering natural gas consumption and reducing greenhouse gas emissions. These improvements play an important role in protecting the environment and addressing the challenges of climate change.

At the same time, the development of renewable energy brings notable socio-economic benefits. The construction and operation of new energy facilities encourage technological progress, create new employment opportunities, and improve the reliability of electricity supply for both households and industries. In addition, the wider adoption of energy-efficient technologies and environmentally responsible practices supports the development of a more sustainable economic system.

Overall, the results of this research suggest that expanding investments in renewable energy, promoting technological innovation, and strengthening international cooperation will be key factors in accelerating Uzbekistan's transition to a green economy and achieving long-term sustainable development.

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