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The Specific Directions for Developing Green Energy Production in Uzbekistan

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Abstract: The article discusses the trends in the development of green energy in Uzbekistan. Uzbekistan is actively developing the green energy sector, which is an important step towards ensuring sustainable economic growth and increasing the country's energy security. With traditional energy resources such as oil and natural gas depleted, the government of Uzbekistan has focused on diversifying energy sources, which includes expanding the use of renewable sources, in particular solar and wind energy. The article systematically analyzes the strategies for the development of green energy in Uzbekistan, production capacities and opportunities. The opinions of scientists and experts on green energy are systematically analyzed, and the author also expressed his own point of view. The article systematizes the mechanisms for the implementation of the use of renewable energy sources in Uzbekistan. Uzbekistan's goals for the construction of new renewable energy capacities by 2026 are studied.

Key words: green energy, renewable energy, solar energy, wind energy, hydrogen energy.

Introduction

Energy and energy resources are among the key factors ensuring the sustainable development of any country's economy, determining its socio-economic progress and the well-being of its population. According to data from industry experts and scientists, the currently identified natural fuel and energy resources worldwide (natural gas, oil) will suffice for approximately 60-150 years of usage. Consequently, many countries are pursuing policies to ensure energy security and improve energy efficiency. The energy crisis of the 1970s revived interest in using solar energy to generate electricity for enterprises and households. In July 1973, UNESCO organized a conference in Paris under the slogan "Solar Energy in the Service of Humanity," providing concrete insights into the state of solar energy worldwide. Until 1973, solar energy was merely a research subject for scientists. However, it subsequently transformed into a new industrial sector. At that time, solar technology required substantial investments, making the mass production of solar panels impractical. Over time, however, the cost of photovoltaic cells significantly decreased, especially in the last decade, by more than 59%. This has paved the way for the widespread use of solar energy in enterprises, organizations, and private homes.

In Uzbekistan, strategic attention has also been directed towards the energy sector, with new energy capacities established in recent years. Nevertheless, population growth and an increase in industrial enterprises have led to a yearly rise in demand for electricity. It is projected that by 2030, the country's electricity demand will rise from the current 74 billion kWh to 110 billion kWh. Naturally, in such a situation, the use of renewable energy sources plays a crucial role in addressing these challenges.

Currently, significant projects are being implemented in Uzbekistan's energy system to ensure the country's energy security, improve energy efficiency, and provide stable energy supply to economic sectors. The government is focusing on further reducing the energy intensity of the country's GDP, lowering production costs, and implementing a "green energy" policy, which involves expanding the use of renewable energy sources such as solar, wind, and hydro energy.

Literature Review

Scholars discuss green energy and renewable energy sources as follows:

Extensive research on renewable energy sources has been conducted in foreign countries. For instance, Italian economist Andrea Borghesi, in his study *"Simulation of Incentive Mechanisms for Renewable Energy Policies" (2013)*, described renewable energy as a promising and modern sector of the energy industry. His research proposed intensive mechanisms for developing this area of energy .

Green energy sources, based on their technology and environmental impact, are divided into renewable and clean energy sources, including solar, wind, geothermal, hydroelectric, water flow and ocean energy, and biomass. Green energy refers to any type of energy generated using natural resources. While subtle distinctions exist between green energy and renewable energy, they are often derived from renewable energy sources. A critical aspect of utilizing these energy sources is ensuring that they do not negatively impact the environment, for instance, by emitting greenhouse gases. Green energy frequently comes from renewable sources such as solar, wind, hydroelectric, geothermal, water flow and ocean energy, biomass, and biofuels. Each of these technologies functions differently, such as using solar panels for solar energy, generating power through wind or water flow, or harnessing energy from ocean surface waves.

1-table. Conceptual Table Highlighting the Differences Between Green Energy and Renewable Energy [13].

Criterion	Green Energy	Renewable Energy
Definition:	Green energy refers to energy derived from natural sources that do not pollute the environment. It is clean energy obtained through processes that have minimal impact on the environment, particularly in terms of carbon emissions.	Renewable energy refers to energy produced from sources that are naturally replenished on a human timescale. These resources are inexhaustible as they are continuously available in nature.
Focus	The primary focus of green energy is on benefiting the environment. It refers to renewable and non-polluting energy sources.	The primary focus of renewable energy is on sustainability and availability. It emphasizes that the energy source is renewable and inexhaustible.
Examples	Solar energy, wind energy, hydropower, and geothermal energy are considered "green" because they have minimal negative impact on the environment and produce little to no pollution during use.	Solar energy, wind energy, hydropower, biomass, and geothermal energy are examples of renewable energy. However, not all renewable energy is considered green.
Environmental Impact	It must be renewable and have minimal impact on the environment (low pollution and emissions).	Renewable energy focuses on the availability of the source, but the process may still involve some pollution (e.g., biomass or large-scale hydropower).
Scope of Application:	Green energy: a subset of renewable energy. All green energy is renewable, but not all renewable energy is considered green.	Renewable energy: Includes green energy as well as sources (e.g., biomass or certain forms of hydropower) that may not be entirely environmentally friendly.

In conclusion, green energy is always environmentally friendly and renewable. Renewable energy refers to a source that can naturally replenish itself, but some forms of renewable energy may still have environmental drawbacks.

Research Methodology

The research methodology involved comparative analysis of literature and the use of methods for substantiating hypotheses. The object of the study was selected as Uzbekistan's renewable energy sector. The subject of the research encompasses the system of economic relations associated with the emergence of energy resource efficiency issues, the widespread use of renewable energy sources, and the implementation of effective energy policies to achieve sustainable development goals.

In studying the development of renewable energy to achieve sustainable development goals, a systematic approach was applied, examining economic phenomena and processes in an integrated manner. Logical analysis, synthesis, generalization, induction, and deduction methods were used to draw conclusions from the data.

Analysis and Results

Based on the United Nations Millennium Sustainable Development Goals, Uzbekistan has adopted its Development Strategy. Within the framework of this strategy, Objective 24 outlines tasks aimed at the rapid development of the national economy and ensuring high growth rates. These include:

Ensuring an uninterrupted power supply for the economy and actively introducing "green economy" technologies across all sectors, increasing energy efficiency by 20%;

Raising electricity production by an additional 30 billion kWh, reaching a total of 100 billion kWh by 2026;

Increasing the share of renewable energy sources to 25% by 2026, saving approximately 3 billion cubic meters of natural gas annually;

Ensuring stable operation of Uzbekistan's energy system in coordination with neighboring countries' energy systems;

Reducing losses in industrial sectors and improving resource utilization efficiency;

Expanding the use of renewable energy sources in housing and communal services, social facilities, and other sectors while improving energy efficiency;

Taking measures to manufacture and promote the use of electric vehicles;

Reducing harmful gas emissions per unit of GDP by 10%.

Furthermore, to enhance the use of renewable energy sources, practical measures have been outlined in the following areas. Refer to Figure 1 for details.

The target indicators for establishing new capacities of renewable energy sources outlined in the Development Strategy for 2022-2026 are presented in Table 2.

2- Table Goals for Establishing New Capacities of Renewable Energy Sources by 2026

Stages	Renewable Energy Directions	Newly Established Capacities
1	Establishing an additional 4 GW of capacity through the construction of at least 8 wind power plants (WPP).	1. In 2023, commissioning 3 wind power plants (1.1 GW) in the Beruniy and Qorao'zak districts of the Republic of Karakalpakstan and the G'ijduvon and Peshku districts of the Bukhara region. 2. In 2024, commissioning 1 wind power plant (0.5 GW) in the Tomdi district of the Navoi region. 3. In 2025-2026, commissioning at least 4 wind

		power plants (2.4 GW) in the Republic of Karakalpakstan and other regions.
2.	To achieve a solar photovoltaic (PV) capacity of 4 GW, commissioning at least 10 solar PV plants.	1. In 2023, commissioning 4 solar photovoltaic (PV) plants with a total capacity of 1.1 GW in the Navoi, Jizzakh, Samarkand, and Surkhandarya regions. 2. In 2025-2026, commissioning solar PV plants with a total capacity of 1.8 GW in the Republic of Karakalpakstan and other regions.
3	Establishing additional production capacity of 868 MW of electricity per year through the construction of 15 new hydroelectric power plants (HPPs) and the modernization of 5 existing HPPs.	1. In 2023, completing the modernization of 1 HPP in the Tashkent region and commissioning 2 HPPs with a total capacity of 29 MW in the Kashkadarya and Andijan regions. 2. In 2024, completing the modernization of 1 HPP in the Andijan, Namangan, Surkhandarya, and Tashkent regions and commissioning 4 HPPs with a total capacity of 122 MW. 3. In 2025-2026, commissioning 4 HPPs with a total capacity of 544 MW in the Kashkadarya and Tashkent regions.

Source: Prepared based on Appendix 2 of Decree No. PF-60 of the President of the Republic of Uzbekistan, dated January 28, 2022.

A presidential decree has been adopted on urgent measures to improve energy efficiency in economic sectors and the social sphere, introduce energy-saving technologies, and develop renewable energy sources. This strategy aims to actively attract private and international investments for building renewable energy infrastructure and modernizing the country's energy sector. Over the next decade, the construction of solar power plants with a total capacity of 5,000 MW and wind power plants with a total capacity of 3,000 MW is planned.

Uzbekistan has signed several significant agreements with international organizations and companies. For example, in 2018, a contract was signed with the International Finance Corporation (IFC) to support private investment in renewable energy projects. The "Scaling Solar II" project is being implemented to construct photovoltaic plants. The IFC was engaged as the lead advisor to structure and conduct tenders for solar energy projects.

In 2019, the first phase of international tender bidding was organized with the assistance of the IFC, resulting in the construction of the first photovoltaic plant with a capacity of 100 MW in the Navoi region. The event attracted 23 companies from countries including China, South Korea, Japan, Saudi Arabia, the UAE, India, South Africa, Russia, Spain, Norway, and France. The winning bidder, "Masdar" (UAE), is building a solar power plant with an annual production capacity of 260 million kWh of electricity.

The volume of green energy production in Uzbekistan decreased in 2019 compared to 2014. The main reason for this decline was the reduction in hydropower output.

Table 3. Uzbekistan's Renewable Energy Production Indicators

Year	2014	2015	2016	2017	2018	2019	2020	2021	2022
Production Volume, MW	8102	8 102	8 105	8 106	5 904	6 468	5 016	5 050	6 936
Hydropower	8 100	8 100	8 100	8 100	5 897	6 452	5 000	5 000	6 500
Wind energy						16	16	1	
Solar energy	2	2	5	6	7	0	0	49	436
Renewable energy share of	16.0	16.0	13.9	13.5	10.1	11.2	9.5	7.7	9.3

electricity production									

In 2021, a national strategy for the development of renewable energy sources was established, aiming to achieve 25% of total energy production from renewable sources by 2030. The plan included the construction of large-scale solar and wind power plants, as well as the development of small hydroelectric power stations.

The main challenges in developing green energy production in Uzbekistan can be identified as follows:

1. Barriers to Utilizing Renewable Energy Sources Uzbekistan faces significant obstacles in utilizing renewable energy sources. While the "Law on Renewable Energy Sources" has recently been adopted, the regulatory and legal framework is still underdeveloped. The monopoly of the state electricity company remains unbroken.
2. Additionally, outdated energy infrastructure, insufficient funding and investments in the energy sector, low electricity prices, a lack of qualified personnel in renewable energy technologies, and the absence of clear mechanisms to support the development of renewable energy sources are significant issues [10].
3. Lack of a System for Training Green Technology Specialists What kind of specialists does Uzbekistan need to train to develop green energy? Integrating green economy technologies across all sectors to rapidly develop the national economy and ensure high growth rates is one of the objectives outlined in "The Development Strategy for New Uzbekistan 2022-2026." Achieving this goal also highlights the necessity of training personnel for the green economy. Studies by international organizations like OECD (2011) and Cedefop (2009) emphasize that developing human resources is fundamental to greening the economy.
4. In the 2022-2023 academic year, over 30% of the trained workforce in Uzbekistan was aligned with the green economy (compared to just 5% in the 2019/2020 academic year).

Content analysis of graduate training parameters (master's programs) for the 2019-2020 and 2022-2023 academic years highlights the following conclusions:

Universities in the Republic (including regional branches) are training personnel in critical specialties needed for transitioning to a green economy. These include biotechnologists, specialists in alternative energy (solar and wind), engineers for efficient use of water and land resources, climate risk assessment experts, and bioeconomy specialists.

Additionally, training programs have been established for designing, operating, and producing energy-efficient facilities and technologies, including those involving artificial intelligence.

Thirdly, it has been noted that Uzbekistan consumes 2-3 times more energy to generate one thousand dollars of GDP compared to developed countries, and 44% of the annual demand for oil products is met through imports. Therefore, in the coming years, it will be necessary to reduce energy consumption by 2-2.5 times [12].

In Uzbekistan, 40% of the energy produced is used for heating and lighting buildings, with significant inefficiencies in the process. For example, heating 1 square meter of space requires an average of 400 kWh, while in developed countries with similar climatic conditions, the figure is just 170 kWh.

Conclusions

Based on the research findings, the following conclusions can be drawn:

- Green energy is a foundation for achieving sustainable development without harming the environment. It is a renewable energy source, but to qualify as green energy, it must have zero environmental impact, meaning it emits no or minimal greenhouse gases.

- In the late 1990s and early 2000s, Uzbekistan began exploring the possibilities of using renewable energy sources such as solar and wind energy. Initial steps focused on assessing renewable energy resources and establishing the necessary infrastructure to develop the sector. However, large-scale commercial projects were absent at the time.
- Uzbekistan is among the top countries globally for solar radiation, making it an ideal location for utilizing solar energy. In the late 1990s, the first studies on using solar panels for off-grid applications in rural areas began. For example, some agricultural facilities and remote regions started testing solar batteries to provide electricity. However, the infrastructure was poorly developed, and the projects were localized and limited in scope.
- Recently, the government has also focused on hydrogen energy, which is reflected in the 2021 strategy. Research and development projects in hydrogen energy represent a new direction supported by international partners.

In the future, Uzbekistan has committed to diversifying its energy sources further by expanding renewable energy capacity and emphasizing hydrogen energy. The government continues to promote private investment and international cooperation to achieve green energy goals. Additionally, efforts are underway to integrate innovative technologies, such as energy storage, to enhance energy efficiency and stabilize renewable energy supply. These steps represent a gradual but accelerating transition to a green energy system in Uzbekistan, reflecting its acknowledgment of the need for a global shift toward sustainable energy practices and a reduction in carbon footprints. Transitioning to a "green" economy helps address ecological challenges such as inefficient use of natural resources, including water, air pollution, deforestation, land degradation, and climate change. An increase in the share of the population with high-level IT skills has a more significant impact on the growth of "green" employment than other factors.

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