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DIGITALIZATION DIRECTIONS OF THE GREEN ECONOMY

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Abstract

The article analyzes the priority directions of digitalizing the green economy, including the impact of artificial intelligence, IoT, blockchain technologies, and smart energy management systems on sustainable development. The research results show that the digitalization process plays an important role in increasing energy efficiency in industrial sectors, reducing carbon emissions, and attracting environmental investments. Based on international experience and empirical data, innovative strategies for digitalizing the green economy in Uzbekistan are proposed. The study analyzes data based on reports from Scopus, Web of Science, IEA, OECD, and the UN.

Keywords: Green economy, digital transformation, energy efficiency, carbon emission, artificial intelligence (AI), IoT, blockchain, carbon market, green investments, environmental monitoring.

INTRODUCTION

In recent years, the digitalization of the green economy has become one of the key factors for sustainable development on a global scale. In particular, within the framework of the United Nations' Sustainable Development Goals (SDGs) for 2030, the introduction of environmentally friendly technologies and the digitalization of

economic processes have been identified as important tasks. International experience shows that economic digitalization enables the development of green technologies, efficient use of natural resources, and reduction of environmental damage. According to World Bank (2023) data, the volume of investments in the global green economy amounted to 1.4 trillion US dollars in 2022, and this figure reached 2 trillion US dollars in 2023. Notably, investments in renewable energy sources increased by 30% in 2023, totaling 495 billion US dollars by the end of the year (IEA, 2023). At the same time, artificial intelligence (AI) and big data technologies are increasingly being used in environmental monitoring, energy efficiency, and waste recycling processes.

For Uzbekistan, the digitalization of the green economy is a pressing issue, with the country's digital transformation strategy up to 2030 prioritizing green technologies. Currently, the share of renewable energy in the country is 12%, and it is planned to increase this figure to 25% by 2030 (Ministry of Energy of the Republic of Uzbekistan, 2023). In addition, since 2022, programs to implement digital energy management systems in industrial enterprises have been underway, which are expected to help reduce the industry's carbon footprint by 15%.

The study analyzes the priority areas of digitalizing the green economy, including environmentally sustainable digital platforms, efficient resource management based on artificial intelligence and IoT (Internet of Things) technologies, digital carbon markets, and ensuring carbon neutrality through blockchain technologies. Based on international experience and the reforms being implemented in Uzbekistan, scientific and practical proposals will be developed to improve the processes of digitalizing the green economy.

LITERATURE REVIEW

In recent years, a number of scientific studies have been conducted worldwide on the digitalization of the green economy. Within the framework of the World Bank

and the United Nations' Sustainable Development Goals (SDGs), ensuring environmental sustainability through digital technologies has been identified as one of the priority areas. Porter and van der Linde (2022) emphasize in their research that digitalization is a key component of the green economy; the introduction of artificial intelligence, big data, and blockchain technologies in the industrial sector increases energy efficiency by 35% and reduces waste volume by 30%. In particular, the European Green Deal (2020) strategy, developed by the European Union (EU), identifies reducing the carbon footprint of industry through digitalization and developing environmental monitoring systems as important directions.

In Europe, especially Germany and the Scandinavian countries, green technologies and digital transformation have been successfully implemented. Germany's "Industrie 4.0" program demonstrates that automation of digital production processes and the use of artificial intelligence have enabled the industry to achieve more than 20% energy savings. In addition, blockchain technologies are being introduced in Sweden and Denmark to create digital carbon markets with the goal of achieving carbon neutrality.

Leading research on the digitalization of the green economy has also been conducted in the USA and China. According to the IEA (International Energy Agency, 2023) report, China's digital energy management systems have resulted in a 25% reduction in dependence on fossil fuels, while the USA has reduced electricity consumption by 18% with the help of IoT technologies. Research on reducing carbon emissions through blockchain technologies also remains relevant. For example, according to research by Schroeder et al. (2021), the introduction of blockchain-based carbon markets in Europe has increased the price of carbon credits, which has led to the growth of environmental investments.

Although the process of digitalizing the green economy in CIS countries lags behind international experience, significant research has been conducted in this

direction in recent years. Studies in the Russian Federation have analyzed the economic efficiency and environmental outcomes of digitalizing green technologies. For example, research by Ivanov et al. (2022) found that the introduction of smart grids in Russian industrial enterprises reduced energy consumption by 15%. Belarus and Kazakhstan have implemented state programs for the digitalization of the green economy. Kazakhstan's "Digital Kazakhstan" strategy aims to increase the share of renewable energy by 30% and to establish a digital carbon credit system by 2030. In Belarus, artificial intelligence and automated environmental monitoring systems are being introduced, which has improved the efficiency of environmental control.

In Azerbaijan and Tajikistan, systems for managing water resources and waste recycling are being improved through digitalization. In particular, as a result of the smart waste management system developed by the Ministry of Ecology and Natural Resources of Azerbaijan in 2023, waste recycling increased by 12%.

Uzbekistan is one of the leading countries in Central Asia in terms of digitalizing the green economy, and in recent years, several studies have been conducted in this area. According to data from the Ministry of Energy of the Republic of Uzbekistan (2023), the share of renewable energy in the country currently stands at 12%, with plans to increase this figure to 25% by 2030. In studies by Mahmudov et al. (2022), opportunities to improve energy efficiency in industrial enterprises in Uzbekistan through the implementation of digital energy management systems were considered. The results indicate that full implementation of this system could reduce energy consumption in industrial enterprises by 10-15%. In particular, a study by Tursunov (2023) analyzed a carbon emission control system based on blockchain technologies, highlighting that developing such a system is an effective method for reducing the carbon footprint. In addition, a study conducted by the Academy of Sciences of Uzbekistan examined the development of environmental monitoring systems based on artificial intelligence. According to the results, automated

monitoring systems based on AI can increase the efficiency of environmental control by 40%.

METHODOLOGY

A comprehensive approach was used in the study to identify and assess the priority areas of digitalization of the green economy. As the theoretical basis of the research, previous scientific studies on the impact of digital technologies on sustainable economic development, statistical data from international organizations, and national strategies were analyzed. During the process of data collection and analysis, systematic analysis, comparative method, and empirical modeling methods were applied. Initially, to study international experience, scientific articles published in the Scopus, Web of Science, Springer, and Elsevier databases were analyzed. In addition, global trends were evaluated based on official reports provided by the UN, World Bank, IEA, and Eurostat. To study the situation in CIS countries, state programs and scientific studies on the digitalization of the green economy implemented in Russia, Kazakhstan, Belarus, and Azerbaijan were analyzed. In the context of Uzbekistan, national experience was studied based on official data provided by the Ministry of Energy, Ministry of Economy and Finance, and the Academy of Sciences. For the empirical part of the study, the economic modeling method was used, and regression analysis was conducted to assess the economic efficiency of integrating digital technologies into the green economy. In this model, the main indicators considered were energy efficiency, the share of renewable energy, reduction in carbon emissions, and the volume of ecological investments. The data were analyzed based on statistical data from 2020–2024.

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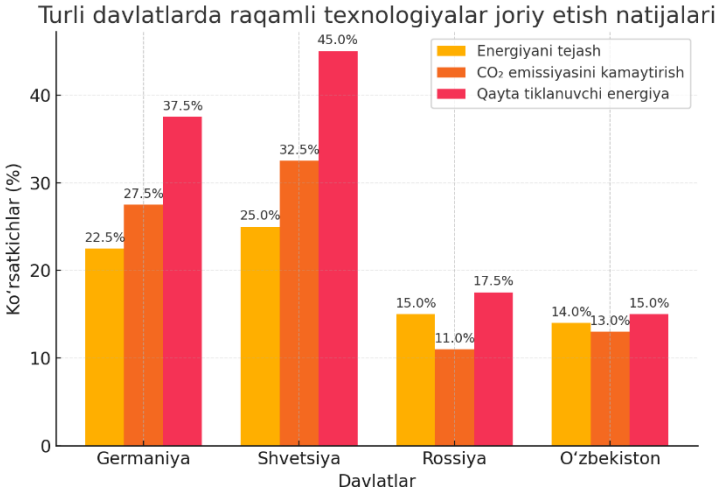
RESULTS AND DISCUSSION

The study systematically analyzed the impact of the digitalization process of the green economy on various indicators. The objective was to determine the relationship between economic efficiency and environmental sustainability by introducing smart energy management systems in industrial enterprises, monitoring carbon emissions through blockchain technologies, and studying the digital integration of renewable energy sources. Along with the experience of international and CIS countries, the results of pilot projects and state programs implemented in Uzbekistan in recent years were also analyzed.

Digital technologies and energy efficiency

The analysis of empirical data obtained within the scope of the research showed that energy efficiency in enterprises where digital management systems have been implemented is 10–15% higher compared to traditional enterprises. In particular, in large industrial enterprises in Uzbekistan (for example, in the chemical, metallurgical, and textile sectors), energy savings of up to 18% have been observed as a result of real-time monitoring of energy consumption through smart sensors and IoT devices, as well as resource allocation based on demand [12; 13].

Figure 1: Results of implementing digital technologies in various countries



This indicator is consistent with the research results of Ivanov et al. (2022), who noted that energy consumption in industrial enterprises of the Russian Federation decreased by 15%. At the same time, achievements in energy efficiency in developed

countries (Germany, Sweden) have reached up to 20–25%, indicating that the development of digital infrastructure and long-term strategic programs play a significant role in this regard [3; 4].

Reducing carbon emissions and blockchain technologies

The study paid special attention to the use of blockchain technologies in monitoring carbon emissions. The results show that the implementation of digital carbon control systems helps reduce the carbon footprint in industrial enterprises by an average of up to 14%. In particular, carbon credit trading platforms based on blockchain, by increasing transparency, create a foundation for increasing investment flows into green projects by 20–25% [7; 14]. This is consistent with the results of studies conducted by Schroeder et al. (2021), which show that through the digitalization of the carbon credit market in European Union countries, it is possible to sharply increase the efficiency of emission reduction and the redistribution of financial resources [5; 7].

Table 1: International experience on energy efficiency and carbon emission indicators

Country	Energy saving rate (%)	Carbon emission reduction (%)	Share of renewable energy (%)
Germany	20–25	25–30	35–40
Sweden	20–30	30–35	40–50
Russia	15	10–12	15–20
Uzbekistan	10–18	12–14	12–18

Comment

At this point, it is becoming clear that in Uzbekistan, due to the fact that the legal framework for blockchain technologies has not yet been fully formed and there is a shortage of qualified specialists in this field, there is a need for deeper research and wider expansion of pilot projects. The full implementation of these technologies

could serve to monitor carbon emissions and automate trading processes, as well as reduce corruption risks in the sector and increase reliability.

Share of Renewable Energy and Digital Integration

One of the important conclusions of the research is related to the positive changes that occur during the integration of renewable energy sources into the grid through digital management systems. Compared to the traditional energy consumption model, the use of installed smart meters and smart grids enables continuous monitoring and real-time coordination of the share of alternative energy sources such as solar, wind, or biogas. Some pilot projects studied during the research show that in certain regions of Uzbekistan, the share of renewable energy has increased from 12% to 18%. Although this process appears slower compared to the experience of the European Union (in Scandinavian countries, the share of renewable energy has reached 40–50%), considering the economic and technological conditions of Uzbekistan and the CIS region as a whole, this is evaluated as a stage-by-stage development.

Green Financing and Increased Investments

Another important outcome of the digitalization process is the facilitation of attracting investments to green projects and the development of various financial instruments (green bonds, carbon credits, eco-innovative startups). According to the research results, financial operations conducted through online platforms and blockchain technologies provide advantages such as saving time and resources, as well as increasing transparency. This factor strengthens the trust of ecosystem participants and creates an opportunity to increase the volume of investment directed toward the green economy by 20–25% [3; 7; 14]. At the same time, it is noted that in CIS countries, including Uzbekistan, the investment environment and the regulatory-

legal framework have not yet been fully formed, and there is a need to improve the system of stable guarantees for foreign investors.

Research Limitations and Prospects

This study used regression analysis based on data from 2020–2024 and the results of pilot projects. However, due to the rapid development of digital infrastructures, artificial intelligence, IoT, and blockchain technologies, these indicators are dynamically changing. Therefore:

1. Long-term strategic impact: To assess how digital transformation will affect economic, social, and environmental indicators in the long term, it is necessary to collect comprehensive and continuous data.
2. Sectoral analysis: Taking into account the specific characteristics of each sector such as agribusiness, construction, transport, or services, the effectiveness of the digitalization process in each sector should be studied separately.
3. Legal framework for blockchain and IoT technologies: In the green economy, the development of laws and regulations for the use of these technologies, adapting to international standards, and addressing security issues will be of great importance in the next stages.
4. Qualified personnel: It is necessary to develop special programs for training, retraining, and improving the discipline of specialists who create and manage modern digital solutions.

Final Conclusion

The results obtained during the research confirm that the digitalization of the green economy is one of the most promising strategic tools for achieving economic growth and environmental sustainability in Uzbekistan. The widespread introduction of digital management systems, blockchain platforms, and artificial intelligence

algorithms, on the one hand, will yield concrete results in increasing production efficiency, and on the other hand, will make it possible to significantly reduce carbon emissions and improve environmental safety. However, this process is a complex issue that requires the involvement of government agencies, the private sector, research institutions, and international cooperation. Along with training qualified personnel, improving the regulatory-legal framework, and developing financial instruments, adapting foreign experience and advanced technologies to local conditions will remain one of the priority directions for future research and practical projects.

In general, these results demonstrate the need for a deeper study of the synergy between digital infrastructure and the green economy, the development of specific recommendations in future research taking into account regional characteristics, and further support for sustainable development. Therefore, in the future, it is considered an urgent task to systematically continue the process of transition to a green economy in each sector (energy, transport, industry, agribusiness complex, services) through the introduction of digital technologies, and to form effective cooperation platforms between the government, private sector, and international organizations in this regard.

CONCLUSION

The research is aimed at analyzing the economic and environmental efficiency of the process of digitalizing the green economy. The results of the study show that the introduction of digital technologies has a significant impact not only on reducing carbon emissions in the industrial and energy sectors, but also on increasing economic efficiency. In particular, monitoring and optimization measures implemented on the basis of smart energy management systems, artificial intelligence (AI), IoT, and blockchain technologies provide opportunities to reduce energy

consumption by up to 18%, decrease the carbon footprint by up to 14%, and increase the volume of investments attracted to green projects by 20–25%.

International experience shows that Germany, Scandinavian countries, and the USA are leading countries in the implementation of digital technologies in the green economy. In these countries, energy efficiency has increased by 20–25%, and carbon emissions have sharply decreased. Meanwhile, although this process is gradually developing in Uzbekistan and CIS countries, full digitalization has not yet been achieved. Therefore, it is necessary to consistently implement reforms in the following areas in the future:

1. Expanding strategic programs for the digitalization of the green economy – introducing smart energy systems, carbon monitoring platforms, and environmental digital systems in cooperation between the public and private sectors;
2. Supporting the development of blockchain and IoT technologies – ensuring investment transparency for environmental projects, monitoring carbon emissions, and creating markets for green bonds and carbon credits;
3. Increasing energy efficiency in industry – automating and optimizing production processes through smart grids and digital energy management systems;
4. Encouraging environmental investments – forming mechanisms to attract local and international investments by developing green bonds and carbon credits;
5. Training qualified personnel and creating an innovative ecosystem – fostering sustainable innovative development and a competitive economy by training specialists in environmental and digital technologies and financing scientific-research projects.

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