



Current State And Prospects Of Digitalization Of The Energy Sector Of Uzbekistan

Gabbarova Ilmira Volodievna

PhD Candidate, 2nd Year (Independent Applicant for PhD Degree),
Graduate School of Business and Entrepreneurship under the
Cabinet of Ministers of the Republic of Uzbekistan

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Abstract: The article examines modern trends and prospects for the digitalization of the energy sector in the context of global transformation. The key drivers for the adoption of digital technologies in the energy industry are analyzed, with a focus on innovative solutions based on the Internet of Things, artificial intelligence, big data, and blockchain technologies. A comparative analysis of international digitalization practices in the USA, the European Union, China, and South Korea is conducted. Special attention is given to the potential adaptation of best practices for modernizing the energy sector of Uzbekistan.

Keywords: Energy sector, digitalization, smart grids, big data, artificial intelligence, blockchain, international experience.

1. Introduction: At the beginning of the 21st century, the energy sector found itself at the center of large-scale transformations associated with the need to improve energy efficiency, sustainability, and environmental performance. Digitalization has become one of the key tools for addressing these challenges, ensuring not only the optimization of traditional processes of electricity generation, transmission, and distribution, but also the development of new forms of energy supply, including distributed generation and active consumer participation in energy markets [1].

The relevance of digitalization is driven by global trends: the growing demand for electricity, the development of renewable energy sources, the tightening of environmental standards, and technological progress in the field of information and communication

technologies (ICT).

2. Current state of digitalization in the energy sector

2.1 Major global trends

The growth of the global economy and population leads to a steady increase in electricity demand. According to the International Energy Agency (IEA), from 2020 to 2040 electricity demand will grow by 45%, with the most active growth expected in developing countries of Asia and Africa [2].

At the same time, energy companies face increasing pressure from international environmental agreements such as the Paris Agreement (2015), which require a transition to low-carbon and renewable energy sources [3].

Technological progress plays an important role in the process of digitalization: the development of 5G networks, Internet of Things (IoT) technologies, artificial intelligence (AI), and big data analytics enables the creation of new models for energy system management, focused on flexibility, adaptability, and resilience.

2.2 Current Practices

Digitalization encompasses:

- Production processes: intelligent control of power plants, automation of dispatching centers.
- Transmission and distribution: creation of smart grids, integration of energy storage systems.
- Consumption: deployment of smart meters, mobile applications for energy consumption management.
- Interaction with the market: P2P energy trading platforms, personalized tariff offers.

According to the IEA report [4], in 2023 more than 50% of energy companies in OECD countries used Smart Grid and IoT-based solutions, which made it possible to increase the reliability of electricity supply and reduce costs by 12-18%.

3. Innovative approaches in Digitalization of Energy Companies

3.1 Applying Big Data and Machine Learning Technologies

Big Data technologies make it possible to:

- Model short-and long-term demand forecasts [5];
- Conduct predictive equipment diagnostics, reducing

the number of failures [6];

- Develop dynamic tariff plans based on consumer behavior analysis.

Machine learning (ML) and deep learning (DL) methods are applied to process data from millions of sensors in real time, enabling highly accurate analytics and automated decision-making.

Example: forecasting the condition of transformer substations using convolutional neural networks (CNNs) based on temperature profile analysis [7].

3.2.2 Smart Grids and Intelligent Metering Systems

The implementation of Smart Grids enables the integration of diverse generation sources, optimization of energy flows, and enhanced grid resilience through:

- Dynamic load balancing;
- Automatic localization of fault areas;
- Integration of energy storage systems.

The European Commission estimates that Smart Grid technologies can reduce technical losses in power grids by up to 25% [8].

3.3 Digital platforms and Blockchain

The application of blockchain technologies in the energy sector allows to:

- Automate settlements between market participants through smart contracts;
- Ensure transparency of transactions without the need to involve intermediaries;
- Develop peer-to-peer (P2P) energy trading networks.

Pilot projects (e.g., the Brooklyn Microgrid in the USA) demonstrate that blockchain solutions can reduce operational costs in energy markets by 10–15% [9].

3.4 Innovation Ecosystems

The emergence of technology clusters, startup accelerators (such as the Energy Web Foundation, Free Electrons), and university-based research centers contributes to accelerating energy digitalization by creating conditions for the commercialization of scientific developments [10].

4. International digitalization experience

Global practice shows that successful digitalization of the energy sector requires a comprehensive approach

combining technological innovation, government support, and the development of regulatory frameworks. However, digital transformation strategies differ significantly depending on regional conditions. Below is a comparative analysis of digitalization initiatives in the United States, the European Union, China, and South Korea, highlighting effective practices and existing barriers to digital modernization.

4.1 United States

Key features:

Large-scale investment in R&D (over USD 10 billion annually) [11];

Development of microgrids and virtual power plants (VPP);

Extensive deployment of equipment Digital Twins.

4.2 European Union

Key features:

Unified strategy “Digital Europe” (2021–2027) [12];

Priority development of RES and Smart Grids;

Startup support programs under Horizon Europe.

4.3 China

Key features:

Integration of Big Data and IoT in grid management (“Smart Substation” project);

Broad application of distributed generation platforms;

National strategy “Digital Energy 2035” [13].

4.4 South Korea

Key features:

KEPCO Smart Grid development program [14];

Active deployment of AI to optimize urban energy consumption.

Based on a brief overview of international digitalization experience, it can be noted that the United States focuses on decentralization of energy systems, development of microgrids, and digital twins to improve reliability and adaptability. Innovation support programs, such as ARPA-E, actively promote digitalization of energy infrastructure. However, differences in regulations between states sometimes complicate the scaling of technologies [1].

The European Union prioritizes standardized Smart Grids and active consumer involvement in energy processes. Numerous projects under Horizon Europe fund the integration of renewable energy sources using digital platforms and blockchain [2]. Great attention is paid to harmonization of standards and data protection.

China demonstrates the fastest scaling of digital technologies in the energy sector due to strong government support and integration of digitalization into national development programs. Projects such as digital substations and grid management via Big Data and AI platforms ensure high responsiveness and system reliability [3]. However, challenges remain in the areas of information security and excessive dependence on centralized control.

5. Conclusion and Findings

The analysis of international experience and current trends convincingly demonstrates that digitalization of the energy sector is one of the key drivers for improving the efficiency, reliability, and resilience of energy systems under conditions of global change. The application of digital technologies in the energy sector allows to:

- Reduce operating costs of energy companies by 10–20% through optimization of monitoring processes, grid management, and maintenance;
- Significantly increase the integration level of renewable energy sources (RES) thanks to more accurate generation forecasting and intelligent load management;
- Enhance the reliability and resilience of power supply through the deployment of digital twins, Smart Grids, and active demand-side management systems;
- Create prerequisites for the formation of new business models, such as Virtual Power Plants (VPPs), Energy Service Companies (ESCOs), and platform-based solutions for distributed generation management.

The experience of leading countries (the United States, the European Union, China, South Korea) highlights the importance of a comprehensive approach, which includes not only the implementation of advanced technologies, but also the development of an appropriate regulatory framework, ensuring information security, workforce training, and the establishment of an innovation ecosystem.

For Uzbekistan, successful digitalization of the energy sector requires:

- Adaptation of best international practices, taking into account national specifics, including climatic, social, and infrastructural conditions;
- Development of a regulatory framework governing the operation of digital energy systems, protection of personal data, intellectual property, and interaction of energy market participants;
- Active promotion of research and development (R&D) in the field of energy technologies, including support for university research and industrial collaborations;
- Creation of mechanisms to support innovative startups through venture financing, incubators, acceleration programs, and simplified procedures for entering the energy market;
- Establishment of conditions for the development of new business models;
- Development of human capital aimed at training specialists in digital technologies, cybersecurity, and modern energy network management.

In the long term, successful implementation of the digitalization strategy will enable Uzbekistan to strengthen energy security, reduce its carbon footprint, increase the investment attractiveness of the energy sector, and build a foundation for sustainable economic growth.

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