WAYS TO INCREASE THE COMPETITIVENESS OF ENTERPRISES IN THE CONTEXT OF THE DIGITAL ECONOMY IN UZBEKISTAN: ORGANIZATIONAL AND ECONOMIC MECHANISMS FOR THE ELECTRIC POWER INDUSTRY

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1. Abstract

This study provides a comprehensive investigation into the strategic modernization of the electric power industry in Uzbekistan, focusing on the shift from traditional automation to a robust "Digital Economy" framework. Guided by the "Digital Uzbekistan 2030" strategy and the "Concept for Providing the Republic of Uzbekistan with Electric Energy for 2020–2030," the research explores the organizational and economic mechanisms essential for enhancing sector-wide competitiveness. The investigation identifies digitalization as a pivotal driver for operational efficiency, particularly through the implementation of Industrial Internet of Things (IIoT), Artificial Intelligence (AI), and Big Data analytics. Findings reveal that while electricity production has grown significantly—from 59 billion kWh in 2016 to 81.5 billion kWh in 2024—structural challenges persist, including aging infrastructure (50–70% of components exceeding 30 years of service) and an unsatisfied demand of approximately 9.4%. The study details how ERP/CRM systems, Smart Grid concepts, and unified billing (ASKUÉ) stabilize the grid and reduce technical losses (currently averaging 15.19%). Furthermore, it analyzes the institutional transition toward a competitive wholesale market initiated in 2021 and targeting full operation by 2023, while emphasizing the integration of 4.1 GW of renewable capacity and the critical role of domestic software in ensuring lifecycle cost-efficiency and energy security.

2. Keywords

Digital Economy, Digital Transformation, Electric Power Industry, Uzbekistan, Industry 4.0, Smart Grid, Organizational Mechanisms, Economic Competitiveness, Renewable Energy, SCADA.

3. Introduction

The global power sector is currently undergoing a paradigm shift driven by the Fourth Industrial Revolution (Industry 4.0). For a developing economy like Uzbekistan, this transition necessitates a rigorous distinction between traditional "Automation" and modern "Digitalization." Historically, automation was defined as the application of self-regulating technical means and mathematical methods to liberate human labor from the routine processes of energy transfer, data recording, and basic systemic control. However, in the contemporary "Digital Economy" model, digitalization represents an integrated complex of technical and managerial operations. It is characterized by the use of Big Data and Artificial Intelligence (AI) to automate end-to-end business processes in a streaming mode, effectively removing human intervention from routine, high-velocity decision-making.

In the Republic of Uzbekistan, this evolution is not merely a choice but a strategic imperative formalized through the "Digital Uzbekistan 2030" strategy and the "Concept for Providing the Republic of Uzbekistan with Electric Energy for 2020–2030." The national energy landscape is currently characterized by a state of critical transition. As of 2019, the available generating capacity stood at 12.9 GW, heavily reliant on Thermal Power Plants (TPPs), which accounted for 84.7% of total generation, followed by Hydroelectric Power Plants (HPPs) at 14.3% and minor isolated stations at 1%. The aging of these assets presents a formidable barrier to competitiveness; data shows that 66% of main transmission lines, 62% of distribution networks, 74% of substations, and over 50% of transformer points have been in operation for more than 30 years.

This infrastructure fatigue results in significant economic inefficiencies. Many older TPP units operate with a Coefficient of Performance (КПД) of only 25–35%, resulting in a specific fuel consumption nearly twice as high as modern Combined Cycle Gas Turbine (CCGT) units. Furthermore, the national grid faces a chronic "unsatisfied demand" of roughly 9.4%, a gap that directly hinders the growth of industrial enterprises. Projections indicate that by 2030, domestic electricity consumption will reach 120.8 billion kWh—a 1.9-fold increase over 2018 levels. To meet this demand, the state must expand capacity by approximately 11,000 MW.

Digitalization offers the primary organizational mechanism to manage this expansion. The shift toward a digitalized grid allows for the "intellectualization" of energy flows, enabling real-time balancing of supply and demand, which is particularly crucial as Uzbekistan integrates variable renewable energy sources (VRES). The "2020–2030 Concept" envisions a diversified energy mix, including the introduction of nuclear power (АЭС) and significant wind and solar capacities. However, the physical integration of these sources requires a level of monitoring and dispatching precision that traditional automation cannot provide.

Economically, the transition is motivated by the need to reduce technical and commercial losses. In 2019, technical losses in magistral (main) networks were 2.72%, while distribution losses reached 12.47%. Digitalization through SCADA (Supervisory Control and Data Acquisition) and ASKUÉ (Automated System for Monitoring and Accounting of Electricity) is the only viable pathway to reducing these margins to international standards. As the economy grows—with GDP increasing by 55% between 2017 and 2024—energy intensity has already decreased by 7.4%, yet the "Professor's view" remains that deeper digital penetration is required to sustain this decoupling of economic growth from energy consumption.

The energy sector's strategic importance is magnified by the five territorial energy nodes: North-West, South-West, South, East, and Central. Each region possesses unique load profiles and infrastructure constraints. Digital transformation allows for localized optimization within these nodes while maintaining the stability of the Unified Power System (UPS). By implementing AI-driven demand forecasting, the system can reduce the need for daily additional restarts of TPP units, which currently causes excessive fuel consumption and equipment wear. Thus, the digitalization of the Uzbek power industry is a multifaceted mechanism designed to ensure energy security, optimize fuel-to-power ratios, and provide the reliable, low-cost electricity necessary for industrial enterprises to compete on a global stage.

4. Methodology

The research framework for this study is built upon a systemic approach to analyzing large-scale network companies within the Uzbek energy sector. This methodology is designed to evaluate the efficiency of organizational and economic mechanisms before and after the intervention of digital technologies. Central to this approach is a benchmarking process that compares the "Uzbek model" of energy modernization against international standards, such as the European Union's target of reaching 80% renewable energy penetration by 2050.

The methodological core of the study is a narrative expansion of the eight-step algorithm for digital transition:

1. **Awareness of Need:** Institutional recognition that traditional physical models are exhausted and that high-speed computational modeling is required for ОЭС (Unified Energy System) planning.
2. **Global Best Practices:** Analyzing paths like the "One Buyer" transition and the implementation of Independent Regulators to ensure market fairness.
3. **Personnel Preparation:** Moving beyond basic training to the "intellectualization of labor," ensuring staff can manage complex digital interfaces.
4. **Technological Capability:** Establishing the physical infrastructure (fiber optics, sensors) needed for a qualitative leap.

5. **Goal Definition & SWOT Analysis:**
   - Strengths: Established unified grid and high TPP capacity.
   - Weaknesses: Aging infrastructure (>30 years) and low TPP efficiency (25%).
   - Opportunities: Solar/Wind potential and the "Digital Uzbekistan 2030" framework.
   - Threats: Cybersecurity vulnerabilities and dependence on foreign technical support.
6. **Financing:** Utilizing Public-Private Partnerships (PPP) and long-term credits from International Financial Institutions (IFIs).
7. **Project Management:** Implementing SCADA and real-time control mechanisms to adjust project implementation in flow mode.
8. **Incentive Mechanisms:** Aligning personnel rewards with measurable digital outcomes, such as reduced downtime or loss reduction.

Economic modeling for digital projects in this research utilizes a Lifecycle Cost Analysis (LCC) framework. A critical criterion is that any digital intervention must demonstrate a measurable positive effect, even if not immediately expressed in monetary terms (e.g., the SAIDI/SAIFI reliability indices). The methodology emphasizes "technological sovereignty." Given that foreign software support often costs as much as the initial investment over the project's life, the study prioritizes domestic hardware and software solutions that ensure lower maintenance costs and higher cybersecurity.

Furthermore, the study adheres to the synchronization of architectural protocols. All digital projects must utilize Common Information Models (CIM) and IEC standards (such as IEC 61970/61968) to ensure interoperability. This prevents the creation of "digital silos" where different network entities use incompatible formats. The analytical tools include statistical reviews of energy intensity, where we observe that current consumption stands at approximately 56.8 kWh per million sums of GDP, a metric that must be further optimized through digital precision.

5. Results and discussion

The implementation of digital mechanisms in the Uzbek power industry has facilitated a dramatic increase in production capacity and operational efficiency. Production rose from 59 billion kWh in 2016 to 81.5 billion kWh in 2024, representing a 38% increase. This growth was underpinned by the introduction of 11,000 MW of new capacity over a seven-year period—a volume three times larger than the total capacity introduced between 1991 and 2016.

The primary measurable success of digitalization is the ongoing reduction of technical losses. Table 1 outlines the baseline state and the projected impact of digital mechanisms.

Table 1: Technological Loss Reduction and Infrastructure Modernization

Infrastructure Component	Baseline (2019/2020)	Target/Standard	Digital Mechanism	Economic Rationale
Magistral Networks	2.72% Loss	< 2.3%	SCADA / CIM Protocols	Optimized load distribution
Distribution Networks	12.47% Loss	< 9.0%	Smart Meters / ASKUÉ	Commercial loss elimination
TPP Efficiency (КПД)	25% - 35%	> 60% (CCGT)	AI Dispatching	Reduced fuel-to-power ratio
Grid Reliability	Unsatisfied Demand (9.4%)	0%	Digital Twins / IIoT	Predictive maintenance
Renewable Integration	0.2 GW (2019)	4.1 GW (2024)	Grid Code / Smart Grid	Balancing variable output

The deployment of ASKUÉ (Automated System for Monitoring and Accounting) has been completed across the majority of the consumer base, providing a "Unified Data Processing Center" and a modern "Billing" complex. This has significantly reduced commercial losses by ensuring transparent energy accounting.

In the realm of generation, the shift toward a more competitive mix is evident. By the end of 2024, 14 solar and 3 wind power plants were operational across 10 regions, contributing 4.9 billion kWh of "green" electricity. A notable organizational mechanism for competitiveness is the "150,000 Solar Units" program, which targets 800 million kWh of generation annually from household-level solar installations (2–3 kW each) by 2026. This decentralization of the energy source reduces the strain on the central distribution grid and empowers the "prosumer" (producer-consumer) model.

Furthermore, the introduction of ERP (Enterprise Resource Planning) and CRM (Customer Relationship Management) systems has allowed large grid companies like "National Electric Networks of Uzbekistan" and "Regional Electric Networks" to manage assets more effectively. By transitioning from reactive to predictive maintenance using IIoT sensors, the sector can extend the life of the 50% of transformers that are currently over 30 years old, while planning a phased replacement with "digital-native" equipment.

6. Discussion

Innovation vs. Tradition: Balancing the Investment Portfolio

A central dilemma for the Uzbek power sector is the allocation of limited capital between "classic" maintenance and "digital" innovation. While the allure of "Digital Twins" and AI is high, these technologies cannot function on top of a physically crumbling grid. The research advocates for a balanced ratio: 60% of investment should remain focused on the fundamental renovation of physical turbines and lines (e.g., the modernization of the Novo-Angren TPP), while 40% should be dedicated to the "digital layer" (SCADA, Digital Substations). Digitalization is a force multiplier, but it requires a sound physical foundation to multiply.

Cybersecurity and Technological Sovereignty

As the grid becomes more decentralized, particularly with remote wind and solar sites in the North-West and South-West energy nodes, cybersecurity risks increase exponentially. The use of "household-level" routers and insufficient local encryption at remote sites makes the UPS vulnerable to external interference. Consequently, the adoption of "Digital Substation" standards and domestic security protocols is a matter of national security. Furthermore, the economic argument for domestic software is clear: relying on foreign vendors leads to a "subscription trap" where technical support costs eventually equal the initial purchase price. Developing a domestic IT ecosystem for energy management ensures that data remains within national borders and that technical support is cost-effective over the 20-30 year lifecycle of the equipment.

Human Capital: The Intellectualization of Labor

The digital economy shifts the requirements for the workforce from manual proficiency to "intellectual labor." The energy specialist of 2030 must possess high digital literacy and creative problem-solving skills to manage automated systems that handle routine operations.

Features of Personnel Management in Digital Energy:

- **Recruitment Strategy:** Emphasis on stress resistance and digital competencies for managing complex Information Management Systems (IMS).
- **Professional Development:** Continuous learning models and talent management to handle the transition to Industry 4.0.
- **Organizational Culture:** Promoting "team spirit" and the "Code of Ethics," which values responsibility, transparency, and a commitment to environmental purity.
- **Incentives:** A combination of material and non-material rewards focused on "innovation production" and the proactive elimination of technical disruptions.

Market Liberalization and Institutional Reform

The organizational mechanism for competitiveness involves a phased transition to a competitive market. The process began in 2021 with the creation of the "Guaranteed Buyer" (state trading company) and the "Independent Regulator" (a financially independent body outside the government). The goal is to establish a fully competitive wholesale market by 2023. This requires an "Energy Market Operator" equipped with an online platform for transparent trading. By separating the functions of generation, transmission, and distribution, Uzbekistan is moving toward the "European Model," which encourages private investment in generation while keeping the "natural monopoly" of transmission lines under state control.

7. Conclusion

Digitalization in Uzbekistan's electric power industry is not a luxury but a technological and economic necessity. It is the primary tool for managing the 11,000 MW capacity expansion required by 2030 and for reducing the 12–17% technical loss margins that currently hamper industrial competitiveness. The transition from "Automation" to a "Digital Economy" allows for the seamless integration of 4.1 GW of renewable energy and the intellectualization of the national grid.

Strategic Recommendations:

1. **Prioritize Domestic Technological Solutions:** To ensure long-term cost-efficiency and cybersecurity, energy enterprises should favor domestic hardware and software, avoiding expensive and restrictive foreign service dependencies.
2. **Architectural and Standardized Integration:** All digital projects must strictly adhere to the "Grid Code" and international IEC standards to ensure interoperability. The "Digital Twin" approach should be applied to all new substations to allow real-time monitoring by the National Dispatch Center.
3. **Human Capital Evolution:** Personnel management must shift toward supporting "intellectualized labor." This includes revising the "Code of Ethics" to prioritize innovation and digital competency as core professional values.
4. **Phased Market Liberalization:** The transition to the competitive wholesale market must be accelerated, ensuring that the "Independent Regulator" remains a robust, transparent entity that provides equal grid access to both state and private producers.

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