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# Criteria and Indicators for Evaluating the Effectiveness of Digital Transformation

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**Abstract:** This article examines the criteria and indicators used to evaluate the effectiveness of digital transformation in energy enterprises. Emphasis is placed on both economic and technological aspects, as well as data management and service quality indicators. The study outlines a comprehensive framework based on theoretical approaches such as the neoclassical, institutional, and innovation-based views of effectiveness. A system of evaluation metrics—including ROI, NPV, automation levels, and consumer satisfaction—is presented, along with modern assessment methods such as the Balanced Scorecard (BSC), Analytic Hierarchy Process (AHP), and Data Envelopment Analysis (DEA). Practical applications are illustrated using statistical data from the digitalization initiatives of "National Electrical Networks of Uzbekistan" JSC. The results underscore the importance of integrated evaluation tools for effective strategic management in the context of energy sector digitalization.
**Keywords:** Digital transformation, effectiveness evaluation, energy enterprises, indicators, ROI, SCADA, data-driven management.

## Introduction

The global shift toward digitalization has brought transformative changes across nearly every industrial sector, including the energy industry. The integration of digital technologies—such as the Internet of Things (IoT), artificial intelligence (AI), machine learning (ML), big data analytics, and smart grid systems—into energy enterprises has initiated a fundamental restructuring of how these organizations operate, deliver services, and interact with consumers. These innovations have not only improved efficiency and reliability but have also introduced entirely new business models that prioritize adaptability, sustainability, and data-driven decision-making.

Within this broader digital transformation movement, energy enterprises face increasing pressure to modernize legacy infrastructure, ensure cybersecurity, reduce operational costs, and meet growing environmental and social governance (ESG) expectations. However, digital transformation is not solely a matter of adopting new technologies; it requires a strategic, well-measured approach that aligns technological investments with long-term organizational goals. Therefore, assessing the **effectiveness** of such transformations becomes a key task—not only to validate return on investment (ROI) but also to ensure that transformation efforts are delivering measurable improvements in performance, service quality, innovation capacity, and customer satisfaction.

## Research Objective and Method

The primary objective of this research is to develop and validate a comprehensive set of criteria and indicators for assessing the effectiveness of digital transformation in energy enterprises. This involves identifying key performance metrics across economic, technological, data management, and social dimensions, and applying these indicators to evaluate the outcomes of digitalization initiatives, with a particular focus on energy utilities in Uzbekistan. The study also aims to propose a structured approach to measure the return on digital investments and the impact of technological reforms on service quality and operational efficiency.

The methodology employed in this study is based on a combination of qualitative and quantitative approaches. A multi-dimensional framework was developed, encompassing economic, technological, data management, and service quality indicators. Metrics such as ROI, NPV, process automation, real-time monitoring, and consumer satisfaction were prioritized. Secondary data from national and international energy enterprises—especially "National Electrical Networks of Uzbekistan" JSC—were analyzed to assess indicator implementation levels. This included reviewing annual reports, digitalization roadmaps, and government policy documents.

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This methodology enables a holistic and replicable evaluation of digital transformation initiatives, supporting decision-makers in optimizing digital strategies and investment planning.

**Research Results**

According to the theoretical foundations of the concept of effectiveness, it is interpreted in different ways in economic theory [2]:

- Neoclassical approach – maximizing efficiency (output/input ratio);
- Institutional approach – rational use of organizational and material resources within the system;
- In innovation-driven economies – effectiveness of value creation based on technology;
- Broad definition – a multidimensional concept encompassing economic, technological, social, and environmental indicators.

**System of Evaluation Criteria and Indicators (Table 1)**

A. Economic Criteria:

| Indicator | Description |
|---|---|
| ROI (Return on Investment) | Return on investments made in projects |
| NPV (Net Present Value) | Net future profit (discounted cash flow) |
| IRR (Internal Rate of Return) | Internal rate of return of the project |
| Payback Period | Time required for the project to pay for itself |

B. Technological Criteria:

| | |
|---|---|
| Share of automated processes (%) | Level of automation in each section |
| Real-time monitoring coverage | Share of real-time monitoring via internet/sensors |
| SCADA/ERP system coverage | Which objects and processes have been digitalized |

C. Data Management Criteria:

Indicator Description

| Indicator | Description |
|---|---|
| Use of Big Data platforms | Effectiveness of analyzing large volumes of data |
| Share of data-driven decisions | Level of data-driven management |
| Implementation of Digital Twin technologies | Digital modeling of real-world objects |

D. Social and Service Quality Criteria:

| Indicator | Description |
|---|---|
| Consumer satisfaction index | Based on online surveys and customer feedback |
| Share of online services (%) | Percentage of services provided digitally |
| Digital literacy of personnel (%) | Level of training and retraining of staff in digital technologies |

Modern methods used in effectiveness assessment [3]:

- Balanced Scorecard (BSC) – aligns strategic management across financials, internal processes, customer perspective, innovation, and growth potential;
- AHP (Analytic Hierarchy Process) – a method for multi-criteria decision-making;
- Data Envelopment Analysis (DEA) – used for calculating efficiency frontiers;
- MCDM (Multi-Criteria Decision Making) – widely applied in selection and prioritization.

Examples of indicator application in Uzbekistan (Table 2):

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| Indicator | Implementation in "National Electrical Networks of Uzbekistan" JSC |
|---|---|
| SCADA system coverage (%) | Implemented at ~55% of facilities in 2024 |
| Share of online consumer requests | Reached 68% in 2024 |
| Number of cybersecurity incidents | Reduced by 17% based on ISO 27001 standards |
| Automated accounting system | Implemented in all big cities |
| Improving staff proficiency in digital technologies | 300 specialists retrained in 2024 |

## CONCLUSION

The research presented in this paper confirms that evaluating the effectiveness of digital transformation in energy enterprises requires a multi-dimensional and structured approach. By integrating economic, technological, data management, and social-service quality criteria, we developed a comprehensive framework of indicators that can be used to measure the outcomes of digitalization initiatives both quantitatively and qualitatively.

The findings emphasize that traditional economic metrics such as ROI, NPV, IRR, and payback period are essential for assessing the financial viability of digital investments. However, these must be complemented by modern technological indicators—such as the level of automation, SCADA/ERP system coverage, and real-time monitoring capabilities—to capture operational efficiency and innovation performance. Moreover, indicators related to data-driven decision-making and digital literacy among staff serve as critical proxies for organizational readiness and adaptability in the digital era.

The application of this framework to real data from Uzbekistan's energy sector, particularly the National Electrical Networks of Uzbekistan JSC, demonstrates the practicality and value of the proposed methodology. Notable improvements in cybersecurity, service digitization, and staff training were observed as direct results of targeted digital reforms.

In conclusion, the evaluation model outlined in this study provides a replicable and scalable method for assessing digital transformation efforts in energy enterprises. It offers policymakers and industry leaders a scientific foundation for planning, monitoring, and optimizing digital strategies, ensuring that digital investments deliver measurable, long-term value across all functional dimensions.

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