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| Research Article

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Improving Management Efficiency in the Electric Power Industry

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Abstract: This article discusses the existing problems in the electric power sector of the Republic, ways to address them, the dynamics of internal demand for energy resources expected in the economic development of the sector, and the specific energy intensity levels in the industry. It examines reducing energy consumption in the economy, the role of the energy sector in the country's socio-economic development as a key task of energy policy, and the forecast dynamics of electricity production and consumption for the coming years. Proposals and recommendations for the development of the energy sector are provided.

Key words: electric power industry, thermal power plant, thermal power station, production, public-private partnership, management efficiency, profitability coefficient, planning, organization, motivation, control, coordination, correlation coefficient, competitive environment, environmental protection, economic security.

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Introduction: Management efficiency is typically assessed from the perspective of enterprise performance. Many organizations regularly pay dividends to experienced managers to avoid sudden bankruptcy. However, this indicates that annual shareholder profits are not a sufficient measure of corporate efficiency, and more effective actions are required. This study was motivated by an analysis of the operations of large and small enterprises in the Republic of Uzbekistan. The results of the analysis revealed several intriguing facts.

On the other hand, many enterprises fail or generate negative perceptions despite operating strictly under modern management theories and "doing the right things." There are also cases of enterprises functioning abnormally within a market economy. An example of this is the electric power sector, classified as a natural monopoly in Uzbekistan. Being a natural monopoly, this sector often neglected customer service, employed unskilled personnel, ignored planning for extended periods, and faced cases where up to one-fourth of its customers consumed electricity without paying for the services provided.

Analysis of Literature Related to the Topic. According to the results of conducted research, it is necessary to establish a competitive environment and ensure sustainable development in the country's electric power sector while achieving national-level integration in the energy industry to guarantee energy security. Moreover, adopting international regulations fosters bilateral resolutions in energy cooperation between states, creating opportunities for more effective outcomes through agreements reached within the framework of interstate collaboration.

Two main models of integrating national electricity markets can be identified:

1. **Gradual Integration Model:** This model involves the step-by-step unification of national markets to create a single market, as seen in the integration of electricity markets in European Union (EU) countries [1]. Currently, the EU electricity market comprises seven interconnected regional energy market complexes, each uniting the national electricity markets of multiple countries [2]. Integration under this model is achieved through processes such as market structure alignment, regulation mechanism harmonization, and the phased standardization of trading rules in unified markets.

2. **Central American Common Electricity Market Model:** This widely recognized model maintains national electricity markets unchanged while organizing cross-border electricity trade on additional trading platforms, surpassing the volumes traded in national markets [3].

In Armenia, the electricity market has adopted a single-buyer model, where tariffs remain state-regulated, and the industry has been privatized. In Kyrgyzstan, major energy companies have been consolidated under a single holding, with no competitive wholesale electricity market; trade is conducted based on bilateral agreements [4].

In 2018, the United Kingdom invested £17.5 billion in the development of the wind energy sector, resulting in the creation of numerous new jobs. Large-scale electricity battery factories are planned to be built in several countries, including the United States, Sweden, Hungary, Poland, and Germany [5].

The electric power industry is a universal energy carrier essential in all production processes across the national economy and everyday life. It possesses unique characteristics. Electricity can be converted into almost any form of energy, transmitted over long distances, and at the consumption stage, it is considered the cleanest environmental energy carrier [6].

Research Methodology. During the research process, various methods were extensively utilized, including the study and scientific analysis of the electricity production sector, comparative analysis and synthesis, induction and deduction, expert evaluation, scientific abstraction, statistical grouping, correlation and regression analysis, and other techniques.

Analysis and Results. The study focused on the concept aimed at developing the Republic's electric power sector during 2020–2030.

The internal demand for energy resources is determined by the expected dynamics of economic development, structural changes in the economy, and its specific level of energy intensity. Reducing energy consumption in the economy is a primary task of energy policy. Failure to achieve this objective will inevitably hinder the socio-economic development of the country.

The forecast dynamics of electricity production and consumption up to 2030 are presented in **Figure 1**.

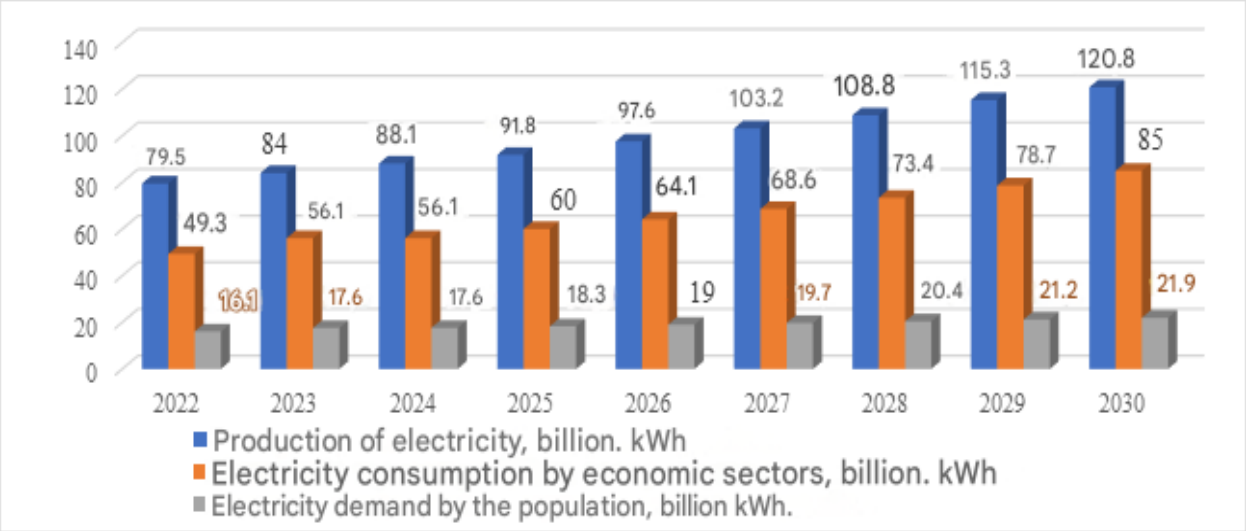

Figure 1. Forecast Dynamics of Electricity Production and Consumption up to 2030, Billion kWh [7]

In 2022, electricity production is forecasted to reach **79.5 billion kWh**, with electricity consumption distributed as follows:

- **Economic sectors:** 49.3 billion kWh
- **Households:** 16.1 billion kWh

By 2030, these figures are expected to increase significantly:

- Electricity production: **120.8 billion kWh**
- Electricity consumption in economic sectors: **85 billion kWh**
- Household electricity consumption: **21.9 billion kWh**

The state's involvement in the electricity supply industry and its support for certain enterprises have led to these developments. These observations prompted us to address the proper calculation of management efficiency. It is essential to evaluate both enterprise performance efficiency and management efficiency.

If an enterprise is performing efficiently, there is no immediate need to assess the results of correct or incorrect management. Thus, it is crucial to distinguish between enterprise performance efficiency and management efficiency.

To measure management efficiency, we propose utilizing a **balanced approach**. This involves focusing on six key factors, five of which are management functions, while the sixth pertains to the results achieved by the enterprise.

The five functions are as follows: **planning**, **organization**, **motivation**, **control**, and **coordination**. Indicators that measure the performance of each function, as well as the percentage of funds spent relative to enterprise revenues, should be determined. This value must be calculated and should not exceed a specific threshold. To avoid errors, the efficiency of each function must be assessed using at least three distinct indicators within the framework of a balanced management measurement.

For a balanced assessment of management efficiency, it is necessary to consider the enterprise's results measured by multiple performance indicators. The study proposes selecting these indicators based on the specific characteristics of the enterprise's core industry.

In this context, factors such as **profitability**, **financial stability**, **market share**, **liquidity**, and **shareholder value** should be taken into account, with management expenses also evaluated as a relevant indicator. Additionally, the accuracy of short-term and long-term planning must be assessed by specialists, considering the macroeconomic environment.

The analysis suggests that under normal conditions, short-term planning accuracy is considered low if the results deviate by more than **35%** from the plan.

During the research, the leading enterprise was identified as the one with the most customers, the highest profitability, and optimal levels of interest, taxes, depreciation, and earnings before depreciation compared to other surveyed enterprises. For the industry, the optimal ratio of interest, taxes, depreciation, and earnings before depreciation to debt is considered **1:2**.

According to survey results, enterprise leaders believe that excessive time and money are spent on performing control functions. Interestingly, the proportion of time and money allocated to motivation typically decreases as control intensifies. With higher levels of motivation, less coordination is usually required.

A detailed study was conducted for an enterprise emerging in the lower sector of the analyzed industry. Analysis results showed that the calculated scores placed the enterprise in **Group 5**, indicating that its profitability was undermined by employees failing to comply with directives from senior executives and engaging in risky behavior.

Otherwise, the bureaucratic structure of the enterprise under study would have already paralyzed its market operations. This is an example of a poorly managed enterprise. Notably, this enterprise allocates **43%** of its management time and budget to control functions, **12%** to motivation, **13%** to planning, **21%** to organization, and **11%** to coordination.

This observation highlights that enterprises in this sector lack motivation while performing control functions. It also indicates that even the best-performing enterprise in this market fails to achieve management balance and lacks the ability to execute effective control.

Based on the findings, several conclusions can be drawn regarding poorly performed functions:

- **Strategic planning** is executed at a moderate level, even for the best-studied markets.
- **Motivation** is poor in all cases, relying solely on financial incentives, with only three enterprises focusing on employee development.
- The **coordination function** is inadequate, as leaders are required to manage coordination independently.

Overall, these shortcomings collectively contribute to **financial issues** within the enterprise.

Given the current conditions of globalization, it is advisable to utilize econometric analyses to evaluate the efficiency of enterprise management. For this purpose, data from the Statistics Agency under the President of the Republic of Uzbekistan for the period 2005–2022 was used to conduct an econometric analysis of management efficiency (**Y**) in Uzbekistan's electric power sector and its influencing factors: energy production costs (**X1**), the volume of energy produced (**X2**), total electricity consumption (**X3**), and the installed capacity of power plants in Uzbekistan (**X4**).

To ensure the proper selection of the factors influencing the dependent variable, the degree of correlation between them and the mutual correlation coefficients of the factors were determined (Table 1).

The correlation coefficient between the selected factors and the dependent variable.

	Y	*X1*	*X2*	*X3*	*X4*
Y	1				
X1	0,9716049	1			
X2	0,6600199	0,680044	1		
X3	0,9673005	0,7916159	0,6810001	1	
X4	0,7322421	0,6713735	0,7250272	0,77234611	1

Focusing on the values in the table:

• Energy production costs (**rY, X1=0.9716**) and total electricity consumption (**rY, X3=0.9673**) are strongly correlated with the outcome variable **Y**.

• The volume of energy produced (**rY, X2=0.6600**) and the installed capacity of power plants in Uzbekistan (**rY, X4=0.7322**) show moderate correlation.

Since the condition **rX1, X2<0.8** is met, indicating no multicollinearity among the factors, the analysis can be further processed using the **EViews** software.

According to the research, over the years following independence, development trends have been observed in the electricity sector of the Republic of Uzbekistan. This process, in particular, became significantly noticeable from 2017, with the volume of energy production increasing by 1.4 times in 2021 compared to 2005, reaching 68,469.8 million kWh. To determine the regression equation for the relationship between the factors, the selected factors were logarithmically transformed due to the different units of measurement, and a non-linear equation was generated, which is then verified based on qualitative criteria (Table 2).

Table 2. Multifactor regression equation of management efficiency of the electric power sector of the Republic of Uzbekistan

Dependent Variable: LNY
Method: Least Squares
Date: 03/11/22 Time: 18:45
Sample: 2005 2021
Included observations: 14

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNX1	0.145105	0.204523	0.709480	0.0461
LNX2	-0.329115	2.098931	-0.156801	0.0089
LNX3	1.826975	1.980526	0.922470	0.0103
LNX4	-0.327695	1.054473	-0.310766	0.0531
C	-4.735221	11.12159	-0.425771	0.0060

R-squared	0.943760	Mean dependent var	10.94500
Adjusted R-squared	0.918765	S.D. dependent var	0.264211
S.E. of regression	0.075305	Akaike info criterion	-2.062093
Sum squared resid	0.051037	Schwarz criterion	-1.833859
Log likelihood	19.43465	Hannan-Quinn criter.	-2.083221
F-statistic	37.75740	Durbin-Watson stat	1.903107
Prob(F-statistic)	0.000012		

Multifactor regression equation of management efficiency of the electric power sector of the Republic of Uzbekistan

LnY=0,145LnX1-0,329LnX2+1,83LnX3-0,328LnX4-4,73522

The identified 1st regression equation parameters, when analyzed for significance based on t-Statistic criteria, show that with α=0.05 and df=11, t_critical = 2.200985. According to the condition t_stat > t_critical, it follows that all parameters are insignificant. However, to be fully confident about whether the parameters are indeed significant or insignificant, a retrospective verification using qualitative criteria such as MAPE (Mean Absolute Percentage Error) and TIC (Tayl inequality coefficient – an alternative measure of Taylor's forecast accuracy) is required (Figure 2).

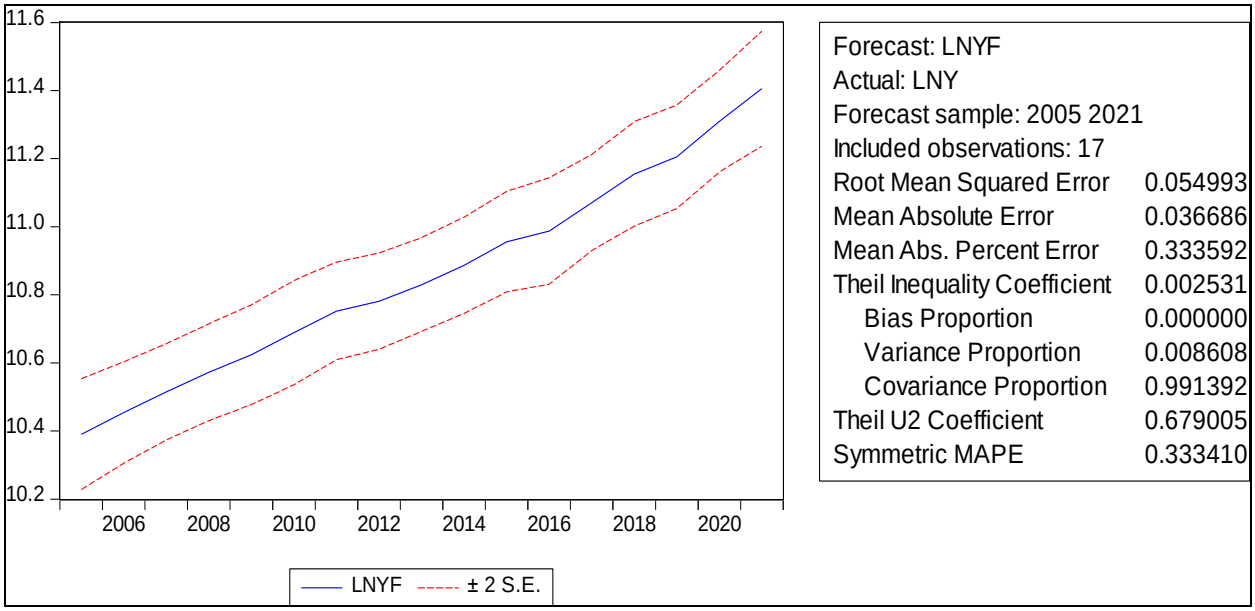

Figure 2. Results of retrospective quality criteria regression parameters 1

Based on the identified data, it can be emphasized that MAPE = 0.334, which in turn implies that MAPE = 0.334 < 10% and TIC = 0.0025 < 1. This indicates the significance of all parameters in the 1st regression equation based on forecast accuracy. According to mathematical principles and to simplify the calculation process and achieve result accuracy, the above-derived 1st regression equation is potentiated, and based on this, the following equation is generated:

$$Y = \frac{X1^{0,145} * X3^{1,83}}{X2^{0,329} * X2^{0,328} * e^{4,73522}} \quad (1^*)$$

Considering the significance of the derived 1*-regression equation, with α = 0.05, k1 = 11, k2 = 4, and F_a = 0.297913, the calculated Fisher value F_x = 37.76 indicates that, based on the condition $F_a < F_x$, the 1*-regression equation is significant. Additionally, since DW = 1.903, there is no autocorrelation, which confirms the reliability and adequacy of the equation.

Based on the identified 1*-regression equation, it can be explained that if the energy production cost is increased by 100 million UZS, the management efficiency in the network is expected to increase by 0.06 million UZS. This, in turn, requires the modernization of outdated technologies currently used in network management. Additionally, if the total electricity consumption in the country increases by 1 million kWh, the management efficiency is expected to increase by an additional 2.15 million UZS, which can be achieved by improving transmission lines and increasing export volumes for new consumers in the network.

Currently, it is more appropriate to focus on updating transmission lines to reduce natural losses and increase export volumes, rather than just increasing the capacity of power stations. Measures should be developed to establish new cooperation agreements for this purpose.

Using the identified 1*-regression equation, the remaining factors are calculated according to the following equations for time (t=15):

- Energy production cost – X1 = -612304 + 1578992.5 * t
- Energy production – X2 = 45686.2 + 1627.4 * t
- Total electricity consumption – X3 = 47498.6 + 1835.7 * t
- Power station capacity – X4 = 10573.4 + 483.8 * t

The multi-factor forecast indicator for the management efficiency of Uzbekistan's electric power industry is determined (Table 3).

Table 3. Multi-factor forecast indicator of the management efficiency of the electric energy network of the Republic of Uzbekistan

Years	Management efficiency mln. soum	Cost of energy production, mln. soum	Energy production, mln. kW hour	Gross electricity consumption mln. kWh	The capacity of power plants is MW
2024	94690.7	26230568.5	73352	78705.5	18798
2025	98074.7	27809561	74979.4	80541.2	19281.8
2026	101472,3	29388553.5	76606.8	82376.9	19765.6
2027	104884,4	30967546	78234.2	84212.6	20249.4

According to the forecast results presented in the table, by 2027, the management efficiency of Uzbekistan's electric power industry is expected to increase by 19.2% compared to 2022, reaching 104,884.4 million UZS. This will be accompanied by a 34.2% increase in energy production costs, a 11.6% increase in electricity production volume, a 12.2% increase in total electricity consumption, and a 13.6% increase in the capacity of power stations.

Conclusion and Recommendations: To improve the management efficiency of Uzbekistan's electric power industry, several tasks should be implemented, including:

- Modernizing or decommissioning outdated energy blocks at thermal power stations in the country through foreign investment.
- Developing modern solar and wind power stations as a priority for the energy sector in the transition to a "green" economy, based on public-private partnerships.
- Constructing new substations in collaboration with foreign investors for stable electricity supply, and carrying out reconstruction and modernization of electrical networks with international foreign credit funds.
- Attracting private investments, in addition to using funds from existing state energy companies, to meet the necessary investment needs in the electric power industry.
- Gradually privatizing part of the shares of power stations through the sale to private investors and creating joint ventures based on the principles of public-private partnerships (PPP).
- Developing measures to meet the increasing electricity demand without significantly raising tariffs, considering the growing population and production in the country.

In general, the proposals and recommendations identified based on the research results should be consistently implemented to play a significant role in improving the management efficiency of Uzbekistan's electric power industry in the future.

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