THE CURRENT STATE OF THE ENERGY SYSTEM OF UZBEKISTAN QUALITY OF ELECTRICAL ENERGY

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Introduction *The quality of electricity supplied to consumers is a critical aspect of energy distribution systems. Key indicators of electrical quality include frequency, voltage, and voltage asymmetry, with these factors determining the degree of non-sinusoidality in the system. Maintaining these indicators within prescribed limits ensures the efficient and economic operation of the electrical grid. Deviations from standard values can result in technical and economic losses, leading to potential damage. Therefore, optimal electrical quality corresponds to minimal deviation from standard values. This article discusses the key quality indicators of electricity, their standard values, and the methods for maintaining these values in distribution networks.*

Abstract: *This paper explores the quality of electrical energy, focusing on essential parameters such as voltage, frequency, and voltage asymmetry. These parameters must remain within certain limits to ensure the efficient and stable operation of the electrical network. The article emphasizes the importance of maintaining these quality indicators to prevent technical and economic damages to both the electrical system and consumers. The paper also examines how voltage regulation is managed through local adjustment methods and the role of transformers in maintaining these standards in distribution networks. It highlights the importance of adhering to standard voltage deviations and provides practical guidelines for managing electricity quality in energy systems.*

Keywords: *Electrical energy, quality indicators, voltage, frequency, asymmetry, electrical network, distribution networks, standard values, regulation, transformers.*

Uzbekistan's energy system is one of the main sectors of the national economy, and its development and efficiency are crucial for economic and social progress. Below is an analysis of the current state of Uzbekistan's energy system.

Electricity Production

As of 2023, Uzbekistan's electricity production capacity includes the following figures:

Total production capacity: approximately 14,100 MW

Annual electricity production: approximately 65-70 billion kWh

Power Plants

Electricity in Uzbekistan is generated from the following main sources:

Thermal power plants (TPPs): accounting for 85% of the total capacity

Hydroelectric power plants (HPPs): accounting for 12% of the total capacity

Renewable energy sources (solar and wind): accounting for 3% of the total capacity

Electricity Consumption

Annual electricity consumption in Uzbekistan is divided as follows:

Industrial sector: 45%

Households: 30%

Agriculture: 10%

Transport and services: 15%

Electrical Grids

Uzbekistan has an extensive network for distributing and delivering electricity:

High voltage grids (220 kV and above): over 10,000 km

Medium voltage grids (110 kV): over 14,000 km

Low voltage grids (0.4 kV - 35 kV): over 250,000 km

Losses and Efficiency

Losses in the transmission and distribution of electricity are a significant issue:

Annual losses: approximately 10-12% of the total generated energy

Main sources of losses: outdated grids and equipment, lack of efficient management systems

Modernization and Rehabilitation Projects

Currently, several projects are underway to modernize Uzbekistan's energy system and improve its efficiency:

Modernization of thermal power plants: upgrading major plants such as Angren TPP, Sirdarya TPP, and Navoi TPP

Renewable energy sources: plans to increase solar and wind energy capacity to 8,000 MW by 2030

Upgrade of electrical grids: extensive renewal of 220 kV and 110 kV high voltage grids planned for 2024-2025

Energy Efficiency

Measures to improve energy efficiency and reduce losses include:

Energy audits: conducting energy audits in enterprises and organizations to enhance efficiency

Smart meter systems: implementing smart meters to enable consumers to manage their energy consumption accurately and efficiently

Renewable energy projects: installing solar panels and wind turbines to diversify energy resources

The development and modernization of Uzbekistan's energy system play a vital role in ensuring the country's economic stability and environmental balance. Measures to enhance energy efficiency and reduce losses contribute to the sustainable development of the energy sector.

Indicators of electricity production in our republic in 2016-2023:

- 2016 - 59.0 billion kWh;
- 2017 - 60.7 billion kWh;
- 2018 - 62.8 billion kWh;
- 2019 - 63.6 billion kWh;
- 2020 - 66.4 billion kWh;
- 2021 - 71.3 billion kWh;

□2022 - 74.3 billion kWh;

□2023 - 78.0 billion kWh*.

In 2023, the volume of electricity production was 19 billion kWh or 32.2 percent more than in 2016.

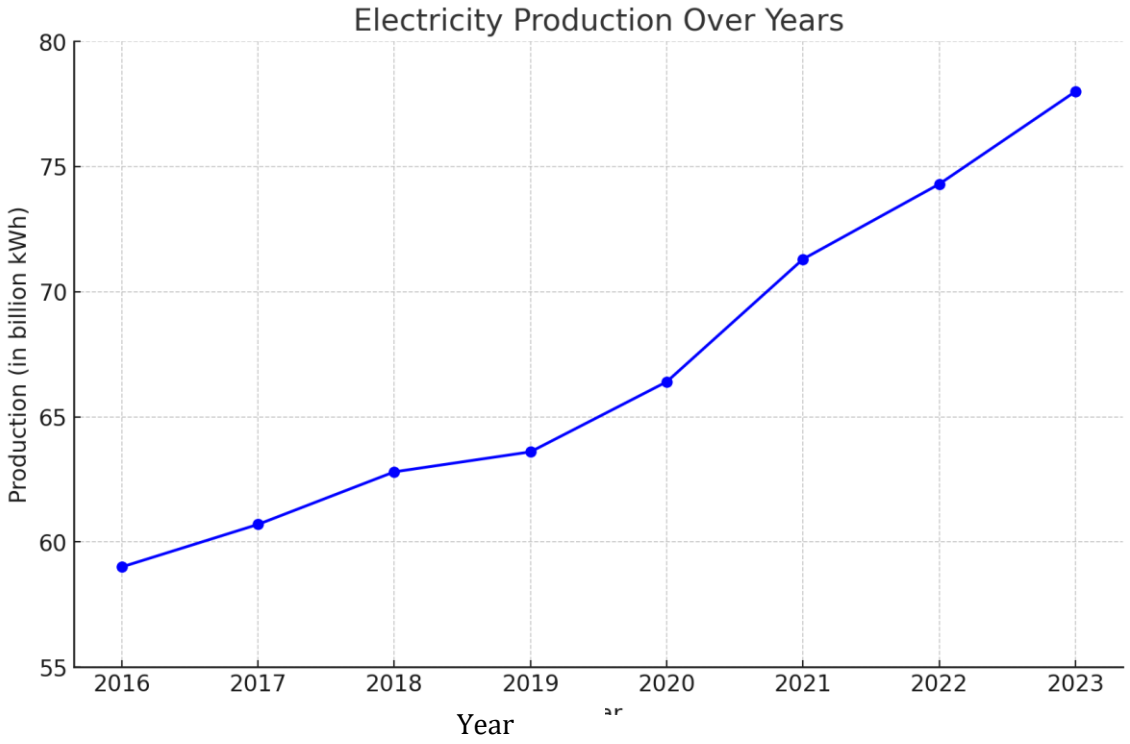

Figure 1.1. Dynamics of increasing energy production indicators of the Republic of Uzbekistan.

General information about electricity consumers in the Republic of Uzbekistan as of January 1, 2024

Table 1.1.

No.	**Consumer Name**	**Quantity**
1	Legal Consumers	433,217 units
2	Household Consumers (Population)	7,656,307 units
Total Consumers		**8,089,339 units**

Information on the Electricity Transmission Network under the Management of "Hududiy Elektr Tarmoqlari" JSC as of January 1, 2024

Table 1.2.

No.	**Type of Electricity Transmission Network**	**Length**
1	0.4-110 kV Electricity Transmission Networks	277,671.6 km
2	Of which 110 kV Electricity Transmission Networks	14,655.4 km
3	Of which 35 kV Electricity Transmission Networks	13,992.2 km
4	Of which 10 kV Electricity Transmission Networks	87,007.9 km
5	Of which 6 kV Electricity Transmission Networks	14,583.8 km
6	Of which 0.4 kV Electricity Transmission Networks	147,432.3 km

Total Number of Transformer Stations under the Management of "Hududiy Elektr

Tarmoqlari" JSC

Table 1.3.

No.	Transformer Stations	Quantity
1	Up to 10/0.4 kV	76,804 units
2	Up to 6/0.4-160 kV	17,734 units
Total Transformer Stations		**94,789 units**

Total Number of Substations under the Management of "Hududiy Elektr Tarmoqlari" JSC

Table 1.4.

No.	Substations	Quantity
1	110 kV Substations	737 units
2	35 kV Substations	1,063 units
3	10 kV Substations	2 units
Total Substations		**1,802 units**

ECONOMIC PRINCIPLES OF CHANGING 0.4 KV NETWORK TO 6 KV NETWORK

When changing the electric network from 0.4 kV to 6 kV, it is necessary to install metal structures in addition to supports. In addition, without changing the 0.4 kV supports, it is possible to transfer high voltages to the support close to the consumer by changing the current conductor to a cable. In this case, the expenses are different. The average cost of a metal structure to be placed on a base is from 350,000 to 500,000 soums, and with the cost of personnel and special equipment for installation, each installation is from 200,000 in addition. It is 300,000 soums. Installation of additional metal structure to the base costs about 600,000 soums per base. Based on the fact that there are a total of 123 power transmission poles in the existing network, an average cost of 74,000,000 soums is required. When an additional metal structure is installed, it is possible to use the existing conductor. However, it is necessary to change the conductors of the existing network, considering that they are outdated. A total of 60,000,000 soums is required to purchase an average 4,000 m long conductor. A total of 134,000,000 soums is required. If the cable and not the base is changed, only the cable costs and the personnel costs will be charged The total cable length required for the existing network is 4000 meters. The average price of SIP-3 cable in the market is 20,000 soums. For use in a 6 kV network, it is necessary to increase the insulating part of the cable, which in turn ensures that the cost of the cable is equal to 30,000 sou on average. Changing the existing network to the SIP-3 cable, together with the costs for a staff member, is an average of 120,000,000 soums. Based on the available economic analysis, the use of special SIP-3 cables leads to efficiency when changing the network voltage from 0.4 kV to 6 kV. By changing the network to 6 kV, it is possible to achieve significant annual energy savings. But when changing the network, it is required to use 10 kVAr transformers that change 6 kV to 0.4 kV for both consumers.

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