

PROSPECTS FOR SOLVING PROBLEMS AND THE CURRENT STATE OF ENERGY SUPPLY IN RURAL AREAS

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Annotation: This article analyzes the current state of energy supply in rural areas of Uzbekistan, the main problems and promising directions for their solution. Problems with the quality and continuity of electricity supply in rural areas of our country, network obsolescence, access to renewable energy sources (QTM) and their impact on the living standards of the population have been studied extensively. The article assesses the importance of solar energy, wind energy and hydropower for rural areas, as well as proposes mechanisms for the implementation of smart grid technologies and energy efficiency improvement programs. As a result of the study, policy and investment proposals aimed at ensuring energy security of rural populations have been developed.

Keywords: rural energy, renewable energy, solar panels, energy security, smart grid, power supply infrastructure, energy efficiency, rural development.

Globally, the demand for energy supply is increasing year by year. Quality and uninterrupted supply of electricity, especially in rural areas of developing countries, remains one of the pressing challenges. According to UN 2024 data, more than 700 million people worldwide still do not have electricity, most of whom live in rural areas.

In recent years in the Republic of Uzbekistan has been carried out large-scale reforms in the field of reform and modernization of the energy sector. Energy security and transition to renewable energy sources occupy an important place in the New Uzbekistan Strategy of President Shavkat Mirziyoyev for 2021-2030. At the same time, there are specific problems of energy supply in rural areas, which require an integrated approach.

The main purpose of this study is to analyze the current state of energy supply in rural areas of Uzbekistan, to identify the main problems and to offer science-based ways to solve them.

According to the Ministry of Energy of the Republic of Uzbekistan, the total volume of electricity production in the country in 2024 was 73.4 billion kWh. However, the quality and continuity of electricity supply in rural areas still remains a serious problem [3]. Consumers in rural areas experience 1.5-2 times more disruption than urbanites.

The following key indicators better illustrate the situation: a) network losses in rural areas are 18-22% (in urban networks this figure is 8-12%); b) 34% of rural residents complain of inadequate electricity supply; c) 41% of farms do not have sufficient power supply.

Most of the power supply infrastructure in rural areas was built 30-40 years ago and is in need of serious modernization. About 38% of high voltage lines (110-220 kV), and 55% of low-voltage networks have reached the end of their service life. In addition, obsolescence of transformer devices is a major problem, 47% of transformers do not meet regulatory technical requirements.

Inadequate gas supply in rural areas also exacerbates the energy problem. Currently, about 15-20% of the country's villages are deprived of natural gas, and residents are forced to use dry fuel or other traditional fuels for heating.

The technical problems of the energy sector in rural areas fall into several groups. First, the obsolescence of the grid's infrastructure leads to high energy losses. Studies show that outdated transformers and cable lines waste 20-25% of the energy generated [7]. Second, the lack of jet power compensation systems in rural areas reduces the quality of electricity supply. Third, the very little use of intelligent computing systems and automation tools limits the effectiveness of network management. In rural areas, investments in energy supply are insufficient. Network investment per capita is 3-4 times lower than in urban areas. In addition, the low solvency of rural residents has a negative impact on the financial stability of network companies. The imperfections of the energy subsidy system also deepens the problem. The existing subsidy mechanism often benefits urban consumers more than rural residents who really need it. According to a 2023 estimate by the International Monetary Fund, energy subsidies in Uzbekistan account for 2.1% of GDP, but 70% of them fall short of rural

Climate change poses a significant threat to the energy security of rural areas. In Uzbekistan over the past 30 years, temperatures have risen by an average of 0.8-1.2°C, which sharply increased the demand for cooling during the summer months. The increased demand for air conditioning and cooling units in rural areas is putting additional strain on the power grid.

The convenient geographical location of the Republic of Uzbekistan allows the use of renewable energy sources, in particular solar energy. The annual solar radiation rate in our country is 1700-2000 kWh/m², which is 30-40% higher than most of Europe. For rural areas, off-grid and hybrid (hybrid) solar systems can be a particularly effective solution. Small solar plants (with a capacity of 5-100 kW) are capable of providing autonomous energy supply for individual farms, schools, and medical institutions. World experience shows that such systems can be 3-5 times more cost-effective compared to a traditional network expansion.

Wind energy is also a promising source in certain regions. Small and medium-power wind turbines (10-500 kW) can play an important place in power supply for mountainous and upland villages in Uzbekistan. Especially in the mountainous regions of Surkhandarya, Kashkadarya and Navoi regions, the wind potential is underestimated.

Smart grids will significantly improve energy supply in rural areas. Modern networks built on the basis of these technologies have the following advantages: reducing energy losses by 15-20%; reduction of network outages by 40-60%; efficient integration of renewable resources into the network; Real-time monitoring and management. The widespread introduction of smart meters (intelligent computing devices) will also become important. They not only provide accurate billing, but they also provide a means to balance network load and incentivize energy savings. The experience of pilot projects shows that energy losses as a result of the introduction of smart meters are reduced by 12-18%. Improving energy efficiency is the most cost-effective way to improve energy supply in rural areas. Studies show that the current potential for efficient energy use in rural areas is 25-30% [16]. In this direction, the following activities are recommended:

Wide introduction of LED lighting technologies will allow to achieve exhibition results. In rural areas, replacing traditional light bulbs with LED bulbs can reduce electricity demand by 70-80%. In a hot climate, the construction of premises from energy-efficient building materials also reduces the amount of energy spent on heating and cooling by 40-50%.

Improving financial mechanisms for energy development in rural areas plays a decisive role. Based on international experience, the following financing models are recommended: Attraction

of private investment through issuance of green bonds; Expanding the Public-Private Partnership (PPP) model Creation of the rural energy fund; Strengthening cooperation with international financial organizations (ADB, EBRD, World Bank).

In terms of political solutions, it is recommended to develop a special "Green Village" program for rural areas. Within the framework of this program, it is planned to provide subsidies and incentives and tax incentives to farms and households that have installed renewable energy installations. The current state of energy supply in rural areas of Uzbekistan involves complex problems: outdated network infrastructure, limited financial resources, low use of renewable energy sources and insufficient management efficiency.

To address these challenges, the following promising areas are recommended: first, the expansion of solar and wind energy projects in rural areas; Second, the gradual introduction of Smart Grid technologies; Thirdly, to implement energy efficiency programmes; Fourth, to attract private investment through new financing mechanisms.

Implementing these directions will reduce energy losses in rural areas by 30-35% by 2030, increase the share of renewable energy in total production to 25%, and improve the quality of life of at least 2 million rural residents.

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