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PROSPECTS FOR THE DEVELOPMENT OF AUTONOMOUS POWER SUPPLY SYSTEMS BASED ON RENEWABLE ENERGY SOURCES IN UZBEKISTAN

Sunnatov Samir Zafar o'g'li

Student of Navoi State University of Mining and Technologies, Uzbekistan

e-mail: samirsunnatov61@gmail.com

Abstract: This article analyzes the technical and economic potential of renewable energy sources in Uzbekistan. The possibilities of using solar, wind, and micro hydroelectric power plants for autonomous power supply systems are studied. Special attention is given to micro hydropower plants due to their high efficiency, environmental safety, and economic advantages. The article also discusses the prospects of improving energy supply in remote and mountainous areas through renewable energy technologies.

Keywords: Renewable energy, micro hydropower plant, solar energy, wind energy, autonomous power supply, hydropower, energy efficiency, Uzbekistan.

Introduction

Today, the rapid growth of energy consumption and the gradual depletion of traditional fuel resources have increased the global demand for renewable energy sources. Environmental problems caused by fossil fuels also encourage many countries to develop clean and sustainable energy systems. In this regard, renewable energy technologies play an important role in ensuring energy security and reducing harmful emissions.

Uzbekistan has significant renewable energy potential due to its favorable geographical and climatic conditions. Solar radiation, wind flow, and water resources create opportunities for the development of autonomous power supply systems in remote regions and industrial sectors.

Solar Energy Potential in Uzbekistan

Uzbekistan is considered one of the countries with high solar energy potential. The duration of sunshine in the republic reaches approximately 2500–3500 hours per year. Solar radiation indicators are especially high during summer seasons, which creates favorable conditions for generating electrical energy using photovoltaic systems.

Currently, solar energy is mainly converted into electricity through photovoltaic and thermodynamic technologies. Many developed countries such

as Germany, China, the USA, Japan, and Spain successfully use solar power plants for industrial and domestic electricity supply.

However, despite the high solar potential, several factors limit the efficiency of solar power plants in Uzbekistan. These include dry climate conditions, high dust concentration in the atmosphere, and relatively low efficiency of photovoltaic panels. In practice, the average efficiency of solar power stations is around 16–20%, which affects their economic effectiveness.

Nevertheless, solar energy remains one of the promising renewable energy sources for autonomous power systems, especially in regions with stable solar radiation [1].

Wind Energy Opportunities

Wind energy is another important renewable energy source with development prospects in Uzbekistan. The geographical location and relief structure of the country create suitable conditions for wind flow formation in certain regions.

Research shows that the average wind power potential in some regions of Uzbekistan reaches 84 W/m². In Navoi region, this indicator exceeds 100 W/m², while mountainous and desert areas also demonstrate favorable wind conditions. Wind speeds above 3 m/s are observed for long periods during the year, especially in elevated territories.

Today, several projects related to wind farms are being developed in Uzbekistan, including technical and economic studies in the Bostanliq district of Tashkent region. These projects aim to evaluate the effectiveness of large-scale wind power plants in the country.

Despite these opportunities, wind turbines have certain disadvantages. Their practical efficiency is often lower than theoretical values and depends strongly on seasonal and climatic factors. In many cases, the actual efficiency of wind generators remains within 12–19%, which limits their economic attractiveness for industrial enterprises [2].

Advantages of Micro Hydropower Plants

Among all renewable energy sources, hydropower is considered one of the most efficient and environmentally friendly technologies. Micro and small hydropower plants generate electricity using the natural flow of water without causing serious environmental damage.

One of the major advantages of micro hydropower plants is their high efficiency compared to solar and wind systems. In addition, micro HPPs require relatively low operational costs and have long service life. They preserve natural water quality and do not negatively affect agricultural or domestic water use.

Uzbekistan has considerable hydropower resources. There are more than 650 rivers and numerous canals and reservoirs throughout the country. However, only a small percentage of the existing hydropower potential is currently utilized.

Micro hydropower plants are especially effective in remote mountainous regions where centralized electricity networks are unavailable or difficult to install. These systems can provide reliable electricity for rural settlements, mining enterprises, agricultural facilities, and small industrial sectors.

Another important advantage of micro HPPs is their environmental sustainability. Unlike fossil-fuel-based power generation, hydropower systems do not produce harmful atmospheric emissions. Therefore, they contribute to reducing environmental pollution and improving ecological stability [3].

Technical and Economic Efficiency

The comparative analysis of renewable energy sources shows that hydropower systems have higher practical efficiency than solar and wind technologies. While solar and wind power strongly depend on weather conditions, water flow in many regions remains relatively stable throughout the year.

The development of autonomous energy systems based on micro hydropower plants can significantly reduce fuel consumption and improve energy independence in remote territories. Furthermore, the integration of modern digital monitoring and control technologies can increase the operational reliability of such systems.

Renewable energy projects also provide economic benefits by reducing electricity transmission costs and supporting local industrial development. The implementation of small-scale hydropower systems can become an important factor in the sustainable development of Uzbekistan's energy sector [4].

Conclusion

In conclusion, renewable energy sources are becoming increasingly important for the future development of autonomous power supply systems in Uzbekistan. Solar and wind energy have considerable potential, but their efficiency and economic effectiveness are influenced by climatic conditions.

Among renewable energy technologies, micro hydropower plants demonstrate the highest efficiency, environmental safety, and economic advantages. Their application in mountainous and remote regions can significantly improve electricity supply reliability and reduce dependence on traditional fuel resources.

Therefore, expanding the use of micro hydropower plants and integrating them with modern digital technologies is one of the most promising directions for the sustainable development of Uzbekistan's energy system.

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