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INCREASING ECONOMIC EFFICIENCY BASED ON DIGITAL PLATFORMS IN THE IMPLEMENTATION OF ALTERNATIVE ENERGY TECHNOLOGIES (THE CASE OF RURAL AREAS)

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Abstract: This article examines the issues of enhancing the impact of digital platforms on economic efficiency in the process of implementing alternative (renewable) energy technologies in rural areas. The article highlights the importance of digital monitoring systems, mobile applications, online financing, and government e-services in the energy sector. It also analyzes the main economic and organizational barriers encountered in the implementation of solar, wind, and biogas technologies in rural areas. Based on the research findings, recommendations are developed to reduce the payback period of energy projects, decrease maintenance costs, and ensure convenient access to financial resources for the population and farms through the development of digital platforms.

Keywords: alternative energy, renewable energy sources, digital platform, economic efficiency, rural areas, green economy, digitalization, energy management, financing, investment attractiveness.

Annotatsiya: Mazkur maqolada qishloq hududlarida muqobil (qayta tiklanuvchi) energetika texnologiyalarini joriy etish jarayonida raqamli platformalarning iqtisodiy samaradorlikka ta'sirini oshirish masalalari ko'rib chiqilgan. Maqolada energetika sohasida raqamli monitoring tizimlari, mobil ilovalar, onlayn moliyalashtirish va davlat elektron xizmatlarining ahamiyati yoritilgan. Shuningdek, qishloq hududlarida quyosh, shamol va biogaz texnologiyalarini joriy etishda yuzaga keladigan asosiy iqtisodiy va tashkiliy to'siqlar tahlil qilingan. Tadqiqot natijalariga asoslangan holda energiya loyihalarining qoplash muddatini qisqartirish, texnik xizmat ko'rsatish xarajatlari kamaytirish hamda raqamli platformalarni rivojlantirish orqali aholi va fermer xo'jaliklarining moliyaviy resurslardan qulay foydalanishini ta'minlash bo'yicha tavsiyalar ishlab chiqilgan.

Kalit so'zlar: muqobil energetika, qayta tiklanuvchi energiya manbalari, raqamli platforma, iqtisodiy samaradorlik, qishloq hududlari, yashil iqtisodiyot, raqamlashtirish, energetikani boshqarish, moliyalashtirish, investitsion jozibadorlik.

Аннотация: В данной статье рассматриваются вопросы повышения влияния цифровых платформ на экономическую эффективность в процессе внедрения альтернативных (возобновляемых) энергетических технологий в сельской местности. В статье подчеркивается значение цифровых систем мониторинга, мобильных приложений, онлайн-финансирования и государственных электронных услуг в энергетическом секторе. Также анализируются основные экономические и организационные барьеры, возникающие при внедрении солнечных, ветровых и биогазовых технологий в сельской местности. На основе результатов исследования разработаны рекомендации по сокращению срока окупаемости энергетических проектов, снижению затрат на техническое обслуживание и обеспечению удобного доступа населения и фермерских хозяйств к финансовым ресурсам посредством развития цифровых платформ.

Ключевые слова: альтернативная энергетика, возобновляемые источники энергии, цифровая платформа, экономическая эффективность, сельская местность, зеленая экономика, цифровизация, управление энергетикой, финансирование, инвестиционная привлекательность.

INTRODUCTION

Global efforts toward the sustainable development of the world economy and the fight against climate change require a fundamental expansion in the use of alternative energy sources. According to data from international organizations, the growing share of renewable energy sources is of strategic importance for states not only environmentally but also economically. In the Republic of Uzbekistan as well, the transition to a "green"

economy, the improvement of energy efficiency, and the expansion of the share of alternative energy sources have, in recent years, become one of the priority directions of state policy.

Rural areas hold particular significance from the standpoint of implementing alternative energy technologies. On the one hand, these areas have high potential for using solar, wind and biomass resources; on the other hand, developing local energy sources is a socio-economic necessity for settlements and farms located far from centralized energy networks. However, practice shows that implementing such projects in rural areas faces a number of obstacles, including limited access to financial resources, insufficient maintenance infrastructure, and weak information and advisory services.

Under these conditions, digital platforms — remote energy consumption monitoring systems, mobile-application-based energy management tools, online lending and leasing platforms, as well as government e-services — can serve as an important instrument for increasing the economic efficiency of implementing alternative energy technologies. The purpose of this article is to study, using the example of rural areas, the mechanisms through which digital platforms influence the economic efficiency of alternative energy projects, and to develop practical recommendations.

The economic competitiveness of renewable energy sources is also increasing. According to the International Renewable Energy Agency (IRENA), in 2024, 91% of new large-scale energy projects delivered a lower cost of electricity than the cheapest new fossil-fuel alternative. The global average levelized cost of electricity (LCOE) for solar photovoltaic technologies stood at USD 0.043/kWh.

This direction is particularly important for Uzbekistan. The fact that rural residents make up a substantial share of the country's population, together with the need to improve the reliability of electricity supply in certain rural areas and the growth of entrepreneurial activity, requires the modernization of energy infrastructure. According to 2026 World Bank data, nearly half of Uzbekistan's population lives in rural areas, and problems related to the quality of electricity services in some villages are also affecting local business and employment opportunities.

For this reason, it is important not merely to install alternative energy technologies in rural areas, but to integrate them with digital management and monitoring systems.

REVIEW OF LITERATURE ON THE SUBJECT

Issues of alternative energy economics and digitalization have been studied from various angles by international and local researchers. Analytical reports prepared by the International Renewable Energy Agency (IRENA) and the International Energy Agency (IEA) extensively cover the role of digital technologies in managing energy systems, including the impact of "smart grids," energy consumption forecasting systems, and energy trading platforms on economic efficiency.

Research by local economists has analyzed the institutional and financial aspects of improving energy supply in agriculture and rural areas of Uzbekistan, including the development of micro-energy projects. At the same time, existing literature still lacks sufficiently developed studies focused on a comprehensive assessment of the impact of digital platforms specifically on the financial and economic indicators of alternative energy projects in rural conditions, which underscores the relevance of this topic.

Considerable attention is also being paid in foreign scientific literature to the digitalization of renewable energy technologies. In particular, IRENA studies extensively cover the role of digitalization, the Internet of Things (IoT), artificial intelligence, big data, cloud technologies and smart grid systems in integrating renewable energy into the electric power system. It has been noted that the use of digital technologies makes it possible to monitor energy production and consumption in real time, forecast demand, optimize energy flows, and detect technical faults in advance.

Studies devoted to the use of artificial intelligence and machine learning technologies pay particular attention to the issue of forecasting energy production. Since variability in weather conditions directly affects the volume of energy generated by solar and wind power, applying forecasting algorithms based on historical data, meteorological indicators, and real-time data makes it possible to increase the stability of energy systems. This, in turn, helps reduce the costs associated with excess energy production or energy shortages.

Studies examining the impact of digital platforms on economic efficiency focus mainly on optimizing operation and maintenance costs in addition to reducing energy production costs. Remote monitoring and predictive maintenance technologies make it possible to detect equipment faults early, shorten repair times, and extend the service life of equipment. As a result, the overall life-cycle costs of renewable energy facilities are reduced.

RESEARCH METHODOLOGY

In the course of the research, general scientific research methods were used, including systemic analysis, comparative analysis, generalization of statistical data, and logical analysis. In addition, an expert assessment approach was used to evaluate the impact of digital platforms at various stages of implementing alternative energy projects in rural areas. The payback period of the project, maintenance costs, the level of energy loss, and the ease of access to financial resources were selected as the main indicators for the analysis.

In line with the main purpose of the research, the study envisages forming an organizational-economic mechanism for increasing, through digital platforms, the efficiency of implementing solar, wind and other renewable energy technologies in rural areas. In doing so, the impact of digital technologies on the processes of energy production, energy consumption management, maintenance, and investment decision-making is assessed.

In the course of the research, the methods of systemic analysis, comparative analysis, statistical analysis, economic-mathematical modeling, expert assessment, forecasting, and investment efficiency evaluation were used.

1. Systemic approach

On the basis of the systemic approach, the alternative energy system in rural areas is regarded as a single economic-technical system composed of interrelated elements.

2. Statistical and comparative analysis methods

The study uses the comparative analysis method to compare economic indicators before and after the implementation of alternative energy technologies.

3. Methodology for assessing the efficiency of digital platforms

One of the important aspects of the study is to determine the additional economic effect generated as a result of using digital platforms.

4. Assessment of investment efficiency

In determining the economic efficiency of alternative energy projects, it is appropriate to use indicators such as the payback period of investments, net present value (NPV), internal rate of return (IRR), and profitability index (PI).

5. Determining the cost of energy

In assessing the economic efficiency of alternative energy technologies, the levelized cost of electricity (LCOE) indicator is also applied.

6. Digital forecasting of energy production

The study considers the energy production forecasting mechanism as one of the important functions of the digital platform. Here, historical energy production data, solar radiation, air temperature, wind speed, humidity and other meteorological indicators can be used.

7. Assessing the level of digitalization

The study proposes using a composite indicator to determine the level of digitalization of alternative energy facilities in rural areas.

8. Conceptual model of the research

The overall logical sequence of the research methodology is formulated as follows:

Alternative energy source → IoT and smart meters → digital platform → data collection → analysis and forecasting → optimization of energy flows → cost reduction → increased economic efficiency.

In this model, the digital platform is regarded as the main integrating mechanism between alternative energy technologies and economic outcomes.

The empirical base of the research may be formed by data on electricity consumption in rural areas, the production indicators of renewable energy facilities, investment and operating costs, meteorological data, and data generated through digital monitoring systems.

ANALYSIS AND RESULTS

The impact of digital platforms on the economic efficiency of alternative energy projects manifests itself in several directions. First, remote energy consumption monitoring systems and IoT (Internet of Things) devices make it possible to track, in real time, the operation of solar panels, wind generators and biogas plants. This allows faults to be detected in a timely manner, reduces maintenance costs, and increases the overall operating efficiency of the equipment.

Second, online financing and micro-lending platforms are giving farms and rural residents faster and more convenient access to the financial resources needed to purchase alternative energy equipment. Compared with traditional bank lending procedures, applying through digital platforms significantly reduces both the time

and the transaction costs involved.

Third, government e-services — the ability to process subsidies, preferential loans and tax benefits online — reduce bureaucratic barriers and shorten project implementation timelines. In addition, energy trading platforms (peer-to-peer energy exchange) create an opportunity for rural communities to share surplus generated energy with neighboring farms or sell it to the grid, serving as an additional source of income.

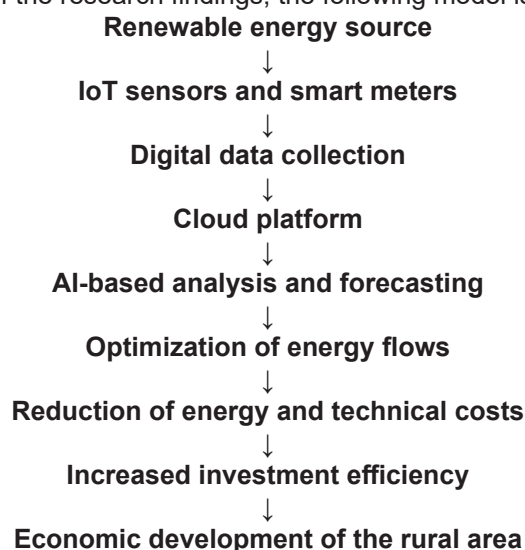
The table below presents a generalized (estimated, formed on the basis of scientific literature and expert assessments) model of the impact of implementing digital platforms on the economic indicators of alternative energy projects (Table 1):

Table 1. Estimated impact of implementing digital platforms on economic efficiency indicators¹

Indicator	Before digitalization	After digitalization (estimated)	Change, %
Level of energy loss	18-22%	8-12%	≈ -45%
Maintenance costs	100 (baseline)	60-70	≈ -35%
Project financing period	6-9 months	1-3 months	≈ -65%
Public awareness of energy saving	low	high	significant increase
Average operating efficiency of solar panels and other equipment	70-75%	85-92%	≈ +15-20%

The table shows that implementing digital platforms makes it possible to significantly reduce the level of energy loss, optimize maintenance costs, and shorten project financing periods. This, in turn, increases the investment attractiveness of alternative energy projects in rural areas and speeds up their implementation.

Based on the generalization of the research findings, the following model is proposed for rural areas:



The important feature of this model is that the digital platform is regarded not as a separate technological tool, but as the management mechanism that ensures the economic efficiency of the alternative energy system as a whole.

CONCLUSIONS AND SUGGESTIONS

Based on the results of the research carried out, the following conclusions and recommendations can be formulated:

1. It is necessary to increase the operating efficiency of equipment and reduce maintenance costs by equipping alternative energy projects in rural areas with digital monitoring and management systems.
2. Financial access to alternative energy equipment should be improved for farms and rural residents by expanding online micro-financing and leasing platforms.
3. It is advisable to continue the digitalization of government services and further improve electronic platforms based on the “one-window” principle for processing subsidies and benefits.

¹ Source: Author's own work

4. It is recommended to develop special programs aimed at developing digital infrastructure in rural areas and increasing the digital literacy of the population.

5. In future research, it is advisable to conduct a deeper quantitative assessment of the impact of digital platforms on economic efficiency, based on real projects implemented in specific regions.

Proposals:

1. The research established that the efficiency of alternative energy technologies is determined not only by the volume of energy produced, but is also closely linked to investment costs, the cost of energy, operating and maintenance costs, energy losses, the operating efficiency of equipment, and the level of digital management.

2. At the same time, it is advisable that future research in this field develop econometric models based on real data for individual regions and districts of Uzbekistan, calculate the precise economic effect of implementing digital platforms, determine the payback period of investments, and compare the economic efficiency of various renewable energy technologies with one another.

In conclusion, digital platforms are an important factor in increasing the economic efficiency of implementing alternative energy technologies in rural areas. Their targeted and systematic development serves not only the sustainable development of the energy sector, but also the socio-economic progress of rural areas.

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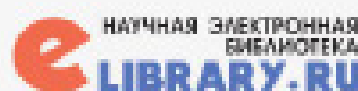
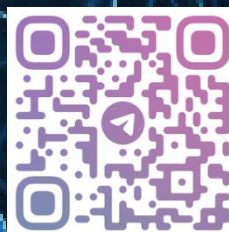
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