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ECONOMIC MECHANISMS FOR THE EFFICIENT UTILIZATION OF ALTERNATIVE ENERGY RESOURCES IN UZBEKISTAN'S ENERGY INDUSTRY AND THEIR IMPROVEMENT DIRECTIONS

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Abstract: This article provides a systematic analysis of the existing economic mechanisms for the efficient utilization of alternative energy resources in Uzbekistan's energy industry and substantiates the priority directions for their improvement. The study evaluates the interrelationships among investment, financial, institutional, and market factors influencing the development of renewable energy sources. Furthermore, it proposes scientific and practical recommendations aimed at assessing alternative energy projects based on comprehensive economic efficiency, introducing differentiated incentive mechanisms, ensuring the rational utilization of regional resource potential, increasing the level of localization, and implementing a digital monitoring system.

Keywords: alternative energy resources, renewable energy sources, energy industry, economic mechanism, energy efficiency, green economy, investment policy, public-private partnership, green financing, tariff policy, energy market, energy security.

Аннотация: В статье проведён системный анализ действующих экономических механизмов эффективного использования альтернативных энергетических ресурсов в энергетической отрасли Республики Узбекистан и обоснованы приоритетные направления их совершенствования. В исследовании оценена взаимосвязь инвестиционных, финансовых, институциональных и рыночных факторов, влияющих на развитие возобновляемых источников энергии. Кроме того, разработаны научно-практические рекомендации, направленные на оценку проектов альтернативной энергетики на основе комплексной экономической эффективности, внедрение дифференцированных механизмов стимулирования, обеспечение рационального использования регионального ресурсного потенциала, повышение уровня локализации и внедрение цифровой системы мониторинга.

Ключевые слова: альтернативные энергетические ресурсы, возобновляемые источники энергии, энергетическая отрасль, экономический механизм, энергоэффективность, зелёная экономика, инвестиционная политика, государственно-частное партнёрство, зелёное финансирование, тарифная политика, энергетический рынок, энергетическая безопасность.

INTRODUCTION

The global transformation of the energy sector has marked the beginning of a new stage in economic development. The continuous growth in global energy demand, the increasing risks associated with climate change, and international commitments aimed at achieving carbon neutrality are fundamentally reshaping the structure of energy systems. Consequently, the development of alternative energy sources is no longer viewed solely as an environmental initiative but increasingly as a strategic instrument for stimulating investment activity, strengthening industrial competitiveness, reducing dependence on energy imports, and ensuring sustainable long-term economic growth. As a result, improving the economic mechanisms that promote the deployment of renewable energy has become one of the key priorities of public policy in both developed and developing countries.

Uzbekistan is experiencing similar trends, as industrial expansion, rapid urbanization, and population growth continue to increase the demand for electricity. Despite possessing significant natural gas reserves, the country is actively pursuing the strategic objective of diversifying its fuel and energy balance, reducing the cost of electricity generation, improving resource efficiency, and mitigating environmental impacts. To address these priorities, Uzbekistan has implemented a series of reforms in recent years, including the construction of solar and wind power plants, the expansion of public-private partnership (PPP) projects, the attraction of foreign investment, and the promotion of green energy initiatives. At the same time, the country's considerable renewable energy potential creates favorable opportunities for the further strengthening of institutional and financial mechanisms aimed at enhancing the economic efficiency of alternative energy projects.

Practical experience indicates that the pace of renewable energy development depends not only on technological capabilities but also on the effectiveness of economic incentive mechanisms. Ongoing improvements in investment conditions, expanding financing opportunities, the gradual development of electricity market pricing mechanisms, continuous modernization of regional energy infrastructure, and the broader integration of energy efficiency assessment indicators are expected to further enhance the economic performance of renewable energy projects. As a consequence, Uzbekistan possesses strong potential to further increase the economic benefits generated from its abundant renewable energy resources.

These challenges necessitate a comprehensive reassessment of the existing economic mechanisms governing renewable energy development. In particular, the effective integration of investment incentive instruments, differentiated tariff policies, green financing mechanisms, tax and customs incentives, carbon-oriented economic evaluation methods, support for energy-efficient technologies, and market-based instruments encouraging private sector participation is essential for ensuring the sustainable development of the energy sector. Within this framework, economic performance should be evaluated not only by the volume of electricity generated but also through a broader set of indicators, including investment returns, resource efficiency, value-added creation, regional economic development, and environmental outcomes.

The scientific relevance of this study lies in the fact that previous research has predominantly examined renewable energy from technical, environmental, or investment perspectives, while relatively limited attention has been paid to the interrelationships among economic mechanisms, their integrated impact on the performance of the energy industry, and the development of comprehensive economic governance instruments. In particular, optimizing economic mechanisms by considering regional resource potential, investment attractiveness, and energy consumption patterns within the specific conditions of Uzbekistan remains an important scientific and practical challenge.

Accordingly, the objective of this study is to conduct a systematic analysis of the existing economic mechanisms for the efficient utilization of alternative energy resources in Uzbekistan's energy industry, identify the factors influencing their effectiveness, and develop scientific and practical recommendations for improving these mechanisms. The study proposes an integrated conceptual framework that combines economic incentives, investment efficiency, green financing, market-based instruments, and regional resource potential within a unified governance system. This approach is expected to enhance the competitiveness of Uzbekistan's energy industry, strengthen national energy security, optimize production costs, and facilitate the country's transition toward a green economy.

REVIEW OF LITERATURE ON THE SUBJECT

The issue of utilizing alternative and renewable energy resources has been widely examined in the economic literature, primarily in the context of energy security, investment efficiency, environmental sustainability, and institutional reforms of energy markets. Previous studies emphasize that integrating solar, wind, hydropower, biomass, and geothermal resources into the economy should not be limited merely to expanding generation capacity. Instead, renewable energy development requires a comprehensive framework that integrates tariff policies, government guarantees, preferential financing, competitive auctions, long-term power purchase agreements (PPAs), tax incentives, and mechanisms for grid connection as interrelated components of an effective economic system.

In its review of Uzbekistan's energy policy, the International Energy Agency (IEA) highlights that the country's energy system remains heavily dependent on natural gas, while significant parts of the electricity network are physically and technologically outdated. The report further notes that the rapid growth in electricity demand has substantially increased the need for new generation capacity [1]. It identifies the gradual liberalization of the electricity market, tariff reforms reflecting actual economic costs, the establishment of transparent market conditions for independent power producers, and the integration of renewable energy into the national grid as key policy priorities. From our perspective, this approach provides an important theoretical foundation for

Uzbekistan; however, it does not sufficiently address the socio-economic mechanisms required to balance tariff reforms with households' affordability and industrial production costs. Therefore, tariff liberalization should be accompanied by targeted compensation mechanisms, incentives for energy efficiency, and differentiated tariff structures.

The IEA's report *Solar Energy Policy in Uzbekistan: A Roadmap* identifies solar energy as one of the principal instruments for diversifying the country's fuel and energy balance [2]. Besides the construction of large-scale photovoltaic power plants, the study emphasizes the importance of promoting distributed generation, rooftop solar systems, electricity storage technologies, and modern energy management systems. It also recommends providing long-term guarantees for investors, simplifying land allocation procedures, and establishing transparent grid connection regulations. In our view, under Uzbekistan's conditions, the economic benefits of solar energy should not be assessed solely by the amount of electricity generated. The evaluation framework should also incorporate natural gas savings, reductions in electricity shortages during peak demand periods, improvements in regional electricity supply, and the mitigation of environmental damage.

IRENA's report on renewable power generation costs demonstrates that technological progress, economies of scale, and competitive procurement mechanisms have significantly reduced the cost of electricity generated from solar and wind energy technologies [3]. According to the report, competitive auctions enhance price competition among investors and enable the discovery of more economically efficient electricity prices compared with administratively regulated tariffs. We believe that this conclusion is highly relevant to Uzbekistan. Nevertheless, selecting the project with the lowest tariff should not automatically imply selecting the most efficient project. Evaluation criteria should also include financial sustainability, localization level, energy storage capacity, grid connection costs, and the probability of completing the project within the planned implementation period.

Another IRENA study devoted to renewable energy auctions emphasizes the importance of appropriately allocating project risks among governments, investors, electricity purchasers, and consumers [4]. According to the study, exchange rate fluctuations, inflation, grid constraints, construction delays, and the creditworthiness of electricity purchasers directly influence tariff bids. If excessive risks are transferred to investors, they tend to demand higher tariffs or withdraw from projects; conversely, if governments assume all project risks, fiscal liabilities increase substantially. From the author's perspective, Uzbekistan's auction mechanism should evolve from the principle of selecting the "lowest price" toward the concept of achieving the "optimal price with manageable risk." Accordingly, payment guarantees, partial insurance against exchange rate risks, clearly defined contractual liabilities, and compensation mechanisms for grid-related constraints should be established in advance.

The World Bank's project supporting electricity generation through private sector participation in Uzbekistan highlights the importance of government guarantees, power purchase agreements, and investment risk mitigation instruments for attracting private investment into renewable energy projects [5]. The study concludes that expanding the role of independent power producers can reduce the investment burden on the state budget while accelerating the introduction of modern technologies into the energy sector. In our opinion, although public-private partnership mechanisms represent an essential instrument for developing Uzbekistan's energy industry, their effectiveness should not be assessed solely by the volume of attracted investment. A comprehensive evaluation should also consider contract duration, guaranteed electricity purchase prices, the government's contingent liabilities, and the long-term impact of these commitments on electricity tariffs for consumers.

The World Bank's documentation on the development of the Navoi Solar Power Plant examines the implementation of the Scaling Solar model, which combines international competitive auctions, standardized contractual arrangements, and payment guarantee mechanisms [6]. This approach is characterized by its ability to provide transparent conditions for investors, shorten project preparation periods, and reduce electricity tariffs through market competition. From the author's perspective, this model served as an effective initial solution for the development of large-scale solar power plants in Uzbekistan. However, at the next stage of renewable energy expansion, it is necessary to move beyond standardized project models toward a differentiated approach that considers regional electricity demand, grid transmission capacity, and local resource characteristics. Otherwise, the rapid growth of generation capacity may outpace the development of transmission infrastructure.

The Asian Development Bank's assessment of Uzbekistan's energy sector indicates that the country possesses significant solar, wind, and hydropower potential, while the ongoing modernization of the electricity transmission network creates favorable conditions for the large-scale integration of renewable energy [7]. The study highlights the importance of further upgrading grid infrastructure, improving transmission efficiency, and expanding the digitalization of system management and metering to support the sustainable development of

the energy sector. In our opinion, the economic mechanism for the efficient utilization of alternative energy resources should encompass not only the financing of electricity generation projects but also coordinated investments in substations, transmission infrastructure, dispatch management systems, and energy storage facilities within a single integrated investment package.

Radovanović et al. analyzed the transition toward sustainable energy systems in Central Asian countries and concluded that, despite the region's considerable renewable energy potential, significant barriers remain in institutional governance, market competition, the investment climate, and policy consistency [8]. The authors argue that technological opportunities alone cannot ensure a successful energy transition without appropriate economic and political conditions. We believe that this conclusion is particularly relevant to Uzbekistan's energy sector. The mere availability of solar or wind resources does not automatically generate economic benefits; rather, an institutional framework capable of transforming natural resource potential into investment projects, productive assets, and sustainable revenue streams must be established.

Eshchanov, Stultjes, Eshchanov, and Salaev investigated public perceptions and policymakers' attitudes toward the adoption of renewable energy technologies in the Khorezm region of Uzbekistan [9]. Their findings demonstrate that, besides technological availability, public awareness, household income, access to financing for initial investment costs, and confidence in renewable energy technologies play decisive roles in their widespread adoption. Therefore, incentive programs for households and small businesses should not rely exclusively on subsidies. Preferential loans, installment payment schemes, opportunities to sell surplus electricity to the grid, service guarantees, and technical advisory support should be integrated into a unified support mechanism.

Lesser and Su proposed an economically efficient feed-in tariff (FIT) framework for promoting renewable energy development [10]. They argue that guaranteed tariffs stabilize long-term investor revenues and facilitate private investment in capital-intensive energy projects. At the same time, excessively generous tariff levels may increase consumer costs, while the failure to adjust tariffs in response to declining technology costs may generate excessive returns for investors. In our opinion, rather than applying a single fixed long-term green tariff, Uzbekistan should implement a periodically revised tariff mechanism that reflects technology type, project capacity, regional conditions, and changes in equipment market prices. Under such a framework, guaranteed feed-in tariffs would be more appropriate for small-scale projects, whereas competitive auctions should remain the preferred mechanism for utility-scale renewable energy plants.

Winkler, Magosch, and Ragwitz examined the effectiveness of renewable energy support auctions across different countries [11]. Their research indicates that although auctions can reduce public support costs, excessively low tariff bids may increase the risk of project delays or non-completion. Furthermore, limited competition among bidders may distort auction outcomes in favor of large market participants. From our perspective, the effectiveness of renewable energy auctions in Uzbekistan should not be evaluated solely by the winning tariff. Instead, greater emphasis should be placed on actual commissioned capacity, electricity generation performance, project implementation within the planned schedule, and the overall fiscal burden imposed on the government.

Del Río and Kiefer analyzed the influence of renewable energy policy instruments on technological innovation and concluded that different support mechanisms produce different innovation outcomes [12]. According to their findings, while auctions effectively reduce prices in the short term, excessive price competition may encourage investors to adopt only mature, low-cost technologies, thereby limiting experimentation with innovative technological solutions. We believe that Uzbekistan's renewable energy policy should distinguish between economic efficiency and technological innovation. Competitive auctions should be applied to commercially mature solar and wind technologies, whereas emerging sectors-including energy storage, green hydrogen, waste-to-energy technologies, and smart grids-should be supported through pilot grants, innovation-oriented tariffs, and research and demonstration projects.

RESEARCH METHODOLOGY

This study employs a systematic approach to evaluate the economic mechanisms for the efficient utilization of alternative energy resources in Uzbekistan's energy industry and to identify priority directions for their improvement. The research involves a comprehensive review of national and international academic literature concerning renewable energy development, investment promotion mechanisms, tariff policy reforms, green financing instruments, and strategies for improving energy efficiency.

The empirical foundation of the study consists of official statistical data related to Uzbekistan's energy sector, reports published by international organizations, national regulatory and legal documents, and findings from previous scientific research. To assess the current state of renewable energy utilization, a combination of

statistical observation, data classification, dynamic and structural analysis, comparative evaluation, scientific abstraction, analytical reasoning, and synthesis methods was employed.

ANALYSIS AND RESULTS

The current stage of development of Uzbekistan's energy industry is characterized by rapidly growing electricity demand, increasing economic pressure on conventional fuel resources, and the need to diversify the country's energy production structure. In 2025, Uzbekistan generated approximately 86.7 billion kWh of electricity. According to long-term projections, national electricity demand is expected to reach 117 billion kWh by 2030 and approximately 135 billion kWh by 2035. These trends indicate that meeting future energy needs will require not only expanding generation capacity but also fundamentally restructuring the country's energy mix.

For many years, Uzbekistan's energy system has relied predominantly on natural gas. According to the International Energy Agency, as of 2021 natural gas accounted for 79% of the country's total energy supply, while coal represented 8.2%, oil products 11.4%, and hydropower 1.2%. The contribution of solar, wind, and other renewable energy sources has been expanding progressively in line with the country's ongoing energy reforms. Such an energy structure highlights the strategic importance of continuing energy diversification, thereby strengthening the resilience and long-term sustainability of the national energy system.

This energy structure also creates important opportunities for further economic development. First, the gradual expansion of renewable energy will enable natural gas resources to be utilized more efficiently in sectors capable of generating higher value added. Second, the modernization of thermal power plants and the introduction of advanced technologies are expected to improve electricity production efficiency. Third, the balanced development of natural gas production and renewable energy capacity will contribute to strengthening the long-term reliability of the national energy supply. From this perspective, expanding the use of renewable energy should be regarded not only as an environmental objective but also as an effective instrument for improving the allocation of national energy resources across different sectors of the economy.

At the same time, the existing financing model provides valuable opportunities for the further enhancement of economic efficiency. When electricity purchase prices are denominated in foreign currency while tariff revenues are collected in the national currency, appropriate financial instruments can effectively manage exchange rate fluctuations. In addition, government guarantees supporting payment obligations create favorable conditions for attracting long-term investment while requiring balanced fiscal planning. Furthermore, the lowest tariff offered by investors should be considered together with broader indicators of economic efficiency. Tariff competitiveness may be complemented by higher localization of equipment manufacturing, greater use of domestic technologies, and coordinated investments in transmission and infrastructure. Consequently, the economic evaluation of renewable energy projects should extend beyond tariff comparisons and incorporate broader indicators such as domestic value creation, localization levels, fiscal sustainability, lifecycle costs, and the overall contribution of each project to the long-term development of Uzbekistan's energy sector.

Overall, Uzbekistan has achieved substantial progress in expanding its renewable energy generation capacity. However, the next stage of development should shift the strategic focus from the quantitative expansion of installed capacity toward maximizing its economic efficiency. Achieving this objective requires the establishment of an integrated management framework that effectively coordinates investment policies, tariff regulation, financing mechanisms, infrastructure development, localization strategies, and monitoring systems. Such an integrated approach would enable renewable energy resources not only to alleviate electricity shortages but also to contribute to natural gas conservation, strengthen industrial cooperation, stimulate regional employment, and enhance the country's long-term energy security.

Based on the above analysis, an integrated economic mechanism for the efficient utilization of alternative energy resources in Uzbekistan's energy industry is proposed. The mechanism aims not only to improve the efficiency of resource utilization but also to strengthen energy security, promote environmental sustainability, and support long-term economic growth. The conceptual framework of this proposed economic mechanism is presented in Figure 1 (Figure 1).

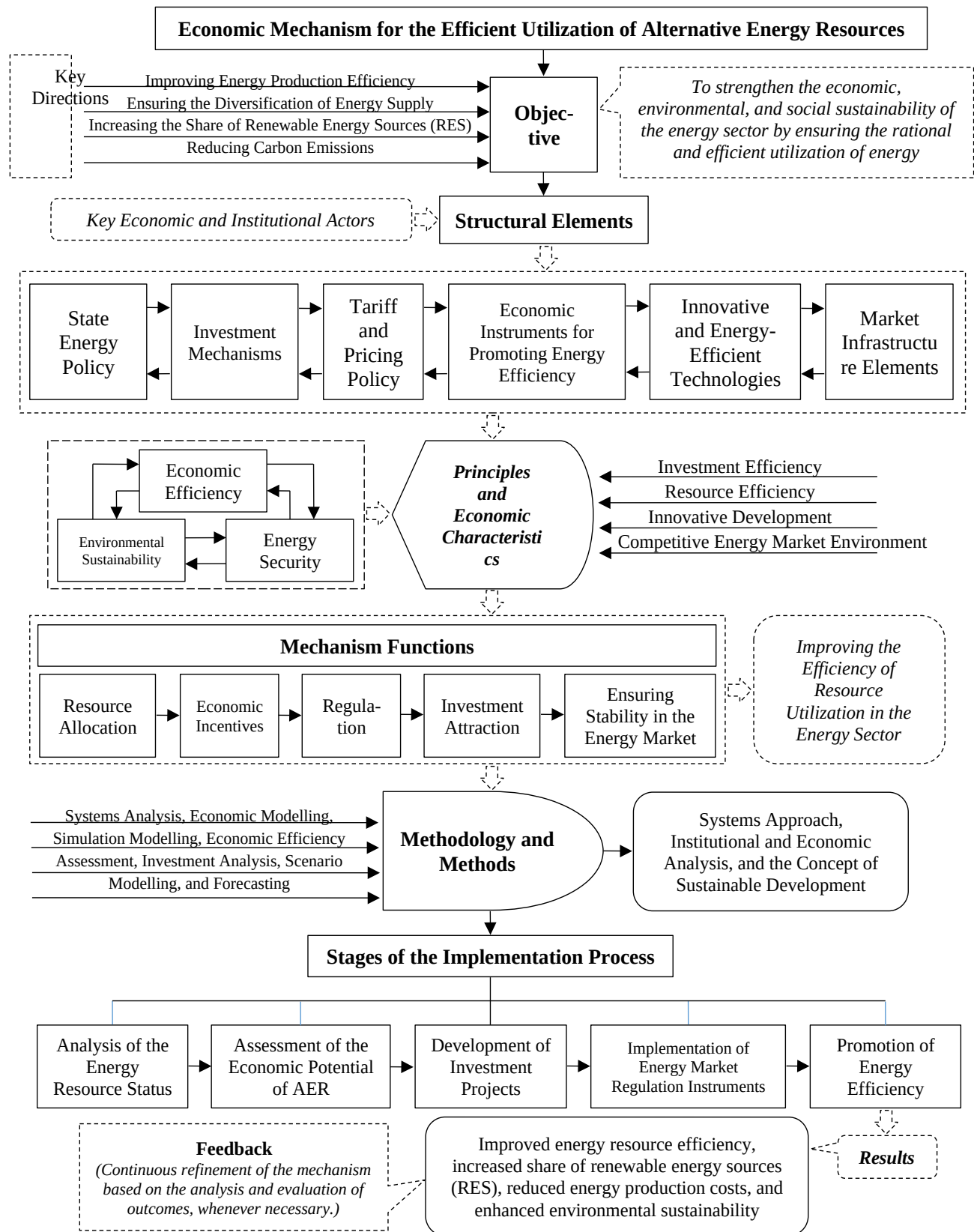


Figure 1. Economic Mechanism for the Efficient Utilization of Alternative Energy Resources in the Energy Industry¹

¹ Author's compilation.

The proposed Economic Mechanism for the Efficient Utilization of Alternative Energy Resources in the Energy Industry integrates the strategic objectives, economic instruments, and implementation stages of Uzbekistan's energy sector development into a unified framework. The principal advantage of this mechanism lies in its comprehensive perspective, which considers renewable energy development not as an isolated technological initiative but as an integrated economic system encompassing energy policy, the investment environment, market infrastructure, and energy efficiency. Consequently, the proposed framework contributes not only to expanding electricity generation but also to promoting the rational utilization of energy resources, strengthening national energy security, and supporting sustainable economic development.

A key feature of the mechanism is its ability to integrate resource allocation, economic incentives, investment promotion, and energy market regulation into a single functional framework. This integrated structure enhances the effectiveness of government economic policies, encourages broader private sector participation, and establishes the institutional conditions necessary to ensure the long-term financial sustainability of renewable energy projects.

Furthermore, the sequential organization of the implementation stages integrates all major processes into a continuous management cycle, beginning with the assessment of renewable energy resource potential and extending through project development, the introduction of market-based instruments, and the promotion of energy efficiency. This systematic approach improves the scientific basis of policy decisions, enables continuous monitoring of resource utilization efficiency, and provides the flexibility to adjust economic mechanisms in response to changing economic and energy market conditions.

CONCLUSIONS AND SUGGESTIONS

Based on the findings of this study, the following policy recommendations are proposed:

1. Introduce a Comprehensive Economic Efficiency Index for renewable energy projects by considering electricity generation efficiency, investment returns, natural gas savings, carbon emission reductions, domestic value added, and regional economic impacts;
2. Implement differentiated incentive mechanisms by applying competitive auctions for large-scale projects, preferential green financing for medium-sized businesses, and subsidies combined with net-billing for household renewable energy systems;
3. Allocate investments based on a Regional Renewable Energy Potential Index, incorporating renewable resource availability, grid infrastructure, electricity demand, investment attractiveness, and regional economic performance to improve investment efficiency;
4. Link tax and customs incentives to the level of localization, encouraging domestic manufacturing, reducing import dependence, promoting industrial cooperation, and creating employment opportunities;
5. Develop a real-time digital monitoring platform to evaluate electricity generation, energy efficiency, investment returns, natural gas savings, carbon emission reductions, and the effectiveness of government support measures.

The implementation of these recommendations will improve the economic efficiency of renewable energy utilization, optimize investment allocation, strengthen private sector participation, promote domestic industrial cooperation, and increase the share of renewable energy in electricity generation. Ultimately, these measures will enhance Uzbekistan's energy security and accelerate its transition toward a green economy by emphasizing long-term economic efficiency rather than merely expanding generation capacity.

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