



## ENHANCING RENEWABLE ENERGY SYSTEMS IN UZBEKISTAN THROUGH THE APPLICATION OF INTERNATIONAL BEST PRACTICES

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**Abstract:** *The transition toward renewable energy systems has become a global priority in response to increasing energy demand, environmental challenges, and the need for sustainable development. Uzbekistan, possessing significant potential in solar, wind, and other renewable energy resources, has initiated a series of reforms aimed at modernizing its energy sector. However, the efficiency and large-scale integration of renewable energy technologies remain constrained by technological, financial, and institutional barriers.*

*This study examines international best practices in the development of renewable energy systems and evaluates their applicability within the context of Uzbekistan. By analyzing successful models from leading countries, the research identifies key factors such as technological innovation, policy support, investment mechanisms, and infrastructure development that contribute to effective renewable energy deployment. The study also highlights existing challenges in Uzbekistan, including limited local production capacity, insufficient grid integration, and the need for skilled human resources.*

*Based on a comprehensive analytical and comparative approach, the paper proposes practical recommendations to enhance the performance and sustainability of renewable energy systems in Uzbekistan. The findings contribute to the formulation of strategic policies aimed at improving energy efficiency, strengthening energy security, and promoting a transition toward a low-carbon and sustainable energy future.*

**Keywords:** *renewable energy, alternative energy, energy efficiency, sustainable development, energy policy, international best practices, green economy, energy transition, Uzbekistan*

**1. Introduction.** The transition to renewable energy systems has emerged as a critical priority in the context of global efforts to ensure energy security, environmental sustainability, and long-term economic growth. In recent years, Uzbekistan has undertaken significant reforms aimed at diversifying its energy

mix and increasing the share of renewable energy sources, particularly solar and wind power. Despite this progress, the sector still faces several structural challenges, including limited technological capacity, insufficient infrastructure, and gaps in institutional and regulatory frameworks. In this



regard, the study of international best practices becomes highly relevant, as it provides valuable insights into effective models of renewable energy development and management. Therefore, this research aims to analyze global experiences and identify practical approaches that can be adapted to improve the efficiency and sustainability of renewable energy systems in Uzbekistan.

The utilization of renewable energy sources has become an increasingly pressing issue in the Republic of Uzbekistan. In the context of rapid economic growth, ongoing industrialization, and population expansion, the demand for energy continues to rise significantly. At the same time, the limited nature of conventional fossil fuel resources, their adverse environmental impacts, and the intensifying challenges of global climate change necessitate a transition toward sustainable and renewable energy systems.

In response to these challenges, the government of Uzbekistan has undertaken comprehensive reforms aimed at transforming the national energy sector. In particular, under the leadership of Shavkat Mirziyoyev, the national development framework Uzbekistan-2030 Strategy identifies the modernization of the energy system, the implementation of green economy principles, and the expansion of renewable energy capacity as key strategic priorities. These initiatives are designed to enhance energy independence, ensure the efficient

utilization of natural resources, and strengthen environmental sustainability.

Furthermore, the integration of renewable energy technologies is expected to play a vital role in reducing greenhouse gas emissions, diversifying energy supply sources, and fostering long-term socio-economic development. Therefore, the transition toward renewable energy in Uzbekistan is not only an environmental necessity but also a strategic imperative for achieving sustainable growth and resilience in the national economy.

**2. Literature review.** The development and integration of renewable energy systems have become central topics in contemporary economic and environmental research, particularly in the context of sustainable development and global climate change mitigation. A substantial body of literature highlights that renewable energy sources—such as solar, wind, biomass, and geothermal—play a critical role in reducing greenhouse gas emissions, enhancing energy security, and supporting long-term economic growth. International organizations emphasize that the transition toward clean energy is not only environmentally necessary but also economically viable due to the declining costs of renewable technologies and increasing efficiency levels.

Studies conducted by leading global institutions demonstrate that the share of renewable energy in total global energy production has grown significantly over the past decade, driven primarily by



advancements in solar and wind technologies. Research findings indicate that government policies, including subsidies, tax incentives, and regulatory support, are key determinants of successful renewable energy deployment. Moreover, the concept of a “green economy” has been widely discussed in academic literature as a framework that integrates environmental sustainability with economic development, highlighting the importance of innovation, investment, and institutional reforms in the energy sector.

In the context of developing and transition economies, including Uzbekistan, scholars have focused on the challenges and opportunities associated with renewable energy adoption. Existing studies point out that while Uzbekistan possesses substantial natural potential for solar and wind energy, the sector is still constrained by technological limitations, insufficient infrastructure, and a lack of skilled human resources. At the same time, recent research underscores the importance of international experience, suggesting that the adaptation of best practices from countries with advanced renewable energy systems can significantly accelerate the development process. These practices include the implementation of smart grid technologies, diversification of financing mechanisms, localization of equipment production, and strengthening of legal and institutional frameworks.

Furthermore, empirical studies highlight that public awareness,

stakeholder engagement, and capacity-building initiatives are essential for ensuring the effective implementation of renewable energy projects. Comparative analyses of different countries reveal that integrated approaches—combining technological innovation, financial support, policy consistency, and social participation—yield the most sustainable outcomes. Therefore, the existing literature collectively suggests that the successful development of renewable energy systems in Uzbekistan requires not only resource availability but also a comprehensive and coordinated strategy that incorporates international best practices and local conditions.

**3. Materials and methods.** This study employs a comprehensive and systematic research methodology to analyze the development of renewable energy systems in Uzbekistan based on international best practices. A combination of qualitative and quantitative research approaches was utilized to ensure the scientific validity and reliability of the findings.

First, the analytical method was applied to examine existing literature, including reports from international organizations, academic publications, and official statistical data related to renewable energy development at both global and national levels. This approach enabled the identification of current trends, challenges, and opportunities in the renewable energy sector, particularly in the context of Uzbekistan.



Second, a comparative analysis method was used to evaluate the differences and similarities between renewable energy systems in Uzbekistan and those of leading countries. This comparison focused on key indicators such as technological development, policy frameworks, investment mechanisms, and infrastructure capacity. The findings from this analysis provided a basis for identifying best practices that can be adapted to local conditions.

Third, statistical analysis was conducted using data obtained from reputable sources to assess the dynamics of renewable energy capacity, production volumes, and investment trends. This method facilitated a more objective understanding of the sector's development and allowed for evidence-based conclusions.

Finally, a recommendation-based (normative) approach was employed to develop practical proposals aimed at improving the efficiency and sustainability of renewable energy systems in Uzbekistan. These recommendations are grounded in both empirical findings and international experience, ensuring their relevance and applicability.

Overall, the integration of these research methods contributes to a well-rounded, scientifically grounded, and practically oriented study that addresses both theoretical and applied aspects of renewable energy development.

**4. Analysis and results.** Alternative energy is a relatively recent concept that

encompasses innovative and перспективные methods of generating thermal and electrical energy, which, although not yet universally adopted, are gaining increasing importance in the global energy landscape. The primary significance of alternative energy lies in its substantially lower environmental impact compared to conventional energy sources, particularly fossil fuels. This characteristic has become especially critical in the context of intensifying global climate change, where reducing greenhouse gas emissions and minimizing ecological degradation have become urgent international priorities.

Alternative energy is generally classified within the broader category of renewable energy sources (RES), which includes hydropower, bioenergy, solar, wind, and other sustainable energy forms. These energy sources are characterized by their ability to regenerate naturally and provide long-term solutions to energy supply challenges. However, the classification of certain types of energy—particularly bioenergy—remains a subject of academic debate. While bioenergy utilizes biological materials (biomass) as a substitute for fossil hydrocarbons in heat and power generation, some scholars argue that it should not always be fully categorized as a purely renewable or alternative energy source. This is due to factors such as resource limitations, land use concerns, and the environmental impact associated with large-scale biomass production.



Nevertheless, despite these debates, the overall role of alternative and renewable energy in modern energy systems continues to expand. Their integration into national energy strategies is increasingly viewed as a key mechanism for achieving sustainable development, enhancing energy security, and mitigating environmental risks. As a result, countries-including Uzbekistan-are actively exploring the potential of alternative energy sources as part of a broader transition toward a low-carbon and resilient energy economy.

Nuclear energy remains a complex issue from the perspective of environmental safety and long-term sustainability. While nuclear power plants provide a relatively low-carbon source of electricity, their operation generates radioactive waste that requires secure and long-term management. In addition, the potential risk of accidents poses significant threats to both the environment and human health. Historical nuclear incidents have clearly demonstrated the масштаб and severity of such risks, highlighting the long-lasting ecological, social, and economic consequences associated with nuclear disasters.

In this context, the development and expansion of alternative energy sources-such as wind, solar, geothermal, space-based, and, to some extent, bioenergy-have become increasingly important. These energy sources are considered more environmentally friendly and sustainable, as they significantly reduce

harmful emissions and minimize ecological damage compared to conventional and nuclear energy systems. Their widespread adoption is essential for ensuring a safer and cleaner energy future.

Furthermore, the global demand for electricity continues to grow steadily due to population increase, industrial expansion, and technological advancement. At the same time, environmental challenges such as air pollution and rising levels of carbon dioxide (CO<sub>2</sub>) emissions are intensifying, contributing to global climate change. In this regard, transitioning to renewable and alternative energy sources is not only an экологический necessity but also a strategic imperative for achieving sustainable development, mitigating climate risks, and ensuring long-term energy security.

Between 2014 and 2018, global electricity generation increased by approximately 11.27%, reflecting the growing demand for energy driven by economic development, industrial expansion, and population growth. The most rapid growth was observed in Asian countries, particularly in China, where electricity production rose by nearly 21% during the same period. However, this expansion in energy production has been accompanied by a significant increase in environmental pressures. Specifically, global carbon dioxide (CO<sub>2</sub>) emissions grew at an average annual rate of 3.4%, contributing to the acceleration of climate change and environmental degradation.



In this context, the Russian Federation represents a notable case. With annual CO<sub>2</sub> emissions reaching approximately 1.755 billion tons, Russia ranks among the world's largest emitters, occupying the fourth position globally. Moreover, the growth rate of emissions in Russia has, in certain periods, exceeded that of major emitters such as China, India, and the United States. Despite this, the share of renewable and alternative energy sources in Russia's overall energy mix remains relatively low. As of 2018, renewable energy accounted for only 17.2% of total energy production, while the share of alternative energy sources was as low as 0.12%.

The country's energy system continues to rely heavily on fossil fuels, including oil, natural gas, and coal, which limits the development of cleaner and more sustainable energy solutions. The insufficient level of policy support, weak incentive mechanisms, and limited investment in advanced technologies have hindered the full realization of the potential of alternative energy in Russia. Consequently, the formulation and implementation of effective state-level policies aimed at promoting renewable energy development, introducing high technologies, and improving energy efficiency have become critical priorities. Strengthening regulatory frameworks, enhancing financial incentives, and fostering innovation are essential steps toward ensuring a transition to a more sustainable and environmentally responsible energy system.

At the global level, the share of "green" capacity within the total volume of renewable energy utilization has increased significantly over the past five years, effectively doubling during this period. This rapid expansion reflects both technological progress and the growing commitment of governments and private sectors to sustainable energy solutions. In 2021, electricity generation from rooftop solar photovoltaic systems exceeded 100 GW of installed capacity worldwide, and this figure continued to rise further in 2022, indicating the increasing role of decentralized energy production in modern energy systems.

Australia provides a notable example of successful renewable energy integration at the household level. Often referred to as a "green continent," approximately one in every four households in Australia is equipped with solar panels. As a result, the country generates a substantial volume of solar energy, with total production reaching several million megawatt-hours annually. Furthermore, Australia has set ambitious targets, aiming to meet up to 77% of its domestic energy demand through solar energy by 2026. This demonstrates a strong policy commitment and effective implementation of renewable energy strategies at both national and local levels.

India also ranks among the leading countries in renewable energy development, particularly in the solar energy sector. In 2021, approximately 1.5 GW of solar capacity was installed at the



household level, reflecting the country's efforts to promote distributed energy systems. Currently, India operates more than 40 large-scale solar power plants. Among them, the Bhadla Solar Park, located in the state of Rajasthan, stands out as one of the largest solar energy facilities in the world. Covering an area of approximately 5,660 hectares and with a total installed capacity of around 2.2 GW, it represents a significant achievement in large-scale renewable energy deployment.

These international experiences highlight the growing importance of renewable energy in meeting global energy demands while reducing environmental impact. They also demonstrate that both centralized and decentralized approaches-ranging from large solar parks to household-level installations-are essential for achieving sustainable and resilient energy systems.

According to the report published by the International Energy Agency (IEA) in March 2025, the global installed capacity of renewable energy sources increased by 25% in 2024. The most notable growth was observed in the solar energy sector, where total installed capacity reached approximately 2.2 trillion kilowatts. During the same year, worldwide commissioning of solar and wind power plants added 670 gigawatts of new capacity, accounting for roughly 80% of the overall growth in electricity generation and producing an additional 660 billion kilowatt-hours of electricity. Specifically, solar power plants

contributed 480 billion kilowatt-hours, while wind power plants generated 180 billion kilowatt-hours.

Hydropower plants further supported this expansion by producing an additional 190 billion kilowatt-hours of electricity, a growth largely influenced by favorable climatic conditions, including increased rainfall and filled water reservoirs. As a result, the total gross electricity generated from alternative energy sources reached approximately 850 billion kilowatt-hours. This represents a substantial contribution to the global electricity supply, equating to nearly the annual electricity consumption of the Russian Federation, thereby illustrating both the scale and significance of the recent surge in renewable energy deployment.

These data underscore the accelerating transition toward low-carbon and sustainable energy systems worldwide, highlighting the critical role of solar, wind, and hydropower technologies in meeting rising electricity demand while simultaneously mitigating environmental impacts and contributing to global climate goals.

According to the International Energy Agency's (IEA) "Global Energy Review 2025," the global installed capacity of renewable energy sources (RES) increased by 25% in the past year, reaching approximately 700 gigawatts (GW). This represents the highest growth rate observed over the last two decades. In 2024, solar energy experienced particularly rapid expansion, with 550



GW of new capacity commissioned—a 30% increase—bringing the total global installed solar capacity to 2.2 terawatts (TW). Wind energy capacity also expanded by 120 GW during the same period.

China maintained its global leadership in renewable energy by commissioning over 340 GW of new solar photovoltaic capacity in 2024, along with an additional 80 GW of wind energy capacity. These developments highlight China's continued dominance in both solar and wind power sectors.

Furthermore, global electricity demand grew by 2.2% in 2024, significantly surpassing the average annual growth rate of 1.3% recorded between 2013 and 2023. This accelerated increase reflects a resurgence in energy consumption even among developed nations, emphasizing the rising global demand for electricity and the urgent need for expanded deployment of renewable energy technologies to meet environmental and economic sustainability objectives.

In the past year, global electricity consumption increased by 4.3%, equivalent to approximately 1,100 terawatt-hours (TWh). This surge is primarily attributed to record-high global temperatures, which intensified demand for cooling systems, alongside significant expansions in industrial production, the electrification of transport, and the rapid development of data centers and artificial intelligence (AI) infrastructure.

The remaining 62% of global electricity demand was met through conventional energy sources, distributed as follows: natural gas accounted for 28%, coal 15%, oil 11%, and nuclear power 8%. Despite the substantial growth in renewable energy capacity, solar and wind power still represent a relatively modest share of the overall energy mix. Their utilization for heating purposes remains technically challenging and economically less efficient, limiting their immediate applicability in certain sectors of global energy consumption [2].

In 2024, clean energy sources, including renewable energy, accounted for 40.9% of global electricity generation, surpassing the 40% threshold for the first time in history. Notably, the combined share of wind (8.1%) and solar (6.9%) energy exceeded that produced by hydropower plants (14.3%) (Ember Climate and Energy Analytics Center, 2024). This milestone underscores the rapid deployment of variable renewable energy technologies and highlights a structural shift in the global energy mix toward low-carbon sources.

China continues to dominate the global installation of solar and wind capacities, representing 64% of the total newly installed capacity worldwide. According to the Global Energy Monitor as of July 2024, China added 180 GW of new solar power capacity and 159 GW of new wind capacity, resulting in a cumulative total of 339 GW—nearly twice the combined capacity of all other countries. China has committed to



stabilizing or reducing greenhouse gas emissions by 2030 and achieving carbon neutrality by 2060, demonstrating a strong policy framework supporting large-scale renewable energy deployment.

Following China, the United States leads with 40 GW of newly installed capacity, while Brazil, the United Kingdom, and Spain account for 13 GW, 10 GW, and 9 GW, respectively. These developments reflect a globally distributed effort to expand renewable energy infrastructure, although the scale and pace of deployment remain uneven across different regions, influenced by national policies, financial incentives, and technological capabilities [3].

Despite the significant expansion of renewable energy capacities, China still relies heavily on coal-fired power plants to meet its electricity demand, which continues to exert substantial negative impacts on the environment. Integrating electricity generated from variable renewable sources and transporting it over long distances to economic centers presents considerable technical and logistical challenges. In April 2024, Denmark's Hyme Energy launched the Molten Salt Storage (MOSS) platform, a technological innovation that enables more efficient storage and distribution of renewable energy, addressing some of these integration challenges.

Developed countries have increasingly adopted energy efficiency as a strategic priority within their science and technology agendas. Investment in energy and environmental research and

development, as well as experimental and engineering projects, represents approximately 4.5% of total expenditures, while environmental protection budgets account for 1.7% (OECD, 2015). These figures illustrate the prioritization of sustainable energy development and the integration of scientific innovation into national energy strategies.

In Uzbekistan, the electricity sector remains heavily dependent on thermal power plants, which generate approximately 88.7% of total electricity production, primarily using natural gas and oil. With electricity demand projected to reach 107 billion kWh by 2030, this reliance significantly increases the risk of rapid depletion of domestic fossil fuel resources. Consequently, there is a pressing need to diversify the national energy mix, enhance renewable energy deployment, and implement innovative storage and distribution technologies to ensure energy security and environmental sustainability.

Energy efficiency and conservation have become increasingly critical issues for rapidly developing countries, including Uzbekistan. As the national economy and infrastructure undergo modernization and the population continues to grow, electricity demand is rising substantially, exerting additional pressure on natural resources and the environment. In 2023, per capita electricity consumption in Uzbekistan increased by 1.2 times compared to 2016, reflecting the growing energy needs of households and industry alike.



Addressing high energy consumption cannot rely solely on the introduction of energy-efficient technologies or clean energy sources; rather, energy conservation represents a collective responsibility for society as a whole. In this context, fostering a culture of rational energy use, particularly among youth and students, and promoting habits of energy saving are crucial components in building a sustainable and environmentally healthy society. Encouraging such behavioral and educational interventions complements technological measures, ensuring that economic growth does not come at the expense of environmental integrity and energy security [1].

In our view, the development of green energy in Uzbekistan plays a pivotal role in strengthening ecological sustainability, energy independence, and economic security. The country has implemented various incentives and subsidy schemes to promote the adoption and expansion of renewable energy sources. As a result of these measures, the use of solar, wind, and other renewable energy forms has been steadily increasing across the nation.

However, the energy sector in Uzbekistan has not yet achieved a fully market-based mechanism. Electricity and natural gas prices remain largely regulated by the state, and the liberalization of the energy market has progressed only partially. At present, the average price for one kilowatt-hour (kWh) of electricity supplied to

households is approximately 295 Uzbek soums, while its actual production cost is around 970 soums. Similarly, one cubic meter of natural gas is sold to the population at 380 soums, whereas its true cost is approximately 1,890 soums.

To cover this substantial price gap, the government allocates over 14 trillion soums annually from the national budget, equivalent to approximately USD 1.15 billion, as subsidies. While these subsidies make energy resources more affordable for consumers, they impose long-term limitations on the financial sustainability of the energy sector. This situation reflects the state's policy aimed at reducing energy costs for the population; however, it also highlights the urgent need to enhance competition within the energy market and further advance price liberalization.

Between January and June 2025, the "Solar Household" program in the Republic of Uzbekistan witnessed substantial uptake among individual users, which led to a significant increase in the volume of subsidies provided. During this period, a total of 28,538 users benefited from the program, with June alone accounting for 26,225 participants.

At the same time, the total number of subsidies disbursed reached 93,900, which was notably higher than the June figure of 26,500. The total subsidy amount for the January-June period amounted to 63,498 million Uzbek soums, representing a considerable increase compared to the 22,804 million soums recorded in June alone.



Regionally, the largest subsidies were allocated in Khorezm Province (19,151 million soums), the Republic of Karakalpakstan (9,673 million soums), Bukhara (5,118 million soums), Tashkent city (4,947 million soums), and Tashkent Province (3,703 million soums). The lowest subsidies were recorded in Surkhandarya (918 million soums) and Andijan (870 million soums) provinces.

These data demonstrate the wide geographical coverage of the “Solar Household” program and illustrate the effectiveness of Uzbekistan’s financial support system in promoting the adoption of renewable energy among households. By facilitating access to solar energy solutions, the program not only encourages sustainable energy consumption but also provides tangible economic benefits to the population across the country.

State subsidies for energy resources are not only of economic significance but also carry important social and environmental implications. Ensuring the stable supply of electricity and natural gas to the population is a fundamental responsibility of the government. However, questions regarding the efficiency and equity of the subsidy system remain: are the allocated funds being used for their intended purposes, are they distributed fairly across all social groups, and do they promote the rational use of natural resources? According to Article 68 of the Constitution of the Republic of Uzbekistan, land, subsoil resources, water, flora and fauna, and

other natural resources are considered national wealth and must be protected by the state while being utilized efficiently. From this perspective, subsidies should not only facilitate energy provision but also contribute to the conservation and sustainable management of natural resources.

Between 2016 and 2024, per capita electricity consumption in Uzbekistan gradually increased, reflecting the growing economy and improving living standards. During this period, the average consumption rose from 1,414.8 kWh to 1,779.6 kWh per person, representing an increase of over 25%. In 2018, electricity consumption experienced a sharp rise, followed by a slight decline in 2019-2020, but stable growth resumed from 2021 onwards. By 2024, nationwide electricity consumption had increased by 364.8 kWh per capita compared to 2016 levels. This trend is associated with the expansion of electricity generation capacities, the growing utilization of renewable energy sources, and the increasing prevalence of household appliances among the population.

The observed increase in electricity consumption highlights both the growing energy demand of the population and the need for sustainable energy policies that balance economic growth with environmental protection and resource efficiency. Effective subsidy mechanisms, coupled with the promotion of renewable energy adoption, are therefore essential to ensuring equitable access to energy, optimizing resource



utilization, and advancing the country's long-term energy sustainability goals.

A regional breakdown of electricity consumption in Uzbekistan indicates that Navoi Region consistently exhibited the highest consumption levels across all years, primarily due to the presence of large-scale industrial enterprises operating in the area. Tashkent city also maintained high consumption rates, which can be attributed to dense population settlements, as well as the extensive development of manufacturing, service sectors, and urban infrastructure. Similarly, Bukhara, Kashkadarya, Namangan, and Sirdaryo regions demonstrated a stable increase in electricity consumption, reflecting the expansion of industrial activity, infrastructure development, and growth in social services within these regions.

In contrast, the Republic of Karakalpakstan experienced a sharp increase in consumption in 2018, followed by a decline in subsequent years. This fluctuation may be linked to challenges in energy supply or economic factors that led to reduced consumption. Regions such as Samarkand, Surkhandarya, and Khorezm, while displaying relatively lower per capita consumption, nevertheless demonstrated an overall upward trend, indicating gradual economic and social development.

Between 2016 and 2024, the growth in per capita electricity consumption across Uzbekistan mirrors rising economic activity, increased production

volumes, higher household incomes, improved living standards, and the effectiveness of reforms in the national energy system. Simultaneously, the introduction of energy-efficient technologies and renewable energy sources is essential to ensure rational resource utilization while meeting the population's growing energy demands. Such measures not only enhance living standards but also strengthen ecological sustainability and national energy security.

An analysis of electricity consumption distribution highlights a significant inequality in energy usage: approximately 75% of the population consumes only 26% of total electricity, whereas the remaining 25% of the population accounts for more than 74% of consumption. These statistics underscore the uneven allocation of energy resources and the critical importance of tiered pricing mechanisms implemented by the government to address inequities and encourage rational consumption.

However, the root cause of the issue lies beyond simple subsidy allocation. Households with insufficient natural gas supply naturally tend to consume higher amounts of electricity, as electricity often substitutes for gas-based heating and cooking. Therefore, the most effective solution, drawing upon international best practices, involves liberalizing the energy market, establishing electricity tariffs based on market principles, and providing targeted support to low-income and under-served population groups.



**5. Conclusions and recommendations.** Research conducted as part of this study indicates that in 2025, the average price of electricity in Germany ranged between 35 and 39 euro cents per kilowatt-hour (kWh), making it one of the most expensive countries for electricity consumption globally. Despite these high prices, Germany exemplifies effective mechanisms for promoting energy-efficient consumption, emphasizing market-based approaches to optimize electricity use across both residential and industrial sectors. These mechanisms include dynamic pricing, incentives for energy-saving technologies, and educational initiatives to encourage rational energy consumption.

In Germany, although electricity prices rank among the highest worldwide, there exist practical measures to mitigate the financial burden on consumers. These measures include subsidies for vulnerable households, time-of-use tariffs to shift consumption to off-peak hours, and support for decentralized renewable energy generation, such as rooftop solar installations. The German experience demonstrates that market liberalization, combined with targeted assistance and energy efficiency incentives, can significantly reduce unnecessary energy consumption while ensuring affordability and fairness.

Firstly, in Germany, each consumer has the right to independently choose their electricity provider. If a household has maintained a long-term contract with

a single supplier, it is possible that the consumer is paying higher tariffs than necessary. By switching to a different provider, the average household can save up to approximately €850 per year. The new supplier automatically terminates the existing contract, making the process convenient and free from bureaucratic obstacles.

Secondly, selecting the appropriate tariff is of critical importance. The German electricity market offers over 14,000 different tariff options, allowing each consumer to choose a plan that best matches their specific consumption needs. Factors such as the price per kilowatt-hour, whether the tariff is fixed or variable, and promotional bonuses for new customers should be carefully considered when making a selection.

Thirdly, achieving energy efficiency should not be limited solely to changing tariffs. Rational electricity use within households and industrial processes is equally important. Recommended measures include utilizing appliances rated with the A+++ energy efficiency class, unplugging devices that are not in use, and installing “smart” energy management systems. These practices collectively enhance energy savings, reduce unnecessary consumption, and contribute to both economic and environmental sustainability.

The experience of Germany demonstrates that organizing the electricity market based on competition, ensuring free choice among suppliers, and enhancing public knowledge on energy



efficiency can significantly reduce overall energy consumption. This example holds important scientific and practical implications for Uzbekistan, particularly in improving energy efficiency among both households and industrial sectors.

In recent years, Uzbekistan has implemented systematic reforms to promote renewable energy sources (RES) and integrate them across various economic sectors. The legislative framework has introduced a series of incentives and benefits for producers, investors, and consumers. For instance: manufacturers of renewable energy equipment are granted tax exemptions for five years; entities installing solar, wind, or other systems with a nominal capacity of 0.1 MW or more receive ten-year exemptions from property and land taxes; and households not connected to centralized grids are exempt from land taxes for three years.

Starting January 1, 2018, new requirements were established to ensure rational energy use: state institutions, industrial enterprises, and multi-apartment residential buildings are mandated to employ energy-saving technologies during design, construction, or renovation. Additionally, solar water heaters with certification and energy-efficient lighting systems are required in hot water supply systems.

In the same year, practical steps toward the development of green energy were taken. During the President of Uzbekistan's visit to France, an agreement was signed with Total Eren SA

to construct a 100 MW solar power plant in Samarkand, resulting in the establishment of Tutly Solar LLC with foreign investment. The electricity generated is guaranteed to be purchased by Uzbekistan National Electric Grid Joint Stock Company (NEGU JSC), ensuring stable market integration and promoting renewable energy adoption.

Considering Uzbekistan's climatic conditions, it is essential to expand the use of solar, wind, and hydropower resources across industrial, agricultural, municipal, and residential sectors. Effective economic mechanisms to promote this include: partial or full government coverage of connection costs to renewable energy systems; provision of state guarantees for renewable energy projects; implementation of a "green certification" system; establishment of stable tariffs for renewable energy sources; restrictions on the import of high-energy-consuming equipment; and development of credit systems for low-energy consumption technologies.

In addition, attention is being given to developing skills and competencies in energy saving and efficient energy use among both legal entities and individual consumers. Collectively, these measures serve to promote the development of green energy in Uzbekistan, enhance energy efficiency, and create a favorable environment for attracting foreign investment.