

**PROBLEMS OF THE WORLD ENERGY MARKET AND SUSTAINABLE
DEVELOPMENT**

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Abstract. This article analyzes the formation of the global energy market, its development trends, and its interconnection with global sustainable development processes. At present, the growing demand for energy resources, geopolitical factors, climate change, and environmental issues are accelerating the transformation of the energy sector.

The study examines the balance between traditional and renewable energy sources, energy security, decarbonization processes, and changes within the framework of the "green economy" concept. It also evaluates the imbalances emerging in the global energy market, including uneven resource distribution, price volatility, and shifts in investment processes, from the perspective of their impact on sustainable development goals.

The research findings contribute to the development of scientific and practical conclusions aimed at improving energy policy, increasing energy efficiency, and ensuring environmental safety.

Introduction.

The sustainable functioning of the world economic system in the 21st century is directly related to the level of development of the energy sector. Energy resources are one of the main factors of the production process, ensuring the uninterrupted operation of industry, transport, agriculture and services. Therefore, the world energy market is of particular importance as a strategic segment of the global economic system.

In recent years, the energy market has been undergoing fundamental structural changes. On the one hand, population growth and economic growth are sharply increasing energy consumption, and on the other hand, climate change, environmental pollution and limited natural resources require a reconsideration of the use of traditional energy sources. In particular, the increase in carbon emissions has exacerbated the problem of global warming and made it necessary to introduce new, environmentally friendly models of energy production and consumption.

Today, the concept of sustainable development is recognized as a priority area at the international level. The energy sector is one of the central links of this concept, since the harmony between economic growth, social well-being and ecological balance depends on energy policy. From this point of view, the development of renewable energy sources, increasing energy efficiency, introducing innovative technologies and expanding the volume of "green" investments are becoming the main transformational directions of the global energy market. However, there are a number of problems in the global energy market. These include the uneven geographical distribution of energy resources, geopolitical tensions, volatility of energy prices,

lack of infrastructure and energy supply problems in developing countries. These factors complicate the process of achieving sustainable development goals and require improving energy policy based on an integrated approach. Therefore, the purpose of this article is to analyze the current state and development trends of the global energy market and identify the main problems associated with sustainable development. The research systematically examines global changes in the energy market, the increase in the share of renewable energy, decarbonization policies, and energy security.

Literature review. The issue of the global energy market and sustainable development issues has been widely studied in the fields of energy economics, environmental policy, and international economics. One of the fundamental scientific foundations in this area is the World Energy Outlook reports regularly published by the International Energy Agency (IEA)¹. These reports analyze the dynamics of global energy demand, changes in the fuel mix, energy security and investment flows based on in-depth economic modeling. According to IEA forecasts, decarbonization of energy systems is a key factor in achieving sustainable development goals, and the share of renewable energy should increase sharply by 2050. The inextricable link between sustainable development and energy also occupies a special place in the framework of the Sustainable Development Goals (SDGs) developed by the United Nations. In particular, Goal 7 — “Affordable and Clean Energy” — provides for increasing energy efficiency and increasing the share of clean energy. The joint reports published by the World Bank and the International Renewable Energy Agency (IRENA) assess the volume of investments in energy infrastructure, universal access to electricity and the development of renewable sources based on statistical data². According to the study, inadequate energy infrastructure in developing countries is one of the main factors slowing down the process of sustainable development. Another scientific source that has deeply analyzed the link between the energy sector and climate change is the assessment reports of the Intergovernmental Panel on Climate Change (IPCC)³. According to the IPCC scientific conclusions, the energy sector accounts for a large share of global greenhouse gas emissions. Therefore, the transition to a low-carbon economy, increasing energy efficiency and introducing green technologies are considered the main conditions for environmental sustainability.

Theoretically, the issue of the relationship between energy and economic growth has been studied by many scientists based on empirical studies. In particular, Stern (2004) analyzed the cointegration relationship between energy consumption and GDP, proving that energy is an important determinant of economic growth. Also, a panel data analysis conducted by Apergis and Payne (2010) showed that there is a long-term positive relationship between renewable energy consumption and economic growth⁴.

The issue of energy market transformation and energy transition processes is studied in the works of Vaclav Smil based on a historical-economic approach [Smil, V. (2017). *Energy and Civilization: A History*. The MIT Press.]. He emphasizes that the transformation of energy

¹ International Energy Agency. (2025). *World Energy Outlook 2025*. International Energy Agency. <https://www.iea.org/reports/world-energy-outlook-2025>

² International Energy Agency, International Renewable Energy Agency, United Nations Statistics Division, World Bank, & World Health Organization. (2025). *Tracking SDG7: The Energy Progress Report, 2025*. International Energy Agency. <https://www.iea.org/reports/tracking-sdg7-the-energy-progress-report-2025>

³ Intergovernmental Panel on Climate Change. (2011). *Special Report on Renewable Energy Sources and Climate Change Mitigation*. Cambridge University Press.

⁴ Apergis, N., & Payne, J. E. (2010). Renewable energy consumption and economic growth: Evidence from a panel of OECD countries. *Energy Policy*, 38(1), 656–660. <https://doi.org/10.1016/j.enpol.2009.09.002>

systems is a long-term and capital-intensive process, and that technological innovations and institutional factors play a decisive role in this process.

In recent years, the issue of the green economy and the effectiveness of energy investments has also been at the center of scientific research. In the report on climate economics prepared by Nicholas Stern, it is proven based on scientific modeling that failure to take measures to combat climate change will lead to significantly higher economic losses in the future [Stern, N. (2007). *The Economics of Climate Change: The Stern Review*. Cambridge University Press.]. The author points to the modernization of energy systems and the promotion of green investments as a key factor in long-term economic sustainability.

The literature review shows that the global energy market and sustainable development is a multifaceted scientific problem, encompassing energy economics, environmental policy, investment strategies, and global governance mechanisms. While existing research has broadly covered global trends, the issues of adapting energy policies, improving energy efficiency, and improving investment mechanisms within individual regions and developing countries require more in-depth empirical analysis.

Analysis and discussion of results.

Based on the content of this topic, the research methodology was focused on a comprehensive analysis of the processes of innovative development of industrial enterprises and the introduction of digital technologies. The research process used a combination of theoretical and practical methods. First of all, an analysis of scientific literature was carried out. Also, scientific articles, monographs and official statistical data on economic development, sustainable growth and investment efficiency were analyzed.

The research used methods of analysis and synthesis, comparison, statistical grouping, and assessment of the dynamics of economic indicators. In the practical part, the level of efficiency was assessed based on the financial and innovative indicators of industrial enterprises, existing problems were identified and their cause-and-effect relationships were studied. Also, based on a systematic approach, mechanisms for managing innovative activities were considered and economic and logical conclusions were drawn. Based on the research results, practical recommendations were developed for improving the innovation strategy and widespread introduction of digital technologies in enterprises.

Analysis and results.

The analysis shows that in recent years the global energy market has undergone a significant transformation. Global economic growth, population growth and industrial expansion are sharply increasing the demand for energy services. At the same time, electricity is becoming the mainstay of the global energy system. Along with the increase in energy consumption, energy generation systems are also being modernized through new technologies, renewable energy sources and digital control systems. However, this process also raises a number of challenges from the perspective of sustainable development.

One of the important results in the energy market is that global energy-related carbon dioxide (CO₂) emissions have increased by more than 50 percent since 2000. This indicates a direct relationship between economic development and energy consumption. At the same time, there is a rapid development of renewable energy technologies. In particular, solar and wind energy have begun to occupy a leading position in the structure of new electricity generation capacities in recent years. The growth in sales of electric vehicles is also changing the structure of energy consumption, creating the basis for a long-term decrease in oil demand.

One of the factors playing an important role in the development of the energy system is the increase in the share of developing countries in the energy market. In particular, Asia and other emerging economies are becoming the main drivers of energy consumption growth.

Industrialization, urbanization and infrastructure development in these countries are causing an increase in energy demand. As a result, the geographical structure of the global energy market is also changing. At the same time, one of the important problems hindering the development of sustainable energy is the issue of energy security. Geopolitical tensions, trade restrictions and technological competition in recent years have negatively affected the stability of energy supply. Energy security is now not limited to fuel resources, but also depends on electricity infrastructure, technological supply chains and important mineral resources.

Strategic minerals, which are essential for the production of energy technologies, are playing a key role in the global energy transition. Technologies such as batteries, electric vehicles, solar panels and wind turbines rely on these minerals. However, the production and processing of these resources is highly concentrated in a few countries. For example, of the 20 strategic minerals required for energy technologies, one country leads the processing of 19, with an average share of 70 percent. This creates a high level of risk in global supply chains.

Forecast of global electricity production (TWh)

1-table⁵

Area	2010	2023	2024	2035 (forecast)	2050 (forecast)
World	18 494	26 179	27 290	37 819	50 667
Northern America	4 632	4 883	4 998	5 910	6 841
USA	3 880	4 007	4 102	4 854	5 472
Central and South America	924	1 178	1 221	1 645	2 404
Europe	3 559	3 419	3 487	4 560	5 950

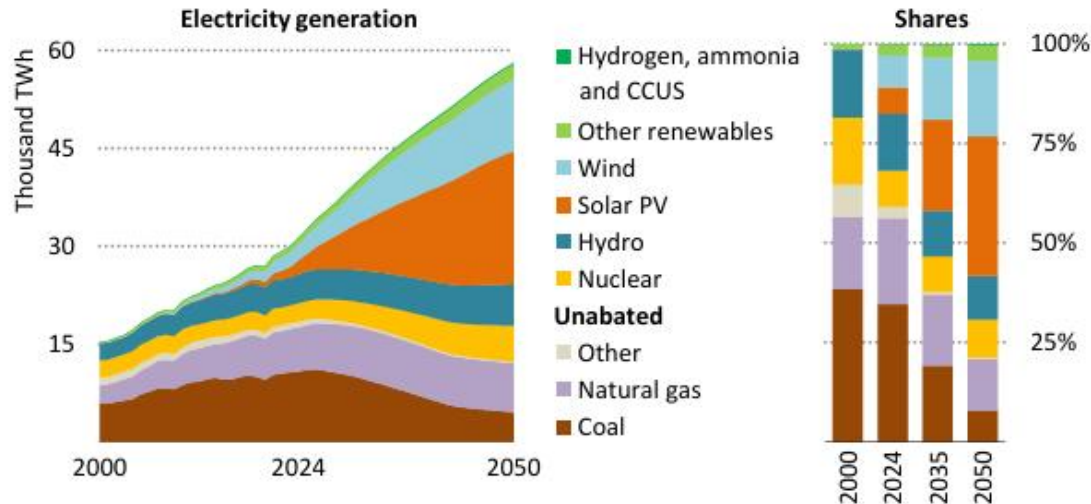
The table shows that global electricity production has been increasing significantly in recent decades. In 2010, global electricity production was 18,494 TWh, and by 2024, this figure had reached 27,290 TWh. According to forecasts, this volume is expected to reach 37,819 TWh in 2035 and 50,667 TWh in 2050. This indicates a rapid growth in electricity consumption.

The increase in demand for electricity is primarily due to economic development, urbanization and the expansion of digital technologies. In particular, the expansion of industrial production, population growth, and the development of transport and services in developing countries are leading to an increase in energy consumption.

When analyzed by region, electricity generation is also showing an upward trend in almost all regions. For example, in North America, the figure of 4,632 TWh in 2010 is projected to reach 5,910 TWh in 2035. Electricity generation in European countries is also expected to increase and is expected to reach almost 6,000 TWh in 2050. This process indicates that the global energy system is increasingly electrified.

⁵ IEA, World Energy Outlook 2025.

**Global electricity generation by source (2000–2050)
1-figure⁶**



The graph depicts how the composition of electricity generation has changed over time. According to the graph, a significant transformation is taking place in the global energy system.

According to the graph, in 2024, the share of fossil fuels in electricity generation will be approximately 60 percent. However, as a result of the transformation of the energy system, this figure is projected to fall to below 40 percent in 2035 and to be around 20 percent by 2050. The main reason for this is the rapid development of renewable energy sources. Currently, about a third of global electricity generation comes from renewable energy sources. This figure is expected to exceed 50 percent by 2035 and reach more than 66 percent by 2050. In particular, solar and wind energy are the fastest growing energy sources. Their combined share is projected to increase from the current 15 percent to 40 percent in 2035 and to 55 percent in 2050. At the same time, nuclear power will continue to play an important role in the energy system, accounting for about 10 percent of total electricity generation. This process demonstrates the growing importance of sustainable development principles in the energy sector. The expansion of renewable energy sources not only ensures energy security, but also reduces greenhouse gas emissions. Therefore, many countries are directing their energy policies towards decarbonization and the development of green energy technologies.

Analysis shows that high concentration in the mineral resource market can lead to disruptions in production processes. For example, resources supplied by countries other than the main producer country can cover only about half of the total demand. This indicates the weakness of supply chains and the high dependence of the global energy system on external factors. In such conditions, disruptions in the supply of mineral resources can have a significant impact on industrial production, technological development and the competitiveness of national economies. The concentration of energy technology production in geographically limited areas is also a significant problem for sustainable development. For example, more than 80 percent of solar panel production capacity is accounted for by one country, and more than 85 percent of the battery production chain is located in this region. Such high concentration creates conditions close to monopoly in the global energy market, increasing the risk of price volatility and instability in supply.

⁶ IEA, World Energy Outlook 2025.

Another important problem of the energy system is the risks associated with climate change. The energy sector remains the main source of global greenhouse gas emissions. According to current development trends, the increase in global temperatures can reach 2.5–3 °C. This poses a serious threat to the ecological balance, food security and human health. Therefore, decarbonization of the energy system, increasing energy efficiency and widespread introduction of renewable energy sources are becoming a priority of global policy.

In general, the analysis shows that the global energy market is in a complex and multifaceted transformation. On the one hand, new technologies and renewable energy sources are creating great opportunities for sustainable development. On the other hand, energy security, strategic resource supply, geopolitical risks and climate change remain major obstacles to ensuring the sustainable development of the global energy system. Therefore, future energy policy should focus on ensuring a balance between energy security, economic efficiency and environmental sustainability.

Conclusions and recommendations.

The results of the study show that the global energy market is currently undergoing profound changes. The growth of the world economy, the expansion of industrial production and population growth are significantly increasing the demand for energy resources. At the same time, climate change, environmental problems and energy security issues require a fundamental rethinking of energy system development strategies. The study showed that there is a strong correlation between energy consumption and economic development, which will lead to further electrification of the global energy system. The fact that electricity production is expected to increase sharply in the coming decades indicates the need to modernize the energy infrastructure.

The analysis showed that increasing the share of renewable energy sources in the energy sector is an important factor in achieving global sustainable development goals. In particular, solar and wind energy are the fastest growing energy sources, which are increasingly taking up a large share in the structure of electricity generation. This process accelerates the decarbonization of the energy system and serves to reduce greenhouse gas emissions. At the same time, the transformation of the energy system is sharply increasing the demand for strategic mineral resources. The high geographical concentration of the supply of these resources creates new economic and geopolitical risks in the global energy market. The results of the study also show that the issue of energy security is gaining increasing importance in modern energy policy. Energy security is directly related not only to the level of fuel resources, but also to the development of energy infrastructure, technological supply chains and innovative technologies. Therefore, ensuring a balance between economic efficiency, environmental sustainability and energy security is an important task in the development of the energy system.

Based on the results of this study, the following scientific and practical proposals can be put forward. First of all, to ensure the sustainable development of the energy system, it is necessary to increase investments in renewable energy sources. This will not only reduce environmental problems, but also ensure long-term energy security. Secondly, it is important to widely introduce innovative technologies to increase energy efficiency. Energy-saving technologies reduce production costs and increase economic efficiency.

At the same time, in order to ensure the stability of global energy supply chains, it is necessary to diversify the production and processing of strategic mineral resources. This will help reduce the dependence of the global energy system on external factors. Fourth, the modernization of energy infrastructure and the introduction of digital technologies play an important role in increasing the efficiency of the energy system. Digital control systems allow

optimizing the processes of energy production, transmission and consumption. Strengthening international cooperation in the development of energy policy is also important. Global energy problems, in particular climate change, energy security and resource allocation, can only be effectively resolved on the basis of international cooperation. Therefore, the development of technological exchange between countries, the implementation of joint investment projects and support for green energy initiatives are important factors in the formation of a sustainable energy system.

In general, the global energy market will remain one of the main factors of economic development in the coming decades. To ensure the sustainable development of the energy system, it is necessary to implement comprehensive strategies aimed at increasing energy efficiency, developing renewable energy sources and ensuring environmental safety. This will contribute to the sustainable development of the global economy and maintaining ecological balance for future generations.

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