ENERGY SECURITY

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ENERGY SECURITY: NEW CHALLENGES AND GLOBAL TRENDS

In the conditions of a permanent world energy crisis and its strengthening against the background of full-scale aggression of russia in Ukraine, questions regarding risks to national energy security come to the fore in the world. At the same time, the world is undergoing the fourth energy transition, which requires the development of a new concept of energy security by countries that are both suppliers of energy resources and their consumers. The aim of the research is to develop the conceptual principles of energy security, taking into account modern challenges caused by simultaneously growing crises in energy, economy and geopolitics. The creation of such a basis makes it possible to identify a number of solutions for neutralizing new threats that arise, in particular, in the context of the "green" transition. The research was conducted using the methods of scientific abstraction and systematization, analysis and synthesis, generalization, comparison. Conceptual features of energy security management in conditions of radically changed context, strengthening of crisis phenomena and threats of

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ЕНЕРГЕТИЧНА БЕЗПЕКА: НОВІ ВИКЛИКИ ТА СВІТОВІ ТРЕНДИ

В умовах перманентної світової енергетичної кризи та її посилення на тлі повномасштабної агресії росії в Україні на перший план у світі виходять питання щодо ризиків для національної енергетичної безпеки. Водночас у світі триває четвертий енергетичний перехід, що потребує вибудовування нової концепції енергетичної безпеки країнами, які є як постачальниками енергетичних ресурсів, так і їх споживачами. Метою статті є розроблення концептуальних засад енергетичної безпеки з урахуванням сучасних викликів, зумовлених одночасно наростаючими кризами в енергетиці, економіці та геополітиці. Створення такої основи дає змогу визначити низку рішень для нейтралізації нових загроз, які виникають, зокрема, у контексті "зеленого" переходу. Дослідження проведено з використанням методів наукового абстрагування та систематизації, аналізу та синтезу, узагальнення, порівняння. Представлено концептуальні особливості управління енергетичною безпекою в умовах радикально зміненого контексту, посилення кризових явищ і загроз різного характеру. Підтверджено

various natures are presented. The hypothesis that energy security is a complex category that expresses the ability of the fuel and energy complex of the region to supply the domestic market with the necessary volume and range of energy resources at stable and acceptable prices, to quickly mitigate unexpected fluctuations in demand for fuel and energy resources and to ensure uninterrupted energy supply and energy carrier parameters in real time. Based on the analysis of scientific publications and practical models of energy security, theoretical provisions, methodological principles and energy security management tools that meet modern requirements have been developed. In particular, the key global trends of changes in the energy markets are defined, the types and forms of modern energy threats and risks are outlined. It outlines the impact of the "green" transition that many countries have undertaken and confirmed at the UN Climate Change Conference (COP28), emphasizing further energy security, taking into account both the reduction of dependence on fossil fuels and the new challenges associated with renewable energy sources. The results of the research are of practical interest during the development of energy policy, plans and specific actions aimed at ensuring energy security in a turbulent global environment.

Keywords: energy security, gas, oil, electricity, nuclear energy, renewable energy sources, energy transition, European integration.

гіпотезу, що енергетична безпека є комплексною категорією, яка виражає здатність паливно-енергетичного комплексу регіону постачати на внутрішній ринок необхідний обсяг і номенклатуру енергоресурсів за стабільними та прийнятними цінами, оперативно пом'якшувати несподівані коливання попиту на паливно-енергетичні ресурси та забезпечити безперебійне енергопостачання і параметри енергоносія в режимі реального часу. На основі аналізу наукових публікацій та практичних моделей енергетичної безпеки розроблено теоретичні положення, методологічні засади і засоби управління енергетичною безпекою, що відповідають сучасним вимогам. Зокрема, визначено ключові глобальні тренди змін на енергетичних ринках, окреслено види та форми сучасних енергетичних загроз і ризиків. Встановлено напрями впливу "зеленого" переходу, який багато країн взяли на себе та підтвердили на конференції ООН зі зміни клімату (COP28), наголошуючи на подальшій енергетичній безпеці, враховуючи як зменшення залежності від викопного палива, так і нові виклики, пов'язані з відновлюваними джерелами енергії. Результати дослідження становлять практичний інтерес під час розроблення енергетичної політики, планів і конкретних дій, спрямованих на забезпечення енергетичної безпеки в турбулентному глобальному середовищі.

Ключові слова: енергетична безпека, газ, нафта, електроенергія, атомна енергія, відновлювальні джерела енергії, енергетичний перехід, євроінтеграція.

JEL Classification: F42, H56, L71, L94, L95, Q 41, Q 48.

Introduction

The ongoing energy crisis amid russia's invasion of Ukraine has highlighted countries' longstanding vulnerability to fossil fuel dependence and reignited global concerns about national energy security. As defined by the International Energy Agency (IEA), energy security is the uninterrupted availability of energy sources at an affordable price (IEA, n. d. *a*). Despite the importance of other aspects of energy security, it is urgent to pay attention to the constant availability of energy supply. In such a context, the key factors of energy security – diversification of supply and political risk of suppliers – come to the fore to understand the historical evolution of energy security and differences between countries.

In addition, the fourth energy transition (ET) is underway in various countries around the world, which largely determines the current sectoral and inter-sectoral context. According to the inventor of this term, the Czech-Canadian scientist V. Smil, the fourth ET is a global transformation of the

world's energy supply systems, aimed at achieving carbon neutrality in all spheres of human activity (Smil, 2010). For the first time, environmental goals (rather than economic or technological ones) gain significant importance in energy supply, and deposits of oil, gas and coal are declared "undesirable" and even dangerous due to their harmful effects on the climate and the environment.

The new ET is distinguished by a wide scale of innovative tasks and a relatively short time for their solution (within 30 years). At the same time, the accelerated and widespread introduction of solar, wind and hydrogen energy technologies, which are considered the main energy carriers in the USA and European countries, requires the creation of an appropriate scientific and technical base, the definition of requirements for logistics, the system and the reconfiguration of energy markets (IEA, 2019*a*; Wolf & Zander, 2021). However, excessive attention to renewable energy sources leads to uncontrollable price volatility; the emergence of investment problems (Moriarty & Honnery, 2022) and, as a result, a sharp decrease in the level of energy security of the region. Thus, the destabilization of primary (natural) energy flows can lead to a decrease in the utilization factor of the installed capacity of wind power plants (WEPs) to economically unacceptable values, which calls into question the further operation of the entire complex of WEPs in the territory. Taking into account plans to decommission coal and nuclear power plants, the problem of stability of energy supply, especially in power systems with uneven load, is sharply aggravated.

This leads to a number of new challenges, the study of which is important for the development of appropriate solutions in the field of energy security. And therefore, the main leading motive of ET, the decarbonization of the global energy industry "by all means", needs to be carefully checked, first of all from the standpoint of new threats to energy security.

Ukraine is both a supplier and a consumer of energy, moving in line with European and world trends in the field of energy. Therefore, the state and its energy policy face new and new challenges, which are complicated by the war and the constant destruction of the energy infrastructure.

The results of the analysis of modern scientific research and publications by domestic authors have shown significant attention to the urgent challenges of global energy and the energy sector of Ukraine during the war.

In the research of O. Sukhodolya and co-authors, the methodological principles of the formation of the energy security risk management system were highlighted, and the processes of determining the current level of energy security of Ukraine were formalized with the help of a mathematical model (Sukhodolya et al., 2023). However, the proposed system of indicators does not take into account global trends and reformatting of the global energy system, in the context of which Ukraine has already begun its own energy transition.

Current trends in the development of world energy and energy security of Ukraine are considered in the article by S. Kogut, in which the author, based on the analysis of current trends in the development of world energy and the structural transformation of the global energy market, draws a conclusion about reformatting the national energy policy, which requires the development of new tools for ensuring energy security and search for the optimal configuration of the energy system at the stage of the energy transition (Kogut, 2023).

In the work of A. Ilyenko, threats to the energy security of the state in the pre-war period were outlined and a tendency to their gradual neutralization was revealed by reducing natural gas imports and diversifying supplies (Ilyenko, 2019).

However, despite a significant amount of thorough scientific and scientific-practical domestic research in this field, a number of unresolved issues remain, in particular, regarding the influence of global trends in the energy policy of states and the identification of threats that arise, taking into account both the reduction of dependence on fossil fuels and new challenges, related to renewable energy sources.

The aim of the article is to develop the conceptual principles of energy security, taking into account modern challenges caused by simultaneously growing crises in energy, economy and geopolitics. The creation of such a basis makes it possible to determine a number of solutions for neutralizing new threats that arise, including in the ET context.

The research presented in the article is based on the hypothesis of the need to strengthen the energy security of Ukraine in connection with the emergence of new challenges in this area, associated with the new global energy transition, geopolitical changes in the world and the transformation of climate policy, as well as the integration of Ukraine into the new global the concept of the energy market.

The article is based on a methodology that includes a review of scientific literature, analysis and systematization of existing theoretical ideas about energy security, analytical reports of global structures and institutions (OSCE, International Energy Agency, UN European Energy Commission, International Renewable Energy Agency), as well as international consulting groups Deloitte (London, Great Britain), Accenture (Dublin, Ireland), McKinsey & Company (New York, USA). Methods of scientific abstraction, generalization, and comparison were used.

In practical terms, the results of the research can be used during the development of national energy policy, plans and specific actions to ensure energy security in a turbulent global environment.

The structure of the main part contains three sections, the first of which is devoted to the clarification of terminology and the idea of energy security as a complex interdisciplinary category in which economic, environmental, engineering and management aspects are intertwined, the

second is to the study of trends in global energy security, the third devotes to the identification of risks of "green" transition in Ukraine during the war and post-war period.

1. Energy security content in modern conditions

Energy security is an ambiguous term used in political, economic, environmental, social, technical and other fields (Cherp & Jewell, 2011; Winzer, 2012; Månsson et al., 2014). The interpretation of the term is the subject of a wide and long discussion in the international community, because there is still no unified approach to the definition of energy security. D. Baldwin notes that neither scientists, nor practitioners, nor international institutions have yet managed to develop a comprehensive definition, which obviously indicates the significant interdisciplinary nature of the problem and the impossibility of covering its features from different sides at the same time (Baldwin, 1997). Therefore, each author analyses the issue of energy security either from a position that is considered the most important in a certain professional community, or in connection with a discourse that is currently gaining increased relevance.

Energy security is determined by how diversified and politically secure a country's energy sources are. For our purpose, energy security is defined as security of supply. That is, ceteris paribus, high energy security is observed if there is a diversified portfolio of suppliers (Cohen et al., 2011) with low political risks (Le Coq & Paltseva, 2009).

Energy security can be defined from two polar angles: for economies exporting and importing energy (Willrich, 1976). From the point of view of energy exporters, security of demand is important – guaranteed access to various foreign markets. From the point of view of the economies of energy-importing countries, the reliability of energy supply is of primary importance. In addition to the security of supply and demand dichotomy, energy security is commonly defined by several other dimensions, including sustainability of supply (Blum & Legey, 2012).

According to a study by J. Kim et al. (Kim et al., 2024), security of supply is a dominant topic in the energy security literature. The continuity and availability of energy supply depends on several factors, including the diversity and political risks of supply sources (Le Coq & Paltseva, 2009). The concept of diversity of energy supply, borrowed from portfolio theory in finance, assumes that, other things being equal, there is high energy security if there is a diversified portfolio of suppliers (Gupta, 2008; Cohen et al., 2011; Andre et al., 2014). For fuels such as natural gas, diversification goes beyond the country of origin of supply. The route of transportation, pipeline or sea, is also of great importance. Although there is a more concentrated supply where infrastructure constraints limit pipeline natural gas imports, liquefied

natural gas (LNG) can enhance energy security by expanding sources of supply (Vivoda, 2019). This strategic importance of LNG has reinforced the growing role of LNG in the energy security debate, with LNG supply contracts becoming more flexible and some LNG being sold in spot deals instead of long-term contracts (IEA, 2019*b*).

In the analysis of energy security, renewable energy sources (RES) are gaining more and more importance. RES, replacing energy imports (Gökgöz & Güvercin, 2018), create new challenges for energy security. A number of studies (Ketterer, 2014; Rintamäki et al., 2017) prove that RES can reduce the volatility of electricity prices in some countries, but increase it in others. Since energy security also depends on availability, price volatility is an energy security issue. However, there are examples of how to deal with price volatility in countries with a high share of renewable energy sources. Germany has already taken regulatory and policy measures to reduce the price volatility caused by renewable energy, and they are showing success (Ketterer, 2014). Some studies argue that an electricity system based entirely on renewable energy sources (as opposed to the current energy balance, which is based mainly on oil and natural gas) would significantly improve energy security in Jordan in terms of availability, cost, environment and health and will maintain a constant level of diversity (Abdelrahman et al., 2020).

Energy security and energy independence are closely related, but increasing domestic fossil fuel production to achieve energy independence is delaying the green transition. Therefore, a distinction should be made between energy independence and energy security, as the former focuses only on reducing the share of imported energy in the national energy balance (Cohen et al., 2011). However, increasing energy independence through domestic fossil fuel investment is at odds with the Paris Agreement and efforts to achieve net zero emissions. This means that energy security and sustainable investment can only be achieved jointly through investment in renewable energy capacity (Cevik, 2022).

2. World trends in energy security

Over the past two decades, *coal and oil production has become more concentrated.* Together, the largest coal producers capture an increasing share of the global coal market, with China and, to a lesser extent, Indonesia's share rising from 33% of world production in 2000 to 60% in 2020 (IEA, n. d. *b*). For oil, the last decade has also seen a marked shift towards more concentrated production markets, with the US, Canada and Iraq increasing market share. But, although the combined market share of the 7 leading manufacturers increased, it remained below 60%. In contrast, the global natural gas market has not experienced any significant changes in

concentration over the past two decades, despite some modest changes in the market shares of several natural gas producers (e.g., Qatar, Iran, and China), accompanied by some declines in the share of Russia and Canada. The picture remains practically unchanged in terms of shares of world exports.

Over the past decade, indicators of *political risk and democratic freedom* have worsened in most fossil fuel-producing economies. According to foreign studies, the democracy index compiled by the Economist Intelligence Unit as an intermediate indicator of democratic freedom and two separate indicators of political risks are used to measure political risks: the index of the International Country Risk Guide (ICRG) of the Political Risk Service Group (PRSG) and the ideal point distance measurement (IDP), developed by Bailey et al. (2017). They complement each other by highlighting different aspects of risk. The Democracy Index is based on the electoral process and pluralism, civil liberties, government functioning, political participation and political culture (EIU, 2022). Among the largest components of the ICRG index are government stability, social and economic conditions, and internal and external conflicts (PRS, 2018). The results show that political risks have increased for coal and natural gas, while the picture is mixed for oil producers.

The political distance between producers and consumers of fossil fuels has generally decreased. The IDP indicator is based on voting at the UN General Assembly using a Bayesian logit model with three voting options (yes, abstained, no)[1]. The higher the absolute value of the IDP between a pair of countries, the higher the political risks and potential for energy disruptions if one country depends on the other for energy needs (IMF, 2023). However, due to the limited availability of bilateral fuel trade data, it is constructed only for OECD economies and their imports from fossil fuel suppliers. An interesting fact is that the geopolitical distance between natural gas exporting and importing economies has increased since 2010.

Perhaps this reflects a plateau in globalization after the global financial crisis and the strengthening of trade and financial barriers (Shekhar et al., 2023) since then.

Risks to energy security amid concentrated production and heightened political risks have varied by fuel type in recent years. For example, coal and natural gas production has shifted toward regions with lower rates of democratic freedom, higher risks of internal political instability, and greater geopolitical distance between producing and importing economies. However, the picture for oil is less clear. Production appears to be concentrated in countries with both low and high levels of democratic freedom, as well as in regions with less political risk. The latter largely reflects the increase in the market shares of the United States of America and Canada.

[1] The distance is not estimated, but obtained from a link that provides the most recent version of the distance for all country pairs (Harvard Dataverse, n. d.).

Political risk affects energy security mainly through supply disruptions. In addition to other dimensions of political risk, the concentration of energy production in different governance systems and cultures can also be assessed based on the widely used Freedom House Index (2022). The aim is not to establish a causal relationship between democratic freedom and political risks. To the extent that civil rights and freedom matter for domestic political stability (Aisen & Veiga, 2011), their absence can potentially manifest itself in risks to energy security. The results of the analysis of the share of world production from countries classified as "free", "partially free" and "unfree" showed that coal production, as with other risk indicators, is increasingly concentrated in "unfree" regions. Similar trends are observed for natural gas and oil.

Modern concept of energy security

In their interpretations of energy security, large global consortia emphasize that its main function is to ensure sustainable energy development.

Sustainable development of the electric power industry, for its part, is a condition and consequence of economic growth. It is based on the effective management of all types of risks generated by the uncertainty of the external environment, and is impossible without ensuring sustainable functioning.

Next, we will analyze how energy security is interpreted from the point of view of sustainability in the world.

Experts from the Asia-Pacific Energy Research Center provide the following interpretation: energy security is the ability of the economy to guarantee the availability of supplies of energy resources in a sustainable and timely manner, while the price of energy is at a level that will not have a negative impact on economic indicators (APERC, 2007). The center has developed the 4A model of energy security, which is based on four principles:

- *availability* (availability of energy resources);
- *accessibility* (physical availability of energy for consumers);
- *affordability* (financial availability of energy for consumers);
- *acceptability* (acceptability of consumption conditions). Different scholars use this model as a basic framework from which they develop their own improved approaches (Cox, 2014; Sovacool & Mukherjee, 2011). For example, E. Cox (Cox, 2014) develops the 4A model, emphasizing that energy security must be ensured not only in the short term, but also, most importantly, in the long term, which implies increased attention to the reliability of energy systems, as well as stable economic and ecological indicators of their functioning (*Figure*). At the same time, reliability is a property of energy objects, and energy security characterizes the state of the state, its economy and society.

Energy security is ensured not only by the impact of energy facilities, but also by external factors that reduce risks (Ayoo, 2020).

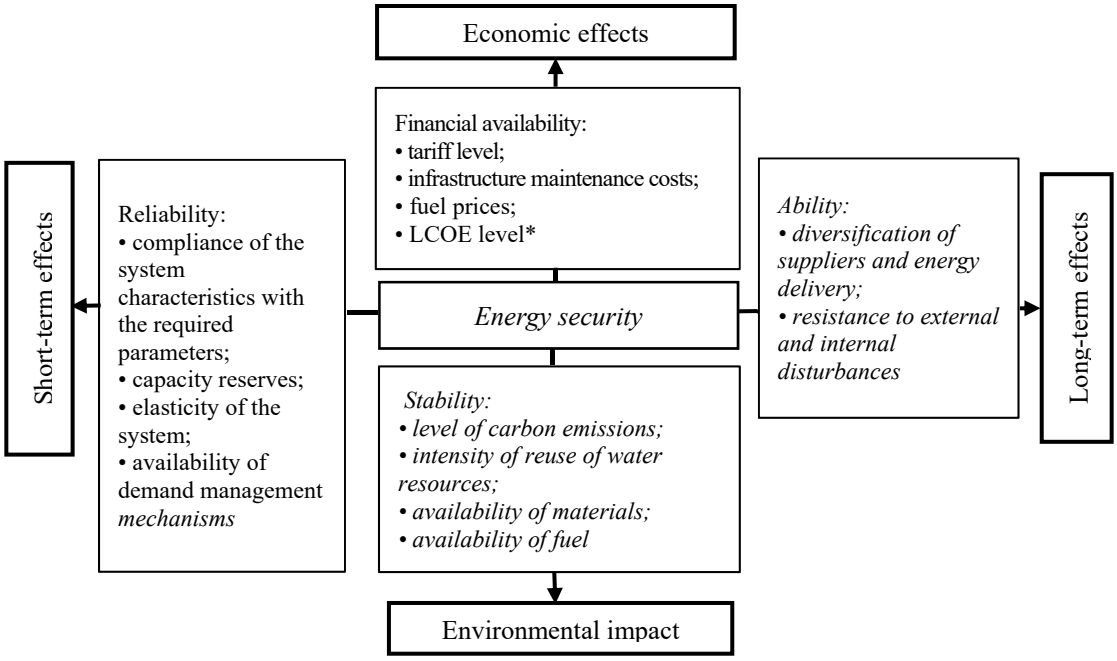

Figure. Conceptual idea of energy security

* Levelized cost of electricity (LCOE) is a measure of the average net present cost of electricity production for a generator over its lifetime. It is used to plan investments and compare different methods of electricity production on a consistent basis.

Source: summarized and constructed by the authors from (Cox, 2014).

Price is one of the leading criteria in this group of definitions, since price as a mandatory functional component of energy security determines the level of energy availability for consumers. But it is quite difficult to objectively substantiate this. According to D. Deese's classic study, energy prices ... are affordable if they do not cause serious disruptions to normal social and economic activity (Deese, 1979). It should be noted that some business entities do not feel the devastating effects of changes in energy prices, while others (especially large energy-intensive consumers, where the cost of electricity is significant in the structure of their production costs) react to such changes extremely sensitively. Thus, the term "affordability" in relation to energy security should always be distinguished and should answer the question "affordable to whom?" (Cherp & Jewell, 2016).

The results of the analysis of interpretations of energy security as a factor (or condition) of energy sustainability indicate that these interpretations give priority to economic and social determinants, while engineering and technical aspects are considered complementary (or indirect). A number of other interpretations are based on the principles of a systems approach, in which technique and technology are no less important than social and economic issues.

From the point of view of a systemic approach, energy should simultaneously increase the level of vitality and reduce the level of

vulnerability. The viability of energy systems is determined by their structural and operational parameters: structure, composition, and technical condition, modes of use of fuel bases, energy sources, energy network infrastructure, and energy reserve capacities. Vulnerability is an indicator that reflects the ratio of the degree of exposure to risks that may arise in various energy systems to their resilience potential. This definition uses specific systems engineering patterns related to ensuring the resilience of complex systems by creating protective structures to prevent system collapse, reduce vulnerability, and increase flexibility (Florin, 2016).

Usually, three interrelated groups of risks affecting the level of energy security are distinguished (Elbassoussy, 2019; Axon & Darton, 2021; Hu et al., 2022).

The first is the violation of state integrity arising as a result of deliberate actions of foreign states.

The second is natural and man-made disasters associated with the lack of fuel and energy resources, aging infrastructure, climate disasters.

The third is the unpredictability of social and economic factors: changes in the preferences of investors and end consumers, structural shifts in the markets of various goods and services, reorientation of export-import flows.

Neutralization of the first group of risks creates the so-called "perspective of sovereignty", which ensures the country's energy independence, the appropriate level of diversification of energy production methods and types of energy carriers in the regional energy balance (energy mix) (Shahzad et al., 2021; Devaraj et al., 2021; Yao, 2014). The goal of neutralization of the second group of risks is the formation of the "strength perspective" of the energy system - its non-destructive ability and physical protection from external influences. The elimination of the third group of risks is aimed at creating a "perspective of stability" of the energy system - first, its ability to function and provide energy needs of the region in conditions of increased uncertainty; secondly, proactive readiness for configuration changes in connection with future challenges and threats. In this case, the concept of "sustainability" takes on a much broader and more complex meaning.

During the study of subjects of energy security, it is customary to distinguish three groups of countries: countries producing energy resources; importing countries; transit countries that receive commercial benefits from the use of their territory for the transit of energy resources. Research on energy security most often focuses on the issue of consumer countries, that is, the second and third groups. They tend to equate energy security with security of energy supply (Winzer, 2012) and energy independence (Hakes, 2015).

In the global transition to carbon neutrality, exporters lose their traditional markets and export revenues, a situation that can be corrected. Exporters also face the need for decarbonization and radical transformation of the energy sector, which requires significant financial resources and technology. Dependence on the import of "green" technologies and services becomes their main threat.

Thus, based on the analysis of theoretical foundations at the current stage of energy market development, the following definition of the country's energy security can be formulated: it is a state of protection of citizens and the economy against the threat of not satisfying reasonable energy needs; ensuring acceptable quality and price under normal conditions and under extraordinary circumstances; ensuring protection against violations of the stability and continuity of fuel and energy supply.

Under normal conditions, the specified state of protection corresponds to the provision of justified (rational) energy needs in full. In emergency situations, this corresponds to the guaranteed supply of the necessary minimum volume of needs.

In this definition, "energy security" is considered as a complex category that expresses the ability of the country's (region's) fuel and energy complex to perform the functions of maintaining stable and economically acceptable prices for energy for all categories of consumers, as well as ensuring: timely and full fulfillment of fuel supply contracts – energy resources for the domestic market in the necessary volume and assortment for the short- and long-term perspective; operational coverage of unplanned fluctuations in demand for PER; continuity of current energy supply and regulatory parameters of energy carriers in real time.

3. Energy transition of Ukraine

Energy transition means the global restructuring of the economy to stop the use of fossil fuels such as coal, oil and gas, which are the main sources of greenhouse gases and cause climate change. This process aims to completely switch to carbon-free technologies and efficient energy consumption. The importance of the energy transition for all countries is to stop climate change, which causes droughts, floods, storms, heat waves and rising sea levels. The basis of this transition is *renewable energy and increased energy efficiency*, contributing to a 90% reduction in greenhouse gas emissions in key sectors, including transport, industry, agriculture, urban development and utilities. These measures are also aimed at solving other critical problems: from ensuring energy security to improving air quality in cities and reducing financial costs of energy.

Analyzing the relevant conditions in the energy sector of Ukraine, three groups of energy transition risks can be identified (Energy Transition, 2023):

I. Technical related to the connection and balancing of "green" capacities. Including:

- *integration of renewable energy sources:* a large share of such renewable energy sources as solar and wind energy can cause problems with the stability of the energy system due to their variability and unpredictability;
- *outdated equipment and infrastructure:* many parts of Ukraine's energy system are outdated, requiring modernization or replacement in order

to effectively integrate new technologies and manage the load from renewable energy sources;

- *energy storage:* insufficient development of energy storage technologies can make it difficult to manage load peaks and variations in energy production from renewable sources;
- *cyber security:* the growing digitalization of the energy infrastructure increases the risks associated with cyber attacks, which can damage control systems and affect the stability of energy supply;
- *dependence on imported technologies:* Ukraine may depend on imported technologies for renewable energy sources, which creates a risk in case of changes in trade policies or global supplies;
- *technical competence:* the need for qualified specialists to manage, maintain and implement the latest technologies in the energy sector, given their complexity and specificity.

II. Economic, related to the lack of predictability in the market, and other factors that affect the economic indicators of the "green" transition, in particular, are:

- *high capital costs:* investments in renewable energy, adaptation of existing infrastructure require significant initial costs. This is an additional financial burden for the state and the private sector, especially in conditions of a limited budget;
- *price volatility in the market:* the transition to renewable energy may lead to changes in the pricing of traditional energy sources, which will potentially affect the country's economy and its dependence on energy imports;
- *instability of subsidies and support:* political and economic uncertainty can lead to changes in government support for renewable energy projects, which creates risks for investors and developers;
- *labor market risk in traditional sectors:* the transition from fossil fuels to renewable energy sources is likely to lead to job losses in sectors dependent on coal, oil and gas;
- *competition in international markets:* integration with the global renewable energy market may face high competition, especially from countries with more advanced technologies and larger scale of production.

III. Legal risks relate mainly to regulatory and legislative aspects that may affect the successful implementation of strategies for the transition to renewable energy and energy efficiency. They include:

- *instability of legislation:* changes in domestic legislation, especially frequent and unpredictable legislative changes, can create uncertainty for investors and companies engaged in projects in the field of renewable energy, which makes it difficult to plan long-term investments;
- *inconsistency of national legislation with international regulations:* in the process of adapting Ukrainian legislation to international standards, legal conflicts may arise;

- *delays in obtaining permits and licenses:* bureaucratic procedures for obtaining the necessary permits and licenses for the implementation of renewable energy projects can complicate doing business and delay the implementation of projects;
- *risks related to land relations,* for example, issues of access to land plots for large-scale renewable energy projects (wind farms or solar plants) can complicate land legislation, property rights and provoke conflicts with local communities;
- *problems regarding the execution of contracts:* the existence of legal and administrative obstacles to the effective execution of contracts, especially in the part of the relationship between the state and private companies, may create risks of shortages, delays in payment or fulfilment of contractual obligations;
- *data and privacy protection:* given the high degree of integration of IT systems in the management of energy resources, the legal aspects of cyber security and data protection acquire great importance, taking into account the vulnerability of systems to possible malicious attacks.

The war in Ukraine further complicated the situation, causing new risks regarding the "green" transition. This created threats not only for existing facilities, but also for projects started earlier. In addition, the accumulation of negative factors may affect the planning of new renewable energy projects in the post-war period.

Therefore, in order to reduce risks and restore the sector, a number of measures need to be implemented using an integrated approach, including improving the legal framework, simplifying administrative procedures and creating transparent and predictable legal conditions for attracting investment and stable work in the renewable energy sector.

In the short term, it is necessary to create conditions for continuing the implementation of projects that were started before the active phase of the war. This concerns the extension of the terms of validity of the technical conditions for connecting these objects to electric networks. In parallel, measures should be developed to minimize economic and legal risks for existing and future projects, which will help ensure market predictability. The overall goal is to prepare for the transition of the electricity market to a competitive state. It is also important to analyze the effectiveness of different mechanisms for both renewable energy and balancing capacities to ensure a balanced development of renewable energy in the power system.

In the medium term, during 2024, in the absence of intensive Russian missile attacks on the energy infrastructure of Ukraine, it is necessary to update the data for modelling the energy system. This will make it possible to develop energy development scenarios, taking into account the updated goals for renewable energy, the conditions for their achievement, in particular through the use of balancing capacities. It is also important to ensure the coordination of all strategic documents with a single target

indicator for the development of "green" electricity. It is necessary to implement measures to create a competitive market, balanced development of renewable energy and achievement of new established goals. All this will contribute to the rapid development of renewable energy projects in the post-war period.

In the long term, starting from 2025, measures aimed at the integration of the electricity markets of Ukraine and the European Union should be implemented. This will provide Ukrainian manufacturers with new opportunities, especially in the context of the growing demand for electricity from renewable sources in connection with the decarbonization policy in EU countries. It is important to synchronize all requirements in accordance with European legislative norms in the energy sector in advance. The establishment of European-style market rules, as well as the expansion of opportunities for the sale of "green" electricity, will significantly increase the investment attractiveness of the renewable energy sector in Ukraine and activate the rapid development of renewable energy projects in the post-war period.

These proposals are aimed at reducing existing risks for renewable energy projects. Under the current conditions associated with the military aggression of the Russian Federation on the territory of Ukraine, it is impossible to completely avoid these risks. However, in cooperation with international partners, Ukraine strives for a "green" recovery in the post-war period. Therefore, it is important to focus on planning and creating appropriate conditions for the harmonious development of "green" electricity in Ukraine.

Conclusions

The problem of energy security is becoming multi-criteria. The level of energy security today is determined not only by the assessment of local technological, ecological, economic, material and technical, managerial, social, political, and legal threats (indicators), but also, which is particularly important, by a new consideration of interdisciplinary connections between them.

In the foreseeable future, the global energy situation will be characterized by: aggressive competition and sharp geopolitical contradictions between the countries that are the largest players in the world energy market; the complication of the supply of the main types of PPE and the increase in its cost; a decrease in the stability of energy supply due to a decrease in dependence on fossil fuels in favor of renewable energy; continued decommissioning of coal-fired thermal power plants and nuclear power plants and, as a result, a sharp increase in the volatility of energy prices.

The principles of ensuring energy security relate to the interpretation of the concept of "energy security", the actualization of climate risks, as well as the main directions of organizational and technical transformations in the power industry. It should be noted that it is inadmissible to isolate the energy

sector from advanced technologies, even if the country is fully equipped with reserves of natural energy resources that make it possible to achieve a sufficient level of energy security in the medium-term future. Advanced technologies include, for example, fossil fuel combustion, nuclear power, renewable energy sources, energy conservation and electrification. Such a policy guarantees the country's energy security in the long term, when the uncertainty of future risks and threats is growing sharply. In addition, it will provide the country with a base for exporting advanced technologies.

In order to get rid of dependence on russian fossil fuels, Ukraine is particularly interested in accelerating the energy ("green") transition, which involves a large-scale reform of the economy to minimize the use of fossil fuels, which are the main source of greenhouse gases and cause climate change. However, this process is accompanied by a number of risks of a technical, economic and legal nature, which were significantly increased by the war.

In a strategic plan, achieving climate neutrality requires changes in the direction of integration of the electricity markets of Ukraine and the European Union, synchronization of requirements in accordance with European legislative norms in the energy sector, as well as expansion of opportunities for the sale of "green" electricity, which will strengthen the investment attractiveness of the renewable energy sector in Ukraine and will ensure the rapid development of renewable energy projects in the post-war period.

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