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Review

Energy Security: New Threats and Solutions

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Abstract: The article presents the conceptual features of energy security management under a radically changed context, increasing crisis phenomena, and threats of various natures. The authors substantiate the claim that energy security is a complex category, which expresses the ability of the fuel and energy complex of the region to supply the required amount and range of energy resources to the domestic market at stable and reasonable prices; to promptly 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 an analysis of scientific publications and practical energy security models, the authors developed theoretical provisions, methodological principles, and management tools for energy security that meet modern requirements. In particular, the authors developed the terminological apparatus and identified the types and forms of modern energy threats and risks. The authors analyzed the impact of structural shifts in the electric power industry on the cost of electricity. The authors proposed a set of measures to neutralize negative scenarios in the field of energy security, which had appeared because of geopolitical factors, structural changes in the economy, and high volatility in energy prices. In addition, the authors considered the impact of the transition to low-carbon energy production on energy security, and developed the organizational and technical concept of the energy transition, which aimed to provide energy systems and individual energy facilities with properties of self-protection from emerging threats. The results of the study are of practical interest in the development of regional energy policy, plans, and specific actions that aim to ensure energy security in a turbulent global environment.

Keywords: energy security; energy transition; challenges; threats; energy risks; sustainability; scenario method; systems approach

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1. Introduction

The electric power industry is a critical infrastructure, the state of which determines the viability of any state and the wellbeing of society. This is demonstrated by the systemic accidents in the United States and Canada at the beginning of the century, which paralyzed the lives of half a billion people for several days [1]; accidents in the mid-2000s in Germany [2] and Brazil [3], which led to power outages in almost the entire western part of the South American continent and Western Europe; the 2012 blackout in India [4,5], which de-energized three-quarters of the country's territory. The causes of these "momentary" incidents, which nevertheless cause catastrophic consequences, are usually of a technical (technogenic) nature. In rare cases, they are associated with human errors made during the design, operation, or maintenance of individual elements of power systems [6].

These examples confirm that any failures in the electric power industry have an extremely painful effect on the entire economy and social sphere. However, the range of negative conditions, which provoke instability in the long-term development of this extremely important industry, has expanded dramatically. The impact of the following factors on the electric power industry has been sufficiently studied: uneven distribution of geological reserves of the main types of fuel resources, especially scarce natural gas [7,8]; increased financial instability of the economy in recent decades [9]; increased inter-country conflicts [10,11]; and climatic disasters [12]. Other factors, which have appeared relatively recently, are mainly due to two global processes: new energy transition and the associated energy crisis—the largest one in the last 50 years. The latter is becoming increasingly rampant and could lead to unpredictable consequences. As a result, the problem of ensuring energy security is urgent.

Energy security is an ambiguous term that is used in political, economic, environmental, social, technical, and other fields [13–15]. The interpretation of the term is the subject of a wide and lengthy discussion in the international community, and there is still no single approach to the definition of energy security. D. Baldwin [16] notes that neither scientists, nor practitioners, nor international institutions have yet been able to develop a comprehensive definition, which apparently indicates a significant interdisciplinarity of the problem and the impossibility of covering its features from different angles simultaneously. Therefore, each author analyzes the issues of energy security either from a position that is considered the most important in a particular professional community, or in relation to a discourse that has an increased relevance at the moment. Figure 1 illustrates the exponential growth of interest in this issue in the academic community over the past decade.

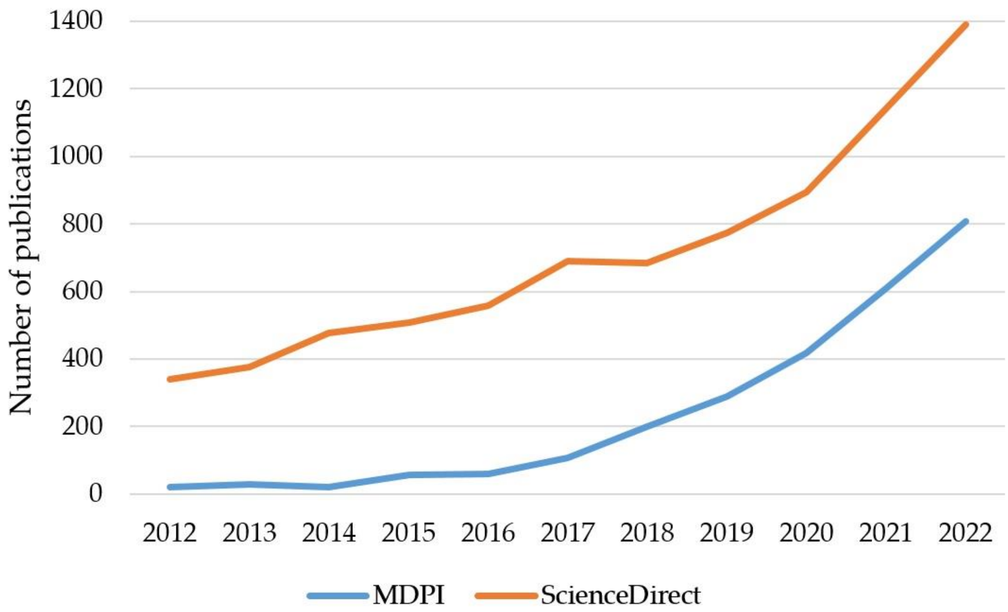

Figure 1. Dynamics of the number of scientific publications in the abstract databases ScienceDirect and MDPI containing the keyword "energy security".

In this article, the authors focus on the study of emerging threats and directions of relevant solutions in the field of energy security through the prism of the energy transition (ET), which is being carried out in different countries and which largely determines the modern industry and intersectoral context.

According to the Czech-Canadian scientist V. Smil [17], the creator of this term, the fourth ET is a global transformation of the world's energy supply systems aimed at achieving carbon neutrality in all areas of human activity. For the first time, environmental goals (not economic or technological) become so significant in energy supply; while oil, gas, and coal reserves are declared "undesirable" and even dangerous in terms of their detrimental effect on the climate and the environment.

The new ET is distinguished by a wide scale of innovative tasks and a relatively short period 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 basic energy carriers in the USA and European countries, requires the creation of an appropriate scientific and technical basis, the definition of requirements for logistics systems, and the reconfiguration of energy markets [18,19]. Meanwhile, excessive focus on renewable energy leads to uncontrollable price volatility; the emergence of investment problems [20,21]; and, as a result, a sharp decrease in the level of energy security in the region. Thus, the destabilization of primary (natural) energy flows can lead to the installed capacity utilization factor of wind power plants (WPPs) dropping to economically unacceptable values, which calls into question the further operation of the entire complex of WPPs in the area. Considering the plans to decommission coal and nuclear power plants, the problem of energy supply stability, especially in power systems with uneven loads, is drastically exacerbated.

Thus, the main leitmotif of ET—decarbonization of the global energy industry "by all means"—requires careful verification, primarily from the standpoint of new threats to energy security.

The purpose of the article is to develop the conceptual foundations 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 range of solutions for neutralizing new threats that arise, among other things, in the context of the ET. The scientific novelty of the research results is manifested in three provisions. First, the research clarifies the terminology and ideas about energy security as a complex interdisciplinary category in which economic, environmental, engineering, and management aspects are intertwined. Second, it further develops methodological approaches to assessing the level of energy security, which should reflect the factors of change in the pricing of fuel and energy resources (FER), in the structure of industrial production and, accordingly, energy consumption. Third, the research elaborates on the organizational and technical concept of ET, with the intention of equipping power systems and individual power facilities with properties of self-protection from emerging threats.

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

2. Materials and Methods

The study was based on a methodology that includes a review of the scientific literature, analysis, and systematization of existing theoretical ideas about energy security. As the final step, the authors elaborated their position on energy security in terms of its characteristics and factors in new conditions, including the identification of relevant challenges, threats, and risks. Based on the authors' conceptualization, progressive solutions were identified in the areas of energy production and consumption, and the supporting organizational and technical concept of ET was formulated.

The information basis of the study included reputable scientific publications selected by keywords "energy security", "factors and threats to energy security", "energy security in the energy transition", "stability, reliability, vulnerability of energy systems". The search for articles was carried out mainly in the abstract databases ScienceDirect and MDPI, as well as in the database of scientific publications of the WIT Press publishing house. In addition, the authors examined analytical reports of global structures and institutions (International Energy Agency, United Nations European Energy Commission, International Renewable Energy Agency), as well as international consulting groups (Deloitte (London, UK), Accenture (Dublin, Ireland), McKinsey & Company (New York, NY, USA)). The list of analyzed sources is given in Table 1.

Table 1. Reference list of analyzed literary sources.

Type of the Source	Data-Base	Journal Title	Number of Sources
Articles	Science Direct	Energy Policy	7
		Energy	4
		Sustainable Production and Consumption	2
		Renewable Energy	2
		Energy Procedia	2
		Energy Strategy Reviews	1
		Science of The Total Environment	1
		Cleaner and Responsible Consumption	1
		Solar Energy	1
		Renewable and Sustainable Energy Reviews	1
		Energy Economics	1
		Resources Policy	1
		Science of The Total Environment	1
		Journal of Cleaner Production	1
	MDPI	Energies	12
		Sustainability	3
		Resources	2
		Economies	1
		International Journal of Environmental Research and Public Health	3
		Climate	1
		Engineering Proceedings	1
		Social Sciences	1
	WIT Press	International Journal of Energy Production and Management	9
		WIT Transactions on Ecology and the Environment	5
		International Journal of Sustainable Development and Planning	2
		WIT Transactions on The Built Environment	2
		International Journal of Environmental Impacts	1
	Other		24
Monographs			13
Analytical reports			16
Internet sources			10
TOTAL			133

3. Theoretical Background

3.1. Approaches to the Definition of the Concept of "Energy Security"

The term "energy security" appeared relatively recently: as recorded by various experts [22–24], it became popular after the introduction of an oil embargo by the OPEC member countries in 1973. As a result of this conflict, which led to a very long global energy crisis, at least three strategic decisions were made in the field of energy security: the International Energy Agency was established; cross-country recommendations on the availability of strategic reserves of key energy carriers were developed; and stringent energy efficiency measures were introduced in the industrial, commercial, and residential sectors.

In their interpretations of energy security, large global consortiums emphasize that its main function is to ensure sustainable energy development. It is appropriate to emphasize that a number of special studies by the authors of this article were devoted to the problem of sustainability in the electric power industry [25–27]. In particular, the authors proposed to distinguish between the concepts of "sustainable operation" and "sustainable development":

- Sustainable operation represents the ability of the industry to meet the needs of the national (or regional) economy for electricity and capacity at any given time, while maintaining the required level of energy supply reliability and quality (measured by frequency, voltage, etc.), having a minimal impact on the environment, and keeping the price at a socially acceptable level (both for consumers and producers). The mode of sustainable operation implies a limited commissioning of new capacities to provide a reserve and to renew fixed capital (disposal coverage, upgrades), increasing the capacity of electrical networks, and improving technological systems of operational dispatch control.

- Sustainable development involves scaling up the power industry (commissioning of new capacities) to ensure economic growth and increase the level of electrification of the national economy through the introduction of progressive energy-intensive processes. Qualitative transformations of the industry (the optimization of generation structure and fuel and energy balance, and the introduction of environmentally friendly installations) take place at the same time.

Sustainable development of the electric power industry is a condition and a 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 it is impossible without ensuring sustainable operation.

We will analyze how energy security is interpreted in terms of sustainability globally.

The International Energy Agency (IEA) defines it as the "uninterrupted availability of energy sources at an affordable price" [28]. In its definition of energy security, the UN similarly focuses on the uninterrupted availability of energy in various forms, in sufficient quantities and at fair prices [29].

Experts from the Asia-Pacific Energy Research Centre provide a similar interpretation: energy security is "the ability of an economy to guarantee the availability of energy resource supply in a sustainable and timely manner with the energy price being at a level that will not adversely affect the economic performance of the economy" [30]. The organization has developed a 4A energy security model based on four principles: availability (availability of energy resources); accessibility (physical accessibility of energy for consumers); affordability (financial affordability of energy for consumers); and acceptability (acceptability of consumption conditions). Various scientists use this model as a basic framework from which they develop their own improved approaches [31,32]. For example, E. Cox [31] develops the 4A model by emphasizing that energy security must be ensured not only in the short-term, but also, most importantly, in the long-term, and this involves increased attention to the reliability of energy systems, as well as economic and environmental indicators of their operation (Figure 2). In this case, reliability is a property of energy facilities, while energy security characterizes the condition 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 the risk of emerging and ongoing threats [33–35].

Some researchers share the point of view of these international institutions: for example, G. Kowalski and S. Vilogorac, in their work "Energy Security Risks and Risk Mitigation" [36], substantiate the main function of energy security: "the availability of usable energy supplies, at the point of final consumption, at economic price levels and in sufficient quantities and timeliness so that, given due regard to encouraging energy efficiency, the economic and social development of a country is not materially constrained".

Price is one of the leading criteria in this group of definitions, because price, as a mandatory functional component of energy security, defines the level of energy affordability for consumers. It is quite difficult, though, to substantiate it objectively. The classic study by David Deese [37] states that "energy prices … are affordable as long as they do not cause severe disruption of normal social and economic activities". It should be noted that some economic entities do not experience devastating consequences when energy prices change, while others (especially large energy-intensive consumers, whose electricity costs are significant in the structure of their production costs) react to such changes extremely sensitively [38]. Thus, the term "affordability" in relation to energy security should always be differentiated, and it should answer the question "affordable for whom?" [39].

An analysis of the interpretations of energy security as a factor (or condition) in energy sustainability allows us to conclude that these interpretations prioritize 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 systematic approach, in which engineering and technology are no less important than socio–economic issues.

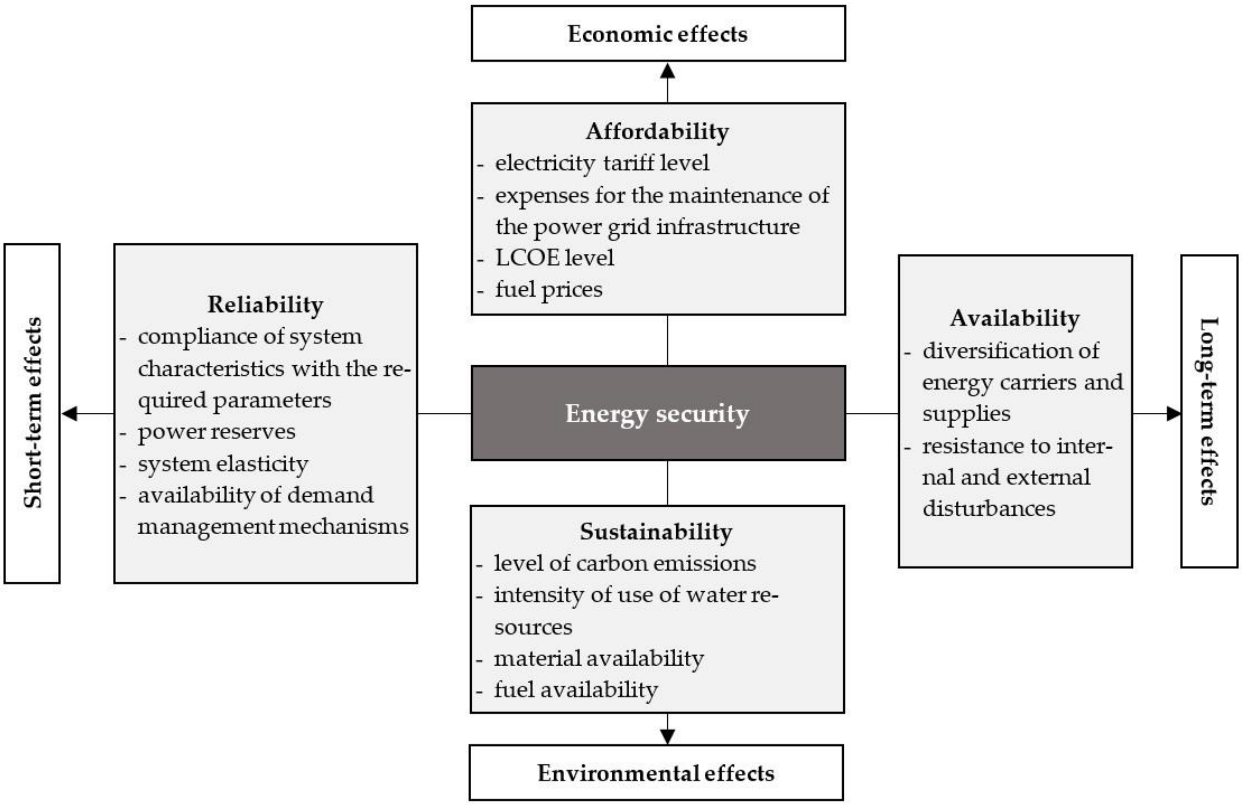

Figure 2. Conceptual idea of energy security (developed by the authors based on the data presented in [31]).

For example, in a series of works [13,39–41], A. Cherp and J. Jewell have a tough debate with experts from the IEA and the Asia-Pacific Energy Research Centre. Cherp and Jewell argue that the views of these experts (their "4A" model in particular) are superficial, populist, and can demonstrate some kind of effectiveness only with the absolute stability of external factors. In the 2014 article "The concept of energy security" [39], Cherp and Jewell show that energy security can be broadly defined as low vulnerability of "vital energy systems", which consist of energy resources, and technologies for their transformation and transportation, as well as energy-consuming complexes designed to solve social problems or ensure the operation of strategic processes. Vital energy systems can be localized at the level of individual territories or industries [40,42]. Examples of vital energy systems include the fuel supply for defense, transport, medical, telecommunications infrastructure [43–45], and the energy supply of isolated territories based on renewable energy sources [41,46,47].

From the standpoint of a systematic approach, the energy sector should simultaneously improve the level of vitality and reduce the level of vulnerability. The vitality of power systems is determined by their structural and operational parameters: structure, composition, technical condition, modes of fuel bases use, energy generating sources, power grid infrastructure, energy backup capacity. Vulnerability is an indicator that reflects the ratio of the degree of exposure to risks that may arise in various energy systems to the potential for their sustainability. This definition uses separate patterns of systems engineering related to ensuring the elasticity of complex systems by creating protective structures to prevent system destruction, reduce its vulnerability, and increase flexibility [48–50].

As a rule, there are three interrelated groups of risks that affect the level of energy security [10,36,51–57]:

1. Violation of state integrity arising from the deliberate actions of foreign countries [10,55,56];
2. Natural and man-made disasters associated with a lack of fuel and energy resources, aging infrastructure, and climate disasters [36,52–54];
3. Unpredictability of socio–economic factors: changes in the preferences of investors and end consumers, structural shifts in the markets for various goods and services, reorientation of export–import flows [36,51,57].

Neutralization of the first group of risks creates the so-called "prospect of sovereignty", which ensures the energy independence of the country and the proper level of diversification of energy production methods and types of energy carriers in the regional energy balance (energy mix) [58–60]. The purpose of neutralizing the second group of risks is to form a "prospect of strength" for the energy system—its nondestructive ability, and physical protection from external influences. The elimination of the third group of risks is aimed at creating a "prospect of sustainability" for the energy system—firstly, its ability to function and meet the energy needs of the region in conditions of increased uncertainty; secondly, its proactive readiness for changes in its configuration due to future challenges and threats. Of course, in this case, the concept of "sustainability" acquires a much broader and more complex meaning.

3.2. Subjects of Energy Security

When considering the subjects of energy security, it is accepted to distinguish three groups of countries: (1) countries that produce energy resources; (2) importing countries; (3) transit countries that benefit commercially from the use of their territory for the transit of energy resources. Studies of energy security most often focus on the issue of consumer countries, i.e., the second and third groups. They tend to equate energy security with security of energy supply [14] and energy independence [61].

The first case refers to guaranteed, sufficient in volume, and affordable supplies of imported carbon energy carriers. A whole set of tools is used to solve this problem [62–64]: economic and logistic (diversification of energy suppliers and supply routes, creation of strategic raw material reserves); technological (diversification of energy production methods, development of alternative energy); political (building "special relationships" with exporters, starting military or cyber conflicts). The second case refers to energy self-sufficiency or energy sovereignty, i.e., the ability of a country to rely on its own energy sources, and not on imports [65].

In this regard, the decarbonization of energy supply as a key goal of the ET is often perceived by importing countries as an opportunity to significantly improve their energy security [66]. However, this argument is controversial, because the ET may bring new problems and challenges to importing countries, including a significant increase in energy costs [67–69] and dependence on rare earth metals (lithium, nickel, cobalt), equipment, technologies, and services necessary for the electrification, digitalization, and decarbonization of energy [52,70].

The states of the first group, which have enough fuel resources not only to meet their own needs, but also to use for exports, consider energy security to be a measure of meeting energy demand (security of energy demand). Their priority is the guaranteed (and acceptable in terms of volume and price) sale of carbon energy carriers in foreign markets [71].

During the global transition to carbon neutrality, exporters are deprived of their usual sales markets and export earnings—a situation that can be irreparable. Exporters also face the need to decarbonize and radically transform the energy sector, which requires substantial financial resources and technology. Dependence on imports of "green" technologies and services becomes their main threat [72]. If they continue to rely on their own available and affordable carbon fuels, they face a high risk of increasing taxes, and during the "sanctions wars" they face a wide range of economic restrictions on the part of the so-called "leaders of energy transition" [73–75].

From an economic point of view, the countries of the first group (exporters–producers of fuel and energy resources) are not equally prepared for ET. According to a study by the International Renewable Energy Agency IRENA [76], these countries can be conditionally divided according to the indicator "the ratio of fossil fuel rent to GDP", which essentially characterizes the level of the state's super profits from the export of hydrocarbons. Group 1 includes countries where this indicator exceeds 20%, and where financial reserves are not enough to decarbonize the energy sector and diversify the economy (Libya, Angola, Republic of the Congo, South Sudan). Group 2 includes countries where the indicator also exceeds 20% of GDP, and whose economies are poorly diversified, but there are financial opportunities for restructuring (mainly the Gulf states such as Saudi Arabia, Iraq, Qatar, Kuwait, the UAE, Oman). Group 3 includes countries where the fuel rent is less than 20% of GDP, and where the economy is already quite diversified and does not critically depend on the export of carbon raw materials (Russia, Iran, Algeria, Kazakhstan, Venezuela). Finally, Group 4 includes countries with fuel rent of less than 10% of GDP and highly diversified economies (Malaysia, Bahrain, Colombia, Norway, etc.). The author's visualization of the presented classification is shown in Figure 3.

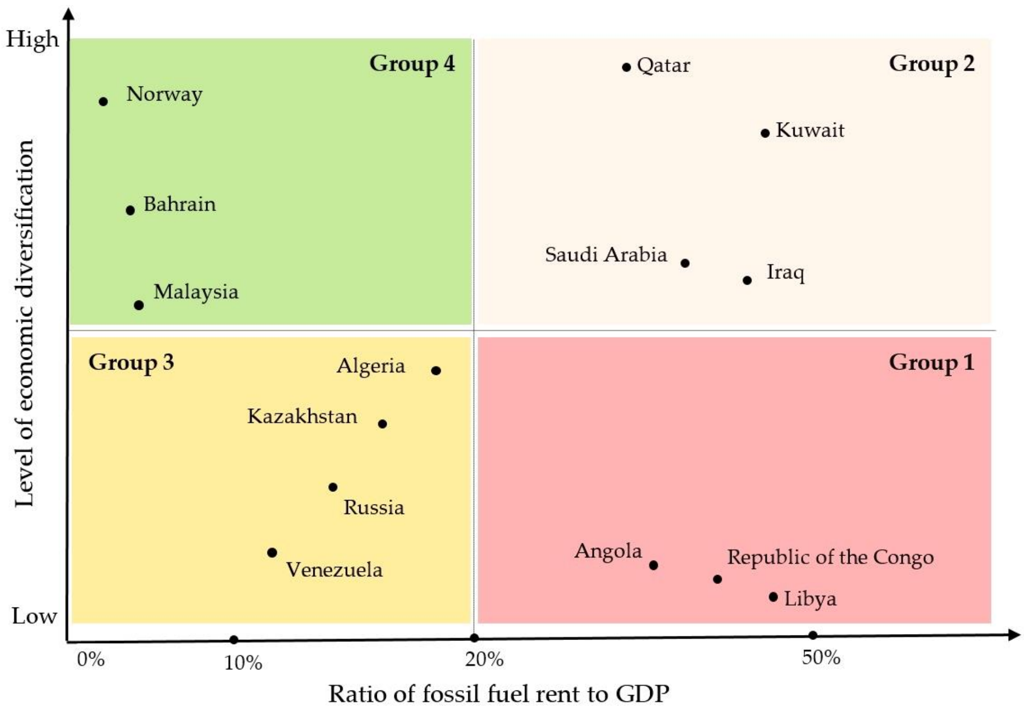

Figure 3. Readiness of exporting countries for the energy transition: visualization of the IRENA method (developed by the authors according to the data presented in [76]).

IRENA experts conclude that only the countries of the first and second groups, in which the economy is completely dependent on the stable export of hydrocarbon resources at high prices, may face significant energy security problems due to the ET. In other countries, the "smoothness" of energy transition will depend on how quickly the state can switch to the development of high-tech industries, including those that provide advanced technologies, equipment, and services for the new type of energy.

Summarizing the theoretical review, it can be concluded that energy security is characterized by the following main "capabilities":

- Sufficient supply of high-quality, technically, and economically available FER by the fuel and energy complex;

- Rational and environmentally friendly use of energy resources by the country's economy and individual consumers, based on the application of appropriate tools for energy consumption planning and energy demand management;
- Sustainability of energy systems to the impact of potential economic, socio–political, man-made, natural, administrative, and legal threats, to power shortages and disruptions caused by these threats.

To implement these factors, appropriate economic, political, institutional, and other conditions must be provided, including a favorable investment and innovation climate. Thus, energy security has not only technological, techno-economic, and managerial, but also political meaning [33,77].

3.3. Methodological Features of Assessing the Level of Energy Security

As a rule, the choice of parameters and factors influencing the level of energy security strongly depends on the specifics of the region. In current conditions, a serious risk to energy security in the modern world is a multi-vector uncertainty regarding the following: achieving the balance between carbon reduction, political ideology, and economic growth; estimating economically viable volumes of reserve (surplus) capacities and their structure; determining the future share of gas in the energy balance of different countries; ensuring uninterrupted supply of energy carriers. Thus, the mechanisms for assessing energy security should be based on multifactorial models.

The model developed in the study by Patrick Gasser [78] can be used as an example. The model interprets energy security using a systematic approach and considers it as a necessary condition for ensuring the elasticity of the energy supply of the region. Model calculations are based on an index assessment of 12 indicators of the energy system operation in the region (country). This assessment allows us to make more targeted decisions in the field of energy security, depending on the values of technical, macroeconomic, political, and investment indices.

The indices include: the System Average Interruption Duration Index (SAIDI); average down-time of the equipment; variety of power grids; risk of a serious accident in the energy system of the region; equivalent factor of the equipment's load-bearing readiness; dependence on energy imports; GDP per capita; a variety of insurance instruments in modernization, reconstruction, technical re-equipment, and new construction projects; the presence of anti-corruption measures; political stability and the absence of violence/terrorism; effectiveness of state measures to support the industry; ease of doing business. According to Gasser's assessment, TOP-10 countries with the highest level of energy security in 2020 included Germany, Canada, USA, Switzerland, the Netherlands, France, South Korea, New Zealand, Taiwan, and Australia.

In general, the indicative method is the most common one for determining the level of energy security. An indicative indicator of energy security is a criterial indicator of the development and operation of the energy sector, its subsystems, and facilities. The value of this indicator reflects the degree of certain threats quite well [78–80]. The indicators characterize the level, composition, and depth of threats to energy security; they can be specific or general [80–82]. Determining the composition of indicators starts with the expert selection of the most important indicators that should be taken into account when assessing the level of energy security. The next step is to substantiate threshold values of these indicators—the values that determine the transition boundary of the indicator's actual value from one area of qualitative states to another—from a normal value to a crisis one.

At the same time, comparing the values of the analyzed indicators with their threshold values does not yet allow us to assess the state of energy security in general. Some indicators may be quite acceptable; the values of others may be in the crisis zone. This may change from year to year. Therefore, an additional iteration is applied—the "packing" of qualitative assessments of individual indicators into a single integral assessment for the analyzed energy system (region). To do this, the significance of a particular indicator is determined in their overall scale, for example, based on the method of paired comparisons [83].

Analysis of energy security crisis situations can be carried out in the following sequence [84,85]:

1. Compiling a preliminary register of research objects (country, separate region, large city, industrial hub);
2. Collecting information to assess crisis situations;
3. Collecting main initial indicators for assessing crisis situations by energy security blocks;
4. Assessing the level of threats to energy security based on a comparison of actual and threshold values;
5. Identifying crisis situations in the regions by energy security blocks—based on the obtained indicators, the regions are ranked according to the level of threats;
6. Collecting additional indicators for regions characterized by a high crisis level—clarifying the dynamics of main indicators in the retrospective period, starting from the base year;
7. Conducting an in-depth analysis of causes and consequences of crisis situations for regions with the worst energy security ratings;
8. Developing program-targeted measures aimed at localizing and neutralizing the impact of crisis situations emerging in the energy complex of the regions.

To implement this algorithm, it is necessary to determine the range of threats to energy security. This range is comprised of conditions and factors that create extreme situations in the fuel and energy supply systems, posing a danger to the normal functioning of these systems and, as a result, a danger to the vital interests of the individual, the society, and the state.

4. The Issue of Energy Security in a Changed Context

4.1. Challenges, Threats, and Risks to Energy Security

Based on an analysis of the theoretical background, the authors formulate the following definition of energy security of a country: it is a state of protection of citizens and the economy from the threat of failing to meet reasonable energy needs; to ensure acceptable quality and price under normal conditions and under extraordinary circumstances; and to offer protection from violations to 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 volume. In emergency situations, it corresponds to the guaranteed provision of the necessary minimum volume of needs.

In this definition, "energy security" is considered a complex category that expresses the ability of the fuel and energy complex of a country (region) to perform the following functions:

1. Ensuring timely and complete provision of contracts for the supply of fuel and energy resources (FER) to the domestic market in the required volume and assortment in the short- and long-term;
2. Maintaining stable and economically acceptable prices for FER for all categories of consumers;
3. Providing operational coverage of unscheduled fluctuations in FER demand;
4. Ensuring the continuity of the current energy supply and regulatory parameters of energy carriers in real time.

To analyze the issue, it is necessary to identify two profiles of the external environment of the industry: near (energy) and far (multifactorial) [86]. The first profile includes elements that have direct relationships with electric power facilities (suppliers of equipment and fuel, consumers of electricity). The second profile influences the industry (with its economic, scientific, technical, climatic, and environmental factors) indirectly, often with a significant time lag. Nevertheless, its final influence can be very strong, and the search for adequate management decisions can be quite difficult.

Identifying the specific challenges and threats faced by the electric power industry relies on these two profiles of the external environment, the factors included in these profiles, and the nature of potential threats and the consequences of their manifestation.

Threat in the field of energy security is the possibility of causing economic damage to the energy facility and the end energy consumer as a result of the impact of various external factors—political, resource, and climatic [39,53]. It is not possible to eliminate the threat at the level of an individual object or even a region, because the immediate source of the threat must be eliminated first. In this regard, it is necessary to minimize the risks by creating a special mechanism for countering and protecting (i.e., an effective energy security system).

Threats arise periodically because of powerful factors (shifts): financial and economic, scientific and technical, resource and energy, and natural and climatic [87]. However, they create not only negative phenomena on an industry scale, but also new opportunities and development trends.

1. Financial and economic crises reduce the energy demand in the national economy and cause a massive outflow of investments, which slows down the technological development of the electric power industry and leads to the critical deterioration of energy facilities.
2. Reassessment of geological fuel reserves and a change in the geography of supplies may require a reassessment of the entire structural policy in the industry.
3. Sustainable climate change both narrows and expands the opportunities for the development of renewable energy sources (RES).

Nevertheless, the lag in the field of high technology reduces the competitiveness of the industry and the products of energy-intensive consumers-exporters.

Scientific breakthroughs in the field of energy technologies, which lead to commercial innovations, have the potential to dramatically increase the functional qualities and social efficiency of the industry. At the same time, they often require a large-scale restructuring of management, a reconstruction of energy systems, changes in operational dispatch control, and an introduction of new models of a competitive electricity and capacity market [88]. In this context, many countries are increasing the share of renewable energy in the structure of generation capacities; are creating energy storage devices; and are developing small (distributed) generation, intelligent power grid complexes, and small and medium-sized nuclear power plants, which have reactors with inherent safety.

These features prove the cardinal differences between external challenges for the electric power industry as a basic sector of the economy and local changes in the production and economic microenvironment of individual energy companies. These changes generate certain threats to competitiveness and financial stability and require the creation of an internal corporate proactive management system to neutralize these threats.

Table 2 presents some of the typical challenges for the electric power industry and their possible consequences, expressed in the form of threats.

Table 2. Challenges and threats determining strategic changes in the electric power industry (systematized by the authors according to [89–95]).

Challenge	Threat
Alarming physical deterioration and obsolescence of energy equipment	Increased accident rate. Excess losses of energy resources. Increased repair and upgrade costs. Lack of investment.
Rapid intellectualization of energy and its integration with other infrastructure sectors of the economy through smart technologies	Unpreparedness of the energy sector for the introduction of advanced scientific and technological achievements. Sharply variable nature of the operating mode of power plants and networks; growth of technological losses in distribution networks, which leads to higher costs throughout the energy supply chain and negatively affects continuity and reliability. Rising electricity prices due to the need to implement large-scale investment projects. Inconsistency of energy development with the demands of active consumers. Vulnerability to hacker attacks.
Increased share of hard-to-recover and converted hydrocarbons (shale oil, liquefied gas, offshore energy resources) in the fuel balance of thermal power plants.	Increased cost of electricity at the respective power plants. Reduced profitability of the energy company. Increased energy prices. The need for additional investment in the reconstruction of boiler units.
Advanced development of renewable energy (RES) as a response to the environmental requirements of the public	Non-optimal share of RES in the structure of generating capacities, which requires periodic unloading (shutdown) of highly efficient thermal power plants and nuclear power plants. Deformation of the energy market and decrease in the effectiveness of its price signals. Increased cost of electricity at the respective power plants. Reduced profitability of the energy company. Increased energy prices. The need for additional investment in the reconstruction of boiler units.
Reduced share of industry in energy consumption	Deloading of energy system schedules. Increased production costs in power plants. Additional need for capital investment in peak capacities. Problems with the introduction of the optimal daily operation schedule at nuclear power plants and large coal-fired thermal power plants.
Decreased demand in the wholesale electricity and capacity market (WECM)	Probable loss of some generating capacities and personnel of power plants during the decommissioning of least efficient, excess capacities without prospects for their modernization. In case they remain, consumer losses will increase due to the overpricing of the WECM and the motivation to switch to autonomous energy supply.
Inclusion of the category of "reliability" (non-failure operation) of energy equipment in the system of market relations; giving this category economic status	Periodic failures of energy equipment (potentially a mass phenomenon) due to the desire to reduce the cost of repairs.
Cybersecurity	Unauthorized intervention in the network management system. Vulnerability of information resources. Vulnerability of relay protection and automation devices and automated process control system.

Risk is the probability of the realization of a threat in a particular event. Risk depends on the nature and scale of the threat, as well as the readiness of the risk object to counteract it. Risks require expert judgment, which must be reviewed periodically. Based on the systematization of scientific publications [10,12,21,36,54,56,66,96–98], the authors identified three groups of the most relevant risks for the global energy industry. Their details are given in Table 3.

The mechanisms for neutralizing risks in the field of energy security are studied by the authors in [25,86,99], including the monograph "Energy Transition. A Guide for Realists" [100]. In the framework of this research, it is necessary to emphasize that the reaction of energy management systems to these risks can take the following forms:

- Disregard of risks (inaction), leading to a complete energy collapse with corresponding consequences for the country (region). Therefore, this option is considered only in a theoretical setting.

- Risk insurance. Additional costs for FER logistics, cargo insurance, the creation of fuel reserves and energy capacity reserves. As a result, energy security is ensured in terms of uninterrupted energy supply, but the prices for fuel, electricity, and heat increase. The level of energy security declines in this area, which may lead to a deepening economic recession in this country, or at least acceleration of inflation. This trend is currently prevailing.
- Implementation of a complex of progressive organizational and technical solutions in the energy sector. Complete provision of energy security of the country (region) based on the creation of national fuel and energy supply systems with increased resistance to new risks in the widest range of threats. This is the most versatile and effective way to counteract risks in the short- and long-term.

Table 3. Characteristics of energy risks.

Type of Risk	Content	Sources	Notes
Geopolitical [10,56,96]	Probability of termination of export (import) of fuel and energy resources (FER) by individual countries.	Various forms of interstate confrontation generated by clashes of geopolitical interests—from economic sanctions and violation of contractual obligations to the threat of direct military action.	Geopolitical risks are eco-nomically based on the development of world trade in FER due to the uneven distribution of FER reserves across the territories of individual countries.
Logistic [36,97,98]	Probability of violation of the timeliness of the FER supply.	Increasingly complicated routes for the supply of FER due to a change in suppliers; transition to other methods of FER transportation (e.g., long distance maritime transportation of LNG).	Logistic risks appear as a consequence of geopolitical risks.
Climatic [12,21,54,66]	Probability of reduced generated capacity of power plants, reliability of electricity and heat supply.	Instability of RES (hydro, wind, solar) parameters; wind loads of overhead power lines; instability of temperature and time characteristics of the cold season (heating period).	

4.2. Energy Security as a Priority Management Object

As a rule, scholars understand energy security management as the implementation of a set of measures at the level of the country (region), energy company, or enterprise that contribute to the achievement of relevant target indicators. Energy security management tools include the development of national energy strategies and policies [101], resource conservation [75,102], demand side management [103], and the diversification of energy carriers and energy production methods [99].

Within the framework of this article, it is fundamentally important to emphasize that in today's reality there is an urgent need to integrate energy security into the electric power complex management system. This is caused, on the one hand, by the consequences of changes in the structure of foreign economic relations, a radical transformation of supply chains, a decrease in natural gas exports, and an increase in exports of electricity intensive materials. On the other hand, the reason for this is the need to ensure a reliable energy supply with prices that stimulate economic growth in a situation when energy systems are saturated with renewable energy and nuclear power plants.

Under such conditions, public-private partnerships become the main principle of management [104,105]. The state provides scientific and methodological guidance and information support for market participants, performs functions of control and coordination, participates in the financing of projects in the field of energy security.

At the federal level, the creation of a National Center for Control and Coordination in the Field of Energy Security has been proposed, as well as a National Energy Security Investment Fund. It is assumed that these structures will have corresponding regional branches.

At the regional level (within the boundaries of the ECO), regional centers are organized with the following functions:

- Monitoring and control of energy security parameters;
- Coordination of interaction between energy equipment suppliers and energy companies;
- Coordination of interaction between energy companies and energy consumers;
- Development of recommendations on energy security for energy supply organizations and large energy consumers;
- Development of investment projects in the field of energy security in partnership with energy companies, large consumers, and regional authorities;
- Management of regional investment fund resources; allocation of capital investments in case of equity participation in the financing of investment projects.

The energy security profile is designed to identify emerging challenges in advance and make proactive decisions that neutralize threats. Currently, the most pressing challenges can be divided into two groups: challenges associated with changes in the pricing of fuel and energy resources (FER), and challenges posed by changes in the structure of energy consumption and industrial production.

4.2.1. Challenges Associated with Changes in the Pricing of FER

The factors which cause rising prices for FER in the conditions of declining energy consumption are the following:

- Increasingly complex logistics of FER due to growing geopolitical risks;
- Insurance of transport risks of suppliers (with the increasing role of long-distance maritime transport in particular);
- Additional conversion of FER at consumption points (inversion of LNG in receiving terminals; blending of different grades of oil at a refinery);
- Growing demand for FER with a decrease in energy consumption (aimed at creating insurance reserves due to the increase in transport and climate risks);
- Reduced production of hydrocarbon FER as a means of protecting the economic interests of suppliers [106,107].

Thus, the main contribution to the increase in FER prices in the foreseeable future will come from additional costs associated with the provision of energy security of FER-importing countries. An increase in energy prices causes a recession in the economy and, as a result, a decrease in energy consumption.

Differential accounting of supply risks for certain types of FER makes the price ratios between them very dynamic (volatile), which is important in optimizing the fuel and energy balance of the electric power industry. For example, in the "natural gas–thermal coal" pair, the price gap increases at first, but then, as demand grows, the more "reliable" energy resource decreases, approaching economically justified values [108,109]. Moreover, such cycles can be repeated. This process is reflected in short- and medium-term contracts based on exchange prices (spot market prices).

As a result, power plants operating on high-risk fuels may occasionally become unprofitable. In such a case, the selling price for energy must increase, or the power plant must shut down and transfer the load to thermal power plants that use alternative, cheaper fuel (if such a possibility exists in the energy system). Trying to solve the problem with long-term, fixed-price contracts only exacerbates the situation by causing a complete shutdown of fuel supplies to these power plants.

4.2.2. Challenges Associated with Changes in Energy Consumption

When a recession in industrial production occurs, the economic performance of the electric power industry is more influenced by the consumption of electricity in the residential sector. In particular, high daily unevenness of household loads causes a sharp increase in the cost of production and transportation of electricity in energy systems.

Rationalization of energy consumption includes general energy saving, increasing the energy efficiency of economic processes, and equalizing daily load schedules. Rationalization is recommended to be carried out within the framework of the demand management programs, which the energy supplying organization offers to consumers in exchange for financial incentives (benefits) [103,110].

The rise of natural gas prices, along with the expansion of nuclear energy, cheap coal, and renewable sources for electricity generation, increases the competitiveness of electricity as an electrification resource. At the same time, saving electricity increases the potential of this resource.

In the household/public utility sector, the electrification is expected to expand in three directions. Firstly, the use of electricity to produce the final heat carrier (electric boilers, water heating devices) [111]. Secondly, the introduction of power and heat supply systems, in which electricity serves as a direct heat carrier [112]. Thirdly, the replacement of household gas stoves with electric ones [113,114].

In industry: replacing hydrocarbon energy carriers with electricity and introducing electrical technologies lead to a significant increase in production efficiency [115]. At the same time, released natural gas resources can be used as raw materials at minimal cost in the petrochemical industry. Thus, electrification becomes a trigger for economic recovery in the country [116].

The prospects for electric cars should be assessed with restrained optimism. The demand for these cars will depend not only on gasoline prices, but also on factors such as the cost of acquiring and owning a vehicle, its versatility, undercarriage load resistance, power reserve per battery charge, the availability of charging stations, and the duration of a full charge [117,118]. The emergence of more economical and environmentally friendly internal combustion engines should also be taken into account [119,120]. In this regard, electric cars are likely to occupy a certain niche in the automotive market, but nothing more. At the same time, increased interest in cars with hybrid (electro-gasoline) engines can be expected [121].

5. Organizational and Technical Concept of Energy Transition in Conditions of Increased Attention to Energy Security

Energy transition (ET) is the process of accumulating a “critical mass” of transformations in the production and consumption of energy. The synergy of these transformations provides the final (target) results of achieving carbon neutrality and energy security. The basis for the ET are:

- Critical contribution of the electric power industry to greenhouse gas emissions (recognized as the root cause of global climate change);
- External factors that pose a threat to the energy security of the country (region).
- Previously, the goal of the ET was expressed exclusively by the carbon-climatic criterion. However, economic factors are becoming a priority in the face of emerging threats to energy security (in particular, sanctions). These factors primarily include energy prices and the reliability of energy supply.

In this regard, the ET should be aimed at giving energy facilities (energy systems) the properties of self-protection from certain threats.

In the ET model, the climatic factor will be identified as one of the groups of criteria, possibly weighted by relative importance, or transferred to the category of limitations.

It should be emphasized that the public demand for ET not only persists, but increases; the hierarchy of goals is changing and is being brought into line with the nature and scale of new threats.

The authors developed organizational and technical foundations of a realistic ET concept, which includes the following provisions.

If ET is considered as finite, then the moment of its completion will be determined by the achievement of its goal. Apologists for "green" energy believe that this goal is the complete elimination of greenhouse gas emissions, reduced to carbon dioxide by electric power facilities in the region (or the energy system) [122,123]. In the initial version of the ET, this task should have been solved exclusively on the basis of renewable energy; then, with the growing realization of the complete futility of this approach, nuclear energy was added to RES. In any case, the possibility of using thermal power plants to produce electricity was completely excluded; coal-fired power plants were excluded unequivocally and immediately, oil-fired power plants were excluded gradually. However, the concept of ET in this interpretation ignores the features of energy production and the patterns of development of electric power systems, and, therefore, cannot be practically implemented.

Firstly, various power plants included in the energy system generate electricity according to a certain specified mode, which is determined by their maneuverability and fuel efficiency [124]. This is necessary to cover the uneven load schedule of the energy system while meeting the requirements for reliability and economic efficiency. Meanwhile, renewable energy installations operate on the so-called "free" schedule due to the instability of natural energy flows. For example, the wind turbine schedule depends on the change in wind speed. The task in such cases is to maximize the supply of clean energy to the energy system or to individual consumers with decentralized energy supply (this is partly ensured by completing the wind turbine with storage devices).

Nuclear power plants operate most stably and economically in the constant load mode with the highest possible capacity factor. That is, they provide the basic part (zone) of the combined schedule of the energy system [125–127].

Thus, it becomes necessary to cover the variable part of the load schedule of the energy system (half-peak and peak zones). This task is solved by constructing highly maneuverable thermal power plants (TPPs) with gas turbine and combined cycle installations [128]. Naturally, this increases the volume of CO_2 emissions in the region, especially with a tendency to deload the schedule due to a decrease in the share of industrial energy consumption.

Secondly, the development of high-capacity wind power plants (WPPs) and nuclear power plants (NPPs) is constrained by well-known site restrictions. Therefore, part of the base load in developing energy systems is forced to be covered by TPPs operating on both natural gas and coal fuel (according to the conditions of fuel supply of the region). Moreover, the share of coal-fired TPPs also depends on the need for highly maneuverable plants, which, as a rule, use only natural gas. Ultimately, carbon emissions are determined by the rate of economic growth that causes an increase (decrease) in energy production in the region.

Thirdly, the construction of WPPs with a "system"-level of installed capacity requires the creation of a mobile operational reserve in the energy system. The reserve is located in highly flexible TPPs, which also contribute to carbon emissions.

Finally, distributed generation plants, as well as consumers' own energy sources (numerous small CHP plants) also contribute to the carbonization of the atmosphere.

Therefore, significant fluctuations in the volume of carbon emissions occur during the ET process. These fluctuations, which can sway to one side or the other, are caused primarily by the dynamics of economic growth and changes in the load schedules of individual energy systems. In any case, the volume of carbon emissions remains quite far from zero [129].

Without calling into question the contribution of RES and nuclear energy to the reduction of greenhouse gas emissions, it should be emphasized that at the current technological level, these power plants cannot solve the problem of decarbonization of the electric power industry.

Saturation of energy systems with RES and NPP generating units, which adhere to natural, climatic, and site restrictions, does not yet indicate the completion of the ET; rather, this is the end of its initial stage. The fact is that the ET goals have not been fully achieved yet. Moreover, there is a certain technological and organizational potential for further decarbonization.

In this regard, the following directions should be considered as promising: increasing the maneuverability of NPPs; developing technologies for carbon-free use of fossil fuels at TPPs, including those based on CO_2 capture in flue gases; introducing methods of energy and capacity demand management, which are aimed at energy saving and rationalization of load schedules in the consumer sector [90,130].

Taking into account the time difference in the implementation of promising solutions and the gradually increasing provision of the relevant objects with innovation, the total duration of the ET period is extremely uncertain. If we apply indicators of time horizons, long-term planning, and forecasting to ET [131], it will not be an exaggeration to say that the end point of ET lies somewhere in infinity.

However, even with the mass introduction of the indicated innovations, it is not possible to achieve zero emissions and, most importantly, to maintain it. For example, it is unlikely that it will be possible to bring the maneuvering qualities of a NPP to the level of a gas turbine of a comparable capacity. The efficiency of installations for the purification of TPPs flue gases from CO_2 may differ significantly from 100%. There are great doubts about the use of these devices for low-capacity decentralized energy supply installations. The problem in demand management lies in the limited and dramatically different rationalization potentials of individual consumers. This prevents the accumulation of a "critical mass" of results, leading to a significant reduction in energy production and emissions, as well as to the equalization of daily load schedules of energy systems.

These provisions lead to an important conclusion: if it is impossible to eliminate the emission of greenhouse gases completely, then it is necessary to learn how to manage this emission by creating appropriate mechanisms. The leading tool in such a management system is the CO_2 emission standard, which reflects the actual decarbonization process. The standard should be differentiated by individual facilities and regions and periodically revised downward.

It should be noted that any decision made during the ET process must be accompanied by an assessment of the consequences for the main elements of energy security: prices and reliability of energy supply. Reliability reduction is unacceptable; for example, the construction of wind turbines provides for the parallel creation of special power reserves in energy system. Reduction of the price burden on consumers, with the advanced development of RES and NPP, can be ensured by distributing new inputs over time, or by using various compensation mechanisms. The latter include tax incentives, the reimbursement of additional energy costs, concessional lending for investments in energy saving, and compensating energy companies for exceeding the electricity production cost over the market price.

It follows from these provisions that, in general, demand management in the consumer sector allows us to solve the problems of ET and maintain the required level of energy security. On the one hand, energy saving and rationalization of consumer load schedules indirectly contribute to the reduction of CO_2 emissions in energy systems; on the other hand, they directly reduce the price of consumed electricity.

6. Discussion

The implementation of conceptual provisions of energy security management, including provisions of the ET concept, requires the implementation of a number of technological, economic, and managerial measures.

In this section, some of these measures are discussed—in particular, prospects and limitations of various types of power plants, as well as related issues of financial and investment support for ET. These issues inevitably arise when implementing modernization programs for energy systems to ensure their compliance with the necessary requirements of energy and environmental security.

Thermal power plants. With high volatility in prices and contracts for the FER supply, which are linked to spot market prices, multi-fuel thermal power plants can become the basis of thermal power generation. Such power plants must comply with the following requirements: work steadily on all types of fossil fuels (gas, fuel oil, coal) in a wide load range; ensure at least 60% efficiency of electricity generation using any FER; and be equipped with a system for capturing carbon dioxide in flue gases, concentrating and transferring CO_2 for further disposal.

The concept of a multi-fuel TPP includes the creation of a system for digital software control of a power facility. The system should monitor prices for competing FER, determine the best time for switching to another type of fuel, and run this process automatically.

Modernized combined cycle plants, which have devices for generating working gas when burning solid and liquid fuels, are the prototype of such power plants.

Nuclear power plants. The resumption of nuclear energy development seems logical and justified in the context of destabilizing fuel markets, rising prices for high-quality FER, and threats to the energy security of a number of countries.

However, in order to function effectively in the current situation, the nuclear power industry should change. Its development should be based on progressive technical solutions, the main goals of which are:

- The creation of an NPP of a fundamental new level of safety based on the concept of self-protection and self-regulation of nuclear power plant reactors;
- A significant increase in the burnup of nuclear fuel; bringing the efficiency of NPPs up to the indicators of condensing TPPs at supercritical parameters;
- Organization of a closed fuel cycle based on a combination of thermal and fast-neutron reactors.

Nuclear power should become completely waste-free. Any disposal of spent nuclear fuel, as well as non-fuel nuclear waste, should be eliminated on the NPP territory and outside it. All waste should be sent for processing and disposal; some components should be neutralized and destroyed.

NPPs are elements of energy systems; therefore, increasing the maneuverability of NPPs is extremely important. They must be adapted for stable and efficient operation both in the base and variable parts of the load schedule of the energy system.

Prices for nuclear fuel supplied to NPPs will depend on the demand for new power plants, the location of the main deposits of natural uranium, and the capacity of nuclear fuel enrichment plants. It is likely that prices will rise at the initial stage of the nuclear energy "renaissance". This will be partially offset by an increase in the energy efficiency of NPPs.

Wind turbines. The prospects for wind energy, the most common form of using RES for electricity generation, are rather uncertain due to various multidirectional factors. On the one hand, the increase in prices for hydrocarbon FER and the problem of the reliability of FER supply increase the relative efficiency of wind turbines (as long as the guaranteed capacity of the units is provided, and regular fluctuations in the flow of primary energy are compensated by backup batteries or operating reserve in the energy system). On the other hand, there are factors that significantly reduce their competitiveness: the commissioning of capacities of highly economical combined-cycle TPPs equipped with devices for capturing greenhouse gases and operating on different types of fuel; the construction of NPPs with increased safety and energy efficiency; and the limitations of wind turbine power.

Under these conditions, the development of wind energy will depend on two main factors. Firstly, the possibility of choosing sites for high-capacity wind power plants (WPPs) that are included in the energy system and that generate wind energy at minimal cost [132]. Secondly, the nature of climatic shifts in traditional locations of wind turbines. Thus, the installed capacity utilization factor of wind turbines can drop to economically unacceptable values when the primary (natural) energy flows are destabilized. This will call into question the further operation of the entire complex of wind turbines in the area.

These factors determine the goals and objectives of R&D in wind energy in the foreseeable future. These include an increase in unit capacities of wind turbines (with a relative decrease in the dimensions of installations); the expansion of the range of wind speeds in which it is technically possible to generate electricity. The first consideration reduces the specific capital investment in wind turbines and the production cost; the second consideration reduces the influence of the climatic factor. Neutralization of the impact of powerful wind turbines on the environment (i.e., noise from operating installations and radio wave interference) is also important.

Recognizing that these considerations are dead ends in terms of expected results (especially the first two) indicates a gradual decrease in the share of wind turbines in the structure of generating capacities in regions with unstable wind loads. This will happen due to a decrease in the economically optimal level of wind turbine capacity, as well as restrictions on the number of installations in the territory. Under these conditions, the construction of "systemic" WPPs, which combine high-power wind turbines, is futile; wind energy will be represented exclusively by small wind turbines that service a narrow sector of decentralized energy supply.

It is obvious that the financial and investment problem is fundamental in the context of ET management [133]. A significant increase in the inflow of investments into the electric power industry will be required. Investments will be directed to the following areas: capital-intensive structural shifts in energy systems; additional costs for the reconstruction and technical reequipment of energy facilities, equipment modernization; and associated capital investments that provide the necessary energy security parameters in the process of ET.

Thus, the total potential of all available sources of investment will determine the rate of the ET effectiveness and the scale of coverage of emission-active territories. Meanwhile, the risks caused by the features of the investment cycle in the electric power industry, as well as the priority of short-term business goals, significantly reduce the possibility of attracting private funds to carry out the necessary transformations.

In this regard, the state begins to play a greater role as an investor, organizer of the pre-investment cycle (development of the concept and program of ET, R&D), and coordinator of all decisions in the field of ET. Along with budget allocations, the creation of extra-budgetary funds should become an important feature in the organization of the investment process. Extra-budgetary funds will be formed at the expense of mandatory contributions from energy market participants, as well as from fines for violating environmental standards.

At the same time, the state should encourage energy companies, as well as power engineering enterprises, to invest in ET. In this regard, the most promising areas of investment are those that give a side effect in the form of increased financial results (profitability) of energy companies. For example, the use of combined cycle technologies leads to a decrease in specific fuel consumption at TPPs, which naturally reduces carbon emissions in the region and production costs for energy generating companies. Similar results are observed when energy companies finance load management programs, or when there is equity participation of interested consumers. In this case, the need for commissioning peak capacities at TPPs is reduced, and the capacity factor of nuclear and highly economical combined cycle power plants is increased.

7. Conclusions

In the foreseeable future, the global energy situation will be characterized by aggressive competition and acute geopolitical contradictions between the countries that are the largest players in the global energy market; by the complication of the supply of the main types of FER and an increase in its cost; by a decrease in the sustainability of energy supply due to a decreasing dependence on fossil fuels in favor of renewable energy; by continued decommissioning of coal-fired TPPs and NPPs and a resulting sharp increase in energy price volatility.

As follows from the presented theoretical review, the issues appearing in energy security were not relevant even a decade ago. It is obvious that the ill-conceived politicized ideology of ET has become a source of fundamentally new threats to the energy security of a group of countries. These threats extend to the reliability of energy supply and electricity prices. This is a consequence of the absolutization of the role of RES in the energy production, the shutdown of coal-fired TPPs and NPPs, and an unforeseen increase in natural gas prices.

In addition, the problem of energy security is acquiring multi-criteria characteristics. The level of energy security today is determined not only by assessing local technological, environmental, economic, logistical, managerial, social, political, legal threats (indicators), but also, which is especially important and new, by taking into account the interdisciplinary relationships between them.

The objectivity of decisions being made on the basis of such a comprehensive assessment depends largely on overcoming the factor of deep uncertainty of the external environment. In this case, scenario methods, which are implemented on the basis of specialized intelligent systems and software systems, are prioritized.

The organizational and technical concept of ET presented in the article assumes a harmonious, long-term combination of the goals of energy and eco-climatic security. However, in the short-term, the emergence of new risks and threats justifies the choice of prioritizing the field of energy security. For example, there may be situations in which the synergy of climatic and logistical risks makes the reliability and cost of energy supply more important in social progress than elimination of greenhouse gas emissions.

The article outlined the principles of ensuring energy security, which were originally developed for FER importing countries. However, they can be considered universal to a certain extent. For example, they apply to the interpretation of the "energy security" concept, the actualization of climate risks, as well as the main directions of organizational and technical transformations in the electric power industry. It should be noted that it is unacceptable to isolate the energy sector from advanced technologies, even if the country is fully provided with reserves of natural FER that enable it to achieve a sufficient level of energy security in the foreseeable (medium-term) future. The advanced technologies include, for example, the combustion of fossil fuels, nuclear power, renewable energy, energy saving, and electrification. Such policy guarantees the country's energy security in the long-term, when the uncertainty of future risks and threats increases sharply. In addition, it allows the country to create a basis for the export of advanced technologies.

In terms of future research directions, modifications to scenario methods are of particular interest. They allow us to predict changes in individual components (indicators) of energy security in the face of growing uncertainty in the external environment. Energy security, in conjunction with the ET requirements, is a new object of scenario modeling. Since there may be different priorities in the ET, the prospective model may be multi-purpose. For example, such a model can justify the economic choice between investing resources in the advanced development of carbon-free energy facilities (with higher unit costs than at replaced TPPs) and investing resources in the country's energy security in order to counter new threats (of political genesis in particular). Thus, multi-objective models can seek a balance between the criteria of minimum CO_2 emissions and maximum levels of energy security in the region.

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