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ANALYSIS OF THE THEORETICAL AND METHODOLOGICAL SUPPORT OF THE STUDY OF ENERGY SECURITY OF THE COUNTRY

Світове енергоспоживання постійно зростає. В цих умовах загострюється проблема пошуку нових можливостей задоволення зростаючих потреб в енергетичних ресурсах. Така ситуація призводить до необхідності розглядати напрями та перспективи розвитку синтетичного рідкого моторного палива в контексті вирішення завдання посилення енергетичної безпеки країни. Об'єктом даного дослідження виступає енергетична безпека країни та її складові, що характеризують внутрішні та зовнішні фактори функціонування енергетичної системи країни. Компонентами енергетичної безпеки країни виступають паливно-енергетичні ресурси та розвинені на її території економічні й інфраструктурні елементи енергетичної системи. Одним з основних проблемних місць об'єкту дослідження є відсутність єдиного підходу до тлумачення сутності поняття «енергетична безпека» та організації процесу її оцінювання.

У ході дослідження були використані методи аналізу, синтезу та системного аналізу.

Системний аналіз складових енергетичної безпеки довів, що загальноприйнятою точкою зору є включення «енергетичної доступності» до змісту поняття «енергетична безпека». Інші складові носять комплексну роль по відношенню до цієї складової. Енергетична безпека представляє узагальнююче поняття різних складових та компонентів, яке неможливо охарактеризувати єдиним індикатором. Відсутність консенсусу щодо змісту цього поняття призводить до різноманіття методичних підходів до його оцінки. Встановлено, що найчастіше для оцінки енергетичної безпеки використовується система індикаторів, розподілених за компонентами та агрегованих у зваженому стандартизованому виді в єдиний інтегральний показник, який і є мірилом енергетичної безпеки.

Доведено, що більшість існуючих методик передбачають виділення та оцінювання окремих складових енергетичної безпеки, але при цьому недостатньо уваги приділяється оцінці її ринкової складової. Обґрунтовано, що основу ринкового підходу до оцінки енергетичної безпеки країни має складати аналіз кон'юнктури ринків окремих енергетичних ресурсів з метою визначення надійності та збалансованості забезпечення енергетичних потреб.

Ключові слова: енергетична безпека країни, енергетична система, паливно-енергетичний комплекс, рідке моторне паливо, методичний підхід.

1. Introduction

Synthetic liquid motor fuel, which is produced from coal, oil, natural gas, biological raw materials, etc., takes key positions in the world fuel and energy balance. Despite the fact that the world's energy consumption is constantly growing, the problem of finding new opportunities to meet growing needs in energy resources is becoming more acute. This situation leads to the need to consider the directions and prospects for the development of synthetic liquid motor fuel in the context of solving the problem of enhancing the country's energy security.

So, it is relevant to justify the theoretical aspects of the study of the country's energy security.

2. The object of research and its technological audit

The object of research is the energy security of the country and its components that characterize the internal and external factors of the functioning of the country's

energy system. The components of energy security are fuel and energy resources and the economic and infrastructural elements of the energy system are developed on the territory of the country.

One of the most problematic places is the absence of a single generally accepted interpretation of the essence of the notion of «energy security» of the country and the approach to its assessment, including isolation of constituent elements of energy security.

3. The aim and objectives of research

The aim of research is substantiation of the theoretical foundations for the study of the country's energy security.

Based on the aim of research, the following tasks are set and solved:

1. Assess the approaches to the interpretation of the essence of the country's energy security analyzed in the scientific literature.
2. Identify the main components of the country's energy security.

3. Substantiate the basic theoretical aspects of the study of the country's energy security.

4. Research of existing solutions of the problem

The problems of the country's energy security are considered quite fully in the scientific literature. In work [1] the analysis of various approaches to the interpretation of the concept of «energy security» and indices of its evaluation is presented. But the advantages and disadvantages of each approach are not highlighted. In [2, 3], attempts have also been made to solve the problem of interpreting the essence of the concept of «energy security» and its evaluation using a system of partial indicators. However, there is no single approach to the formation of a system of such indicators.

The expediency of singling out individual components of the country's energy system and assessing their impact on energy security is justified in [4]. But without attention there were questions of theoretical maintenance of research of laws of formation of power safety at level of a separate country.

The authors of [5] consider the country's energy security in the context of the formation of alternative sources of energy supply. However, the problems of modernizing the infrastructure of traditional sources of energy supply are not fully covered.

In work [6] an attempt is made to substantiate a comprehensive methodology for assessing the country's energy security, which can be used at the state level. But without attention there is an analysis of external factors affecting the formation of the country's energy dependence.

Works [7, 8] are devoted to the analysis of theoretical models for assessing the country's energy security, while the conditions for applying models need to be clarified.

Another attempt to develop a national methodology for assessing energy security is given in [9]. At the same time, out of the author's field of vision, there were some economic factors of energy security, in particular, analysis of the country's energy markets.

The paper [10] is devoted to the analysis of state regulation of the country's energy system, but the problems of theoretical support for its assessment are not sufficiently disclosed.

A number of international organizations are also developing methods for assessing the country's energy security. Such variety of methods requires their generalization for further substantiation of the directions for improving traditional approaches to assessing the problems of the country's energy security and the formation of theoretical support for its assessment.

5. Methods of research

In this research, such general scientific methods are used:

- analysis and synthesis – to generalize the approaches presented in the scientific literature to the study and assessment of the country's energy security;

- system analysis – to justify the theoretical provision of assessing the country's energy security.

6. Research results

Numerous theoretical and methodological studies on energy security cause a lack of consensus on the substance of the concept itself, as well as methods for its evaluation. Among the most often represented components that make up the content of the concept of «energy security», there are [1]:

- energy availability, which reflects the reliability and diversification of energy supplies, as well as geopolitical risks;
- sufficiency of power infrastructure capacities at all stages of the energy chain for reliable energy supply in short- and long-term periods;
- price accessibility of energy, which reflects the absolute level of prices, their volatility, as well as the degree of competition in the energy market;
- social effects that determine the ability to meet basic energy needs;
- energy ecologization, which characterizes the degree of harmful impact on the environment caused by the consumption of primary energy resources and energy carriers;
- state support of the energy sector, which determines the effectiveness of management decisions to overcome short-term energy supply disruptions, and the ability to guarantee the stability of energy supplies in the long run;
- energy efficiency, which is aimed at reducing the level of energy needs in the society through the introduction of less energy-intensive technologies, the organization of highly efficient energy systems, and the application of best practices for managing energy consumption.

The systematization of the components of energy security proves that the generally accepted view is the inclusion of «energy accessibility» to the content of the concept of «energy security». Other components are complementary to this component. Among scientists there is no consensus on the advisability of their inclusion in the substantive essence of energy security (Fig. 1).

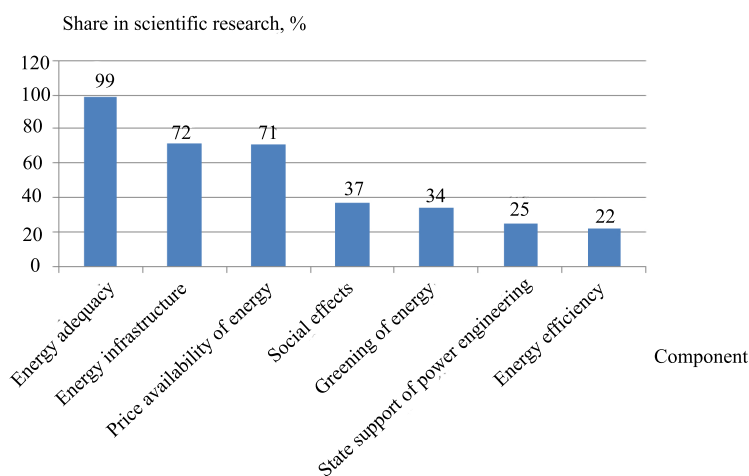


Fig. 1. Distribution of scientific research on energy security by components [1]

Despite this, the authors make an assumption and it is necessary to further identify the concepts of «energy security» and «security of energy supplies», which means

the reliability of ensuring the energy interests of the national economy in the current energy market conditions. Consequently, in the epicenter of energy security, the energy interests of society are found, that is, consumer demand for a particular type of fuel and energy resources or final energy that can be met by various sources.

At the same time imbalances of the energy market conjuncture lead to energy security risks, among which it is expedient to allocate:

- resource risks due to the exhaustion of the energy potential of the national economy;
- internal risks caused by imperfect functioning of the energy facilities of the national economy;
- export risks arising from the dependence of national producers on foreign markets;
- import risks caused by the dependence of the national consumer on imported energy supplies;
- trading risks, which are a consequence of the construction of imperfect relations in the energy market.

Investigation of energy security is advisable to conduct on certain types of energy markets designed to satisfy certain energy interests of society, since most of the needs are not interchangeable. Each energy market of the national economy has its own set of risks and identifies

a model of its national energy security. Thus, the basis for the study of energy security is the market approach.

Energy security is a generalizing concept of various components and components that can't be characterized by a single indicator. The lack of consensus on the content of this concept leads to a variety of methodological approaches to its evaluation. More often than not, a system of indicators distributed across components and aggregated in a weighted standardized form into a single integrated indicator is used to assess energy security, which is the measure of energy security. To assess energy security, from 2 to 68 partial indicators of energy security are used.

One of the first studies of energy security was conducted by the International Energy Agency among the member countries of the Organization for Economic Cooperation and Development (OECD), in which a two-factor assessment model was proposed. Indicators of evaluation were the price of energy and its physical availability [11]. However, this approach was not widespread and was later replaced by the MOSES (Model of the Short-term Energy Security) developed by the author of the paper, which provides for the positioning of the world's countries in 35 short-term energy security indicators (Table 1), distributed by components – types of fuel and energy resources.

Table 1

Methodological approach to the assessment of energy security by the MOSES model *

Component	Parameter		Indicator
Raw oil	External	Risk	Dependence on net imports
			Weighted average political stability of supplies
		Durability	Entry points (ports and pipelines)
	Variety of suppliers		
	Internal		Risk
		Volatility of domestic production	
Durability		Stock level	
Oil products	External	Risk	Dependence on net imports
		Durability	Variety of suppliers
			Entry points (ports and pipelines)
	Internal	Durability	Number of refineries (refineries)
			Flexibility of the refinery infrastructure
			Stock level
Natural gas	External	Risk	Dependence on net imports
			Weighted average political stability of supplies
		Durability	Entry points (ports and gas pipelines)
	Variety of suppliers		
	Internal	Risk	Proportion of offshore production
			Durability
			Intensity of consumption of natural gas
Coal	External	Risk	Dependence on net imports
		Durability	Entry points (ports and railways)
			Variety of suppliers
	Internal	Risk	Share of underground production
Hydraulic energy	Internal	Risk	Annual volatility of production
Atomic energy	Internal	Risk	Unplanned reactor shutdowns
			Average age of nuclear power plants
		Durability	Variety of reactor models
			Number of nuclear power plants

Note:* – built on the basis of data [12]

Now this method represents the official position of the International Energy Agency (IEA) on the specifics of the assessment of energy security. Unlike other methodological approaches, MOSES does not provide for the aggregation of private indicators of energy security, but involves positioning the world's countries on risks and the stability of energy security.

Another methodological approach to assessing energy security was developed by the Institute of Energy of the 21st Century under the US Chamber of Commerce [13], which provides an integrated assessment of energy security risks for 28 indicators distributed among such components:

- reliability and diversity of world reserves and supplies of oil, natural gas and coal;
- impact on the national economy of unreliable and concentrated supplies of oil and natural gas and coal;
- amount of expenditures in the national economy for energy and the impact of price shocks on consumers;
- sensitivity of the national economy to large fluctuations in energy prices;
- intensity of energy use in relation to the population and economic production;
- reliability of generating capacities of electric power industry;
- energy efficiency in the transport sector per unit of GDP and per capita;
- economic impact of national and international mandates for reducing greenhouse gas emissions.

Private indicators include:

- safety in the world's reserves of oil, natural gas, coal;
- dependence on imports of oil, natural gas, coal;
- energy intensity of GDP in value terms;
- volatility of prices for crude oil;
- diversification of electric power capacities;
- CO₂ emissions associated with the use of energy per capita;
- intensity of CO₂ emissions associated with the use of energy per unit of GDP.

The assessment of this index is carried out periodically for 25 countries of the world, including Ukraine.

The Institute for Economic Research in Asia (ERIA – Economic Research Institute for ASEAN and East Asia) has developed another methodical approach to assessing energy security, which relies on 16 particular indicators for 9 components (Table 2).

Aggregation of private indicators for the ERIA approach is not foreseen, but only a comparison with the OECD group of countries.

The World Energy Council (WEC) considers energy security, together with energy equality and environmental sustainability, as an energy trilemma. This approach involves the assessment of the Energy Sustainable Index (ESI) [15], which also includes contextual productivity.

Directly energy security is estimated by 6 indicators, and the energy stability index takes into account 22 indicators. All partial indicators in components and directly components are equivalent:

- energy security (25 %);
- energy equality (25 %);
- sustainability in the environment (25 %);
- political force (8.3 %);
- social strength (8.3 %);
- economic strength (8.3 %).

Table 2

Methodical approach to the assessment of energy security ERIA*

The component of energy security	Component of evaluation	Partial indicator of energy security
Development of internal energy resources	Self-sufficiency	Self-sufficiency coefficient of the total primary energy distribution (including atomic energy)
		Coefficient of ratio of stocks to energy production
		Coefficient of ratio of stocks to consumption of energy resources
Acquisition of foreign resources	Diversification of sources of energy imports by countries	Diversification of sources of energy imports by countries (by types of energy resources)
	Diversification of energy sources	Diversification of sources of the general primary energy distribution or sources of electricity production
	Dependence on the Middle East	Energy dependence on the Middle East for oil and gas
Ensuring the reliability of the domestic supply chain	Reliability of energy supplies	Reserve of generating capacities Frequency/duration of power outage
	Development of energy supply infrastructure	Coefficient of access to commercial energy
Demand management	Energy efficiency	Energy intensity of GDP for the total primary energy distribution Energy intensity of GDP by the total final energy distribution
Readiness for power failures	Strategic reserves	Number of days for which there is enough oil in the land bunkers
Environmental sustainability	Carbon intensity of consumption	Carbon intensity of energy consumption by the general primary energy proposition Carbon intensity of fuel consumption Carbon intensity of GDP Emissions of CO ₂ per capita

Note:* – built on the basis of data [14]

The WEC Energy Sustainability Index is evaluated annually for 125 countries, which involves the calculation of both the integrated indicator and the positioning of the world by individual components.

The World Economic Forum (WEF) considers the assessment of energy security as part of the Energy Architecture Performance Index (EAPI), which takes into account three components:

- 1) economic growth and development;
- 2) stability in the environment;
- 3) access to energy and safety.

Each of these components is estimated by 6 partial indicators (Table 3).

Directly the third component of EAPI is represented by such criteria as: level and quality of access to energy, self-sufficiency of markets, as well as diversification of energy supplies. Therefore, WEF has tried to introduce a market-based approach to assessing energy security.

However, the assessment of energy security in the generalized energy market and the incomplete coverage of conjunctural components indicate a lack of validity of the approach.

of energy security risks, and, consequently, is not able to objectively assess its true level.

7. SWOT analysis of research results

Strengths. The research results allow to note such strengths as:

- accounting for the main research methods presented in the scientific literature;
- assessing the country's energy security;
- emphasis on individual models of energy security assessment, developed by international institutions (MOSES, MEA, ERIA, etc.). This approach has made it possible to determine the priority components of the country's energy security.

Weaknesses. The weak side is the need to attract additional information on the methodological approaches presented in scientific sources.

Opportunities. Assessment and control of not only the state of energy security of the country as a whole, but also its individual components.

Threats. The likelihood of rapid and difficult predictable changes in the state of markets for fuel and energy resources and liquid motor fuel, which will negatively affect the country's energy security.

8. Conclusions

1. Analysis of the approaches presented in the scientific literature to the interpretation of the essence of the concept of «energy security» made it possible to formulate a more precise definition of it as «the reliability of ensuring the energy interests of the national economy in the present situation in the energy market».

2. It has been proved that most of the existing methods provide for the allocation and assessment of individual components of energy security, but insufficient attention is paid to the assessment of its market component. The main components of energy security are:

- economic (economic development, stability of the functioning of the economic system);
- ecological (environment, ecological development);
- energy (access to energy, energy infrastructure).

3. Theoretical aspects of the country's energy security envisage an orientation toward a market approach based on an analysis of the market situation of individual energy resources in order to determine the reliability and balance of energy requirements.

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Table 3

Indicators of Energy Architecture Performance Index (EAPI) WEF*

Component	Criterion	Local indicator
1. Economic growth and development	1.1. Efficiency	1.1.1. Energy intensity (GDP per unit of energy consumption)
	1.2. No distortion/availability	1.1.2. Degree of artificial distortions in gasoline prices (index)
		1.1.3. Degree of artificial distortions in prices for diesel fuel (index)
		1.1.4. Electricity prices for industry
	1.3. Support/Suppression of Growth	1.1.5. Energy import costs as % of GDP
		1.1.6. The cost of energy exports in % of GDP
2. Sustainability in the environment	2.1. The share of low-carbon fuel sources in the energy basket	2.1.1. The share of alternative and nuclear energy, including biomass, in the balance sheet
	2.2. The effect of harmful emissions	2.2.1. CO ₂ emissions from electricity generation
		2.2.2. Emissions of methane in the energy sector per capita
		2.2.3. Nitrous oxide emissions in the energy sector per capita
		2.2.4. Emissions of particulate matter (10 μm) per cubic meter. m
		2.2.5. Average fuel economy for cars
3. Access to energy and security	3.1. Level and quality of access	3.1.1. Level of electrification of the population
		3.1.2. Quality of electricity supply
		3.1.3. Percentage of population using solid fuel for cooking
	3.2. Self-sufficient/multilateral markets	3.1.4. Net import dependence as a percentage of energy consumption
		3.1.5. Diversification of imports from partner countries, %
	3.3. Supply diversification	3.1.6. Diversification of the general primary energy distribution

Note:* – built on the basis of data [16]

Ukraine assesses energy security as part of the economic security of the national economy. The approved national methodology does not provide for the allocation of energy security components, and its overall level is proposed to be assessed by 10 partial indicators that reflect different types of fuel and energy resources. And also qualitative indicators of the rationality of constructing an aggregate fuel and energy balance. So, the methodological approach approved at the national level to assess energy security does not contribute to the comprehensive identification

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