The Central Research institute
of the Armed Forces of Ukraine

Military Science. Vol. 2 No. 2 (2024)

DOI: 10.62524/msj.2024.2.2.01

Substantiation of the indicators' system for assessing the state's energy security

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Abstract. The relevance of the article is due to the need to develop a indicators' system for assessing the state's energy security, which is important in the context of the aggressor's deliberate attempts to destroy Ukraine's energy systems.

The article is aimed at presenting a indicators' hierarchy that comprehensively characterise the main factors affecting energy security. The indicators development system is based on a systematic analysis of these factors.

The article presents the proposed indicators' hierarchy for assessing energy security, which are divided into two groups – military and non-military, and allow assessing both the condition of main energy's system elements (nuclear energy system, electricity system and fuel supply system), energy supply of the Armed Forces of Ukraine, and general indicators – energy independence, diversification of ways and energy's resources supply volumes, critical infrastructure condition and energy efficiency of the national economy.

A possible generalised approach to the calculation of these indicators based on aggregates of

lower-level partial indicators is also proposed.

In general, the proposed indicators' system allows to consistently assess the contribution of the energy factor to the to the meaning of overall state's defence security importance; to obtain unified energy's security level integrated indicators (provision), which will allow an unambiguous state affairs' assessment in this sphere; to determine the dynamics of changes in significant indicators when the factors on which they depend change, and, accordingly, to assess the measures' effectiveness the taken to strengthen the condition of state's energy and military security; to identify sources of possible dangers that could lead to the condition of the military (energy) state's security aggravation.

Directions for further research may include the procedure development for determining the energy supply integral indicators of the Armed Forces, energy security and their impact on the state's economic, defence and national security.

Keywords: military security, energy security, energy sector, energy carriers, electricity, energy supply, energy independence.

Introduction

As a result of the russian federation's aggression, the issue of national and, in particular, military security has become particularly important. In this context, it should be noted that the state's military security largely depends on the military-economic component, which implies a condidion of the defence sector economy that guarantees a sufficient level of military consumption during armed confrontation.

It is quite clear that military-economic security directly depends on the state's economic capabilities to maintain the military security system, i.e., on economic security.

Economic security is the main indicator of economic walfare and is determined by the contribution of all its components: social, environmental, military, legal, energy, information and other spheres of life.

At present, economic development has reached a level where the energy sphere plays a key role in terms of its impact on other economic components. Therefore, determining the energy factor contribution to economic security is crucial for analysing economic security and determining the military security condition.

At the same time, a prerequisite for the existence and state's development is to create conditions for neutralising or eliminating threats to both the energy system and the state's economy, i.e., to ensure the state's energy security.

Energy security is one of the national security most important components, a prerequisite for ensuring sustainable state's development. Energy security envisages ensuring the national interests' protection in the access area to reliable, sustainable, affordable and modern energy sources for all consumers in a technically reliable, safe, cost-effective and environmentally acceptable manner in normal conditions and crisis situations (On approval of the Energy Security Strategy, 2021).

Since the beginning of the russian aggression in 2014, a number of problems have arisen related to energy carriers supplies, loss of energy generating enterprises, etc., which has significantly worsened the difficult situation in the Ukraine's energy sector, which has hardly developed during the independence years.

In such a situation, an urgent scientific task is to assess the energy security condition, determine its impact on military and national security, which will further allow to substantiate ways to overcome the emerging problems.

Methodological Framework

The proposed system of indicators was developed on the factors' analysis basis that affect the state's energy security.

Recently, Ukraine has paid considerable attention to the military security problems, for example, (Bohdanovych, 2019) and (Bohdanovych, 2020), (Bocharnikov, 2019), (Hohoniants, 2019), as well as its important component – energy security (Sukhodolia, 2020), (Ilienko, 2019), (Matviichuk, 2018), (Topalov, 2022), (Pavlenko, 2022). However, most studies consider only one energy security aspect – political or technological. Often, energy security is understood only as the condition of the state's energy resources (oil, gas, coal). The issue of developing a methodological apparatus for substantiating measures to ensure military security by improving the state's energy security has not been sufficiently studied.

A significant drawback in this regard is the lack of a systematic approach to the study of the relationship between the state's energy security and its military security, which would allow taking into account the entire range of energy security threats, assessing their impact and justifying a list of measures aimed at improving the energy security level and, accordingly, ensuring the required level of military security.

At the same time, this complication creates a contradiction between the state's economic capabilities to improve its own energy security (in order to achieve a certain economic and military security level) on the one hand, and the need to maintain the military security system in constant readiness to counter threats on the other. This is especially important in a period when the energy sector components can be physically destroyed in a very short time.

Results and Discussions

Assessing the effectiveness of the state's energy security and measures to improve it is important for determining rational ways to ensure (increase) military security. This is especially important in the case when reaching the required level of military security cannot be achieved only by building up military power.

Military security, as a structural element of national security, characterises the ability of a state and its armed forces to confront or prevent damage to its national security by armed violence means. This is its main specificity.

In order to assess the contribution of energy security to military security, the author proposes an approach that provides its consistent assessment. To implement such an approach, we propose an appropriate indicators' system, the general structure of which is shown in Fig. 1. The proposed system contains only indicators that take into account the impact of the military security energy component.

The **military** sphere indicators characterise the energy supply condition of the Armed Forces of Ukraine.

It is proposed to use the following indicators:

Fuel supply (diesel, petrol and aviation kerosene);

electricity supply condition (mobile equipment and stationary system condition, electricity supply needs of the armed forces).

The general approach is to calculate these indicators as (Semenenko, 2021):

$$E_r = f(m_r) = 1 - e^{-m_r}; \quad (1)$$

$$m_r = \frac{S_{rn}}{S_{rp}},$$

where m_r – indicator characterising the supply of the *r*-th type resources;

S_{rn} – available stocks of the r-th type resources;

S_{rp} –demand for the r-th type resources;

E_r – supply condition of the r-th type resources.

In the **non-military** sphere, a number of indicators are used to determine the energy security condition, which characterise the electric power systems' condition, fuel supply system and nuclear

power system. In addition, indicators are proposed to assess the state's energy independence, the energy supply diversification degree, and the energy efficiency of the national economy, which, as experience has shown, has become important since the beginning of the confrontation with russia and the disruption of traditional energy and energy carriers supply routes.

The partial indicators' convolution for all non-military sphere indicators is carried out similarly to the formula (1).

The electricity systems condition indicator (except for nuclear power enterprises) is calculated using a number of known partial indicators that are calculated or determined on the statistical data basis:

share of TPSs capable to operate on two or more interchangeable fuel types;

depreciation of main production funds of fuel and energy sector enterprises;

the total income share of fuel and energy sector enterprises allocated to their modernisation and technological upgrading of main funds;

main production capacities' utilisation level of fuel and energy sector enterprises;

reserve capacity - the total established capacity ratio of power plants to the maximum actual load in the power system;

energy conversion efficiency of power generating capacities.

The fuel supply system condition is calculated using the following partial indicators:

ensuring reserve volumes and storage tanks for fuel and energy resources (oil, oil products, including fuel oil, gas, coal, etc.);

ratio of underground gas storage facilities employment to meet domestic and export needs;

level of energy transmission capacities load (oil, gas and electricity transmission systems);

unproductive losses of energy resources' main types (natural gas, oil, coal, heat and electricity) during their transportation, conversion, distribution and transmission (percentage of their final consumption).

The nuclear energy system condition is calculated using the following partial indicators:

share of energy produced by nuclear power plants in the total consumption;

depreciation of nuclear power enterprises' main production funds;

share of the total income of nuclear power enterprises allocated for their modernisation and technological renewal of main funds;

load level of the nuclear power enterprises' main production capacities;

reservation – the total installed capacity ratio of nuclear power enterprises to the maximum actual load in the power system;

energy conversion efficiency of nuclear power enterprises generating capacities.

To assess energy independence, a mono-criterion approach was chosen, based on the one indicator employment – the share of own energy resources in total consumption. This approach is justified within the framework of this study from the point of view of the need to determine an integral indicator, which is impossible when using the approaches set out in (Sobolevskyi, 2003).

Critical infrastructure's condition. Critical infrastructures of the state's energy system mean systems and resources so vital to the energy system's functioning that their incapacitation or destruction has a significant (critical) impact on national (military) security.

The study considered only those impacts on critical infrastructure related to military threats (disabling, destruction, capture). Natural and man-made threats were not taken into account. In practice, it is sufficient to consider only a limited number of attack types and object types on which they can be carried out.

At the same time, since the threat value determination implies a dependence on parameters, it should be taken into account that the threat can be represented in the format of a probability distribution, rather than a single indicator.

The critical infrastructure threat indicator is calculated using a number of partial indicators:

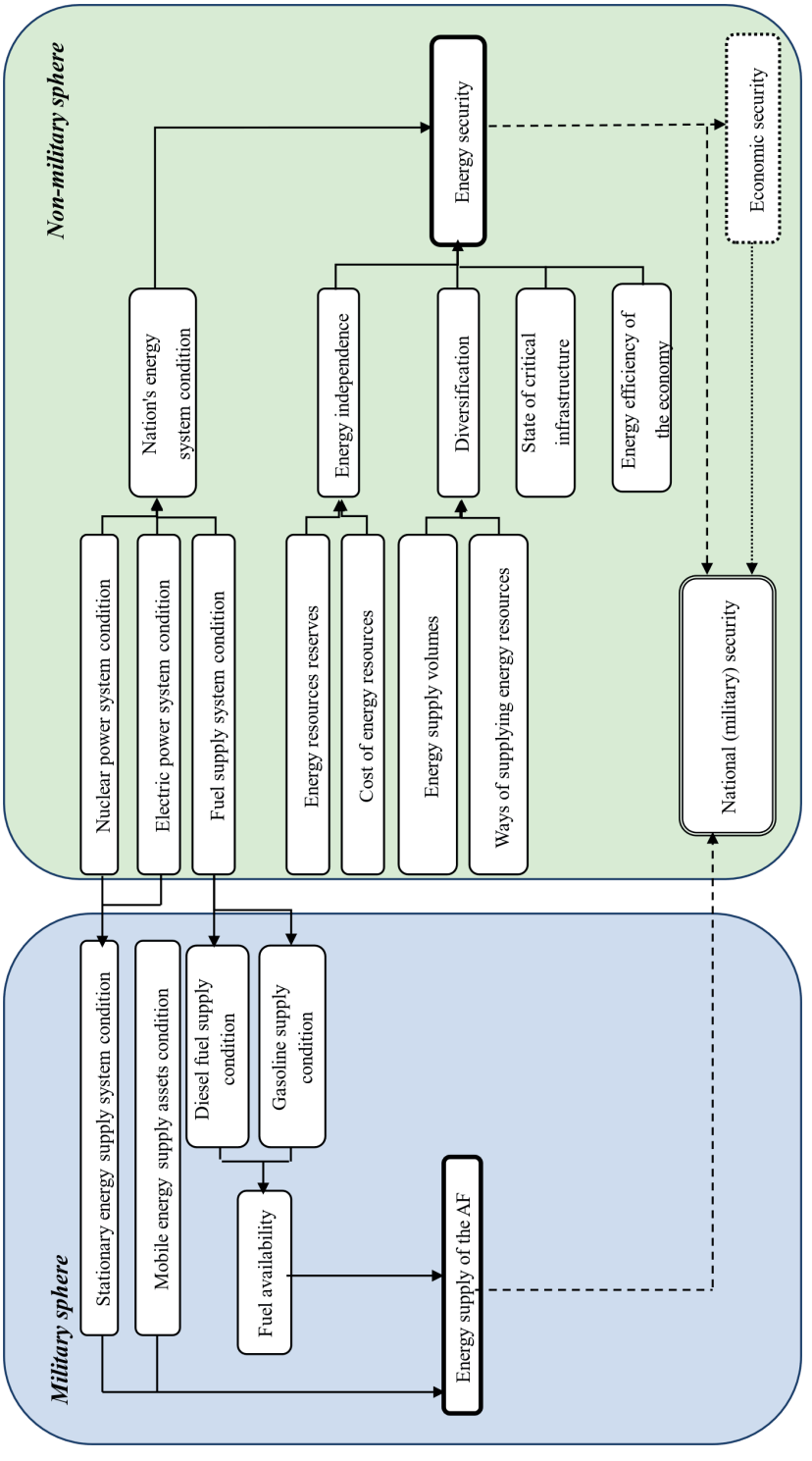


Figure 1. Indicators' system for assessing the state's energy security

threat – the probability that a certain target may be attacked in a certain way over a certain period of time;

vulnerability – the probability that an attack of a certain type appears to be successful if it is carried out;

consequences – the amount and type of damage caused by a successful attack.

The consequence magnitude is determined by the expected amount of damage over a specific period of time for a defined type of attack that results to damage to a certain target. It varies from "0" - no consequences, to "1" - complete destruction (capture) of an object or system.

The concept of the national economy energy efficiency refers to the qualitative economy condition that ensures rational and efficient employment of fuel and energy resourses in accordance with the existing level of economic and cultural development of the society, equipment and technology development, the prevailing type of society's worldview and the state's development priorities. At the same time, GDP energy efficiency is the inverse of GDP energy capacity, and the lower the energy capacity is, the higher the energy efficiency of the state's economy (Sukhodolia, 2003).

It's necessary to note that although GDP energy capacity reflects the relative efficiency of a state's employment of energy resources, it is not considered to be an absolutely accurate criterion. The GDP energy capacity indicator reflects only the trends in the national economy development in terms of energy usage, and its dynamics tracks the chosen type (energy-saving, extensive) and trends in the state's economic development.

It is proposed to calculate the value of economy energy efficiency using a number of partial indicators that comprehensively characterise the economy condition, its energy resources usage and environmental impact.

To calculate the indicators, the values of such primary indicators as the the total amount of energy consumption for production (V), the output volume (Pr) and the emissions volume into the environment (Br) are used. It should be noted that the calculations do not use the gross (extensive) values of these indicators, but rather partial efficiency indicators, which are determined by their ratio:

energy efficiency (in the general sense it is the efficiency ratio)

$$m_{en} = \frac{Pr}{V};$$

technological efficiency (reflects the internal characteristics of production processes and is the inverse share volume of harmful emissions to the environment)

$$m_{teh} = \frac{V}{Br};$$

environmental efficiency (characterises the environmental friendliness of a final product unit)

$$m_{eco} = \frac{Pr}{Br};$$

energy wastefulness (high values of this indicator by its meaning reflect environmentally efficient systems that are characterised by significant energy consumption)

$$m_{rast} = \frac{VPr}{Br};$$

environmental wastefulness (high values of this indicator reflect energy efficient systems that have a significant impact on the environment)

$$m_{prir} = \frac{BrPr}{V};$$

innovativeness (high values of this indicator indicate the production advantage over energy consumption)

$$m_{inn} = \frac{Pr}{VBr};$$

Conclusion

Thus, the proposed indicators' system allows:

to consistently assess the contribution of the energy factor to the importance of the overall state's military security;

to obtain unified integrated indicators of energy security level (provision), which will allow an unambiguous assessment of the affairs condition in this sphere;

to determine the dynamics of changes in significant indicators when the factors on which they depend change, and, accordingly, to assess the effectiveness of the measures taken to strengthen the state's energy and military security;

to identify sources of possible dangers that may lead to aggravation of the state's military (energy) security by determining critical values of indicators and to determine their importance (priorities).

The proposed indicators of the Armed Forces of Ukraine enegy supply, energy independence and energy efficiency of the state's economy, as well as diversification of fuel and energy resources supplies allow for a more complete consideration of the factors that have decisive impact on the state of military (energy) security of the country.

A direction for further research could be the development of a procedure for determining the integral indicators of energy supply of the Armed Forces, energy security and their impact on the economic, military and national security of the state.

Recommendations

The materials of the article can be used in the methodological approach development to assessing the energy security condition, modelling and predicting processes in the energy sector. The article may also be useful for information and analytical services' specialists, scientists and analysts involved in the development and justification of state decisions in the energy sector.

References

1. Cabinet of Ministers of Ukraine. (2021, 4 August). *On approval of the Energy Security Strategy* (907-p./2021).
2. Bohdanovych, V. Yu., (2020). *New approaches development to the integrated employment of military and non-military assets of the security and defence sector to ensure the military security of Ukraine. Methodological apparatus development for predicting the military-political situation.* The Central Research Institute of the Armed Forces of Ukraine.
3. Bohdanovych, V. Yu., Romanchenko, I. S., Svyda, I. Yu., & Syrotenko, A. M. (2019). *Methodology for the integrated employment of military and non-military assets of the security and defence sector to counter modern threats to the military security of Ukraine.* NALF.
4. Bocharnikov, V. P, Svieshnikov, S. V. (2019). *Security environment 2030.* Master Books.
5. Hohoniants, S. Yu., Hrytsai, P. M., & Shapran, O. O. (2019). General provisions of the methodology for assessing the level of military threat based on taxonomic methods. *Modern Information Technologies in the Field of Security and Defence,1* (34), 29–36.
6. Sukhodolia, O. M., Kharazishvili, Yu. M., Bobro, D. H., Smenkovskyi, A. Yu., Riabtsev, H. L., & Zavhorodnia, S. P. (2020). *Energy Security of Ukraine: System Analysis and Strategic Planning Methodology: Analytical Supplement*. NSRI.
7. Ilienko, A. S. (2019). Energy Security of Ukraine: Essence, Threats and Regulatory Mechanisms. *Scientific Notes of TNU*. Vol. *30* (69), No. *4*, 61–66.
8. *Current challenges and threats to energy security of Ukraine. Analytical note.* (2023). NSRI.
9. Matviichuk, N. (2018). Threats to the Energy Security of Ukraine. *Economic Journal of Lesya Ukrainka Eastern European National University, 1* (13), 11–25.

10. Topalov, M. If Russia goes for escalation: how Ukraine is facing a complete energy blockade. *Ekonomichna Pravda*.
11. Pavlenko, O., & Serebrennikov, B. Electric accession to the EU: what will save the Ukrainian energy system during the war with Russia. *Evropeiska pravda*.
12. Semenenko, O., Solomitskyi, A., Onofriichuk, P., Chernyshova, I., Skurinevska, L., & Pekuliak, R. (2021). Methodical Approach to Assessing Level of the State Energy Security and Its Influence on the National Security and Economy of the Country. *Scientific horizons*, Vol. *24*, No. *4*, 90–96.
13. Sobolevskyi, O. V. (2003). Main directions of energy security system formation of Ukraine in the innovative development conditions. *Problems of Science*, *10*, 40–52.
14. Sukhodolia, O. M. (2003). Energy intensity of the gross domestic product: trends and factors of influence. *Collection of scientific papers of the National Academy of Public Administration under the President of Ukraine*, *2*, 18–25.