Assessment of risks and threats to regional energy security of the Republic of Belarus

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Abstract. Energy security ensuring is one of the main tasks of the state, while the sustainable socio-economic development of the region directly depends on the level of regional energy security. Risks and threats to energy security of regions assessment is an important task. In this article the methodology of calculating a comprehensive indicator for assessing risks and threats to the regional energy security of the Republic of Belarus is proposed.

1 Introduction

In modern conditions, the main tasks of the state include national security ensuring and its component – economic security. Energy security is the most important element of economic security. It affects all spheres of the state's activities and is the basis for its sustainable economic development. Currently, energy security ensuring is relevant at the level of the country's regions. One of the most important conditions for sustainable socio-economic development of regions, which determines the quality of life of the population and the effectiveness of regional governance, is to ensure regional energy security. In this regard, it is important to assess the threats to regional energy security with the development of proposals for their neutralization.

Research in the field of energy security is constantly conducted by Russian, Belarusian and foreign scientists. The developments of Russian scientists deserve attention. Thus, the work of V.I. Rabchuk and S.M. Senderov substantiates the scale of realization of strategic threats to energy security [1], and the assessment of the stability of forecasts of development of the energy complex and regional energy supply systems to economic threats to energy security is considered in the work of Y.D. Kononov and D.Y. Kononov [2]. Energy security of the region as an element of sustainable development is studied in the work of Y.A. Vladimirov, O.V. Novikova, L.V. Koryakina [3], and the methodological basis for assessing the energy security of regions is considered in the work of S.I. Bortalevich [4]. Classification of the main types of threats to energy security of energy regions of the country is considered in the work of I.D. Elyakova [5], and the ontological model of energy security threats is presented in the work of T.I. Vorozhkova and N.I. Pyatkova [6]. Strategic threats to energy security as risks of reducing the quality of life of the population are studied in the work of V.I.Loktionov [7]. Features of assessing threats to the economic security of enterprises in the

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electric power complex are reflected in the work of N.N. Danilova, Yu.A. Khegai, O.S. Sityaeva [8]. The overall concept of energy security, taking into account supply and demand within the framework of the private market and government regulation, is given in the work of foreign authors Helsius Blum, Louis F.L. Legey [9]. The analysis of the initial causes affecting energy security is considered by Chinese researchers [10]. The work of Belarusian researchers deserves attention. Thus, in the work of E.P. Korsak presented the formation of a system of threats to the energy security of the Republic of Belarus [11], and in the study by T.G. Zoryna, V.V. Panasyuk, S.G. Prusov carried out a typology and analysis of the significance of risks and threats to the energy security of the Republic of Belarus, taking into account the integration of the Belarusian NPP into the energy system [12]. V.M. Syropushchinsky and N.I. Kamotskaya developed an economic model of assessment and institutional conditions for ensuring energy security of the Republic of Belarus [13-14]. It should be noted that in our country the problem of energy security of the state as a whole is being studied, but due attention is not paid to its assessment at the regional level. At the same time, in the works of V.V. Panasyuk, a study of risks and threats to energy security was carried out not only for the country as a whole [15], but also considered regional aspects of risks and threats to energy security of the Republic of Belarus [16-17].

Regional energy security ensuring is currently particularly relevant due to the increasing risks and threats that affect energy facilities at various levels.

The purpose of this study is to develop methodological support for assessing risks and threats to the energy security of the regions of the Republic of Belarus.

2 Research Methodology

In order to effectively develop measures to improve regional energy security, it is necessary to assess the risks and threats to regional energy security. First of all, it is necessary to identify threats to regional energy security - a set of short-term and long-term events, as well as the probability of their occurrence, characterized by energy risks. Threats and risks can negatively affect the functioning of energy infrastructure and socio-economic development of the region. Various methods are used to calculate risks to assess the state of various systems (technical, economic, etc.), so in the work of S.G. Kharchenko the international experience of working with risks is considered [18]. The system approach of risk description on life safety issues is performed in [19-21]. Work with complex indicators as a set of private risks is presented by N.N. Brushlinsky [22]. Work with comprehensive indicators as a set of private risks is presented by N.N. Brushlinsky [22]. Calculation of a comprehensive indicator to assess the fire safety of regions is performed by L.V. Arshinsky [23].

The use of an algorithm for calculating a comprehensive indicator for assessing risks and threats to regional energy security is the subject of this article. The application of the methodology for calculating the comprehensive indicator allows us to assess the risks of a particular region of the country, and consists of the following consecutive steps:

Step 1: Selection and classification of indicators for assessing risks and threats to regional energy security.

A written survey was conducted prior to the selection. More than 30 managers and specialists of regional energy systems and the republican energy association of the fuel and energy complex (hereinafter - FEC) of the country participated in the survey. Survey participants completed a ranking of risks at all stages of energy production (generation, transmission, distribution). Risks were ranked by classifying them into production, financial and information risks. According to the results of the survey on the list of risks and threats, their classification, ranking by the degree of their importance [12], the following list of risks and threats was selected for the calculation of the comprehensive indicator, which is presented in Table 1.

Table 1. List of Risks and Threats to Regional Energy Security and Their Classification.

Risk No.	Risk classification	Name of risks
Risk 1	production	Depreciation of fixed assets
Risk 2	production	Insufficient utilization of own energy sources
Risk 3	production	Insufficient availability of own generation
Risk 4	production	Decrease in reliability of energy equipment operation
Risk 5	financial	Increase in the cost of energy resources for heat and electricity generation
Risk 6	financial	Deficit of working capital of energy enterprises in the region
Risk 7	financial	Decrease in solvency of consumers in the region
Risk 8	informational	Insufficient equipment of generators of energy sources with automated process control systems
Risk 9	informational	Low digitalization of the region's fuel and energy enterprises.

As shown in the Table.1, the indicators for assessing risks and threats to energy security are classified into groups of production, financial and informational nature. The most numerous is the group of production indicators due to the fact that the technological component is of particular importance for the energy industry. The next largest group of indicators is the group of financial indicators, which reflects the economic efficiency of energy enterprises in the region. Due to the full-scale implementation of digital technologies in the country's energy sector, informational risks are also included in the list of risks.

Step 2: Collection of a database to calculate indicators for assessing risks and threats to regional energy security.

When collecting initial data on risks in the context of regions and the country as a whole for the calendar year, information was used from the statistical data book "Energy Balance of the Republic of Belarus" of the National statistical committe of the Republic of Belarus (hereinafter - Belstat) [24] and reporting statistical and accounting information from the state production association of electric power industry "Belenergo" (hereinafter - Belenergo) [25]. Sources of information and calculation methodology for specific risks are presented in Table 2.

Table 2. Sources of Information and Methodology for Calculating Energy Security Risk Assessment Indicators.

Risk No.	Calculation methodology	Source of information
Risk 1	Depreciation of fixed assets - accounting data, %	Belenergo
Risk 2	Installed capacity utilization factor - reporting data	Belenergo
Risk 3	Share of own electricity generation in electricity consumption - statistical data, %	Belstat
Risk 4	Average outage frequency index (SAIFI) - reported data	Belenergo
Risk 5	Share of regional energy companies' expenditures on the purchase of dominant fuel (natural gas) in the total amount of expenditures - statistical data, %	Belstat
Risk 6	Working capital ratio - accounting data	Belenergo
Risk 7	Share of 100% timely payment of consumers for the supplied energy – reported data, %	Belenergo
Risk 8	Share of generators of power sources in the regions equipped with automated process control systems to their total number - reporting data, %.	Belenergo
Risk 9	Level of energy enterprises digitalization - reporting data, %.	Belenergo

Step 3: Calculation of risk assessment indicators for the region and the country.

The calculation of risk indicators for the region (R_{1-9}^{reg}) and the country as a whole

(R_{1-9}^{coun}) is based on the data provided by the National Statistical Committee [24], Belenergo [25] and the methods for calculating the energy security assessment indicators specified in the previous step. The results of calculating risk indicators for regions and the country as a whole are shown in Table 3.

Table 3. Values of risks and threats to the energy security of the country and regions.

Region	Year	Risk 1	Risk 2	Risk 3	Risk 4	Risk 5	Risk 6	Risk 7	Risk 8	Risk 9
Bel-energo (country)	2018	0,456	0,436	1,03	0,8867	0,37	0,28	0,83	0,5	0,47
	2019	0,471	0,459	1,06	0,8392	0,37	0,37	0,84	0,52	0,5
	2020	0,473	0,43	1,01	0,7317	0,35	0,54	0,89	0,6	0,58
Brest	2018	0,42	0,454	1,7	1,29	0,77	0,31	0,8	0,58	0,49
	2019	0,45	0,538	1,76	1,28	0,78	0,41	0,81	0,58	0,52
	2020	0,451	0,548	1,72	0,71	0,76	0,46	0,85	0,62	0,63
Vitebsk	2018	0,46	0,4	2,6	1,05	0,89	0,41	0,91	0,37	0,53
	2019	0,482	0,447	2,8	1	0,91	0,55	0,92	0,39	0,54
	2020	0,486	0,408	2,55	0,97	0,84	0,56	0,7	0,49	0,56
Gomel	2018	0,539	0,341	0,44	1,07	0,67	0,42	0,75	0,5	0,58
	2019	0,546	0,322	0,43	1,02	0,67	0,38	0,77	0,5	0,58
	2020	0,549	0,316	0,47	0,83	0,67	0,45	0,89	0,5	0,58
Grodno	2018	0,427	0,566	0,66	0,61	0,44	0,05	0,87	0,49	0,59
	2019	0,421	0,556	0,65	0,54	0,42	0,13	0,87	0,51	0,6
	2020	0,421	0,541	0,75	0,54	0,42	0,23	0,88	0,86	0,6
Minsk	2018	0,422	0,521	0,92	0,75	0,76	0,42	0,59	0,59	0,47
	2019	0,44	0,52	0,93	0,72	0,76	0,46	0,91	0,59	0,48
	2020	0,441	0,461	0,83	0,72	0,76	0,42	0,56	0,59	0,5
Mogilev	2018	0,52	0,322	0,59	0,55	0,76	0,51	0,58	0,47	0,51
	2019	0,531	0,291	0,58	0,54	0,76	0,5	0,58	0,5	0,57
	2020	0,531	0,316	0,62	0,58	0,75	0,5	0,82	0,54	0,58

Step 4: Calculation of paired integral risks and comprehensive energy security indicator (hereinafter - CESI) of the region.

The calculation of paired integral risks is performed on the basis of the risk values for the region previously obtained in the previous step, using the formula:

$$(P_{1-9}^{reg} = \frac{R_{1-9}^{reg}}{(R_{1-9}^{coun}}), \qquad (1)$$

where R_{1-9}^{reg}– region-specific risk values;
R_{1-9}^{coun} – country risk values.

CESI of the region calculation is based on the calculation of paired integral risks according to formula (1), using the following formula:

$$(K_{risk\ 1-6}^{reg} = \frac{\sum P_{1-9}^{reg}}{9}), \qquad (2)$$

where P_{1-9}^{reg} –paired integral risk values.

Using the described approach, paired integral risks and a comprehensive energy security indicator are calculated for each region and for each year of the period 2018-2020.The calculation results are shown in Table 4.

Table 4. Values of paired integral risks and complex indicators of energy security risk assessment of the regions of the Republic of Belarus.

Region	Year	Risk 1	Risk 2	Risk 3	Risk 4	Risk 5	Risk 6	Risk 7	Risk 8	Risk 9	CESI
Brest	2018	0,921053	1,041284	1,650485	1,454833	2,081081	1,107143	0,963855	1,16	1,042553	1,269143
	2019	0,955414	1,172113	1,660377	1,525262	2,108108	1,108108	0,964286	1,115385	1,04	1,294339
	2020	0,953488	1,274419	1,70297	0,970343	2,171429	0,851852	0,955056	1,033333	1,086207	1,222122
Vitebsk	2018	1,008772	0,917431	2,524272	1,184166	2,405405	1,464286	1,096386	0,74	1,12766	1,385375
	2019	1,023355	0,973856	2,641509	1,191611	2,459459	1,486486	1,095238	0,75	1,08	1,411279
	2020	1,027484	0,948837	2,524752	1,32568	2,4	1,037037	0,786517	0,816667	0,965517	1,314721

Gomel	2018	1,182018	0,78211	0,427184	1,206722	1,810811	1,5	0,903614	1	1,234043	1,116278
	2019	1,159236	0,701525	0,40566	1,215443	1,810811	1,027027	0,916667	0,961538	1,16	1,039767
	2020	1,160677	0,734884	0,465347	1,134345	1,914286	0,833333	1	0,833333	1	1,008467
Grodno	2018	0,936404	1,298165	0,640777	0,687944	1,189189	0,178571	1,048193	0,98	1,255319	0,912729
	2019	0,893843	1,211329	0,613208	0,64347	1,135135	0,351351	1,035714	0,980769	1,2	0,896091
	2020	0,890063	1,25814	0,742574	0,738007	1,2	0,425926	0,988764	1,433333	1,034483	0,967921
Minsk	2018	0,925439	1,194954	0,893204	0,845833	2,054054	1,5	0,710843	1,18	1	1,144925
	2019	0,934183	1,132898	0,877358	0,85796	2,054054	1,243243	1,083333	1,134615	0,96	1,141961
	2020	0,932347	1,072093	0,821782	0,98401	2,171429	0,777778	0,629213	0,983333	0,862069	1,026006
Mogilev	2018	1,140351	0,738532	0,572816	0,620277	2,054054	1,821429	0,698795	0,94	1,085106	1,074596
	2019	1,127389	0,633987	0,54717	0,64347	2,054054	1,351351	0,690476	0,961539	1,14	1,016604
	2020	1,122622	0,734884	0,613861	0,792675	2,142857	0,925926	0,921348	0,9	1	1,01713

Step 5: Interpretation of the results.

At this step, it is proposed to assign the situation to one of the levels of the region's energy security risk status, according to Table 5.

Table 5. Interpretation of the assessment of risk levels based on the value of the complex indicator of regional energy security.

Status Level	Metric Interval Boundaries	Interpreting the Assessment
1st	more 2,0	High Level
2nd	From 1,0 to 2,0	Intermediate
3rd	From 0,0 to 1,0	Low

As shown in the Table 5, in order to simplify the interpretation of the results, the quantitative values of the CESI were divided into three categories, characterizing low, medium and high levels of energy security risks.

3 Results

The proposed methodology for assessing risks and threats to regional energy security by calculating comprehensive indicators of regional energy security allows us to assess the level of risks and threats in a particular region of the country in relation to other regions in a certain calendar year.

As shown in the Table 4, according to the obtained calculations of complex indicators of the regions and the proposed interpretation of the levels of risks and threats according to Table 5, a high level of risks and threats to energy security has not been identified in any region of the Republic of Belarus. The lowest level of risks and threats (<1.0) belongs to Grodno region, insignificant exceeding of the threshold value (>1.0) with transition to the average level of energy security risks and threats assessment state belongs to Gomel and Mogilev regions. The average level of assessment of risks and threats in these regions is due to risks characterizing the level of depreciation of fixed assets, and in the Gomel region - risks of reducing the reliability of energy equipment and the low level of energy enterprises digitalization in the region. In the Brest and Vitebsk regions, threats to energy security are increasing due to production risks associated with insufficient utilization of the generating capacities in these regions of the largest power plants - Lukomlskaya and Berezovskaya GRES, and with an insufficient share of electricity generation in the region's own consumption. Also in these regions, financial risks associated with the shortage of working capital of energy enterprises in the region and the need for increased costs to pay the cost of gas due to the high specific costs of equivalent fuel for the production of thermal and electrical energy at the old condensing units of Lukomlskaya and Berezovskaya GRES have a negative impact. In the Minsk region, the increase in risks in 2019 was caused by production risks associated with climatic conditions and a significant decrease in heat supply and peak electricity generation through the condensation cycle. In 2020, thermal power generation in

the Minsk region significantly increased due to the coronavirus pandemic and the decision of local government authorities to extend the heating period, and as a result, a reduction in energy security risks in this calendar year. It should be noted that factors such as the covid period of 2020 and the launch of the first power unit of the Belarusian Nuclear Power Plant significantly changed the structure of electricity production and consumption and influenced the state of energy security of the country's regions.

According to an earlier study on the use of an indicative method for assessing the energy security of regions of the Republic of Belarus [17], the values of integral indicators of regional energy security and comprehensive indicators for assessing risks and threats to energy security of the period under study are interrelated. To assess the relationship between integral indicators of regional energy security and comprehensive indicators for assessing risks and threats to energy security, a correlation analysis was carried out. According to the results of the correlation analysis, it was revealed that there is a strong negative interrelation between the integral indicators of regional energy security and comprehensive indicators for assessing risks and threats to energy security. The correlation coefficient is -0.804 (Figure 1).

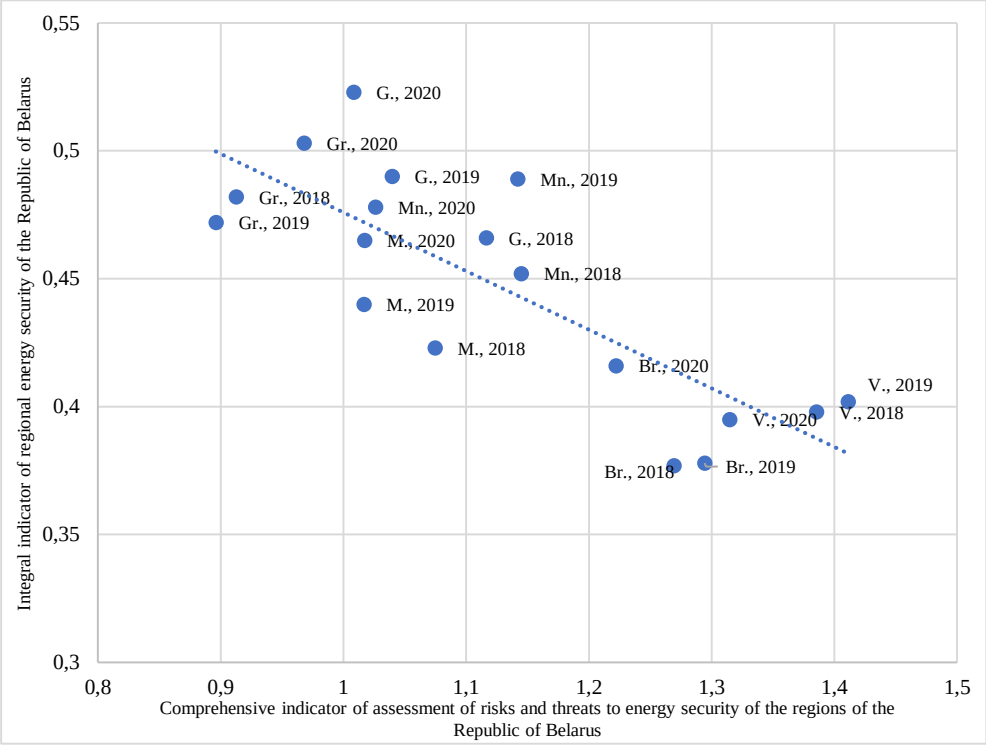

Fig.1. Scatter diagram of comprehensive risk indicators and integral energy security indicators of the regions of the Republic of Belarus.

As shown in Figure 1, high levels of integral energy security indicators of the Gomel, Grodno and Mogilev regions in relation to other regions are due to low-level conditions of risks and threats, which is confirmed by the values of integrated indicators for assessing risks and threats to energy security of these regions of the country.

Thus, we can conclude that the presence of interrelations between the integral indicators of regional energy security and comprehensive indicators of regional energy security allows us to accurately assess the risks and threats to regional security.

4 Conclusions

Based on the study, the following conclusions can be drawn:

1. The use of a comprehensive indicator of regional energy security allows determine the level of risks and threats to energy security of a particular region in relation to other regions of the country.

2. To calculate a comprehensive indicator for assessing the level of risks and threats to the energy security of regions, it is possible to apply the proposed formula (2), using the calculated data of risks and threats of the region and country of a particular calendar year. This is confirmed by the presence of a strong feedback with high correlation coefficients between integral indicators of energy security and coefficients for assessing risks and threats to energy security of the country's regions.

3. The above calculation of a comprehensive indicator for assessing risks and threats to energy security is proposed to be included as one of the stages of the economic mechanism for ensuring regional energy security.

References

1. V.I. Rabchuk, S.M. Senderov, Strategic threats to energy security of Russia until 2030: the nature of transformation and priority measures to minimize the consequences of implementation, *Izvestiya Rossiiskoi Akademii Nauki. Energetics*, **1**, 50 - 58 (2019)
2. Y.D. Kononov, D.Y. Kononov, Estimation of stability of the forecasts of the fuel and energy complex development and regional energy supply systems to the economic threats to energy security, *National Interests: Priorities and Security*, **15**, issue 12, 2517 - 2526 (2019)
3. Y.A. Vladimirov, O.V. Novikova, L.V. Koryakina, Energy security of the region as an element of sustainable development, *Regional Economics: Theory and Practice*, **20**(1), 49 - 73.
4. S.I. Bortalevich, Methodological bases for assessing the energy security of regions, *Economic analysis: theory and practice*, **38**(293), 33-37 (2019)
5. I.D. Elyakova, Classification of the main types of threats to the energy security of the energy districts of the Republic of Sakha (Yakutia), Economics and *Entrepreneurship*, **10**, 331 - 336 (2019)
6. T.N. Vorozhkova, N.I. Pyatkova, Ontological model of threats to energy security, *Information and mathematical technologies in science and management*, **3**(7), 35 - 41 (2017)
7. V.I. Loktionov, Strategic threats to energy security as risks of reducing the quality of life of the population, *National interests: priorities and security*, **16**, issue 4, 730- 744, (2020)
8. N.N. Danilova, Yu.A. Khegay, O.S. Sityaeva, Features of the assessment of threats to the economic security of enterprises of the electric power complex, *Creative Economy*, **16**(8), 3241 – 3258 (2022), DOI:10.18334/ce. 16.8.115102
9. X. Blum, Luis F.L. Legey, The complex economics of energy security: delivering energy benefits in support of sustainable development, *Energy Economics*, 34 (6), 1982-1989 (2012)
10. L. Zhang, W. Bai, H. Xiao, Q. Ren, Measuring and improving regional energy security: a methodological framework based on both quantitative and qualitative analysis, *Energy*, **227**, 120534 (2021)

11. E.P. Korsak, Formation of the system of threats to energy security of the Republic of Belarus, *Energetika. Proc. CIS Higher Educ. Inst. and Power Eng. Assoc*., **62**(4), 388-398 (2019)
12. T.G. Zorina, V.V., Panasyuk, S.G. Panasyuk, S.G. Prusov, Typologization and analysis of the risks and threats to the energy security of the Republic of Belarus taking into account the integration of Belarusian NPP into the energy system, *Energetika*, **5**(65), 385-397 (2022)
13. V.M. Syropushchinsky, N.I. Kamotskaya, Economic model of the energy security assessment of the country, *Energy Strategy*, **6**(48), 29-32 (2018)
14. N.I. Kamotskaya, Organizational and economic mechanism and institutional conditions for ensuring energy security of the Republic of Belarus. Cooperation - catalyst of innovative growth: collection of materials of the 5th Belarusian-Baltic Forum. Minsk October 9-10, 2019. Minsk: BNTU. 2019. P. 66-67.
15. V.V. Panasiuk, Risks and threats to energy security of the Republic of Belarus, *Information and mathematical technologies in science and management*, **1**(29), 99-111 (2022)
16. V.V. Panasiuk, Regional aspects of risks and threats to energy security of the Republic of Belarus. Collection of reports of the II-nd International Scientific Conference "Sustainable development of energy of the Republic of Belarus - status and prospects", Minsk, October 3-6.2022, P.287-295.
17. V.V. Panasiuk, Indicative method of assessment of energy security of the regions of the Republic of Belarus, *Information and mathematical technologies in science and management*, **3**(31), 60-73 (2023)
18. S.G. Kharchenko, R.V. Ananyeva, Retrospective of the international experience of the risk analysis, *International Economics*, **6**, 61-69 (2008)
19. N.A. Makhutov, Security and risks: system researches and developments. Novosibirsk: Nauka, 2017. 724 p.
20. P.G. Belov, Risk management, system analysis and modelling. Moscow: Yurait, 2014. 728 p.
21. S.S. Timofeeva, E.A. Khamidullina, Risk management, system analysis and modeling: a textbook. Irkutsk: Izd-vo IRNITU, 2016. 160 p.
22. N.N. Brushlinsky, E.A. Klepko, A question about local and integral risks, Vestnik of the Academy of State Fire Service of EMERCOM of Russia, **6**, 93-96 (2007)
23. L.V. Arshinsky, V.V. Garmyshev, M.S. Mikheev, S.V. Safonov, Calculation of the complex indicator of the fire danger in the administrative territories of the Irkutsk region, *Information and mathematical technologies in science and management*, **2**, 107-120 (2023)
24. National Statistical Committee of the Republic of Belarus (2021). Statistical collection. Energy balance of the Republic of Belarus. URL: https://www.belstat.gov.by/ofitsialnayastatistika/publications/izdania/public_compilation/index_39984/ (Date of access: 15.08.2023)
25. Website of the State Production Association of Electric Power Industry "Belenergo", Basic information - State Production Association "Belenergo", URL: https://www.energo.by/content/about (Date of access: 15.08.2023)