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The impact of uncertainty on strengthening the economic security of enterprises of the unified energy system of Ukraine

Kateryna Andriushchenko*
Doctor of Economic Sciences, Professor
Kyiv National Economic University named after Vadym Hetman
03057, 54/1 Beresteyskyi Ave., Kyiv, Ukraine
https://orcid.org/0000-0002-6274-5310

Anastasiia Liezina
PhD in Economic Sciences, Associate Professor
Kyiv National Economic University named after Vadym Hetman
03057, 54/1 Beresteyskyi Ave., Kyiv, Ukraine
https://orcid.org/0000-0003-0516-6598

Abstract. The importance of studying the issue of processes of strengthening the economic security of enterprises was quite justified in view of the military situation in Ukraine and the deterioration, in this regard, of the economic situation of enterprises. Conditions of uncertainty are normative for economic entities, but they acquired a new meaning and became basic for enterprises. The goal was to form a theoretical and methodological basis for the processes of strengthening the economic security of enterprises in the energy sector of Ukraine based on the theory of uncertainty. The work was based on an approach to separating the stages of the uncertainty assessment process, dividing the main products of enterprises into components and using the method of analysis of hierarchies (MAI). As a result of the analysis of a wide range of scientific literature, it was determined that within the framework of the methodology of economic security, it is customary to use the tools of the theory of riskology and the corresponding methods and models of management. This work revealed the theory and practice of economic security of energy enterprises through the concept of uncertainty theory. A classification by types of uncertainty and the conditions of its occurrence for enterprises of the Unified Energy System of Ukraine (UES-U) was highlighted, which helped to choose the necessary tool for analysis. The conclusions obtained have significant methodological value for forecasting the development of the Unified Energy System of Ukraine as a whole, aiming for the lowest possible level of uncertainty. This was possible because the modelling of the Unified Energy System of Ukraine began with components that had a lower level of uncertainty and was subsequently expanded to include other energy facilities, which were coordinated with the configurations of the initial group. The results obtained made it possible to carry out comprehensive forecasting of the development of the Unified Energy System of Ukraine, taking into account factors of economic security and aiming to minimise the impact of uncertainty.

Keywords: sustainable development; risks; analysis of hierarchy's method; energy industry; economic sustainability; modeling of energy system development; forecasting

Introduction

In the unstable economic environment of enterprises, risks and threats that arise in situations of uncertainty are of key importance. Martial law and constant destruction exacerbated the deterioration of the situation. In this regard, the issue of risk management and their impact on the economic security of enterprises required attention. Some aspects of the study of risk management are presented among scientists. O.V. Varaksina *et al.* (2023) noted that an important aspect of risk management at enterprises was the definition of their circle of internal and external representatives

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*Corresponding author

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and the use of combined management tools to avoid any consequences associated with the further impact on the activities of the enterprise. Researchers emphasised the relevance of covering these issues and highlighted the issue of identifying threats as a priority in the direction of timely confrontation with them in order to achieve the best results of conducting economic activities. Researcher V.V. Kovalenko (2018) studied in depth the issue of the impact of risks on the economic security of enterprises and highlighted that the main factor of influence is uncertainty, which becomes a prerequisite for choosing means of combating and countering any threats. The author revealed the issue of obtaining positive consequences from any risks while minimising the negative manifestation. In this case, reasonable risk management will lead to their neutralisation. This position deserves attention and more broadly reveals the essence of the mechanism for creating conditions for improving the economic security of enterprises through risk management. It is also worth noting G.O. Seleznyova & R.D. Stepanenko (2023), who paid attention to modern types of risks and focused on digitalisation processes, which is an updated direction for identifying types of threats in modern business conditions of enterprises. They determined that an important aspect is the implementation of economic security monitoring based on a risk-based approach, as well as modeling organisational design for enterprise stakeholders. It is the implementation of modern methods and tools that can help facilitate and accelerate the processes of identifying potential threats to the economic security of enterprises. Accordingly, such an approach can be considered a further development of theoretical developments that deserves attention.

According to O.V. Toporkova *et al.* (2019), the essence and target nature of "risk management" were determined, which plays a significant role in making management decisions under conditions of uncertainty and can contribute to improving the activities of business entities due to their sustainable growth, reducing costs, profitable investment of capital and obtaining greater profits. The work of the scientists investigated the issue of financial risks, which is generally a rather narrow subject of analysis, but the results presented by them demonstrate the importance of using management reports for conducting economic and mathematical modeling in the process of internal economic risk control. Such a proposal is sound and creates the prerequisites for the further development of a general system of indicators for strengthening the economic security of enterprises. Risk management was covered in detail by N.S. Skopenko & I.V. Yevseeva (2020), who presented this direction of management in the general system of ensuring the economic security of enterprises. The authors thoroughly described the types of risks and proposed the author's vision of forming a concept of decision-making under the conditions of determining the impact of risks on the activities of enterprises. In development of the above, it is worth noting the work of L. Sarana *et al.* (2021), who identified six main interrelated stages of risk management, which has a positive effect on reducing additional costs of enterprises. Scientists have paid sufficient attention to risk management and its consequences for the formation, provision and strengthening of economic security of enterprises, but the diversity of approaches creates a wide field of ramified approaches and, accordingly, the lack of a stable statement and systematisation.

The study of scientific literature on the processes of strengthening and ensuring economic security through the prism of risk management provides answers to the questions of how to manage them at the moment of their occurrence, but there are no approaches to changing circumstances and the environment. Such conditions are partially described in the work of A. Sokolov (2024), in which the author drew attention to the enterprise's response to manifestations of external and internal risks through adaptive management. And he provided recommendations for the implementation of artificial intelligence tools for risk forecasting, which indicates the intention to predict all possible conditions of uncertainty. But it is worth noting that the author described only the financial and economic factors of enterprise security and exclusively for the maritime logistics industry, which is not unified and requires further development for wider application in other sectors of the economy. All the presented developments expand scientific searches for the development of the methodology of economic security and create a basis for further research in the direction of presenting the processes of determining possible risks and identifying uncertainty, which certainly affect the processes of its strengthening. The goal was to provide a theoretical and methodological justification for mechanisms for strengthening the economic security of enterprises of the unified energy system of Ukraine in conditions of uncertainty by formalising influential factors, prioritising risks, and determining directions of strategic response.

Materials and Methods

To determine the impact of risks, threats and uncertainty on the processes of forming and strengthening the economic security of enterprises of the unified energy system of Ukraine, uncertainty, its components and impact on strengthening economic security were analysed in more detail. Summarising the results of the analysis of a wide range of literary sources within the framework of the methodology of economic security, it was decided to use the tools of the theory of riskology and the corresponding methods and models of management.

As part of the methodological approach to the study of the formation of economic security of energy sector enterprises, the specifics of the impact of uncertainty on strategic management processes were taken into account. The theoretical basis was the concept of uncertainty theory, according to which uncertainty is divided into structured and unstructured. Based on previous work (Bahuguna *et al.*, 2022; Andriushchenko & Lezina, 2024), attention was focused on predictive unstructured uncertainty in the dynamic environment of the energy sector of Ukraine. Within the framework of the study, the classification of uncertainties proposed by V.I. Korcheva & N.M. Kriuchkova (2015) was used as a theoretical basis, according to which a preliminary division of risks associated with the economic security of enterprises was carried out. This made it possible to structure the sources of uncertainty and adapt the subsequent assessment to the specifics of each type (epistemological, model, parametric, random).

An important aspect was the chosen field of study and its features, which included: the level of reliability of power equipment, stability of energy generation, constant operating modes of generating and distribution equipment, professionalism and competence of workers, regular renewal of fixed assets (including planned and current repairs), close attention to working conditions and compliance with safety rules in places of increased danger (generation facilities), etc. In view of this, an assessment was presented in four stages or eight steps: description of the measurement and its model; analysis of input quantities and their uncertainty; correlation analysis; calculation of the total standard uncertainty; calculation of the values of the output value; calculation of the expanded uncertainty and presentation of the final result of the calculations (Fig. 1). Each stage of the presented uncertainty assessment was aimed at obtaining general information about risks and their impact on the processes of forming, ensuring and strengthening the economic security of enterprises.

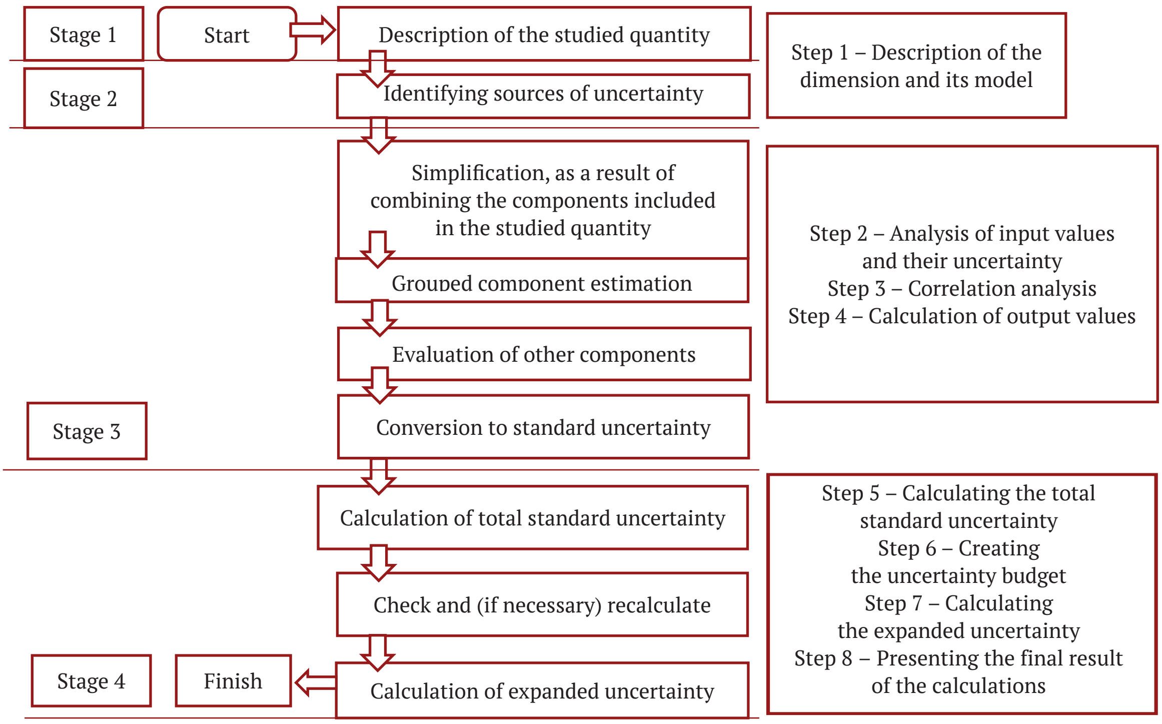

Figure 1. Uncertainty assessment process

Source: developed by the authors

The methods are also based on the method of analysis of hierarchies (AHI) (Saaty, 1980). When building a hierarchical model, it was necessary to determine the composition of the most important components of the Unified Energy System and the factors that affect the uncertainty of its development prospects. The number of both should not be large, so as not to clutter the model with insignificant details, not to complicate the preparation of initial information and the interpretation of the calculation results. Guided by this, the characteristics of the following components were selected, which are part of (full or partial components) the main types of work for all the enterprises studied in this work: coal mining; natural gas mining; electricity production by nuclear carriers; electricity production by hydro carriers; heat energy production using combustible substances; use of alternative renewable energy (which can be estimated through their share in the production of electricity and heat energy); Thus, the six main characteristics (electricity production; gas production; coal production; alternative energy; heat production; oil product production) of the Unified Energy System (UES-U) that shape its dynamics were studied for the enterprises of the Unified Energy System (JSC NNEGC Energoatom, NEC Ukrenergo, JSC Ukrhydroenergo, JSC NJSC Naftogaz of Ukraine, PJSC DTEK Kyiv Regional Networks, JSC DTEK Zakhidenergo, JSC DTEK Dniproenergo and PJSC Centrenergo).

A 9-point comparison scale was used, in which each score was given a weight in accordance with the impact on uncertainty and its impact on the level of economic security of enterprises. The factors of the probability of coincidence of events A and B were applied according to the gradation, under which these events are different and radically different from each other. In this case, each of their coincidences has its own score on the comparison scale. It was proposed to determine odd coincidences, where 9 points means that factor A absolutely exceeds factor B in significance; 7 – that A is clearly more important than B; 5 – A is much more important; 3 – A is slightly more important than B; 1 – A and B are equally important. Even scores 8, 6, 4 and 2 express intermediate gradations of assessments. A necessary requirement when using the hierarchy analysis method was compliance with transitivity and good indicators of consistency of the initial data in the matrices of pairwise comparisons. If these requirements were violated, which is especially often the case when working with a group of experts (representatives of enterprises involved in determining indicators, audit companies, state authorities, etc.), other methods were used. It is worth noting that the experts were heads of departments of the specified enterprises, who were surveyed in 2024 in an online format through an anonymous questionnaire in compliance with ethical standards, distributed by the strategic planning department of each enterprise (National commission for the protection of human subjects of biomedical and behavioral research, 1979). The representatives of the experts in the analysis were employees of the companies (under the conditions of participation, the information is confidential and makes distribution impossible) and general data of the State Statistics Service of Ukraine (2024). If paired assessments are given by one expert, then performing a fairly simple preliminary ranking procedure allows avoiding transitivity violations and keeping the consistency indicators of pairwise comparison matrices within the required limits. This procedure was also applicable during the work of a group of experts.

Results and Discussion

The Unified Energy System of Ukraine is a complex hierarchical system that operates in conditions where the initial data are not defined, local goals are not coordinated, and the internal organisation is disrupted due to new properties that arise when achieving a global goal. The analysis involved enterprises with different forms of ownership, covering a wide geography of activity and representing the main areas of the energy sector of Ukraine, in particular: JSC NNEGC Energoatom, NEC Ukrenergo, JSC Ukrhydroenergo, JSC NJSC Naftogaz of Ukraine, PJSC DTEK Kyiv Regional Networks, JSC DTEK Zakhidenergo, JSC DTEK Dniproenergo and PJSC Centrenergo. For energy enterprises, the most inherent and effective is the original method that allows assessing the probability of the occurrence of predicted events through a matrix of posterior forecasting errors and a matrix of refined estimates obtained on the basis of new information. The product of these matrices carries complete information about the errors inherent in the expert when making forecasts. The vector of probabilities of the occurrence of predicted events is an eigenvector of this complete matrix of forecast errors, which corresponds to its unit eigenvalue. When assessing forecasts as indicators of forecast uncertainty, the standard deviation of individual forecasts relative to the median agreed forecast was used (Bahuguna *et al.*, 2022; Andriushchenko & Lezina, 2024). A probabilistic-statistical approach is also widely used in energy research. The dependence of demand and prices for energy resources in the region is studied in the context of the complexity of the interrelationships of the economy and energy and the increase in uncertainty about the future development of the country and territories. The behavior of energy suppliers and large consumers is simulated depending on changes in energy prices, the capabilities of existing and new technologies, energy saving measures, etc.

Accordingly, for the task of assessing the levels of uncertainty of information required for forecasting the prospects for the development of energy enterprises, the probabilistic-statistical approach will be inoperable due to rapidly changing external conditions, when retrospective information quickly becomes outdated. When building forecasting models of the fuel and energy complex and its branches, the problem of assessing the adequacy of the model output data to the forecasting goals, as well as the possibilities of improving their quality in information aspects, is relevant. At the initial stages of modeling, it is necessary to have an idea of what size and complexity of models it makes practical sense to develop and apply. The pursuit of size and complexity should not be an end in itself - only a harmonious combination of model and information components will contribute to the success of forecasting research. Given the increasing volatility of social and economic processes in the environment in which the enterprises of the unified energy system operate and develop, the uncertainty that accompanies attempts to forecast its prospects is also growing. Therefore, the pursuit of quantitative accuracy of forecasts loses practical significance (Korobskyy & Siroshtan, 2018).

Accordingly, it is appropriate to identify means, indicators and tools with which it is possible to record the proportionality of model constructions and the quality of available information. The difficulty lies in the fact that this information is of a qualitative nature (including completeness, reliability and other aspects). Its quantitative content (set of indicators, their dynamics over time) is of secondary importance. Among the methods that work with qualitative indicators, it is worth noting the method of analysis of hierarchies (AHI), developed by the American mathematician T.L. Saaty (1980). Based on pairwise comparisons of the influence of features or factors, it ultimately forms a generalised assessment of their significance, expressed in dimensionless units (fractions or percentages). AHI is just right for solving the task of qualitatively assessing the information component of forecasting studies of the Unified State Economic System, since this problem lends itself well to hierarchical structuring. Since for many tasks of economics and management related to relations between people, it is not possible to operate with clearly defined results of numerical measurements, the MAI in such a situation gives researchers the opportunity to obtain stable and realistic results, having as initial information comparative expert assessments of a qualitative nature, obtained by pairwise comparison of factors and indicators.

Factors affecting the uncertainty of forecasts include the following – volatility of energy consumption and production caused by crisis phenomena in the world economy and natural disasters; inertia of energy extraction and production processes; scientific and technological progress that determines the competitiveness of traditional and new alternative energy sources, including renewable ones. These factors have different effects on the uncertainty of forecasting results. The method of analysis of hierarchies (AHI) by expert comparison of the influence of a particular factor of each pair of indicators allows us to numerically assess the generalised uncertainty of forecast estimates in relative units (or percentages). Thus, a basis appears for ranking the reliability (as a value, inverse uncertainty) of forecasts. The above characteristics of the Unified Energy System form the lower level of the hierarchy, and the factors - the middle one. The model closes at the upper level with a final indicator – uncertainty (Fig. 2). The hierarchy constructed in this way is complete, which simplifies the work with it and the interpretation of the obtained calculation results, and increases their reliability. After constructing the hierarchy, it is necessary to conduct a pairwise evaluation of the factors and enterprises of the Unified Energy System of Ukraine and record the obtained estimates in the form of inversely symmetric matrices. This method is universal, although it is worth noting that other scientists, such as M. Potomkin *et al.* (2020) and M.B.G. Isaksen & K.R. McNaught (2023), use a wider range of alternatives. In their work, seven factors are identified, which leads to a greater variety of possible combinations between the hierarchy and alternatives. In this case, experts must evaluate and predict the combination of a larger number of coincidences, which leads to a larger analysis.

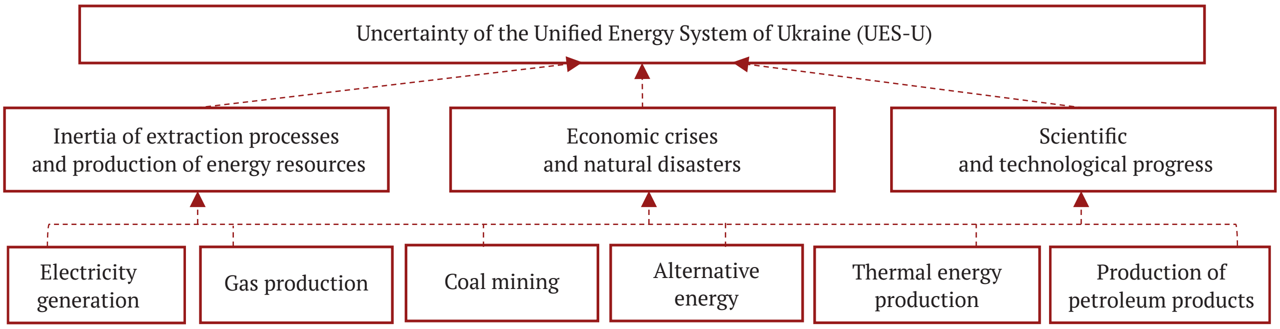

Figure 2. Hierarchy of UES-U enterprises

Source: developed by the authors

To solve the task of finding the uncertainty levels of the forecasts of the enterprises of the Unified Energy System, a 3 × 3 inverse-symmetric matrix for uncertainty and three 7 × 7 matrices for factors affecting uncertainty will be filled with pairwise estimates. All their elements are evaluated by experts. It is worth noting that such opinions differ. And in the work of O.O. Zrobok (2023), military aggression against Ukraine is also included in the uncertainty factors, which is a significant factor. The author gave this element significance due to the lack of a specific time frame and in connection with the significant loss of a large number of fixed assets of energy enterprises due to attacks. In the case when any factor can be associated with a quantitative indicator, the values of the latter are converted into qualitative estimates using a 9-point scale used in the MAI (Saaty, 1980). When filling in the matrix of pairwise comparisons of factors to describe their impact on the final indicator, one should be guided by the following result of the preliminary ranking procedure: crises – inertia – scientific and technological progress. In this case, the significance of the first factor in comparison with the second exceeds the significance of the second factor in comparison with the third, which is expressed by the following pairwise estimates:

$$\begin{bmatrix} 1; \frac{1}{3}, 3 \\ 3; 1; 6 \\ \frac{1}{3}; \frac{1}{6}; 1 \end{bmatrix}. \quad (1)$$

In this matrix, the factors in the rows and columns are arranged in the same order as in the previous formula (1). The normalised eigenvector of this matrix, corresponding to its largest eigenvalue, is [0.250, 0.655, 0.095], and the consistency ratio (SR) is 0.016, which is significantly less than 0.1 – the permissible upper limit of the consistency ratio values. Data on the significance of the components of the OES-U for the factors are presented in the form of matrices, the columns and rows of which correspond to the components of the OES-U in the order specified in formula (1). For the first factor – inertia of the processes of extraction and production of energy resources – the ranked series (in descending order) looks like this: electricity – thermal energy – coal – gas – oil – oil products – alternative energy sources, and the matrix of pairwise comparisons – with its own normalised vector [0.351, 0.066, 0.104, 0.160, 0.031, 0.241, 0.045], the value of relative consistency (VU) = 0.025. The order of the components of the Unified Energy System-U corresponds to the order of formula (2):

$$\begin{bmatrix} 1;5;4;3;7;2;6 \\ \frac{1}{5};1;\frac{1}{2};\frac{1}{3};3;\frac{1}{4};2 \\ \frac{1}{4};2;1;\frac{1}{2};4;\frac{1}{3};3 \\ \frac{1}{3};3;2;1;5;\frac{1}{2};4 \\ \frac{1}{7};\frac{1}{3};\frac{1}{4};\frac{1}{5};1;\frac{1}{6};\frac{1}{2} \\ \frac{1}{2};4;3;2;6;1;5 \\ \frac{1}{6};\frac{1}{2};\frac{1}{3};\frac{1}{4};2;\frac{1}{5};1 \end{bmatrix}. \quad (2)$$

For the second factor – the state of war in the country and natural disasters – the ranked series is as follows: oil – oil products – electricity – non-traditional energy sources – coal – gas – thermal energy. The pairwise comparison matrix is represented by the formula (3) with the normalised eigenvector [0.160, 0.351, 0.045, 0.068, 0.104, 0.031, 0.241] and the value of relative consistency (RC) = 0.025:

$$\begin{bmatrix} 1;\frac{1}{3};4;3;2;5;\frac{1}{2} \\ 3;1;6;5;4;7;2 \\ \frac{1}{4};\frac{1}{6};1;\frac{1}{2};\frac{1}{3};2;\frac{1}{5} \\ \frac{1}{3};\frac{1}{5};2;1;\frac{1}{2};3;\frac{1}{4} \\ \frac{1}{2};\frac{1}{4};3;2;1;4;\frac{1}{3} \\ \frac{1}{5};\frac{1}{7};\frac{1}{2};\frac{1}{3};\frac{1}{4};1;\frac{1}{6} \\ 2;\frac{1}{2};5;4;3;6;1 \end{bmatrix}. \quad (3)$$

For the third factor – scientific and technological progress – the following series was obtained: alternative energy sources – electricity – petroleum products – gas – oil – thermal energy – coal. The matrix of pairwise comparisons for scientific and technological progress is as follows, represented by formula (4):

$$\begin{bmatrix} 1;4;3;6;\frac{1}{2};5;2 \\ \frac{1}{4};1;\frac{1}{2};3;\frac{1}{5};2;\frac{1}{3} \\ \frac{1}{3};2;1;4;\frac{1}{4};3;\frac{1}{2} \\ \frac{1}{6};\frac{1}{3};\frac{1}{4};1;\frac{1}{7};\frac{1}{2};\frac{1}{5} \\ 2;5;4;7;1;6;3 \\ \frac{1}{5};\frac{1}{2};\frac{1}{3};2;\frac{1}{6};1;\frac{1}{4} \\ \frac{1}{2};3;2;5;\frac{1}{3};4;1 \end{bmatrix}. \quad (4)$$

With a normalised eigenvector [0.241, 0.068, 0.104, 0.031, 0.351, 0.045, 0.160] and a relative consistency value (RS) = 0.025. As a result of the presented calculations using formulas 1-4, we can say that the original data are of fairly high quality - all matrices satisfy the transitivity requirements, and their relative consistency indicators are much less than 0.1. After multiplying on the right side of the 7 × 3 matrix, consisting of columns of normalised eigenvectors of all three factor matrices, by the normalised eigenvector of the uncertainty matrix of forecasts of the components of the Unified Energy System-U, a vector was obtained, the components of which are the weights (numerical indicators of relative importance) of the seven considered components, which form the lower level of the hierarchy in Figure 1 – 0.215, 0.254, 0.065, 0.087, 0.110, 0.085, 0.184. As a result, the following ordered sequence of uncertainty indicators in relative values was obtained (Table 1)

Table 1. Uncertainty indicators of the components of the UES-U

Component	Uncertainty, %
Coal mining	25.4
Natural gas mining	21.5
Electricity generation (nuclear energy)	18.4
Electricity generation (hydro energy)	10.9
Thermal energy generation (combustibles)	8.7
Energy generation (alternative sources)	8.5

Source: calculated by the authors

It is noticeable that the components of the unified energy system of Ukraine are clearly divided into two groups by the magnitude of uncertainty, which are accompanied by forecasts of their development. This is of important methodological importance for obtaining forecasts of the development of the unified energy system of Ukraine as a whole and with the minimum, if possible, level of uncertainty. This is possible if the modeling of the Unified Energy System of Ukraine begins with components with a lower level of uncertainty, and then complements the model with options for other remaining energy facilities, related (coordinated) with the options of the industries from the first group (Korcheva & Kriuchkova, 2015).

It is also worth noting that the level of uncertainty in percentages for such energy components as coal and natural gas, the indicators of which are quite large, therefore it is worth considering the opinions of other scientists, such as Yu.T. Matveeva & I.A. Vakulenko (2022) and H. Pudycheva (2021), who paid significant attention to the processes of decarbonisation of the energy sector of Ukraine. Thus, in the study of the first scientist, the environmental aspects of enterprise development are dictated by the increasing use of green energy sources, which forms their social responsibility and support for a thrifty attitude to available resources. The analysis of recent publications in the most authoritative scientific publications highlighted in the work demonstrates a high level of interest among the scientific world community in these issues, and the high level of citations indicates the relevance of the issues studied. In this case, the general trend towards decarbonisation of economic activities of enterprises on the global scale forms a modern orientation towards socially responsible conduct of business. In continuation of the above analysis, the second author further developed the presented theory of decarbonisation in the direction of adding aspects of decentralisation and digitalisation in these processes, which is formed as a concept of "3D". In this direction, the author determines the importance of autonomy in making decisions on the economical use of energy resources using modern tools of digital transformation, which form an updated paradigm of energy market trading. In this case, the sustainable development of energy enterprises through decarbonisation, decentralisation and digitalisation, prompts the need for a complete reformatting of the market, which further changes the chain from production to final consumption of any types of energy.

Over the past six years (since 2019), the development of our state has had a vector towards the European Union, which encourages a reduction in carbon dioxide emissions into the atmosphere. From the point of view of the economy and strengthening the economic security of energy enterprises, this issue has not been widely analysed. The results of the research by V. Omelchenko *et al.* (2022) were correct, who identified the features of changes in economic indicators as a result of the implementation of decarbonisation of the energy sector. These changes are significant factors of uncertainty, especially in the aspect of the presented research on the involvement of investors in energy transition projects. In this case, it is the theoretical foundations of uncertainty and the theory of fuzzy sets that play a significant role in predicting the results of financial investments and forming the prospective level of receipt of income from investments. A proposal has been formulated for expected results, which include decarbonisation of the energy sector through the transition to low-carbon energy systems, development of clean electricity and heat, increased energy efficiency and energy conservation in all sectors of the economy and at civilian facilities.

In continuation of this issue, the results of K. Gura & V. Petruk (2021), which are based on the results of the global trend towards decarbonisation processes, are quite relevant. The highlighted aspects of the transition to new energy-saving technologies in the USA, European countries, Japan, and Asia are presented in a comparative form in accordance with climate changes, which record a constant stable increase in temperatures as a result of the use of carbon-containing energy sources. At the same time, there is an opinion that uncertainty is an important aspect of the enterprise's activities, because it is through risks and failures that it is possible to achieve the desired. The works of S.S. Horvey & J. Odei-Mensah (2023) and A. Qazi & M.C.E. Simsekler (2021) pay attention to risks as management factors in conditions of uncertainty, but the works are more generalising and theoretical in nature, which is not supported by analytical calculations.

The authors present a study of the theoretical basis of the theory of uncertainty and determine its further development by implementing enterprise management through risks. But this opinion is not supported by practical results, which casts doubt on the proposed theory and, accordingly, leaves it at the level of a theoretical hypothesis. Instead, V. Grushko *et al.* (2021) pays great attention to uncertainty and its etymology, the work distinguishes uncertainty and risks, the causes and consequences of their occurrence. It already describes in more detail the practical aspects of the occurrence of risks in various forms of occurrence. In general, it is worth saying that the presented developments give an idea of the further development of the energy industry, taking into account the trends in the development of modern digital technologies, but requires significant elaboration of the consideration of aspects of uncertainty as an important factor in the probability of the occurrence of any events in the future.

Conclusions

The analysis of uncertainty for the enterprises of the unified energy system of Ukraine based on the selected stages of these processes helped to generalise information about the data and determine the structure of information search, its reliability and general characteristics. In the future, this contributed to the presentation of the development based on hierarchical modeling of a method for finding a comparative assessment of the uncertainty of the components of the unified energy system of Ukraine (by division into its main products - coal mining, natural gas, nuclear, hydroelectric power, thermal energy and energy from alternative sources) made it possible to distinguish between them two groups that have significantly different levels of uncertainty of the information necessary to obtain forecasts. The results obtained regarding the most uncertain components of the Unified Energy System of Ukraine include coal mining (25.4%), and the smallest – alternative energy sources – 8.5%, formed an idea based on the presented results regarding the most vulnerable areas of energy supply.

On the one hand, coal and natural gas production are characterised by high uncertainty, and on the other hand, the production of thermal energy, electricity (for various carriers), as well as alternative and renewable energy sources are characterised by moderate uncertainty. In this case, taking into account the theory of uncertainty, in the processes of modeling future promising directions of sustainable development of enterprises in the energy sector of Ukraine, it is worth simultaneously paying attention to the economic security of these enterprises, because its correctly formed and secured components also reduce the likelihood of risks in the future and, through the effect of synergy, contribute to minimising threats in general, which is especially relevant in conditions of martial law. That is, for future searches for the impact of risks in conditions of uncertainty, which is the basic provision of the theoretical concept of the system of economic security of enterprises, on the sustainable development of this industry, it is quite natural to conduct an in-depth analysis of these risks (if reliable information about them is available) as well as harmonisation of their impact on the processes of economic activity of enterprises in order to eliminate any manifestations of negative impact. To do this, it is necessary to expand the search for scientific justification and feasibility of applying methods and tools of uncertainty theory to the processes of strengthening the economic security of enterprises and to deepen the foundation in the direction of improving methodological tools.

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Вплив невизначеності на зміцнення економічної безпеки підприємств об'єднаної енергетичної системи України

Катерина Андрющенко
Доктор економічних наук, професор
Київський національний економічний університет імені Вадима Гетьмана
03057, просп. Берестейський, 54/1, м. Київ, Україна
https://orcid.org/0000-0002-6274-5310

Анастасія Лєзіна
Кандидат економічних наук, доцент
Київський національний економічний університет ім. Вадима Гетьмана
03057, просп. Берестейський, 54/1, м. Київ, Україна
https://orcid.org/0000-0003-0516-6598

Анотація. Важливість вивчення питання процесів зміцнення економічної безпеки підприємств є досить обґрунтованою з огляду на військовий стан України та погіршення, в зв'язку з цим, економічного становища підприємств. Умови невизначеності є нормативними для суб'єктів господарською діяльності, але набувають нового сенсу та стають базовими для підприємств. Метою було формування теоретичного та методологічного підґрунтя процесів зміцнення економічної безпеки підприємств галузі енергетики України на основі теорії невизначеності. В роботі за основу обрано підхід щодо виокремлення етапів процесу оцінювання невизначеності, поділу основних продуктів підприємств на складові та використання методу аналізу ієрархій (МАІ). В результаті аналізу широкого спектру наукової літератури було визначено, що в рамках методології економічної безпеки прийнято використовувати інструментарій теорії ризикології та відповідні методи і моделі менеджменту. В даній роботі було розкрито теорію й практику економічної безпеки енергетичних підприємств через концепцію теорії невизначеності. Виділено класифікацію за видами невизначеності та умовами її виникнення для підприємств об'єднаної енергетичної системи України (ОЕС-У), що допомогло обрати необхідний інструмент для аналізу. Отримані висновки мають важливе методологічне значення для прогнозів розвитку об'єднаної енергетичної системи України загалом та із мінімальним, по можливості, рівнем невизначеності. Це можливо, якщо моделювання ОЕС-У почати зі складових з меншим рівнем невизначеності, а потім доповнювати модель варіантами інших об'єктів енергетики, що залишилися, пов'язаними (узгодженими) з варіантами галузей з першої групи. Отримані результати дозволяють здійснювати цілісне прогнозування розвитку об'єднаної енергетичної системи України з урахуванням чинників економічної безпеки та мінімізацією впливу невизначеності

Ключові слова: сталий розвиток; ризики; метод аналізу ієрархій; енергетична галузь; економічна стійкість; моделювання розвитку енергосистеми; прогнозування