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Factorial model of the strategy of increasing the level of energy security of enterprises in terms of resource-saving

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Abstract. The strategy of increasing the energy security of enterprises, and also the factors of influence on their production relations, socio-economic development and functioning in a crisis are studied. It is proved that the scarcity of energy resources requires an assessment of the factors influencing energy security and taking them into account in the formation of business strategies. The concept of energy security was further developed through the prism of a factor model of strategy implementation taking into account energy saving policy. In the course of the research the methods of critical analysis, structuralization, factorial, generalization, scenario, matrix, impulse process was used. The scientific result concerns a substantiated strategy to increase the level of energy security of enterprises based on the structuring of the factor environment and the built factor model that takes into account formal and informal aspects. The practical value of the study consists in substantiated strategic measures, the implementation of which ensures the maximum possible growth of energy security of enterprises, in particular: investment in energy efficiency, energy efficiency of enterprises, development of eco-consciousness of staff, which allows to justify a stable and prone system of energy security of the state to growth.

1. Introduction

The dynamics of the present are inextricably linked to the economic crisis caused by the pandemic of the COVID-19, which has significantly increased the dangers and threats of functioning of the industrial industry. The growing imbalance of the external environment and unfavorable conditions on the political and economic horizons require decisive action to identify effective levers of security management, including energy, socio-economic systems. The problem of energy security management and the need to diagnose its level faced with Ukrainian enterprises due to the significant energy consumption of manufactured products, which is much higher compared to industrial enterprises in leading countries. Therefore, identifying effective models of energy security management of enterprises, which provide a long-term perspective for timely diagnosis of its level is a challenge today. The new operating conditions require the top management of enterprises to apply effective principles of energy security management. The purpose of which is to reduce the level of consumption of fuel and energy resources per unit of final product while reducing the negative impact on the environment.

The use of diagnostic models helps to accept management decisions at the strategic, tactical and operational levels of management. Therefore, the strategy and tactics of energy security management are closely linked. On the basis of the developed strategy by top management to ensure the required level of targets for the operation of the enterprise, as well as the formed global strategy of security



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management, tactical measures are reflected. The main purpose of tactical management is to implement strategic plans. However, the results of the tactical level of energy security management are the key indicators for making changes to the management strategy as a whole.

The key point in the application of diagnostic models is to determine the place of diagnostic in the enterprise and its information and analytical support. In this context, monitoring of the state of the enterprise in order to develop analytically substantiated proposals for effective management decisions, which is based on the analysis of consumption of available fuel and energy resources and the relevant production infrastructure. The reliability and completeness of such information is a fundamental factor in a timely, adequate and effective management decision. The ability to quantitatively predict the use of diagnostic models also depends on the expected results of the top decisions and is based on the probability of using the apparatus of mathematical modeling.

Munir Theeb [1] presents the new knowledge management framework as a methodology for integrating design and diagnosis tasks, models, and modelling environments around a common approach for improved integration of generalized design and diagnostic modelling to facilitate the development and implementing of change models in the organizations.

Raoni B B, Lopes T L and Henrique de Oliveira L G [2] offer the choice of the appropriate diagnostic tool and point out its importance for management decisions. According to the authors, companies should take into account the specifics and strategic intentions of innovation management initiatives before making a diagnosis. Baharudin, I S and Abdullah B [3] analyze the models, highlighting their values, advantages, disadvantages. Recognizing the factors that contribute to the work of building / engineering companies, the authors propose a new diagnostic model that is more suitable for this industry. Liang J, Qin Z, Xiao S, Ou L and Lin X [4] define the work process for online diagnostic services using the cloud. The authors propose an effective and safe scheme for classifying the decision tree in the proposed work process. The optimization process is considered by the authors Christopher A, Kanter-Ramirez, Josue A, Lopez L, Beltran-Rocha L, Ferková D [5], who argue that the basis is the analysis of a conventional information system management system. In order to propose a new special structure. In order to propose a new special structure, proposed an optimized information control system, which is the basis of an optimized digital platform.

Voynarenko M, Mykoliuk O, Bobrovnyk V, Greguš M and Svistunov O [6] emphasize the importance of managing energy efficient development of enterprises by developing a prediction model of energy security in the enterprise management system.

The authors [7; 8], consider that the study of energy security of enterprises should be conducted using dynamic optimization models with appropriate target functions of its components and many restrictions on the parameters of the models. Modeling in this format is a powerful tool for cognition and prediction of processes and phenomena that are characteristic of the system under study.

The analysis of sustainability and security of enterprises was carried out using a wide range of classical and advanced modeling methods. In particular, in article [9] statistical discriminant analysis and models on fuzzy logic related to artificial intelligence tools are used for this, and in work [10] the assessment of the sustainability of enterprises is carried out on the basis of fractal analysis. It should be noted that one of the factors that can affect the energy security of an enterprise is the exchange rate of the national currency in relation to the cryptocurrency. Research in forecasting the bitcoin rate is presented in [11]. Shmygol N, Cherniavska O, Pulina T and Zavgorodniy R offer the model of the resource-efficient strategy implementation on the basis of trade margins distribution between processing and extracting enterprises [12]. The model of resource efficiency diagnostics in oil and gas sector of the economy was improved in the study [13], which takes into account variation in defining weighting coefficients which show the experts' system of preferences.

2. Modelling of energy security

In the scientific economic literature there is no single approach to modeling the assessment of the level of energy security of industrial enterprises. In this regard, it is necessary to form a list of compliance requirements, namely: a) dynamism provides a description of the energy security of the enterprise in

development, as it is undeniable that economic processes depend on time; b) adequacy of the model - conformity of the model to the object (process) of modeling; c) determinism is related to the nature of the reflection of causal relationships, because the factors of chance in this case have an impact on the enterprise, the results of their impact are taken into account in the indicators, they come to the energy security model as a plural (predetermined) indicators; d) identity during the building a model it is necessary to indicate the ways of using information about the object, as well as ways of interpreting the results, that is the use of modeling results relative to the real object.

The model of energy security diagnostics is a purposeful assessment of the enterprise state, identification of trends and prospects of its energy efficiency development. That is, the diagnostic model should reflect the essence of the management problem which is modulate, the state of the diagnostic object. In this case, simplification of the model, cutting off insignificant details will allow to find effective and adequate solutions to the problem [14-16]. This process is provided by the assessment of the most important indicators in order to make effective management decisions aimed at further successful operation of the enterprise in a competitive market environment. Taken into consideration, the modeling process in general includes the following steps, figure 1.

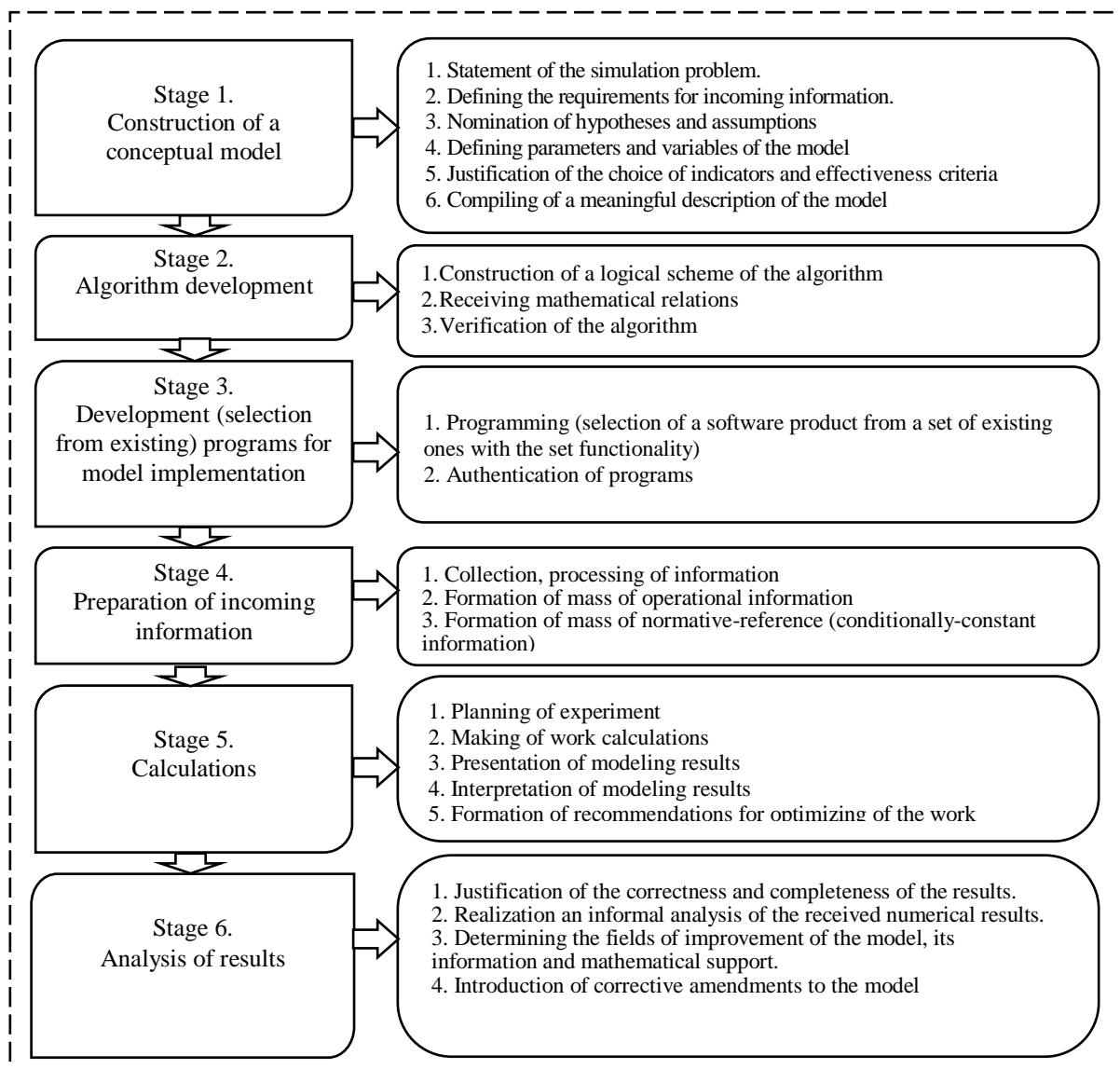


Figure 1. Stages development of the model of diagnostics of energy security of the enterprise

Notice that the use of different energy efficiency indicators, which form a certain plural, allows to fully reflect the activity features of the enterprise, control it and determine the real impact of each of them on activity results. According to experts, in terms of each of the components, it is determined that a significant number of parameters that determine both energy efficiency and energy security of enterprises are not subject to quantification, due to their weak structure [17-19].

However, in practice, it is well established that the level of economic security is affected not only by quantitative indicators, but qualitative, which are extremely difficult to assess without the use of soft modeling methods.

In particular, an effective tool for the study of weakly structured socio-economic systems is cognitive modeling, which allows to identify the main patterns and scenarios of development in the environment of resource conservation policy based on the construction of sign digraph, whose top represented by u_1, u_2, \dots, u_n and take the values of $v_i(t)$ at discrete moments of time $t = 0, 1, 2, \dots$, correspond to the main structural elements of the research problem and consistent with each other causal relationships, which are marked by arcs. It is assumed that the value of $v_i(t + 1)$ is determined by the value of $v_i(t)$ and data about other have increased or decreased their values top u_i adjacent to u_i at time t . If an increase of the parameter value of the top from which the arc emerges per unit of numeraire leads to an increase in the value of the parameter of the top into which it enters, the relationship is considered positive, otherwise - negative. Methodological principles of cognitive modeling were first proposed by R. Axelrod [20].

Taking into account the latest achievements of scientists, the results of practical research, we have summarized and structured the following set of factors of subjective and objective impact on the level of energy security of enterprises in developing countries, figure 2.

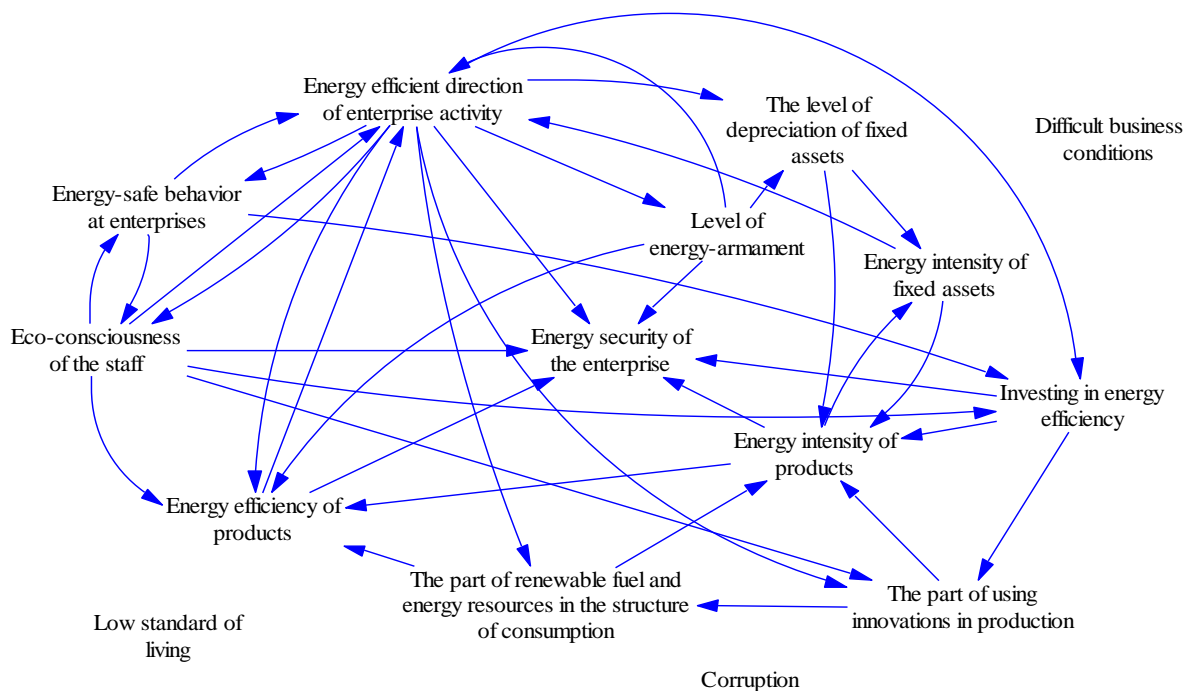


Figure 2. A digraph of the G-factor environment of energy security of enterprises

Note that the impact on the target peak "Energy security of the enterprise" can be direct and partial, and external externalities will include such peaks, the impact of which, of course, determines the impact, but it is almost impossible to level, in particular: difficult business conditions; corruption; the low standard of living, table 1.

Table 1. Grouping of impact factors

Name of the impact level	The nature of the impact	Object of impact (name of the top)
Externalities	It's taken into account, but almost impossible to level the impact	Difficult business conditions, Corruption, The low standard of living
The level of state impact	Direct	Energy efficient direction of enterprise activity Investing in energy efficiency
	Partial	The part of renewable fuel and energy resources in the structure of consumption Energy security
The level of enterprises impact	Direct	The level of depreciation of fixed assets Energy intensity of products Energy efficiency of products Level of energy-armament
	Partial	The part of using innovations in production Energy security
The level of individuals impact	Direct	Energy-safe behavior at enterprises
	Partial	Eco-consciousness of the staff Energy security

Thus, the impact on the target peak is uneven, which must be taken into account when justifying the strategy and the available opportunities to increase the level of energy security of enterprises.

To justify the strategy of increasing the level of energy security of enterprises, we use the impulse process, the theoretical and applied principles of which are presented in the works of F. Roberts [21].

Therefore, on the basis of the formed sign digraph G we form a contiguity matrix $(A_G = A = [a_{ij}]_{n \times n})$ under this condition [21, p. 318–321]:

$$\text{sgn}(u_j, u_i) = \begin{cases} 1, & \text{if the rib } (u_j, u_i) \text{ is positive,} \\ -1, & \text{if the rib } (u_j, u_i) \text{ is negative,} \\ 0, & \text{if the rib } (u_j, u_i) \text{ is missing.} \end{cases} \quad (1)$$

The autonomous impulse process is investigated by the following rule [21, p 320]:

$$p(t) = p(0) \times [A^t], \quad X(t) = X(0) + [A^0 + A + A^2 + \dots + A^t], \quad (2)$$

where $p(t)$ vector of parameters values changes of digraph peaks on the corresponding measure of modeling; $p(0)$ vector of initial impulses at the peak of the cognitive model; A adjacency matrix for the corresponding oriented graph; t simulation cycles ($t = 0, 1, 2, 3 \dots k$), that reflect the sequence of changes in the state of the system; $X_{(t)}$ values of peak parameters on the simulation cycle t ; $X_{(0)}$ values of peak parameters on the initial simulation cycle; $A_{(0)}$ single matrix.

Gradually launching a disturbing impulse into the various control peaks of the digraph, we obtain scenarios for the development of the target peak, which will identify factors influencing the positive growth of the level of energy security of enterprises [22-26].

3. Substantiation the level of increasing strategy of energy security of enterprises

As a result of the application of the pulse process, the following results are received. The best results of the dynamics of the target peak of the energy security of enterprises are shown in figure 3.

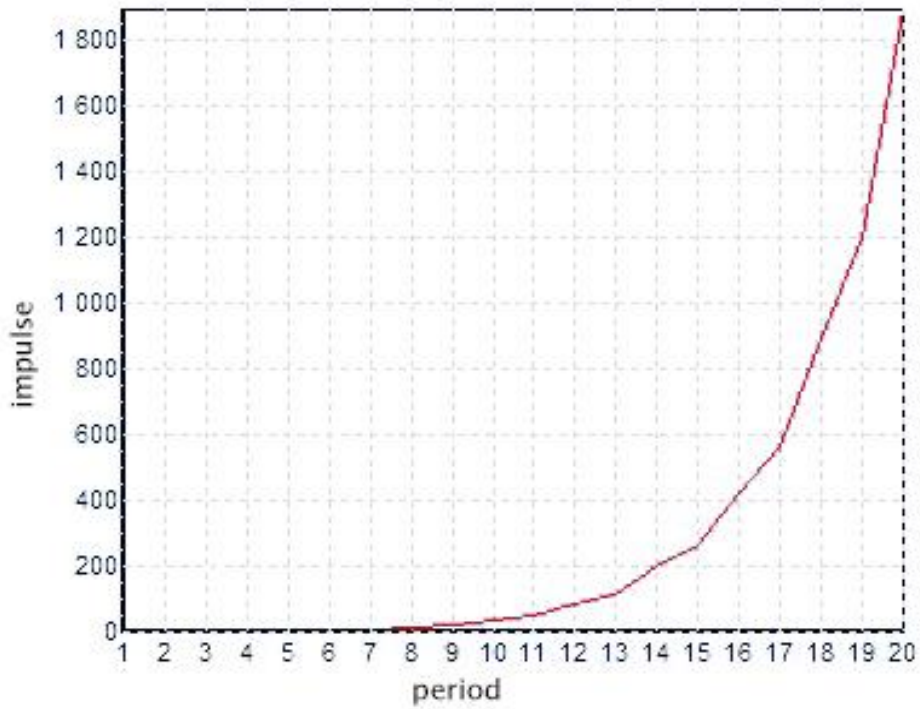


Figure 3. Dynamics of the level of energy security under the impact of an excitatory pulse to the peak – Investing in energy efficiency

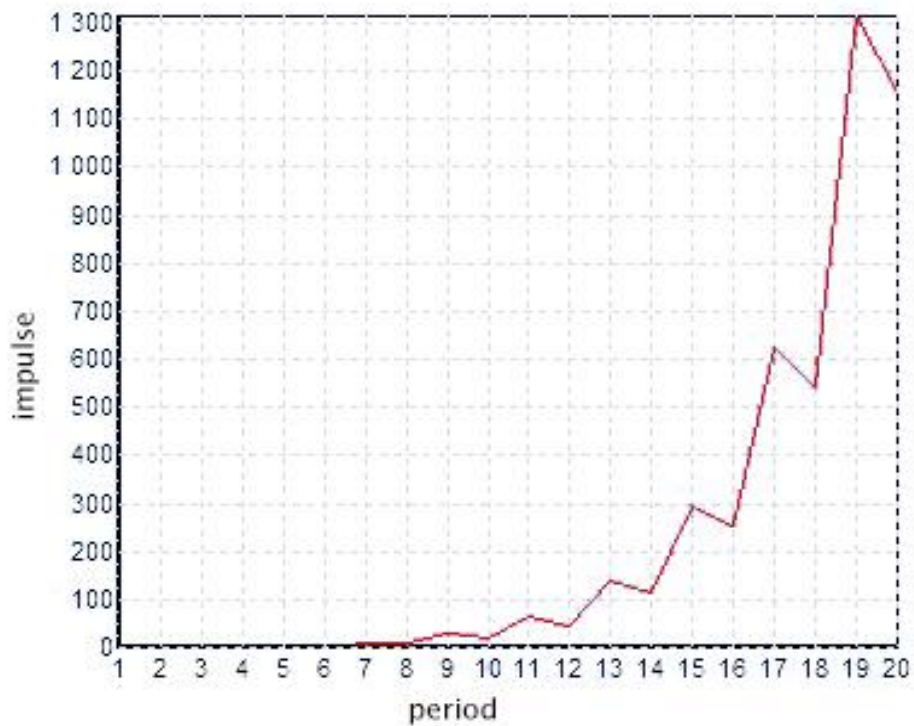


Figure 4. Dynamics of the level of energy security under the influence of the disturbing impulse to the peak – Energy-efficient direction of enterprise activity

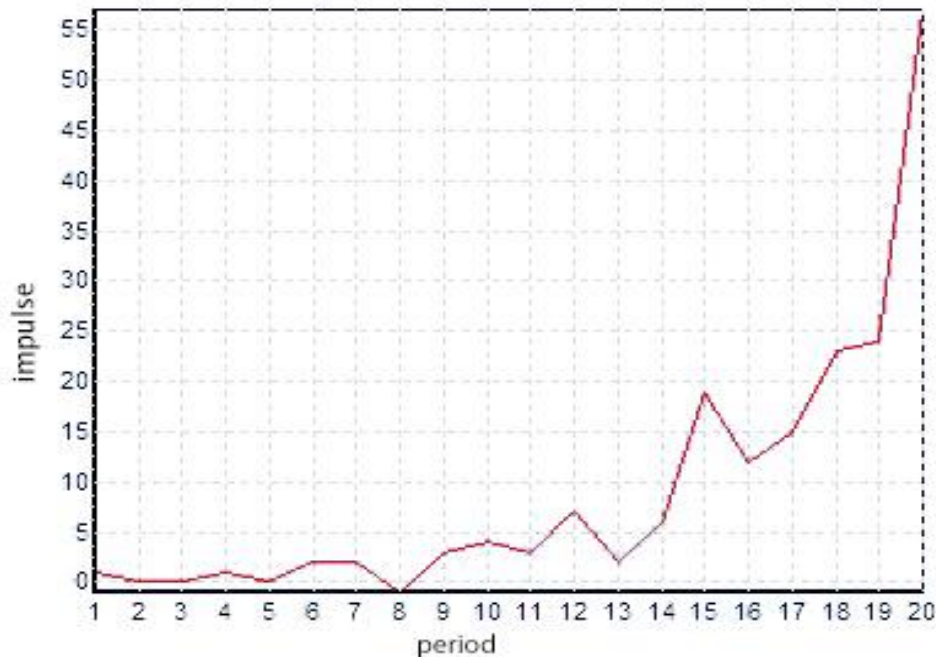


Figure 5. Dynamics of the level of energy security under the impact of the disturbing impulse to the peak - Eco-consciousness of the staff

Because the following peaks have a positive impact on the energy security of enterprises, such as Investing in energy efficiency, Energy efficient direction of enterprise activity, Eco-consciousness of the staff, then the strategy of improving the energy security of enterprises will be based on the principles of forming eco-conscious behavior of entities and justification of investment measures and energy efficiency of enterprises. The influence of other factors on the target peak also gives positive results, but with a significant delay in time and does not reach a high level.

4. Conclusions

The results of the study allow us to conclude about the possibility of solving the problem of energy security management of machine-building enterprises in the context of identifying priority indicators of its impact. This is confirmed by the developed algorithm for building a structural and logical model for diagnosing the energy security of the enterprise and a model of impact of indicators of influence on the energy security of the enterprise.

The strategy of increasing the level of energy security of enterprises based on the structuring of the factor environment and the built factor model, which takes into account formal and informal aspects, is substantiated. As a result of the model implementation, the main strategic measures have been identified, the implementation of which ensures the maximum possible increase in the level of energy security of enterprises, in particular: investment in energy efficiency, the energy efficiency of enterprises, development of eco-consciousness of staff. Only on the basis of the simultaneous development of formal and informal components of energy security in enterprises is it possible to justify a sustainable and growth-friendly system of energy security of the state.

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