

Entropy Paradigm of Project-Oriented Organizations Management

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Abstract. Almost everything that prevents organizations from being successful and achieving their goals can be combined into one category – “entropy”. The organization’s vital activity is accompanied with three types of entropy: information, structural, and energy. Each project of a project-oriented organization contributes to a change in entropy of the organization. To identify the systemic relationship of the three types of entropies, a project-oriented organization has been presented in the form of the system that exchanges energy, substance and information with the external environment within the structure corresponding to business processes. This systematic approach made it possible to link together three types of organization entropies. The main factors affecting the growth of each type of entropy, as well as the relationship of entropies are established. The conceptual model of energy dissipation in the project-oriented organization is formed.

Keywords: Entropy, Energy, Information, Structure, Business-processes, Project

1 Introduction

One of the global trends in modern science is the transfer of categories, concepts and methodologies, corresponding to such a concept as “transdisciplinarity”, a discussion of which can be found in [1,2]. According to [2], transdisciplinarity is a research strategy that crosses disciplinary boundaries and, in the broad sense, means the unity of knowledge beyond individual disciplines.

Thus, modern science erases the boundaries between different fields of knowledge, forming a unity of conceptual and methodological approaches to the study of objects, processes or phenomena of various nature. It can be argued that the universalization of concepts and categories is a global trend in today's research. An example of this

transfer is “entropy”, which began its existence as a purely technical category within thermodynamics, describing the properties of macroscopic systems. Later, entropy became a measure of a certain order, which is reflected at the information level, and entropy began to be used as a measure of uncertainty in information theory. Today, there are attempts to use entropy as a thermodynamic category as a characteristic of the state of enterprises and organizations. The basis of this approach is the comparison of “energy” with the resources of enterprises, organizations, or rather with the capabilities of resources, which play a peculiar role of fuel giving energy in the process of use. In particular, the energy of an enterprise is understood as a combination of energies of various types of resources, not only material but also energy (entrepreneurial energy) of management and human resources (psychic energy, personnel motivation according to [3]). Such attempts to transfer the “entropy” approach correspond to the unity and universality of global laws inherent in the world around us at any level of its consideration within the transdisciplinarity

2 Literature Review and Research Problem Statement

Let us analyze the use of such a category as “entropy” in modern research related to the activities of enterprises and organizations with the identification of various types of entropies and their specifics. Note that the systematization of knowledge about entropies was presented in [4,5], but these works are more philosophical in nature and do not provide a specific methodology and the corresponding methods of using entropy in the context of managing organizations.

The most accessible for understanding the essence, so to say, is the concept of “information entropy”, that is a measure of uncertainty, which, due to a fairly clear interpretation, has found its application in separate studies related to the processes of functioning and development of enterprises, including project-oriented ones (for example, in [6-10]).

The use of “structural entropy” in the context of the order and chaos of socio-economic systems began with publications [11,12] and was, in fact, the central category for the whole scientific direction “synergetics” (the science of self-organization).

Thus, structural and information entropy are widely used in research on the functioning and development of enterprises. Since these types of entropy “fit” into the context of sociotechnical systems and project-oriented organizations, the next logical step was attempts to use thermodynamic / energy entropy to manage enterprises in general and projects in particular. Such an idea, in particular, was also determined by the widely spread category of “entrepreneurial energy” [13], as mentioned above. That is, on the one hand, the application of certain types of entropies to organizations logically led to the idea of applying energy / thermodynamic entropy; on the other hand, the use of the category “energy” in the context of a specific resource of organizations ([13,14]) also led to the idea that organizations have energy entropy.

In [15-20], energy entropy is used as a characteristic of the enterprise state, and, in particular, in [15], the system for the formation of external and internal entropy of the enterprise is built, the mathematical description of possible options for their dynamics

is proposed, and the connection between entropy and “economic rejection” of the enterprise is established.

Thus, as a result of the analysis of publications, the following conclusions can be made:

1) various types of entropies are used in the application to the management of organizations, including project-oriented ones. At the same time, the presence of the relationship of various types of entropies remains unclear. In [4], there is a thesis that today there are two views on the system entropy: according to the first, different types of entropies are one and the same entropy, but from different points of view; according to the second, the total system entropy is the sum of various types of entropies, taking into account their normalization. At the same time, both opinions are more unreasoned subjective points of view of various authors than scientifically substantiated provisions;

2) the practical majority of publications on the use of energy entropy in the context of enterprise and organization management does not provide a clearly structured approach and postulates of the "entropy" approach in the management of organizations or projects. The value of these publications is that they, in fact, set a guideline for further research, which should form a methodological basis for the application of energy entropy within spreading the idea of transdisciplinarity.

Thus, the issues of applying the entropy approach to managing organizations remain open and require fundamental substantiation of the main provisions that should form the basis of the entropy paradigm of managing organizations.

It should be noted that the current situation with entropies in the context of organizations is explained by the fact that the “intuitive” understanding that everything that happens in our world obeys the same global laws and it takes time for clear awareness, identification and research. On balance, the aim of this research is to formulate the basic principles of the entropy paradigm of management of project-oriented organizations, which are selected as a specific object, taking into account the progressiveness in all aspects of the project-oriented approach to management giving the necessary flexibility in the use of resources and meeting market demands. Since energy entropy, as the least studied category, requires more detailed consideration, the particular task of the research is to establish the main provisions of energy-entropy processes of the organization.

3 Structure, Energy and Information

In the broad sense of the word, a project-oriented organization is an enterprise, company or organization whose management is built on the principles of the project methodology. Therefore, it should be noted that the formulated entropy paradigm, on the whole, is naturally inherent in any type of organization, but for project-oriented ones it has its own specific features. Therefore, the main provisions of this paradigm are presented below in a general form for all types of organizations, and for project-oriented ones, in particular, taking into account their specificity. For a clear identification of the place, role and relationship of various types of organization entropies, an

appropriate system model of a project-oriented organization should be formed. The formation of the entropy paradigm involves, first of all, a systematic representation of the organization, taking into account the information-material-energy approach to the system as a universal system model. So, according to the systematic approach (for example, [17]), an enterprise, company, organization is an integral system continuously interacting with the external environment, from / into which energy, information, and substance enter (See Fig.1). “Substance” is considered as a material product or service created by the organization, namely, the subject of the organization’s activities. In addition, the organization has a certain structure, including the distribution of resources, technology (production structure) and the organization of business processes. Thus, information, energy and structure are three integral attributes of any organization, including project-oriented one.

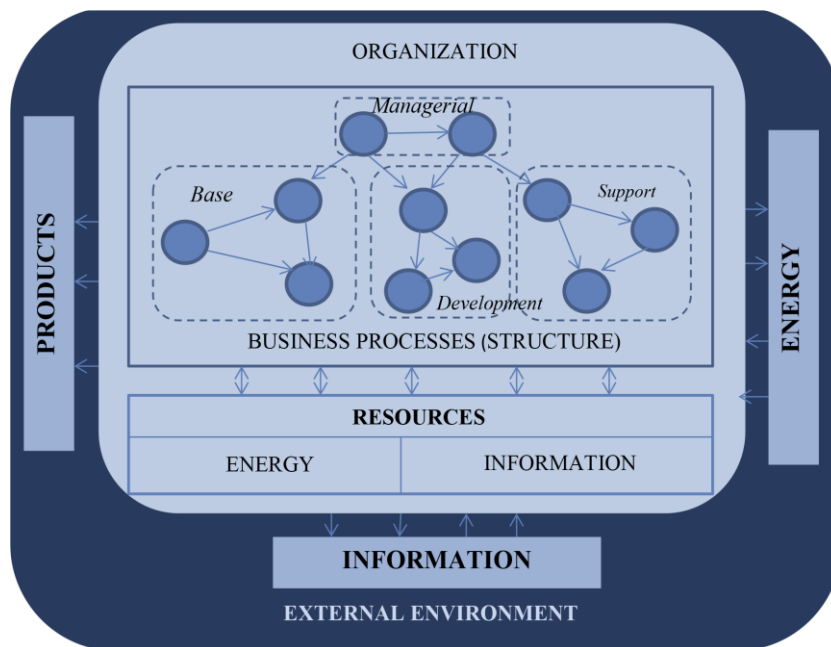


Fig.1. Organization as a unity of structure, energy and information

Energy is considered as all types of resources of the organization (with the exception of information, as a specific type of resources). Note that in some sources in this context the term “quasienergy” is used (for example, [15,16]), emphasizing in this way that the organization’s resources are not the energy itself, as it is commonly considered in physics, but, actually, a certain possibility of resources, that is a specific energy, inherent exclusively in systems associated with the social component (sociotechnical systems, for example). Without limiting the generality, in the future, the term “energy” will be used in the context of the properties of various types of resources of the organization. Indeed, energy is that, in fact, allows performing work in the context

of the classical approach to the definition of energy. The work of the project-oriented organization (however, like any other) is the implementation of business processes (main, managerial and support) related to the main business and development processes. The “substance” generated by the organization is its “product” (the result of its activity, goods, service (services)), which is formed as a result of the “operation of the system” and “offered” to the external environment in exchange for “energy” in form, most often, of financial resources. In addition, from the external environment, the organization receives the necessary resources of various types, for example, human resources, raw materials, etc., as well as information. Information, unlike energy, is not consumed, but can be useful or not useful for the organization, while information about the organization and its product is also distributed in the external environment, which forms the information cycle. Thus, the exchange of energy, information and substance between the organization and the external environment allows the organization to carry out its activities in accordance with the structure, that is, a certain set of business processes that can be classified as business processes of management, main activities, support and development processes. The implementation of the work involves the use of resources, the quantity, properties and characteristics of which determine the quantitative and qualitative characteristics of each business process individually and the activities of the organization as a whole. Thus, energy is a kind of integral property of the resource (integrity is that energy is determined by a combination of quantitative and qualitative characteristics of the resource), which is reflected and consumed in the implementation of business processes. In project-oriented organizations, work (business processes) is structured according to projects that are related both to the main activity and to the development of the organization (See Fig. 2).

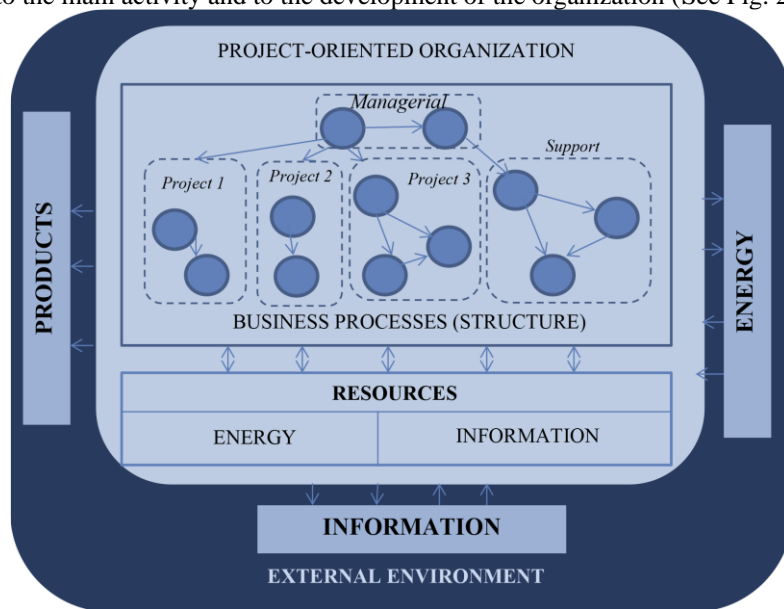


Fig.2. Project-oriented organization as a unity of structure, energy and information

Everything else is similar to what was established above for all types of organizations. Any organization is characterized by the presence of goals, the achievement of which can be defined as success of the organization. These goals are related both to the organization's current activities and its development. Moreover, success in this context does not always accompany organizations, which can be caused by a variety of reasons, such as unreasonable management, adverse changes in the market, lack of necessary resources, incompetence of labor resources, etc.

4 The System of Organization Entropy

Almost everything that prevents organizations from being successful and achieving their goals can be combined into one category – “entropy”. Moreover, the property of entropy is such that the higher it is, the worse it is for the organization, and when the certain maximum is reached, entropy becomes destructive for the organization. The question arises – what kind of entropy is concerned? The presence of energy, information and structure in the organization is considered to determine the existence of entropy of the appropriate type. The set of “entropies” of the organization corresponds to the main types of entropy distinguished in modern science: information, structural, energetic, which are logically connected with the main components of the organization's system representation. Thus, the activity of any organization is associated with the existence and dynamics of three types of entropies. And each of them, upon reaching a certain level, can be destructive for the organization.

Since in the project-oriented organization, main and development business processes are structured by projects, each project affects the dynamics of each type of organization entropy. Thus, each project forms information entropy, energy entropy and structural entropy. It can be concluded that the “entropy contribution” of the project to the overall organization's entropy (for each of its types) is an important characteristic of the project (See Fig.3).

Information entropy serves as a measure of uncertainty in which decisions are made and the organization's business processes are implemented. And, in fact, the emerging risks, which are associated precisely with uncertainty, are the result of the impact of information entropy. Ignorance of the future market situation is also a manifestation of information entropy. The higher information entropy is, the greater the uncertainty, and, therefore, the lower the probability of achieving goals and ensuring the organization's success.

Structural entropy characterizes the orderliness of the organization as a system, so the “coherence” of the organization's business processes and management procedures, adequate allocations of resources, etc. determine this or that degree of the orderliness of the organization, which is characterized by structural entropy. Thus, the “ideal order” and “complete chaos” being two extreme states of the organization determine the corresponding minimum-maximum for structural entropy in terms of structure. An increase in the latter corresponds to the growing “chaos” in the organization and indicates the need for structural changes in the organization.

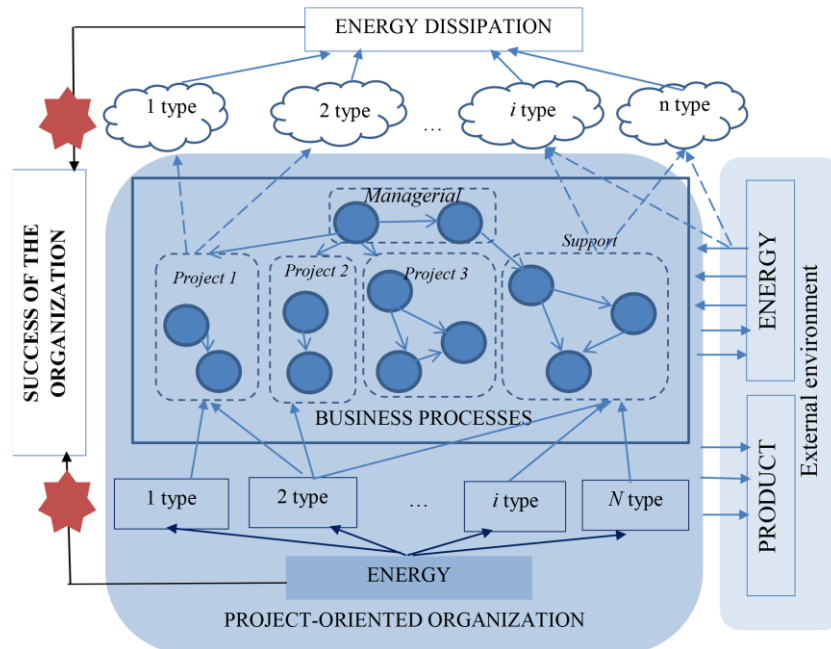


Fig.3. The model of energy dissipation formation in a project-oriented organization

To clearly identify the essence of energy entropy for the organization, it should be taken as a fact that:

- 1) it is impossible to consider an organization literally as a system in thermodynamics with mechanical transfer of thermodynamic categories, since these are the systems that are completely different in nature;
- 2) there is no concept of a reversible / irreversible process for the organization – all its processes are irreversible; you cannot return an organization to any previous state, much less together with the external environment;
- 3) a property that is inherent in both the organization and the thermodynamic system is energy loss. The reasons for this phenomenon are fundamentally different, but the fact of its presence allows the use of the term “energy entropy” for organizations. In its classical sense, energy entropy is a kind of “shadow” of the organization’s life (if we rephrase the idea expressed in [5] with respect to organizations) and is associated with natural dissipation of energy. As previously determined, for the organization, energy is both material and intangible resources (See Fig.4).

In the process of implementing business processes of all kinds, dissipation of energy, that is its loss, takes place. And this is precisely what generates energy entropy. Energy losses are the natural aging or wear of equipment and other material objects, “obsolescence” of labor resources, which means the absence of their development in accordance with requirements of the dynamically developing external environment, loss of time by labor resources, spoilage in production, production waste, etc.

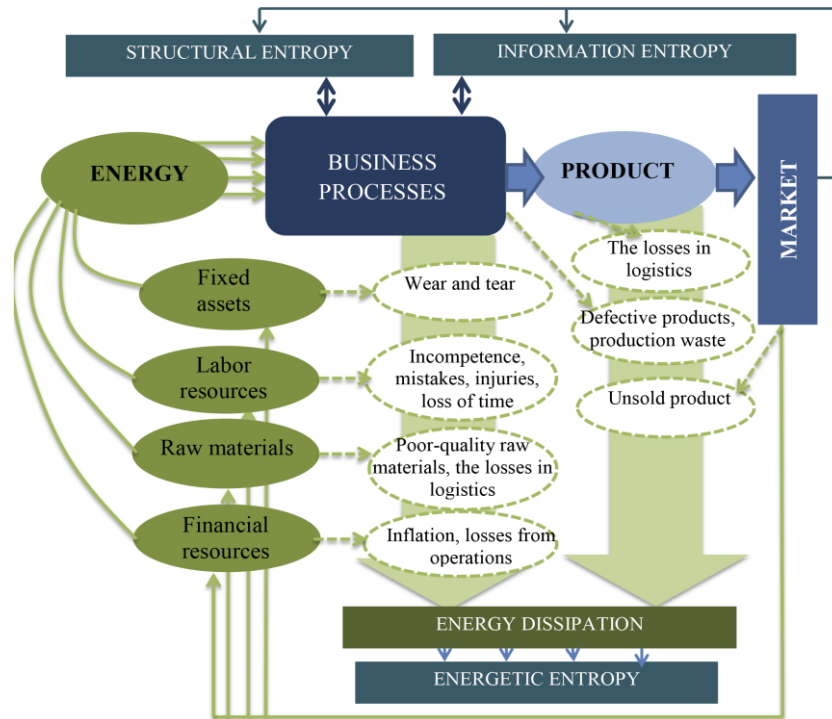


Fig.4. The model of energy loss formation in the project-oriented organization

Thus, energy entropy of organizations is associated with energy losses (energy resources) of various types. As noted above, an increase in entropy leads to an unfavorable state of the organization. Fig. 5 shows the system of the main factors affecting the growth of entropy of the project-oriented organization. It should be noted once again that, in our opinion, it would be unlawful to use the sum of entropies as a kind of “integral entropy” of the organization, since these entropies, firstly, have a different nature; secondly, they are interconnected.

So, the growth of information entropy can be associated not only with the nature of the external environment, but also with the incorrect organization of business processes. For example, the organization has reliable information necessary to make decisions on a specific problem. However, due to the lack of a specific “order” in the structure, the necessary information may simply not be available to those who need it. Thus, an increase in structural entropy leads to an increase in information entropy. Indeed, energy losses in an organization depend on the quality of business processes, which is determined by the structure in the indicated context, which affects structural entropy. With an increase in structural entropy, that is, with a decrease in order in business processes and an increase in chaos, energy losses increase, which leads to an increase in energy entropy. Thus, business processes are the basis for the formation and change of all three types of the organization's entropies, which once again con-

firms the conclusion made as a result of the analysis of entropy growth factors (see Fig. 4).

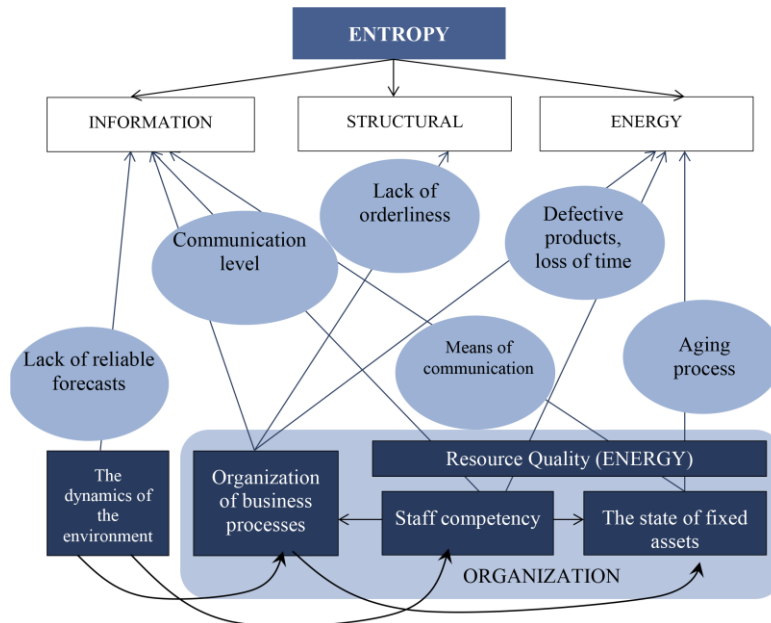


Fig.5. The system of organization entropy growth factors

The reason for the poor orderliness of the organization, that is, business processes, is, first of all, incorrect decisions of the top level of management (organization management system) and the inability to organize and adequately manage the organization. The top level of management in the organization is a specific type of human resources, and, therefore, a specific type of energy of the organization. And in this situation, this energy is unable to organize business processes so that the “work” on creating a product and developing an organization is carried out successfully. Thus, a specific type of energy “launches” the organization and projects in it, and also performs work on managing this system, and if this energy does not meet certain requirements, it will be impossible to successfully complete the specified work and, as a result, to ensure the success of the organization in the future.

5 Conclusions

The organization’s vital activity is accompanied with three types of entropy: information, structural, and energy. Moreover, each project of a project-oriented organization contributes to a change in entropy of the organization. To identify the systemic relationship of the three types of entropies, a project-oriented organization is presented in the form of the system that exchanges energy, substance and information with the external environment within the structure corresponding to business processes.

This systematic approach made it possible to link together three types of organization entropies that “coexist” within the project-oriented organization as “reflectors” of its state. The main factors affecting the growth of each type of entropy, as well as the relationship of entropies are established. The conceptual model of energy dissipation in the project-oriented organization is formed. Further development of this research is the establishment of mechanisms to reduce each type of entropy at the project level and the project-oriented organization as a whole

References

1. Palagin, A.: Transdisciplinarity, computer science and development of modern civilization. *News of the Ukrainian Academy of Sciences* 7, 25-33 (2014).
2. Palagin, A, Petrenko, N.: Development and formation of transdisciplinary and interdisciplinary research and the role of computer science. *Computer modeling: analysis, control, optimization* 1, 46-70 (2018).
3. Petrenko, A.: Management of the organization as a fight against entropy . Institutional repository of the National Aviation University of Ukraine, www.er.nau.edu.ua/bitstream/NAU/14626/1/Entropy.pdf, last accessed 2019/12/1.
4. Prangishvili, I.: Entropic and other systemic laws: Issues of managing complex systems. Institute of Control Sciences named after V.A. Trapeznikov, Moscow (2003).
5. Alekseev, G.: *Energyentropics*. Knowledge, Moscow (1983).
6. Bushuyev, S., Sochnev, S.: Entropy measurement as a project control tool. *International Journal of Project Management* 17 (6), 343-350 (1999).
7. Rusan, N., Bushuyev, S., Bushuyev, D.: Emotional intelligence – the driver of the development of breakthrough competences of the project. In: international scientific and technical conference on Computer Sciences and Information Technologies (CSIT), Lviv, Ukraine, (2017).
8. Shakhov, A.V.: Modeling the movement of an organization in a project environment. *Management of complex systems development* 7, 68-72 (2011).
9. Jae-Yoon, J., Chang-Ho, C., Jorge, C.: An entropy-based uncertainty measure of process models. *Information Processing Letters* 111 (3), 135-141 (2011).
10. Han, W., Zhu, B.: Research on new methods of multi-project based on entropy and particle swarm optimization for resource leveling problem. *Advances in Engineering Research (AER)* 124, 215-221 (2017).
11. Bogdanov, A.: *Tectology. General organizational science*. Finance, Moscow (2003).
12. Kapitsa, S., Kurdyumov, S., Malinetskiy, G.: *Synergetics and forecasts of the future*. Science, Moscow (1997).
13. Bushuyev, S., Murzabekova, A., Murzabekova, S., Khusainova M.: Develop breakthrough competence of project managers based on entrepreneurship energy. In: 12th International Scientific and Technical Conference on Computer Sciences and Information Technologies, CSIT (2017).
14. Yagelskaya, E.: The essence and structure of economic energy. *Problems of Economics and Management* 8 (24), 98-111 (2013).
15. Melnik, L.: Analysis of the energy-entropic prerequisites for the progressive development of economic systems. *Actual problems of economics* 10, 15-22 (2013).
16. Likhonosova, G.: Entropy balancing: a tool for eliminating social-economic exclusion of enterprise. *Time description of economic reforms* 2 (30), 43-51 (2018).
17. Soroka, K.: *Fundamentals of the theory of systems and system analysis*. Kharkiv National Academy of Municipal Economy, Kharkiv (2004).

18. Shestakevych, T., Pasichnyk, V., Kunanets, N., Medykovsky, M., Antonyuk, N.: The content web-accessibility of information and technology support in a complex system of educational and social inclusion. In: proceedings of 13th International Scientific and Technical Conference on Computer Sciences and Information Technologies, CSIT 2018, vol. 1, 8526691, pp. 27-31 (2018).
19. Veretennikova, N., Pasichnyk, V., Kunanets, N., Gats, B. E-Science: New paradigms, system integration and scientific research organization. In: proceedings of the International Conference on Computer Sciences and Information Technologies, 7325436, pp. 76-81 (2015).
20. Bomba, A., Kunanets, N., Nazaruk, M., Pasichnyk, V., Veretennikova, N.: Information technologies of modeling processes for preparation of professionals in smart cities. Advances in Intelligent Systems and Computing 754, 702-712 (2019).