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STRUCTURE OF THE PROJECT-ORIENTED ORGANIZATION ENERGY ENTROPY

Abstract: This study presents the universal formalization of energy entropy for various organizations and its expression for project-oriented organizations. The energy entropy of organizations is determined by information entropy, total energy and the ratio of the achieved level of energy efficiency to the «ideal» level. Entropy is viewed as a measure of uncertainty in the information and organizational space. In the information space, it determines the measure of the missing information for making decisions. In the organizational space, entropy determines the level of entrepreneurial energy that is necessary for the successful operation of an organization in the implementation of projects and programs. The relationship between energy entropy and informational (structural) entropy of project-oriented organizations is established. It is determined that when adding a new project to the current totality, the organization must ensure a balance between the growth of uncertainty (information entropy) and energy efficiency. The method of «decomposition» of the total energy entropy of project-oriented organizations in the form of the sum of local energy entropies for projects is presented. The effect of adding a new project to the structure of a project-oriented organization on its integrated energy entropy is investigated. The presented results form a new look at the qualitative assessment of both a single project and the entire set of projects of a project-oriented organization.

Keywords: project, entropy, energy, model, efficiency.

Introduction

The development of the idea of the universality of the energy balance for systems of various kinds led to the formation of an energy-entropy concept of organizations. According to

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this concept [4], an organization is considered as a system that exchanges matter, energy, and information with the environment, which determines the presence of informational (structural) entropy and energy entropy. Moreover, the latter is the result of the existing order in the organization (i.e., information/structural entropy), which is determined by the structure and implementation of business processes. The energy-entropy concept operates with such categories as «energy», «entropy», «free energy», «dissipation» and allows using energy-entropy to assess the state and dynamics of organizations regardless of their sphere of activity. A certain specificity of project-oriented organizations should also be manifested in the formation of its energy entropy. Therefore, the main provisions of the energy-entropic concept require adaptation to this specificity. In this regard, the study of the structure of energy-entropy of the project-oriented organization is an urgent scientific task.

Analysis of Recent Publications

Project-oriented organizations [5] are a specific category of organizations that manage activities structured as a set of projects. At the same time, management is also reoriented under the principles and methods of project management. This approach provides high efficiency and effectiveness, allowing you to maximize the value of the resources of organizations [3].

The idea of an energy-entropic concept of organizations has been formed over the past decades in the form of a point-based approach by researchers to this problem [7, 15, 16, 18]. In [1, 10], the authors raise the issue of the influence of informational entropy and entropy balance. The dominant and rapidly developing concept of a value-based approach to managing organizations [3, 5, 6] and project management [2, 11, 12, 13, 17, 20] has led to the need for a universal measure of value for both organizations and projects. Energy-entropy is a universal category, which, inter alia, can be used as a specified measure.

The main application of entropy in the context of project management and project-oriented organizations was based on informational entropy [6, 8, 9, 14, 19], which acts as a measure of uncertainty. Nevertheless, the possibility of using the category «entropy» is much wider. Therefore, the idea of the presence of energy entropy in organizations [4] and the relationship of various types of entropies [8] is the basis for a new methodology - the energy entropy concept of practically oriented organizations.

Results

The specificity of project-oriented organizations in terms of the energy-entropy concept [4] is that each project forms a certain contribution to the formation and dynamics of energy-entropy. At the same time, each project as a specific «organization» is a system that exchanges matter, energy and information with the external environment. Therefore, each project is characterized by its processes, which determine the formation and dynamics of energy entropy. Thus, the integrated community of projects of a project-oriented organization determines dynamically changing energy entropy, as a result of the integration of energy entropies of each project.

According to [4], the energy entropy of organizations S is determined by information entropy H, total energy U, the ratio of the achieved level of energy efficiency $\eta = \frac{U + E^{in} - E^{ex}}{U}$ (E^{in} and – incoming energy, E^{ex} – outgoing (free) energy) with «ideal» η^{id}:

$$S = \frac{(U - E^{in}) \cdot U \cdot \eta^{id} \cdot H}{U + E^{in} - E^{ex}}, \quad (1)$$

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that for specific values U, Ein, Eex can be represented as:

$$S = \lambda \cdot H = -\lambda \cdot \sum_{k=1}^{K} p(A_k) \cdot \ln(p(A_k)), \tag{2}$$

$\lambda = \dfrac{(U - E^{in}) \cdot U \cdot \eta^{id}}{U + E^{in} - E^{ex}}$ – coefficient connecting two types of organization entropy;

A_k – organization status options - level E^{in} and E^{ex}, pA_k – the probabilities of these conditions status.

Note that the approach presented in [4] and expressions (1), (2) do not take into account the structure of project-oriented organizations, in which the operational activity forms a set of projects. Therefore, we transform (1) and (2) taking into account the specified specificity.

For each project, $j = \overline{1,n}$ we introduce E_j^{in} – incoming energy; E_j^{ex} – energy allocated to create a project product; H_j – informational entropy of the project, which characterizes the possible results of the project.

$$H_j = -\sum_{k_j=1}^{K_j} p(A_{k_j}) \cdot \ln(p(A_{k_j})), \tag{3}$$

where A_{k_j} the events are that $(E_{k_j}^{in}, E_{k_j}^{ex})$ they have taken on specific meanings, and each project is characterized K_i by such possible events. Given these notations (1) for a project-oriented organization will take the form:

$$S^p = \frac{(U - \sum_{j=1}^{n} E_j^{in}) \cdot U \cdot \eta^{id} \cdot \sum_{j=1}^{n} H_j}{U + \sum_{j=1}^{n} (E_j^{in} - E_j^{ex})}. \tag{4}$$

Note that the informational entropy of an organization can be expressed as:

$$H = \sum_{j=1}^{n} H_j = -\sum_{j=1}^{n} \sum_{k_j=1}^{K_j} p(A_{k_j}) \cdot \ln(p(A_{k_j})) \ , \tag{5}$$

only if the events A_{k_j} of the organization's projects are independent, that is, in a situation where the results of the organization's projects are independent of the results of other projects. This assumption is quite fair and consistent with the practice of project-oriented management. η^{id} accepted as the only one for the whole organization, taking into account what characterizes the capital gain from an energy point of view.

Analysis (4) allows us to draw the following conclusions:

1) each new project of the organization increases information entropy (5) and, accordingly, energy entropy, which can be leveled only by the high efficiency of the project;

2) even though each project increases H, while the free energy of the organization increases

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$$E^{ex} = \sum_{j=1}^{n} E_j^{ex}, \tag{6}$$

which positively affects its energy entropy.

Thus, adding a new project to the current aggregate, the organization must ensure a balance between the growth of uncertainty (information entropy) and increased energy efficiency. That is, the addition of a new project should provide an increase in energy entropy ΔS^p: in the ideal case – $\Delta S^p < 0$, in the acceptable case – $\Delta S^p < 0$. The option $\Delta S^p = 0$ is allowed in situations of a strategic nature (for example, work at low tariffs to increase market share, etc.).

$$\Delta S^p = S^{p+1} - S^p = \\ = \frac{(U - \sum_{j=1}^{n} E_j^{in} - E_{n+1}^{in}) \cdot U \cdot \eta^{id} \cdot \sum_{j=1}^{n+1} H_j}{U + \sum_{j=1}^{n} (E_j^{in} - E_j^{ex}) + (E_{n+1}^{in} - E_{n+1}^{ex})} - \frac{(U - \sum_{j=1}^{n} E_j^{in}) \cdot U \cdot \eta^{id} \cdot \sum_{j=1}^{n} H_j}{U + \sum_{j=1}^{n} (E_j^{in} - E_j^{ex})}, \tag{7}$$

S^{p+1} – energy-entropy of the organization after adding a new project to the totality of ongoing projects.

Let two projects be implemented in a project-oriented organization, and the organization plans to launch another project. Characteristics of the projects are presented in table 1.

Table 1. Projects characteristics

Characteristics	E_j^{in}	E_j^{ex}	H_j
Project 1	20	17	0,5004
Project 2	30	26	1,0297
Project 3	18	15	0,639

Source: created by authors

The calculation results are presented in the table. 2. As you can see, energy entropy has decreased almost twice due to an increase in free energy and the influx of energy.

Note that the total energy of the organization includes related energy, which refers to the entire structure of the organization. Therefore, in (4), (7) this energy is used in a holistic form. However, to solve various kinds of organization management tasks, it is necessary to establish energy entropy for each project.

Table 2. Energy characteristics of a project-oriented organization for a variety of projects

Project-oriented organization's characteristics	Project 1+ Project 2	Project 1+ Project 2+ Project 3
U	80	
E^{in}	50	68
E^{ex}	43	58
H	1,5301	2,1691
S	84,417	46,274

Source: created by authors

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In this situation, it is conditionally possible to accept the distribution of the total energy of the organization U between projects in proportion to the free energy of these projects E_j^{ex}:

$$U_j = \frac{E_j^{ex}}{\sum_{j=1}^{n} E_j^{ex}} \cdot U, j = \overline{1,n}. \tag{8}$$

Nevertheless, since function (4) is non-linear concerning E^{in}, E^{ex}, U the corresponding amendment should be made to the project entropy formula S_j^p:

$$d = \frac{S^p}{\sum_{j=1}^{n} S'^p_j}. \tag{9}$$

This coefficient corresponds to the ratio of the energy entropy of the organization as a whole (4) to the sum of the local energy entropies of projects S'^p_j (11) without correction for the nonlinearity of energy entropy.

Thus, the energy entropy of a project is defined as:

$$S_j^p = d \cdot \frac{(U_j - E_j^{in}) \cdot U \cdot \eta^{id} \cdot H_j}{U_j + E_j^{in} - E_j^{ex}}, j = \overline{1,n}, \tag{10}$$

$$S'^p_j = \frac{(U_j - E_j^{in}) \cdot U \cdot \eta^{id} \cdot H_j}{U_j + E_j^{in} - E_j^{ex}}, j = \overline{1,n}. \tag{11}$$

For the projects discussed above, we calculate energy entropy. The calculation results in table 3. The correction factor was:

$$d = \frac{46,274}{16,922} = 2,73.$$

Table 3. Energy characteristics of organization projects

Project's Characteristics	U_j	S'^p_j	S_j^p
Project 1	23,448	3,0596	8,37
Project 2	35,862	10,86	29,70
Project 3	20,69	3,0022	8,21
Total	80	16,922	**46,27**

Source: created by authors

Taking into account the correction factor (9), the sum of the energy-entropy of the projects corresponds to the energy-entropy of the project-oriented organization. Thus, (2) for project-oriented organizations can be transformed as follows:

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$$S^p = -\sum_{j=1}^{n} \lambda_j \cdot \sum_{k_j=1}^{K_j} p(A_{k_j}) \cdot \ln(p(A_{k_j})) = -\sum_{j=1}^{n} \lambda_j \cdot H_j, \quad (12)$$

where λ_j – are the coefficients that reflect the influence of the informational entropy of each project on the energy entropy of the organization.

Conclusion

In this paper, the energy-entropy concept is applied to project-oriented organizations. A universal formalization of energy entropy for various organizations and its expression for project-oriented organizations is presented. The relationship between energy entropy and informational (structural) entropy of project-oriented organizations is established. The method of "decomposition" of the total energy entropy of project-oriented organizations in the form of the sum of local energy entropies for projects is presented. The effect of adding a new project to the structure of a project-oriented organization on its integrated energy entropy is investigated. The presented results form a new look at the qualitative assessment of both a single project and the entire set of projects of a project-oriented organization.

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