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MONITORING THE DYNAMICS OF A PROJECT-ORIENTED ORGANIZATION ENERGY ENTROPY

The **subject** of the research is the approaches to studying the dynamics of information and energy entropy of a project-oriented organization. The **purpose** of this study is to develop an approach for monitoring the dynamics of energy entropy when adding a new project to the portfolio of a project-oriented organization. To achieve this goal, it is necessary to perform the following **tasks**: determine the expression of the criterion for the success of the project in the framework of the energy-entropic concept of the organization, formulate entropic barriers and ways to overcome them. The following methods are used: systems analysis, probability theory, energy-entropy theory. **Results.** The main parameters that determine the dynamics of the organization's energy entropy are information entropy and relative energy efficiency. When a new project is added to an organization's structure, it takes time to improve its energy efficiency. Therefore, to form conclusions on the analysis of changes in entropy, it is important to review the period and take into account its relationship with new projects of the organization. The dynamics of the information entropy of development projects and their influence on the information entropy of the organization are described. It was found that negative leaps of information entropy are possible as a result of the implementation of projects aimed at changing business processes, quality of resources, etc. The work proposes a criterion for the success of the project, taking into account the time period that is "provided" to the project for the manifestation of its result in terms of energy entropy. Also, the work formulated barriers for information and energy entropies as levels, upon reaching which the organization is destroyed. **Conclusions.** This article presents a tool for analyzing the dynamics of information entropy and energy entropy of a project-oriented organization when a new project is added to the portfolio. Also, a criterion for the success of the project is proposed, taking into account the time period that is "provided" to the project for the manifestation of its result in terms of energy entropy. Entropic barriers of a project-oriented organization are formulated and ways to overcome them are proposed to reduce entropy, increase energy efficiency and ensure its development.

Keywords: entropy; energy efficiency; organization; barrier.

Introduction

The energy-entropy concept considers an organization as an open system with energy turnover due to information-material-energy exchange with the external environment. Energy entropy is a characteristic function of the state of an organization, reflecting the efficiency of its business processes and interaction with the external environment.

Analysis of literature and research

Modern project-oriented management as a progressive methodology for organizing the operational activities of enterprises integrates classical and innovative approaches to management [1]. Information entropy is one of the characteristics that make it possible to assess the quality of management and business processes. This category is used by many researchers [2-6], including in the application to projects and project-oriented organizations in general [7-11]. As a rule, information entropy is understood as a measure of project risk, and its dynamism is considered from a mathematical point of view [12, 13]. The work [14] establishes the relationship between the energy entropy of an organization and the measure of its orderliness - information entropy.

At the conceptual level, the basic provisions of the energy-entropic theory of organization, which includes the identification and model of energy flows, energy balance and the necessary conditions for reducing energy-entropy are presented in [15]. Studies of the influence of information entropy on the energy entropy of the organization were carried out in works [16, 17], this made it possible to establish the conditions under which this influence is maximized.

The purpose of this study is to develop an approach for monitoring the dynamics of energy entropy when adding a new project to the portfolio of a project-oriented organization.

Research results

The influence of projects on the dynamics of the energy entropy of the organization. The existence of energy entropy is an integral part of the activities of organizations, and in principle, it is impossible to ensure its absence. And, as previously noted, not the absolute value of energy entropy, but its change ΔS is *an indicator of the state of the organization*:

$$\Delta S(t_1,t_2)=S(t_2)-S(t_1), \quad (1)$$

where $t_2>t_1$ are the considered time moments on the time axis T. Satisfactory for the organization is such a state in which:

$$\Delta S(t_1,t_2)>\Delta S(t_2,t_3), t_3 > t_2, \quad \Delta S(t_1,t_2), \Delta S(t_2,t_3) \geq 0. \quad (2)$$

that is, the increase in energy entropy decreases over time. It would be desirable to have a "zero" change in the increase in energy entropy, that is:

$$\Delta S(t_1,t_2)=\Delta S(t_2,t_3), t_3 > t_2. \quad (3)$$

The state towards which the organization should strive:

$$\Delta S(t_1,t_2)<0, \quad (4)$$

that is, there is *negentropy (a decrease in energy entropy)* due to its "release" into the external environment, which

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means control over the external environment at a level *at which uncertainty decreases with increasing energy efficiency.*

At the same time, an increase in energy entropy does not at all mean deterioration in the state of the organization. Let's explain this thesis in more detail.

So, an increase in energy entropy S can occur under the influence of the following factors: an increase in information entropy H, a decrease in relative efficiency μ. This, in turn, indicates a decrease in the "temperature" characterizing the "heating" of the controlled part of the organization's external environment.

Control over the external structure is significantly weakened in those situations when the organization begins the implementation of sufficiently risky projects, where level of information entropy at the beginning of the project is quite high. Thus, an increase in information entropy H can occur as a result of adding a new project to the structure of a project-oriented organization. In addition, the new project requires the use of resources, which, on the one hand, can increase the level of outgoing energy E^{ex}, while not increasing the level of incoming energy E^{in} at the first stage. The project (or project product) needs time to achieve the required level of energy efficiency.

Thus, for the formation of conclusions based on the results of the analysis ΔS, *the period of consideration* and consideration of the relationship ΔS with new projects of the organization is important. A short-term increase in energy entropy as a result of changes in the structure of the organization's current projects portfolio can and should lead to its *subsequent positive* dynamics for the organization.

In a project-oriented organization, each project is a relatively independent organizational unit, which is a system of a certain structure with flows of information, energy and matter, and, therefore, all previously characterized and established properties of systems, including the presence of information entropy and energy entropy, are inherent in projects.

The main parameters that determine the dynamics of the organization's energy entropy are information entropy and relative energy efficiency. In general, their behavior for the project can be represented as follows:

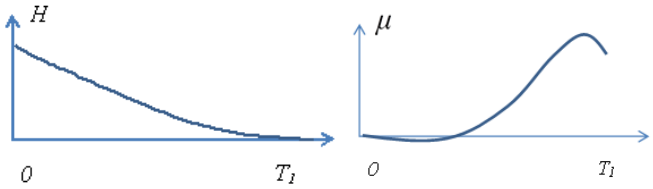

Fig. 1. Dynamics of information entropy and relative project efficiency

That is, the information entropy by the end of the project life cycle becomes "zero" – the variants of the project results are transformed into one specific (already obtained) result with probability 1, therefore:

$$H_i(T_i)=0, i=\overline{1,n}, \quad (5)$$

where T_i is a life cycle of the i-th project, n is a total number of projects of the organization.

Each project is characterized by a certain energy efficiency, which forms a certain value of relative energy efficiency μ_i. By the end of the project, its energy efficiency can have both maximum value and decline, or even tend to 0, which is determined, first of all, by the specifics of the project and its product. The behavior of these characteristics largely determines the dynamics of the project's energy entropy $S_i(t_i)$, which, taking into account (5):

$$S_i(T_i)=0, i=\overline{1,n}, \quad (6)$$

that is, the end of the project leads logically to zero energy entropy.

A completely different situation is observed with the dynamics of the energy entropy of a project-oriented organization. Previously, the structure of the energy entropy of a project-oriented organization was established and the participation of each project in its formation was determined. "High-risk" projects in terms of uncertainty of results and ineffective projects *increase the energy* entropy of the entire organization, violating the established nature of relations with the external environment and the efficiency of energy turnover. The converse is also true.

But the impact of projects on the state of the organization and the "reflection" of this state in the form of energy entropy is much more complicated and not so unambiguous.

Previous studies of the entropy of a project-oriented organization were based on the principles of additivity, which takes place in cases where *projects correspond to operational activities* and are not associated with *qualitative (structural)* changes in the organization, that is, we are not talking about *development projects*.

So, individual projects in a project-oriented organization can be aimed at changing business processes, quality of resources, etc., which by the end of the life cycle of the project and the receipt of its product leads to a change in the basic energy parameters of the organization. Similar projects are implemented to improve the state of the organization. Examples of such projects can be reorganization projects that reduce the information entropy of an organization by, for example, improving the information exchange system.

Fig. 2 shows the dynamics of the information entropy of two development projects and the result of their influence on the information entropy of the organization. The beginning of each project is associated with an increase in the level of informational entropy of the

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organization by the amount of the project entropy. As a result of the implementation of project 1, the level of information entropy of the organization decreases from the value of H^1 (pre-project) to the value of H^2. That is, at the moment of receiving the product of project 1, the new "quality" of the organization reduces the uncertainty of the results of its activities.

The start of project 2 naturally increases the entropy of the organization, gradually leading to the pre-project level. But at the moment of receiving the product of project 2, the entropy of the organization leaps upwards, that is, the new quality of the organization has become worse in terms of the predictability of the results of its activities. Moreover, certain discrepancies in the manageability of the structure of the organization (both external and internal) can lead to an uncontrolled increase in information entropy, which is shown in fig. 2 in the period after the end of project 2.

Examples of such a *negative leap in information entropy* can be the following:

1) the project was aimed at a qualitative transformation not directly related to the impact on information entropy, but the result was such an effect. For example, a change in *any product characteristics of an organization's* project has led to mixed perceptions of these changes by consumers and established clientele. Thus, there is a *marketing miscalculation*;

2) the project was supposed to improve the manageability of the external structure of the organization (that is, the project is *aimed at reducing information entropy*), but the opposite effect was obtained. And in this situation there is a marketing/logistics miscalculation).

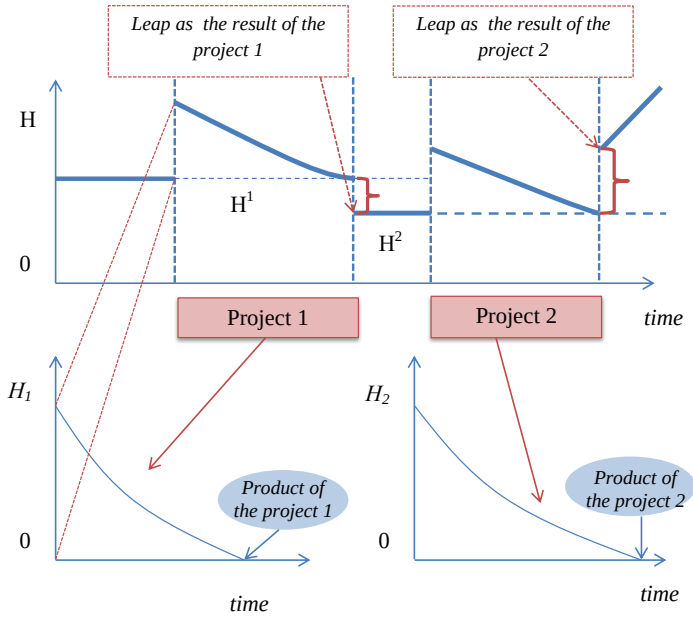

Fig. 2. Impact of development projects on the information entropy of the organization

Thus, any development project leads to a *change in information entropy*, and it is precisely its positive change to ensure that it is the art of the organization management system and the project team.

It is important that even a *"leap up" in information* entropy does not indicate a negative state of the organization. Indeed, an increase in information entropy at the first stage after the implementation of the project can be replaced by its positive dynamics in the future. This is comparable to surgery in medicine, after which a temporary deterioration may occur, after which the healing process takes place. The main thing is that *the period and degree of deterioration should be within controllable limits.*

The main criterion for the success of the project in this case should be the condition for a specific time range:

$$S_{i1}^* \le \Delta S_i(t_1,t_2)=S(t_2)-S(t_1) \le S_{i2}^*, i=\overline{1,n}, \quad (7)$$

$$t_1 = t_i^b + T_i, i=\overline{1,n}, \quad (8)$$

$$t_2 = t_1+\Delta t_i, i=\overline{1,n}, \quad (9)$$

where t_i^b is the start of the i-th project, T_i – the duration of its life cycle, Δt_i – the time period that is "provided" to the project for the manifestation of its result in terms of energy entropy, S_{i1}^*, S_{i2}^* – energy entropy growth limits.

Thus, $\Delta S_i(t_1,t_2)$ shows the change in the energy entropy of the organization as a result of the implementation of the i-th project.

If, however, several projects were implemented in a certain period of time, then, of course, it is quite difficult to single out the influence of each of them on the state of the organization. This requires a more in-depth analysis of the results of each project, manifested in specific energy parameters and information entropy.

So, almost any *development project* is a risk for the organization, since the consequences of even a successful project at first glance can have negative consequences for the organization. That is why energy entropy (its dynamics, its change), as the main integral indicator of the state of the organization, allows us to conclude about the *success and usefulness* of the project for the organization based on (7).

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So, if new projects not related to development are added to the structure of an organization's project portfolio, then ideally the dynamics of the information entropy of the organization should be as in fig. 3, which demonstrates the dynamics of information entropy *H* with and without new projects (dotted line), based on dynamics of information entropy of new projects. Note that in this case, new projects are not aimed at reducing the information entropy of the organization, so the total information entropy of the organization is a composition of the information entropies of all projects.

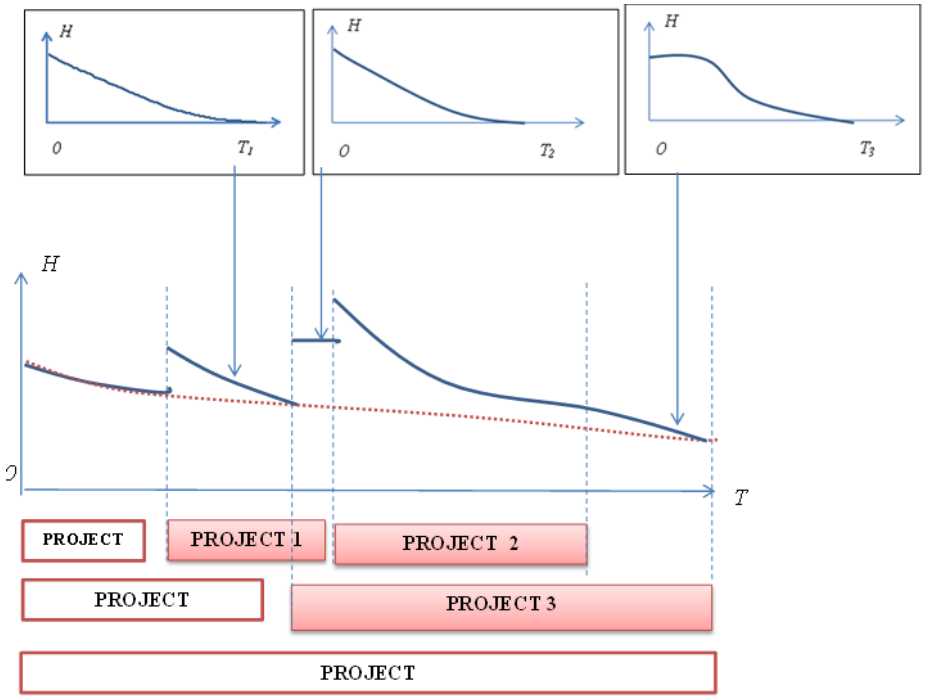

Fig. 3. Dynamics of information entropy of a project-oriented organization

"Leaps" of information entropy at the start points of projects are ultimately leveled, and information entropy is aligned with the level of "up to new projects".

If any projects are aimed at *reducing information entropy* (for example, projects corresponding to advertising or PR campaigns) the total information entropy will be ultimately lower than the level "before new projects" (fig. 4). In this case, the total information entropy of the organization is not ultimately equal to the sum of the information entropies of projects. For example, if a new project 3 should reduce the information entropy of the organization, then after its implementation there will be a corresponding "leap" down.

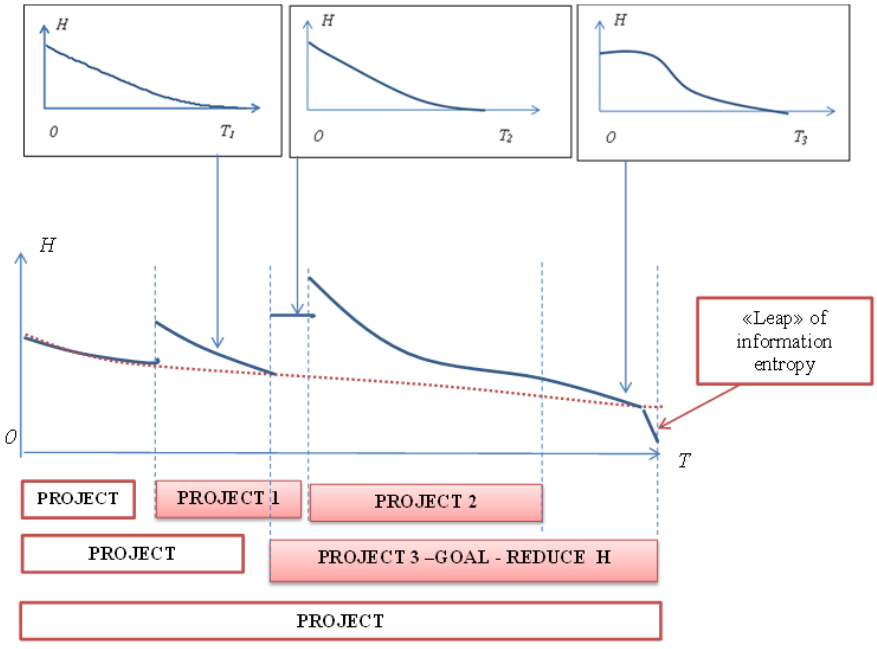

Fig. 4. Dynamics of information entropy of a project-oriented organization during the implementation of a project aimed at reducing it

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Energy entropy is determined not only by information entropy, but also by relative energy efficiency, and each project, having its own efficiency, provides an impact on the energy efficiency of the organization as a whole. Moreover, individual development projects can be aimed at changing efficiency based on, for example, the use of new production technologies that take time to demonstrate their effect. So, for example, in fig. 5, project 1 reduces overall energy efficiency, but in the process of implementing project 2 and project 3, the energy efficiency of the organization reaches a higher level compared to the pre-project.

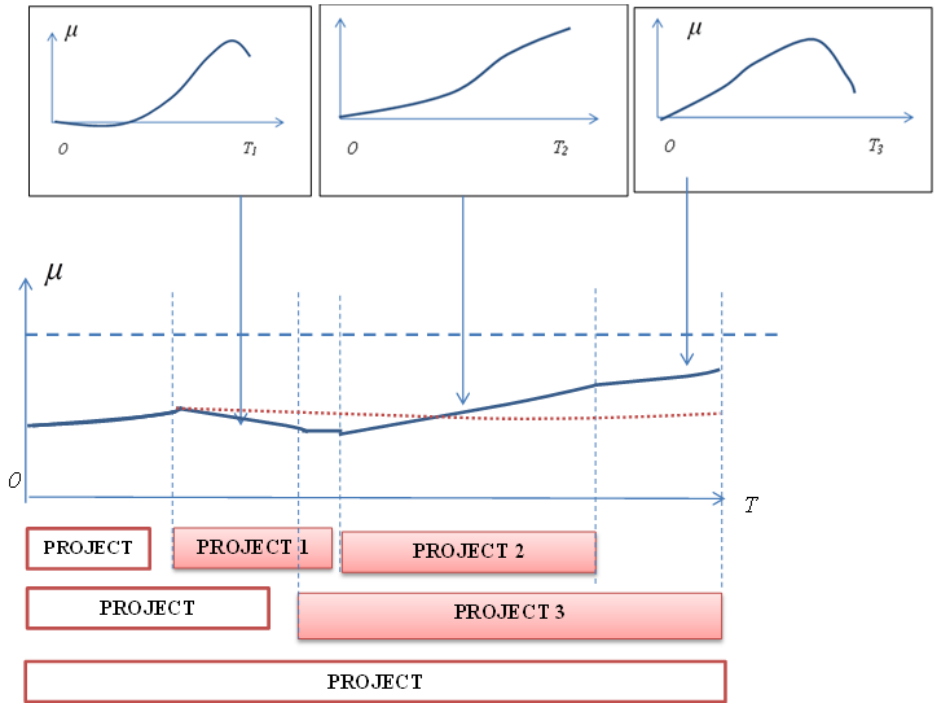

Fig. 5. Dynamics of energy efficiency of a project-oriented organization in the implementation of a project aimed at its improving

And, as mentioned above, assessing the impact of each project on the overall state of the system requires a separate and more detailed consideration of the results of each project.

Entropic barriers of a project-oriented organization. Let's introduce into consideration the concept of *"entropy barrier"*. For a clear understanding of the essence of this term, let's consider other types of "barriers" inherent in the organization.

So, any organization with the existing technology and method of production has a certain barrier in the form of *production capacity*, to overcome which it is necessary to fundamentally change the technology and organization of production, business processes, etc. Whatever the demand for the organization's products, it must "overcome" the production barrier to further increase production and sales. Similar barriers exist in the form of restrictions on sales markets, etc. The organization can *reach another level*, only after radical transformations while breaking another barrier.

As it was previously demonstrated, the entropy of an organization can grow under the influence of negative processes (for example, the inability of management to provide a managed organization or inadequate organization of business processes); and also under the influence of natural causes associated, for example, with the implementation of projects, which at the first stage increases energy entropy. In addition, the coincidence of these processes with negative changes in the external environment can significantly worsen the state of the organization. The question arises – if there is a level of entropy, the achievement of which becomes disastrous for the organization?

The "invisible "entropy also forms a *certain barrier* in the form of a level at which *the organization "collapses"* (fig. 6).

For *informational entropy*, the barrier is such a level of uncertainty, after which the managers of the organization, in principle, are unable to make adequate decisions and act in complete chaos and conditions of uncontrollability of the external environment. With an increase in *H*, the temperature of the organization decreases, that is, the level of "heating" of the controlled part of the external environment decreases leads to activities under conditions of complete uncertainty. At the same time, high energy efficiency of the organization can be observed – that is, the organization does not control anything in the external environment, but due to favorable conditions for it in a specific period of time, it becomes, for example, possible to sell a product at an inflated price, which leads to an increase in energy efficiency.

So, the excitement demand for masks and sanitizers at the beginning of a pandemic can serve as an example of super energy efficiency for manufacturers (sellers) in conditions of complete chaos, that is, maximum information entropy.

For *energy entropy*, the barrier is such a level of energy entropy at which the level of chaos and dissipation of the organization's energy does not "overlap" with the necessary energy efficiency.

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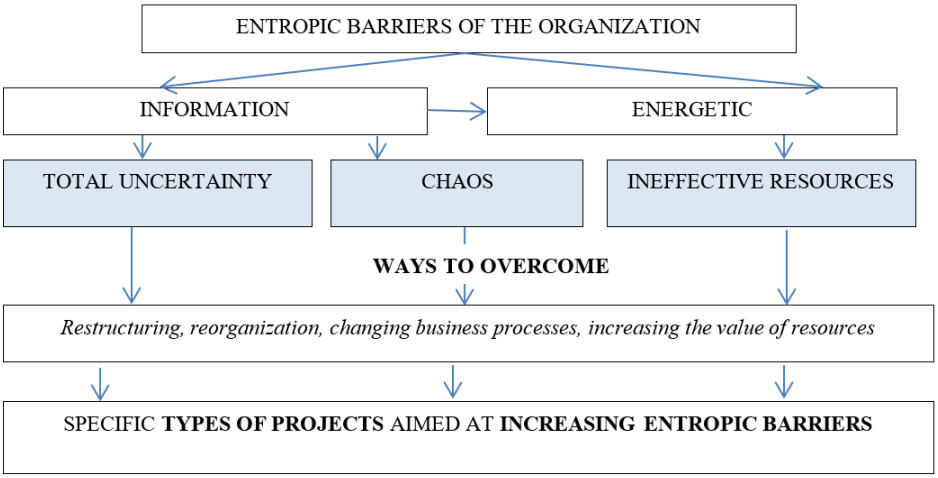

Fig. 6. Entropic barriers of the organization and ways to overcome them

The level of *these barriers* is unique to each organization. In addition, it can be "raised" through certain measures, for example, restructuring, reorganization, staff training (increasing the value of labor resources), etc. Thus, the development of an organization involves *a change in the level of existing entropy barriers*.

Since any activities of a project-oriented organization are projects, the change in the level of entropy barriers is also carried out through projects.

As it was shown above, the entropy of an organization increases in the course of its activity, which can later lead to disastrous consequences. Therefore, the organization, along with projects related to the main activity and with projects for the development of the traditional entity, should implement projects aimed at ***"retaining" entropy and increasing entropy barriers*** (fig. 7).

This figure shows two main options for the dynamics of entropy in an organization:

- the first option assumes a slow increase in entropy within the existing barriers;

- according to the second option, when the level of the entropy barrier changes, the entropy of the organization decreases sharply.

Operational projects entail a change in the total energy of the organization U (forming an increase in the total energy), and also affect the energy efficiency μ and information entropy H. These parameters determine the energy entropy of the organization S. Note that almost every project, by improving one of these parameters both positively and negatively influences others.

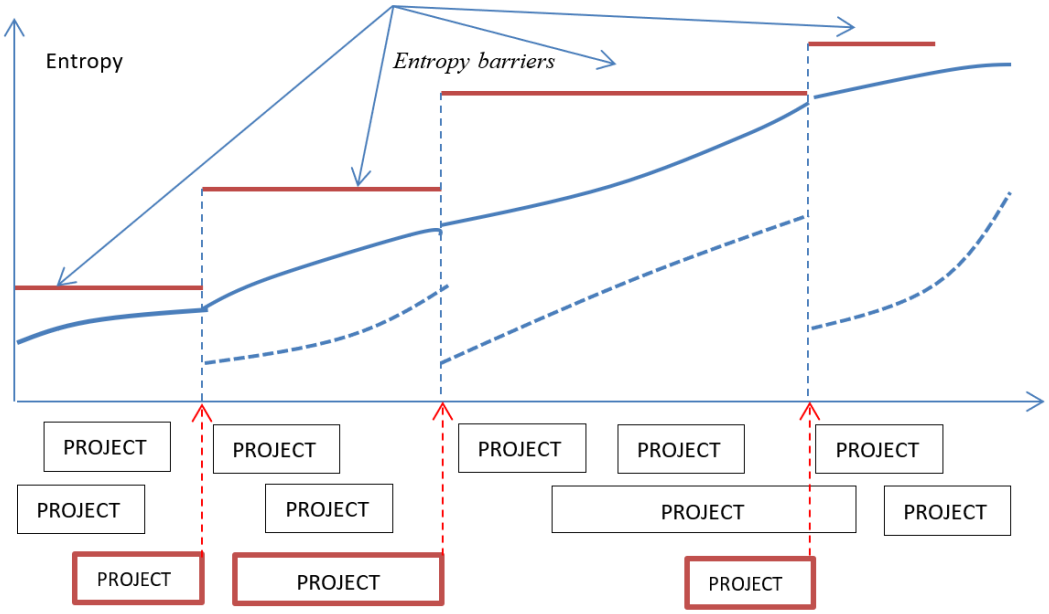

Fig. 7. Overcoming entropic barriers by a project-oriented organization

Thus, the development of a project-oriented organization should ensure, along with traditional development goals, an increase in entropy barriers. For example, specific communication programs aimed at increasing control over the external environment can serve as examples of such projects.

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Conclusions

This article presents a tool for analyzing the dynamics of information entropy and energy entropy of a project-oriented organization when a new project is added to the portfolio. Also, a criterion for the success of the project is proposed, taking into account the time period that is "provided" to the project to manifest its result in terms of energy entropy.

Entropic barriers of a project-oriented organization are formulated and ways to overcome them are proposed to ensure its development, reduce entropy and increase energy efficiency.

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МОНІТОРИНГ ДИНАМІКИ ЕНЕРГОЕНТОПІЇ ПРОЄКТНО-ОРІЄНТОВАНОЇ ОРГАНІЗАЦІЇ

Предметом дослідження є підходи вивчення динаміки інформаційної та енергоентропії проектно-орієнтованої організації. **Метою** даного дослідження є розробка підходу для моніторингу динаміки енергоентропії при додаванні нового проекту в портфель проектно-орієнтованої організації. Для досягнення поставленої мети необхідно виконати наступні **завдання**:

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визначити вираз критерію успішності проекту в рамках енергоентропійної концепції організації, сформулювати ентропійні бар'єри і способи їх подолання. Використовуються такі **методи**: системний аналіз, теорія ймовірності, енергоентропійна теорія. **Результати.** Основними параметрами, що визначають динаміку енергоентропії організації, є інформаційна ентропія і відносна енергоефективність. При додаванні в структуру організації нового проекту необхідно час для підвищення її енергоефективності. Тому для формування висновків з аналізу зміни ентропії важливий період розгляду та врахування її взаємозв'язку з новими проектами організації. Описано динаміку інформаційної ентропії проектів розвитку і їх вплив на інформаційну ентропію організації. Встановлено, що в результаті реалізації проектів, спрямованих на зміну бізнес-процесів, якості ресурсів і т. п. можливі негативні скачки інформаційної ентропії. В роботі запропоновано критерій успішності проекту, що враховує часовий проміжок, який "надається" проекту для прояву свого результату з точки зору енергоентропії. Також в роботі були сформульовані бар'єри для інформаційної та енергетичної ентропій, при досягненні яких організація руйнується. **Висновки.** У даній статті представлений інструмент аналізу динаміки інформаційної ентропії і енергоентропії проектно-орієнтованої організації при додаванні в портфель нового проекту. Також запропоновано критерій успішності проекту, що враховує часовий проміжок, який "надається" проекту для прояву свого результату з точки зору енергоентропії. Сформульовано ентропійні бар'єри проектно-орієнтованої організації та запропоновано способи їх подолання для зниження ентропії, підвищення енергефективності та забезпечення її розвитку.

Ключові слова: ентропія; енергоефективність; організація; бар'єр.

МОНИТОРИНГ ДИНАМИКИ ЭНЕРГОЭНТОПИИ ПРОЕКТНО-ОРИЕНТИРОВАННОЙ ОРГАНИЗАЦИИ

Предметом исследования является подходы изучения динамики информационной и энергоэнтропии проектно-ориентированной организации. **Целью** данного исследования является разработка подхода для мониторинга динамики энергоэнтропии при добавлении нового проекта в портфель проектно-ориентированной организации. Для достижения поставленной цели необходимо выполнить следующие **задачи**: определить выражение критерия успешности проекта в рамках энергоэнтропийной концепции организации, сформулировать энтропийные барьеры и способы их преодоления. Используются следующие **методы**: системный анализ, теория вероятности, энергоэнтропийная теория. **Результаты**. Основными параметрами, определяющими динамику энергоэнтропии организации, является информационная энтропия и относительная энергоэффективность. При добавлении в структуру организации нового проекта необходимо время для повышения ее энергоэффективности. Поэтому для формирования выводов по анализу изменения энтропии важен период рассмотрения и учет ее взаимосвязи с новыми проектами организации. Описана динамика информационной энтропии проектов развития и их влияние на информационную энтропию организации. Установлено, что в результате реализации проектов, направленных на изменение бизнес-процессов, качества ресурсов и т.п. возможны негативные скачки информационной энтропии. В работе предложен критерий успешности проекта, учитывающий временной промежуток, который "предоставляется" проекту для проявления своего результата с точки зрения энергоэнтропии. Также в работе были сформулированы барьеры для информационной и энергетической энтропий как уровни, при достижении которых организация разрушается. **Выводы.** В данной статье представлен инструмент анализа динамики информационной энтропии и энергоэнтропии проектно-ориентированной организации при добавлении в портфель нового проекта. Также предложен критерий успешности проекта, учитывающий временной промежуток, который "предоставляется" проекту для проявления своего результата с точки зрения энергоэнтропии. Сформулированы энтропийные барьеры проектно-ориентированной организации и предложены способы их преодоления для снижения энтропии, повышения энергэффективности и обеспечения ее развития.

Ключевые слова: энтропия; энергоэффективность; организация; барьер.

Бібліографічні описи / Bibliographic descriptions

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