Enthalpy is a Measure of the Energy Potential of Development Organizations' Projects

Sergey Bushuyev[a], Natalia Bushuyeva[b], Svitlana Onyshchenko[c], Alla Bondar[d]

[a,b] *Kyiv National University of Construction and Architecture, Povitroflotsky Avenue, 31, 03680 Kyiv, Ukraine*
[c,d] *Odesa National Maritime University, Mechnikova 34, 65029, Odesa, Ukraine*

Abstract

The development of the entropy concept of management and the idea of considering organizations as a kind of analogue of a thermodynamic system, which is characterized by energy exchange processes within the system and with the external environment, leads to the need to expand the list of indicators of the state of the organization in this context. The state function also includes enthalpy, which reflects the amount of energy available for conversion into heat according to the accepted understanding. Enthalpy is the context of organizations that reflects the "available resource" of the system for energy exchange with the external environment and maintaining the structure of the system. Thus, enthalpy in the context of organizations reflects the "available resource" of the system for energy exchange with the external environment and maintaining the structure of the system. The purpose of this study is to substantiate and analyze the enthalpy equation of organizations. This approach is conditioned by the objective development of the idea of applying the laws of thermodynamics to the management of organizations. Within the framework of this study, an equation for the change in the enthalpy of an organization based on the Gibbs-Helmholtz equation is proposed. This control links together the increase in free energy, entropy and uncertainty (information entropy). Enthalpy in this approach evaluates the energy potential of the organization. Formulas are proposed for calculating the relative indicators of changes in the realized energy potential and dissipation, which, allow us to evaluate the quality of management as the quality of entrepreneurial energy.

Keywords 1

Entropy, enthalpy, organization potential, control, uncertainty, dissipation, organization state, entrepreneurial energy, information system

1. Introduction

In the context of the turbulence of the external environment and the success of many organizations, contrary to generally accepted strategies, it became necessary to search for new management theories that would provide decision-making tools taking into account not only generally accepted economic laws and marketing postulates. Thus, the universality of the law of conservation of energy was substantiated, which made it possible to extend it to systems that are diverse, including organizations and society as a whole.

Energy is indeed a universal category and can have a specific meaning for each type of system while maintaining the universality of the very idea of energy and its participation in various processes.

For organizations, energy is the resources that are used in the process of energy exchange with the external environment. But the value of resources is not just their monetary equivalent. Having the same composition of resources, different organizations achieve different results and successes. This is due to the quality, and value of the most important resource - the energy of labour resources, it is she

Proceedings of the 3nd International Workshop IT Project Management (ITPM 2022), August 26, 2022, Kyiv, Ukraine
EMAIL: Sbushuyev@ukr.net (Sergiy Bushuyev); natbush@ukr.net (Natalia Bushuyeva); onyshenko@gmail.com (Svitlana Onyshchenko); ocheretyankaalla@gmail.com (Alla Bondar)
ORCID: 0000-0002-7815-8129 (Sergiy Bushuyev); 0000-0001-7298-4369 (Natalia Bushuyeva); 0000-0002-728-4939 (Svitlana Onyshchenko); 0000-0003-2228-2726 (Alla Bondar)

who provides one or another value of the remaining resources available. In [1], this type of energy was defined as "entrepreneurial energy".

In this regard, the question arises of assessing the energy potential of organizations, taking into account the results of the implementation of entrepreneurial energy. Assessing entrepreneurial energy in itself is a rather difficult task, but it becomes possible to evaluate the achieved and possible results of an organization, taking into account entrepreneurial energy, within the framework of a thermodynamic approach, in which the internal structure, its efficiency and ongoing energy exchange processes can be judged from the “external” indicators of the system.

The universality of the law of conservation of energy, substantiated in the works of various specialists, made it possible to extend it to systems that are diverse, including organizations and society as a whole. This gave rise to the universalization of other categories of thermodynamics, first of all, entropy. Based on the works [1,2], where, among other things, the equivalent of energy for society and organization in the form of material goods was substantiated, the entropy concept of management was developed [3,4], within which the main patterns of the structure and dynamics of entropy for organizations were formulated. , projects and project-oriented organizations. Energy exchange, dissipation, interaction with the environment through the "external part of the structure" of the organization and temperature an indicators of the effectiveness of this interaction in the context of not only economy but also taking into account the reduction of uncertainty - all this is the result of the extension of the second law of thermodynamics to projects, organizations, society.

But entropy is not the only measure of the state of a system. Moreover, in the context of the entropy concept of control, entropy reflects the result of the interaction between the system and the environment. Thus, entropy evaluates the states of a system from an external point of view. The state function also includes enthalpy, which reflects the amount of energy available for conversion into heat according to the accepted understanding.

Thus, enthalpy in the context of organizations reflects the "available resource" of the system for energy exchange with the external environment and maintaining the structure of the system.

Note that the equations in classical thermodynamics are not "derived" based on certain laws. They are either established empirically or found by methods of statistical physics. For organizations, the generalization of experience and the logical chains of relationships of various categories also make it possible to substantiate certain equations of relationships or clarify the content of those already existing within the framework of thermodynamics or statistical physics.

Thus, the purpose of this study is to substantiate and analyze the enthalpy equation of organizations. This approach is conditioned by the objective development of the idea of applying the laws of thermodynamics to the management of organizations.

2. Analysis of recent research and publication

The idea of extending the laws of thermodynamics to social and economic systems was born quite a long time ago. So, in [2] the author argued that:

«According to thermodynamic theory, any open system, which allows flows of matter and energy to cross its boundaries, is capable of maintaining itself in a steady state only because it "transport" value from its environment to restore the value that has been "consumed" within the system and dissipated».

According to [3] «Energy, as a metaphor, is highly applicable to the economy. The national product, the earning of rents, exchange and barter, are all energetic activities, and the principles of thermodynamics can be applied to them. This is equally true whether the systems are close isolated systems or open systems linked to others. The law of the conservation of energy compensates and explains the differences in work rate and entropy. The second law says that energy moves in one direction only. The third says that at the end of the process, there will still be energy constant».

Social systems are a part of physical systems. In principle, social systems can be described by physical laws. However, there is a long-running debate about how much knowledge from physics can be applied effectively to understand human societies. Compared with the vast amount of literature in both natural science and social science, attempts to understand social systems from physical laws are very sporadic [4].

The justification of the universality of the law of conservation of energy and other principles of thermodynamics gave rise to the universalization of such a category of thermodynamics as entropy. Based on the works [5,6], where, among other things, the equivalent of energy for society and organization in the form of material goods was substantiated, the entropy concept of management was developed [8, 9], within which the main patterns of the structure and dynamics of entropy for organizations were formulated [11,12] for projects and project-oriented organizations.

Energy exchange, dissipation, interaction with the external environment through the "external part of the structure" of the organization and temperature an indicator of the effectiveness of this interaction in the context of not only economy but also taking into account the reduction of uncertainty - all this is the result of the extension of the second law of thermodynamics to organizations and society.

But entropy is not the only measure of the state of a system. Moreover, in the context of the entropy concept of control, entropy reflects the result of the interaction between the system and the environment. Thus, entropy evaluates the states of a system from an external point of view. The state function also includes enthalpy, which reflects the amount of energy available for conversion into heat according to the accepted understanding.

As in the case of "entropy", the applicability of the category "enthalpy" outside of thermodynamics was initially justified for social individuals and systems [13, 14]. Further, this was considered within the framework of the psychology of interaction between the individual and society [15].

According to [14] Gibbs Energy describes the potential for a system to change. If the change in Gibbs free energy is negative, a system will spontaneously change. If positive, the system requires additional inputs to drive the change. Authors in [13] declare, that Enthalpy-the will of action and the associated activity of the system's individuals in pursuit of their goals.

Unfortunately, today there is practically no continuation of research into the essence and regularities of the formation and dynamics of enthalpy for organizations, and social and economic systems.

Even though attention is paid to the problem of assessing the potential of organizations in modern research, within the framework of the universalization of the laws of thermodynamics, attention should be paid specifically to enthalpy and its change, which can serve as the first step in studying the potential of organizations from this point of view.

Thus, the purpose of this study is to substantiate and analyze the enthalpy equation of organizations. This approach is conditioned by the objective development of the idea of applying the laws of thermodynamics to the management of organizations.

3. Organization enthalpy equation

The basis of the universality of the provisions of thermodynamics is the presence of energy in systems of various natures. As previously mentioned, the energy of an organization is all of its resources valued in monetary terms.

But some sources [10] single out such a specific type of energy as "entrepreneurial energy", in [7] such a resource is defined as the energy of labour resources. This is the knowledge, experience, skills, and competence of staff and managers. This is a special type of energy, which is also valued in terms of money (salary, etc.), but plays the most important role in the efficiency of the organization's energy exchange with the external environment. With the same costs for the resources of two organizations, the one with a "special type of energy" - the energy of labour resources or entrepreneurial energy will be more successful. Naturally, a significant role is played by motivation, which allows you to mobilize and realize the potential of employees, but all these issues are separate topics of study.

As you know, enthalpy is a property of a substance that indicates the amount of energy that can be converted into heat. Enthalpy is often defined as the total energy of a substance, since it is equal to the sum of its internal energy in a given state, together with its ability to do work.

Enthalpy is the context of organizations and can be defined as the "available resource" of the system for energy exchange with the external environment and maintaining the structure of the system, which is determined primarily by entrepreneurial energy.

Note that the equations in classical thermodynamics are not "derived" based on certain laws. They are either established empirically or found by methods of statistical physics. For organizations, the generalization of experience and the logical chains of relationships of various categories also make it possible to substantiate certain equations of relationships or clarify the content of those already existing within the framework of thermodynamics or statistical physics.

Entrepreneurial energy provides a certain level of interaction between the organization and the external environment, forming the flows of incoming and outgoing energy E^{in}, E^{ex} (Fig. 1). In addition, the result of the interaction between the organization and the external environment (in [5] it was pointed out to the "controlled part of the external environment" - or the external structure of the organization) is not only a certain ratio E^{in}, E^{ex} but also the level of information entropy *H*, reflecting the degree of uncertainty of the results of the "energy exchange" of the organization. The lower the level of *H*, the higher the qualitative level of entrepreneurial energy of the organization. The state of the organization in terms of its energy exchange with the external environment, the degree of control over it, as well as energy costs for the organization itself (maintaining the structure) is estimated using the entropy *S*.

Taking into account the multidimensionality of systems, the state of which is estimated by entropy and enthalpy, there are various corresponding equations in the literature. In our opinion, the Gibbs-Helmholtz equation is the most appropriate formalization for organizations, since, firstly, it does not use such categories as volume, pressure, or particle mass, which is present in other equations for enthalpy; secondly, this equation connects entropy and enthalpy, which, taking into account the development of the entropy concept of control, is the most rational.

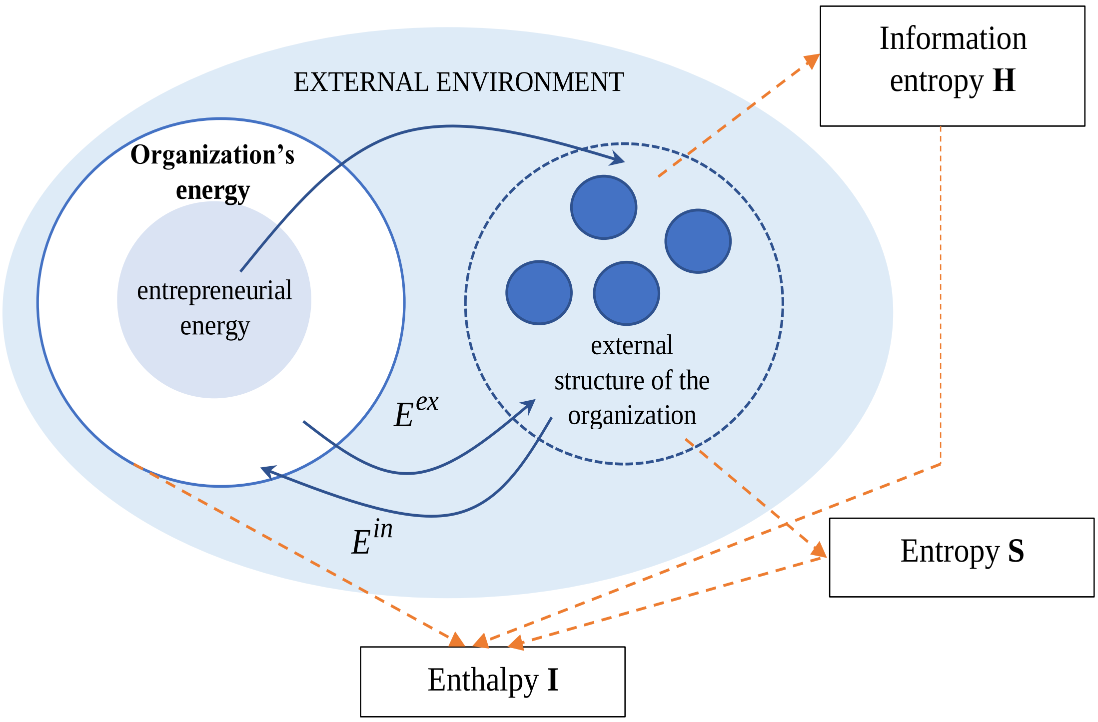

Figure 1: Scheme of the formation of the enthalpy of the organization

The entropy of the system is higher, the greater the degree of disorder of the system. Thus, if the process goes in the direction of increasing the disorder of the system, ΔS is a positive value. To increase the degree of order in the system, it is necessary to expend energy. This follows from the second law of thermodynamics. Quantitatively, the relationship between changes in enthalpy, entropy and free energy is described by the Gibbs-Helmholtz equation.

It should be noted that when assessing the states of the system, it is not the value of the estimated indicator that is important, but its change [6]. According to the Gibbs-Helmholtz equation, energy, enthalpy and entropy are related as follows:

$$\Delta G = \Delta I - T\Delta S, \tag{1}$$

where ΔI is the change in enthalpy, ΔG is the change in energy, T is the temperature, ΔS is the change in entropy.

The category "temperature" for organizations is defined in [6,9]. Temperature is a value that shows the state of the system concerning some "ideal" state. The combination of efficiency and order can act as temperature, so [6]. The following expression for temperature was proposed:

$$T = \frac{\mu}{H}, \tag{2}$$

where μ is the relative energy efficiency of the organization (compared to a certain reference value), H is the information entropy.

The proposed approach to temperature is based on assessing the organization's ability to "warm up" the external environment so that the outflow of energy from there and the inflow into the organization in the form E^{in} of a certain level of order is ensured H. In essence, temperature (2) is the temperature of the environment provided by the organization. Thus, in contrast to temperature in thermodynamics, the temperature of an organization is the temperature of the “controlled” part of the external environment, from where flows of energy and negentropy (or outflow of entropy) come.

From (1) follows:

$$\Delta I = \Delta G + T\Delta S. \tag{3}$$

Note that in this case, the energy of the organization is an analogue of the Gibbs energy (free energy, Gibbs potential, or thermodynamic potential).

From (3) it follows that a certain amount of heat $T\Delta S$ is spent to increase entropy, this part of the energy is lost to perform useful work, it is sometimes called "bound energy". Another part of the heat ΔG can be used to do "useful" work, so Gibbs energy is often also called free energy.

Enthalpy, therefore, is an assessment of the energy potential of an organization, taking into account both informational entropy and entropy in a thermodynamic context.

In terms of the entropy control concept [7]:

$$\Delta G = E^{in} - E^{ex}, \tag{4}$$

where E^{in}, E^{ex}, respectively, incoming and outgoing energy - the inflow of resources and their costs in the course of the organization's activities.

The Gibbs energy indicates how much of the total internal energy of the system is used for "work", so in terms of the organization and its energy, the Gibbs energy can be interpreted as the "realized energy potential" of the organization, while the enthalpy is the "full energy potential" of the organization.

4. Analysis of the Organization Enthalpy Equation

Thus, (2), (3) will take the form:

$$\Delta I = E^{in} - E^{ex} + \frac{\mu}{H}\Delta S. \tag{5}$$

Note that μ H determining the entropy [8], and ΔS depends on the change in energy efficiency and information entropy. In (5) $\frac{\mu}{H}$ this is the reached value of "temperature".

If in thermodynamics absolute values of changes in energy, entropy and enthalpy are of interest for assessing the state of a system, then relative units are necessary from the point of view of organizations and the use of information in management.

It is proposed to use the following indicators:

$$P_{\Delta G} = \frac{\Delta G}{\Delta I} = \frac{E^{in} - E^{ex}}{\Delta I} = \frac{E^{in} - E^{ex}}{E^{in} - E^{ex} + \frac{\mu}{H}\Delta S}, \tag{6}$$

$$P_{\Delta S} = \frac{\frac{\mu}{H}\Delta S}{\Delta I} = \frac{\frac{\mu}{H}\Delta S}{E^{in} - E^{ex} + \frac{\mu}{H}\Delta S}, \tag{7}$$

which together form a unit and reflect, respectively, the shares of the realized energy potential $P_{\Delta G}$ and dissipation $P_{\Delta S}$. The higher the value (6), the more successfully the organization realizes its energy potential.

Fig. 2 for the accepted initial data shows the dependence of the change in enthalpy on the change in entropy for various values of H. Naturally, with an increase in the increase in entropy, an increase in increase in enthalpy occurs, which characterizes an increase in the energy potential.

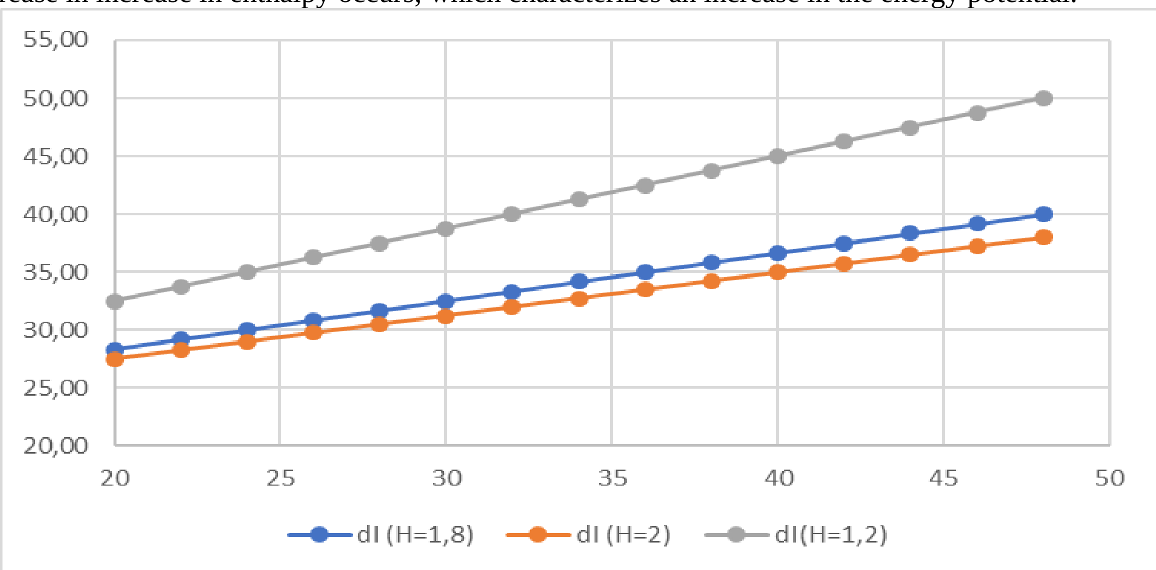

Figure 2: Dependence ΔI on ΔS different values H

The lower the level of information entropy H, the higher the energy potential of the organization, since a low level of uncertainty characterizes the effectiveness of entrepreneurial energy in terms of impact on the external environment and the creation of such conditions for the organization under which the degree of confidence in the results is high. Thus, the enthalpy increases with decreasing uncertainty, and the energy potential increases.

Fig. 3 for the same data shows the dependencies $P_{\Delta G}$ on entropy for different values of H .

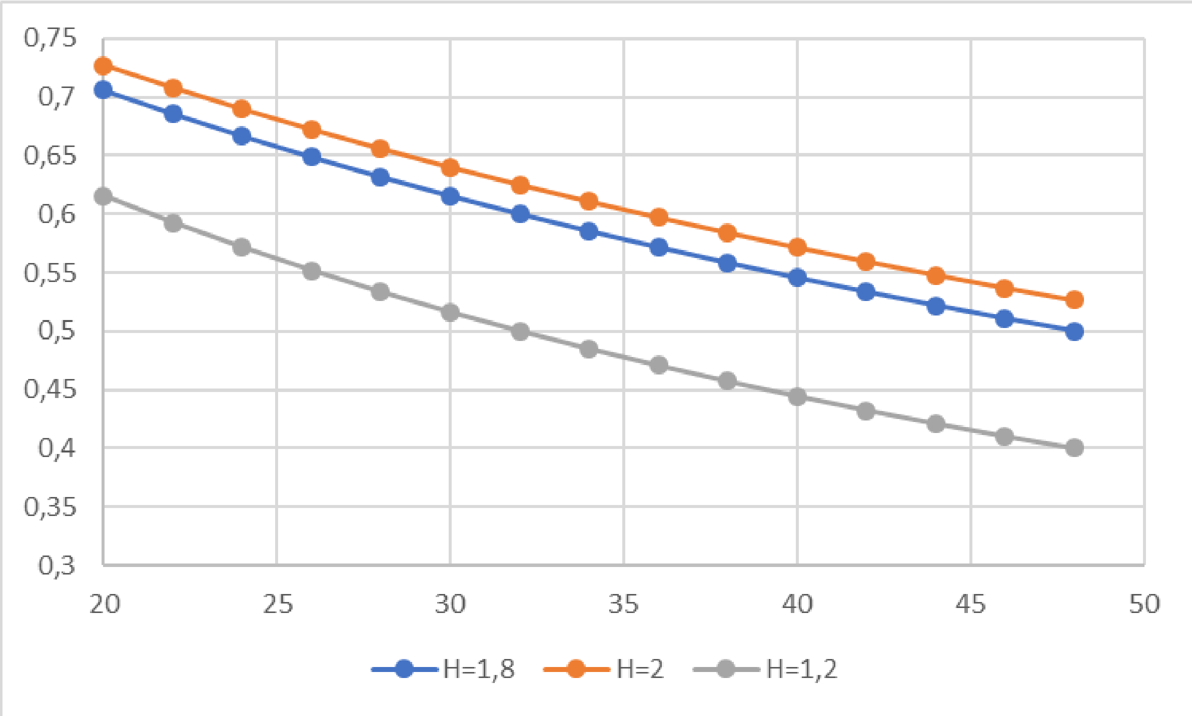

Figure 3: Dependence $P_{\Delta G}$ on ΔS different values H

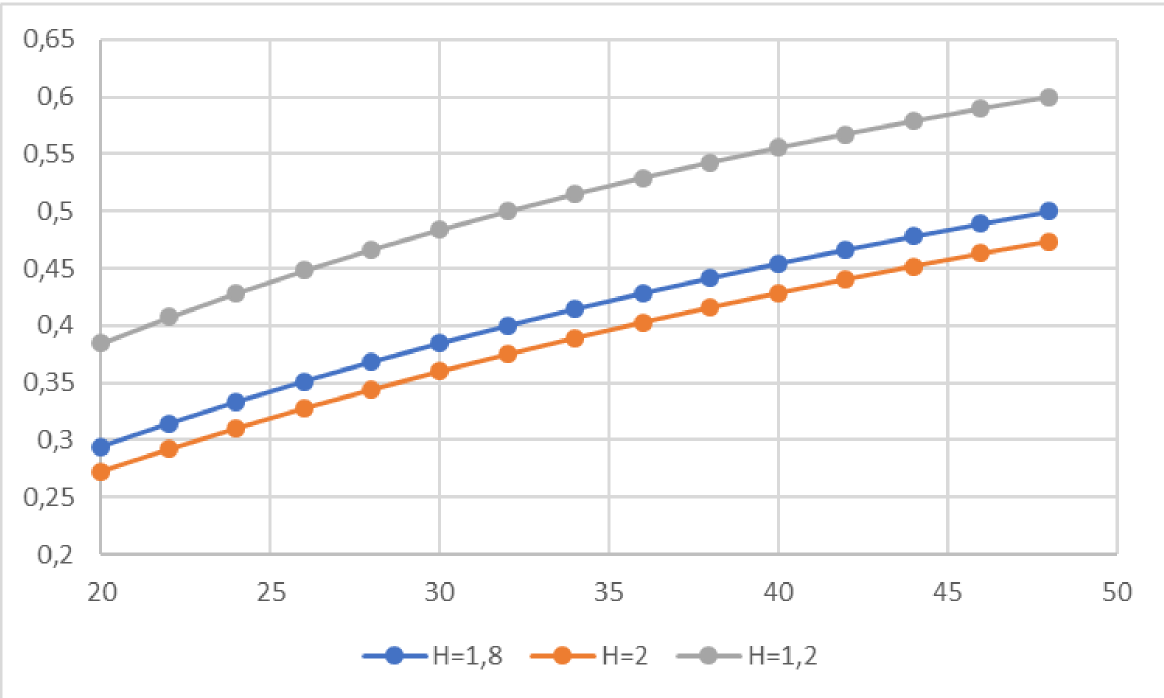

Figure 4: Dependence $P_{\Delta S}$ on ΔS different values H

If the increase in energy (Gibbs energy) is equal, the share of the realized energy potential is higher for a higher level of uncertainty. Accordingly, for the fraction of dissipation $P_{\Delta S}$, the opposite is true (Fig. 4).

According to [7] the entropy of the organization:

$$S = \frac{(U - E^{in}) \cdot U \cdot \eta^{et} \cdot H}{U + E^{in} - E^{ex}}, \tag{8}$$

where S - energy entropy, H - information entropy, U - total energy (capital) of the organization; E^{in} - energy inflow, E^{ex} - energy outflow (free energy directed to the performance of work), η^{et} - an indicator of the reference energy efficiency of the organization.

The relative energy efficiency of the organization:

$$\mu = \frac{\eta}{\eta^{et}}, \eta = \frac{U + (E^{in} - E^{ex})}{U}. \tag{9}$$

Given this expression of entropy, the equation for the change in enthalpy will take the form:

$$\Delta I = E^{in} - E^{ex} + \frac{\mu}{H}\Delta S = (E_2^{in} - E_2^{ex}) + \\ + \frac{U_2 + (E^{in}{}_2 - E^{ex}{}_2)}{U_2 \cdot H_2 \cdot \eta^{et}} \cdot \left(\frac{(U_2 - E^{in}{}_2) \cdot U_2 \cdot \eta^{et} \cdot H_2}{U_2 + E^{in}{}_2 - E^{ex}{}_2} - \frac{(U_1 - E^{in}{}_1) \cdot U_1 \cdot \eta^{et} \cdot H_1}{U_1 + E^{in}{}_1 - E^{ex}{}_1} \right), \tag{10}$$

where, respectively, $U_2, E_2^{in}, E_2^{ex}, H_2$ and $U_1, E_1^{in}, E_1^{ex}, H_1$ are the values of the total energy, energy inflow and outflow, and information entropy at the current and previous time.

Table. 1 presents the data and results of calculating the change in entropy and enthalpy based on the above formulas.

Table 1

Data and results of calculating the change in entropy and enthalpy

t	U	E^{in}	E^{ex}	H	S	ΔS	ΔI
0	100	80	70	2	54,55	-	-
1	110	90	70	1,8	45,69	-8,85	-954,44
2	130	120	100	1,5	19,50	-26,1	-3386,7
3	150	120	100	1,5	59,56	40,06	6031,20

As you can see, the total energy of the organization U grows, the information entropy gradually decreases, and the level of entropy S first decreases, then increases (due, first of all, to the increase in "bound" resources - the share E^{ex} at time t=3 decreases relative to the previous period). Accordingly, the increase in entropy is initially negative (for t=1.2), for t=3 it is positive. The increase in enthalpy is also negative at first since the potential of the organization is used in sufficient volume, this is evidenced by a decrease in both informational entropy H and energy entropy S; for t=3, the enthalpy increase is significant, which indicates a significant energy potential of the organization (the U level confirms this), but this potential should be realized, which is expressed by the value $\Delta G = E^{in} - E^{ex}$.

Note that according to the proposed approach, the following logical chain is formed (Fig. 5). An adequate qualitative and quantitative level of entrepreneurial energy contributes to an increase in the temperature of the organization - information entropy (the level of uncertainty and uncontrollability of the external environment) decreases and/or relative energy efficiency increases, which leads to an increase in the difference between energy inflows and outflows. All of these factors ultimately contribute to an increase in enthalpy, which, among other things, affects entrepreneurial energy [15]. But this issue requires a separate study [16].

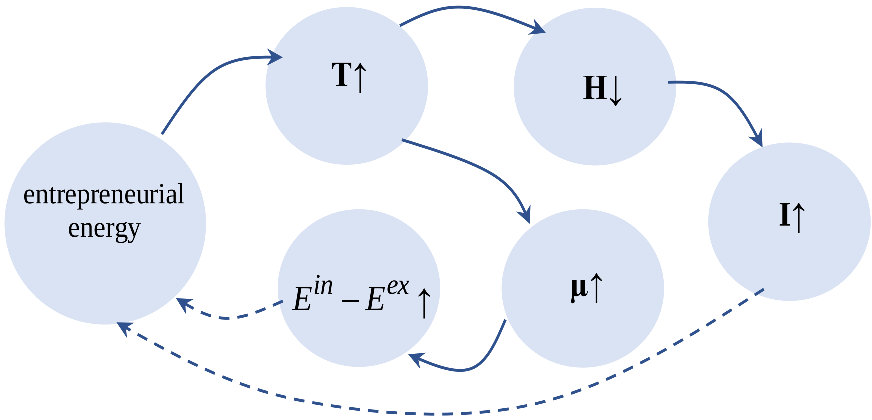

Figure 5: Logical chain of interrelations of enthalpy components

Note that entrepreneurial energy is a driver of entropy reduction and an increase in the level of "free energy". Unlike classical thermodynamics, where the temperature is more of an external factor, for organizations, the temperature level (the ratio of energy efficiency and information entropy) is to a greater extent the result of the activity of the organization itself and the use of entrepreneurial energy [17]. Therefore, it is natural that the presented results require further analysis and detail, taking into account the characteristics of organizations as socio-economic systems, where the ongoing processes of information and energy exchange with the external environment have certain specifics.

5. Conclusion

The development of the entropy concept of management and the idea of considering organizations as a kind of analogue of a thermodynamic system, which is characterized by energy exchange processes within the system and with the external environment, leads to the need to expand the list of indicators of the state of the organization in this context.

Therefore, within the framework of this study, an equation for the change in the enthalpy of an organization based on the Gibbs-Helmholtz equation is proposed. This control links together the increase in free energy, entropy and uncertainty (information entropy). Enthalpy in this approach evaluates the energy potential of the organization. Formulas are proposed for calculating the relative indicators of changes in the realized energy potential and dissipation, which, allow us to evaluate the quality of management as the quality of entrepreneurial energy.

The presented results are the first stage in the study of the enthalpy of the organization, forming a conceptual approach to assessing the state of the organization through this indicator, and, of course, requires further development and detail. So, according to the property of enthalpy, it is an additive quantity, that is, its final value for a certain system is the sum of the enthalpies of subsystems. This, in particular, can be used further to consider project-oriented organizations and study the status of each project and its role in the overall project portfolio of the organization.

6. Acknowledgements

The authors express their deep gratitude to the German Academic Exchange Service (DAAD), financed from funds by the Federal Foreign Office, for its financial support of the “Virtual Master Cooperation Data Science” (Project-ID: 57513461) [18] and the European Union ERASMUS +

program for financial and technical support of the project «Cross-domain competences for healthy and safe work in the 21st century (Work4Ce)» (№ 619034-EPP-1-2020-1-UA-EPPKA2-CBHE-JP) [19].

7. References

[1] N. Kunanets, A. Kazarian, R. Holoshchuk, V. Pasichnik, A. Rzheuskyi, Information support of the virtual research community activities based on cloud computing, in: International Scientific and Technical Conference on Computer Sciences and Information Technologies, CSIT 2018, 2018, pp. 199–202.

[2] V. González, J. Thermodynamic, Laws applied to economic systems. American Journal of Business Education (AJBE) 2(3) (2009) 83–86.

[3] Chen, Jing, Understanding Social Systems: A Free Energy Perspective (September 16, 2008). URL: http://dx.doi.org/10.2139/ssrn.1269035

[4] J. Stepanić, G. Sabol, M. Stjepan Žebec, Describing social systems using social free energy and social entropy, Kybernetes 34 (6) (2005) 857-868.

[5] J. Stepanić, Social equivalent of free energy. Interdisciplinary Description of Complex Systems: INDECS 2.1 (2004) 53-60.

[6] A. Bondar, N. Bushuyeva, S. Bushuyev, S. Onyshchenko. Modelling of Creation Organisational Energy Sergey - Entropy, in: IEEE 15th International Conference on Computer Sciences and Information Technologies (CSIT), Zbarazh, Ukraine, 2020, pp. 141-145.

[7] A. Bondar, S. Bushuyev, V. Bushuieva, S. Onyshchenko, Complementary strategic model for managing entropy of the organization. CEUR Workshop Proceedings 2851 (2021) 293-302.

[8] A. Rzheuskyi, A. Shakhov, V. Piterska, O. Sherstiuk, O. Rossomakha, Management of the technical system operation based on forecasting its “aging”. CEUR Workshop Proceedings 2565 (2020) 130–141.S. Amir, The role of thermodynamics in the study of economic and ecological systems, Ecological Economics 10 (2) (1994) 125-142.

[9] A. Bondar, N. Bushuyeva, S. Bushuyev, S. Onyshchenko, Modelling of creation organisations energy-entropy, in: IEEE International Conference on Smart Information Systems and Technologies (SIST), 2021, pp. 1-6.

[10] A. Bondar, S. Bushuyev, N. Bushuyeva, S. Onyshchenko, Action-entropy Approach to Modelling of ‘Infodemic Pandemic’ System on the COVID-19 Case, in: IEEE 15th International Conference on Computer Sciences and Information Technologies (CSIT), 2020, pp. 215-220.

[11] Guidebook of Program & Project Management for Enterprise Innovation, Third Edition P2M, Project Management Association of Japan (PMAJ), 2017, 427 p.

[12] R. Starkermann Social entropy, enthalpy, exergy and disergy in examples, Mathematical and Computer Modelling 10 (6) (1988) 409-418.

[13] J. Leachman, Initial thoughts on the thermodynamics of societal phase change. URL: https://hydrogen.wsu.edu/2016/04/07/initial-thoughts-on-the-thermodynamics-of-societal-phase-change

[14] J. Bennewitz, Application of the Main Laws of Thermodynamics. Economics (November 1, 2006) URL: http://dx.doi.org/10.2139/ssrn.969980

[15] E. Vasilevskis, I. Dubyak, T. Basyuk, V. Pasichnyk, A. Rzheuskyi, Mobile Application for Preliminary Diagnosis of Diseases. CEUR Workshop Proceedings. 2255 (2018) 275–286.

[16] O. Lozynska, R. Vovnyanka, Yu. Bolyubash, A. Rzheuskyi, D. Dosyn, Formation of Efficient Pipeline Operation Procedures Based on Ontological Approach. Advances in Intelligent Systems and Computing 871 (2018) 571–581.

[17] H. Matsuik, N. Veretennikova, A. Rzheuskyi, R. Vaskiv, Selective Dissemination of Information – Technology of Information Support of Scientific Research. Advances in Intelligent Systems and Computing 871 (2018) 235–245.H. Lypak, V. Lytvyn, O.

[18] The official site of the Dortmund University of Applied Sciences and Arts. URL: https://www.fh-dortmund.de/en/

[19] The official site of the project «Cross-domain competences for healthy and safe work in the 21st century (Work4Ce)». URL: http://work4ce.eu/