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Conceptual Model of Energy Conservation Management

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The article aims to develop a conceptual model of energy efficiency and conservation management. This model can be used to describe and simulate the behaviour of technical and biological systems. There is demonstrated a connection of this model with different areas of research; provided a matrix form of the model, built as a set of vectors. This article describes the process of energy conservation management on the example of the vector sums. There is assessed the effectiveness of the management result.

Key words: Management, Energy conservation, Modelling, Multipurpose management, Key performance indicators.

Power management characterizes the technical and biological systems. In biological systems[1], it is associated with the survival of the system in the external environment and the fight against competitors. In technical systems, energy conservation management refers to the maintenance of the system in operating condition and the fight against competitors. The purpose of energy conservation management it to use less energy for life[2] or technological processes support at the production. Energy conservation management is the scientific field on one side related to the specifics of the field[3], on the other side – to a new kind of management. Dedication of a conceptual model of energy conservation and energy efficiency management is to create and develop the systems allowing for improvement of the energy consumption quality and energy efficiency. As a base of this model there is used the well-known concept of key performance indicators (*KPI*)[4, 5]. It is a system of indicators or parameters, which helps to determine the achievement of strategic and operational objectives of the system or organization. Using key indicators provides an opportunity to assess its condition and assists in evaluating the implementation of management strategies. KPI is a tool to achieve the target goals. Technologies of setting, reviewing and monitoring the goals and objectives form the basis of the concept that became the basis of the modern management and is called management by objectives[6, 7]. Management by objectives is the method of management, which provides foreseeing possible results of activities and planning the ways of their achievement. The founder of "management by objectives" is *Peter Ferdinand Drucker* (1909-2005)[8]. Another assumption in the construction of a conceptual model is the concept of an informational field[9]. As the basic models, there are used the following options: a model of informational situation and informational position[10], a model of multi-purpose management[11, 12]. Within the process of management, there is allowed a possibility of network-centric management[13], if the management concerns geographically distributed enterprises.

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Methodology

Methodology involves application of qualitative and quantitative analysis for the formation of a conceptual model. Behind the paradigm lies the following matter: state assessment $\rightarrow$ development of the managing solution $\rightarrow$ impact on the management object $\rightarrow$ new state assessment $\rightarrow$ assessment of the management goal achievement $\rightarrow$ management cycle iteration. The form of model presentation is a vector one, which is based on qualitative analysis.

Main part

Model construction is based on the assumption of significant or key indicators that characterize the behaviour of the system in the environment. This may be a biological system or a technical system, for example, an enterprise. The set of indicators will be considered as components of the vector in the space of parameters. This gives grounds to apply vector analysis and vector construction of a management model. In connection with the above, this conceptual model is a set of vectors, which together form a matrix of management.

Table 1. Management matrix

Quality vector KPI	Normative value	Objective value	State vector	Controlling actions	Resulting value	Discriminants
1	2	3	4	4	5	6
KPI_1						
KPI_2						
KPI_n						
Additional parameters						

The base vector or the first column of the matrix determines the quality vector of the system. These qualities are the exhaustive characteristic of the system. Therefore, the base vector is formed by the key indicators. When selecting key indicators, it is necessary to carry out correlative analysis[14] to identify and eliminate dependencies between parameters. Indicators may also include the dependent ones, but among them it is necessary to allocate independent ones, which form the basic foundation. The vector may consist only of the *KPIs*, but may also include additional parameters.

Fig. 1 shows the graphs of the energy consumption for the organization for different periods of time. *T* means the time, *C* means expenditures. As a rule, the key indicator is the average annual consumption; it is shown by the solid line and marked by reference numeral 1. Semi-annual consumption is marked by 2 and separated by dotted lines. Quarterly consumption is marked by 3. Monthly consumption is shown by a bold dotted line. Maximum variability possesses a monthly consumption. Thereto related, annual consumption is an integral assessment.

For biological systems this graph corresponds to a smaller period of time, but its essence means an existence of integrated indicator of consumption over a long period of time, and more divergent indicators for short periods of time. The shorter the period is, the higher is the variability of the consumption.

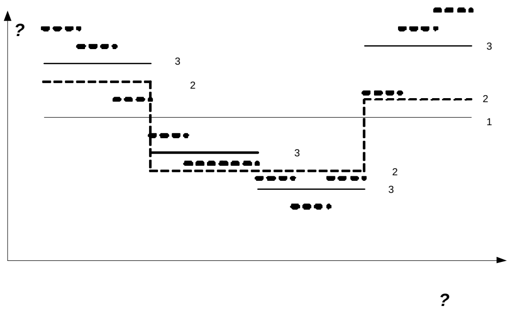

Fig. 1. Parameters of energy consumption

All values in Fig. 1 are indicative, but not all of them are the key ones. As a rule, the key indicator is the annual consumption. The rest play a supporting role.

Thus, in the management matrix (Table 1), the quality vector assigns a set of qualities as management parameters, but does not specify numerical values. Therefore, the following vector (next column) is a vector of normative (desired) quantitative values corresponding to the quality of the first column. It describes the desired behaviour of the system under typical conditions. These values are selected on the basis of experience or statistics of past years. The third column of the matrix represents the vector of the objective values. Under not changing external conditions, it coincides with the vector of normative values. But when the conditions are changed, for example, a colder winter or, vice versa, a warmer winter, its values are adjusted, and it may differ from the normative (average annual) values. The fourth column of the matrix is a state vector of states, i.e. of the real informational situation, in which the system is located. The fifth column of the matrix is a vector of controlling actions directed on the state vector. The sixth column of the matrix is a vector of the resulting values of the parameters that have emerged since the process of management. The seventh column of the matrix is a vector of differences of the actual state from the target values. It allows assessing effectiveness of the management results. Efficacy is determined based on the impact-analysis[15] according to the criterion of management goal achievement[16].

Figure 2 demonstrates the mechanism of vector management within the space of parameters P_1, P_2. For simplification, there is selected a two-dimensional model. In some situations there is a state vector (SV), which describes the actual state of the management object. In this case, there is a normative vector (NV), which specifies the desired state of the object. In order to transfer an object from its current state to a desired one, it is affected by a management action, which is characterized by the management vector (MV). In view of the discrepancy of management or the external factors, influencing the management object, the entire object cannot be transferred to the desired state. This real state (shown by a dotted line) is characterized by a new state vector (NSV). The difference between the new state and the desired one characterises the determinant vector (DV). Vector components are the components of the difference between the new state and the desired state.

Determinant vector gives an opportunity to assess the effectiveness of management according to the level of goal achievement.

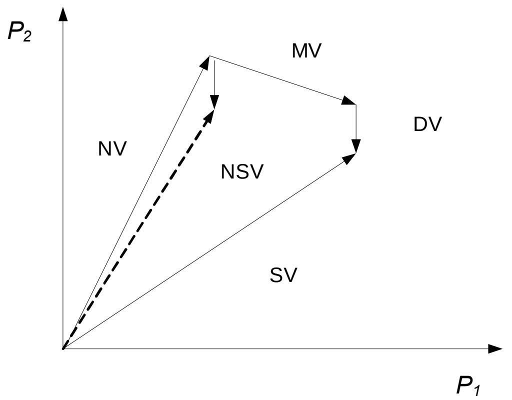

Fig. 2. Management mechanism within the space of parameters

The two-dimensional model is demonstrated for clarity. In practice, there are n-parameters, and respectively, n-dimensional space of parameters.

The real cost of energy resources changes over time. As you know, there exists inflation and rise in prices, and all these require taking into account the use of temporary models. Therefore, stationary models are suitable only for limited periods of time. In order to take into account the time factor in the cost function, there are used analytical descriptions. The simplest description includes four components and can be built on the additive or multiplicative principles. If the components of a time process *F (t)* are independent, then the model is based on the additive principle, shown below

$$F(t)= f_{TR}(t)+ \varphi(t)+Q(t)+ \mu(t) \qquad ...(1)$$

In such a typical time model, there are taken the following components:

$F_{TR}(t)$ – trend.
$\varphi(t)$ – cyclical or seasonal component.
$Q(t)$ – conjunctural or one-time component.
$\mu(t)$ – random component.

When the components of the time process *F (t)* affect each other, strengthen or weaken each other, then the model is based on the multiplicative principle

$$F(t)= f_{TR}(t)\ \varphi(t)Q(t)+ \mu(t) \qquad ... (2)$$

When conducting periodic observations $x(t_1)$, $x(t_2)$,…, $x(t_N)$ of the analysed values, executed during the successive time instants t_1, $t_2,\ldots, t_N$, they form a time series model.

For management, there are also used data and resources. Currently, energy supply management is often associated with the distributed information. In this case it is necessary to apply geospatial data that are organized as system resources[17].

CONCLUSION

Conceptual model of energy conservation management is the basis for the implementation of energy conservation strategy that ensures survival[18] of the system. This conceptual model is based on certain principles, the implementation of which is required for each system. Given the complexity of the influence of different factors on the efficiency of the enterprise, it is advisable to develop a vector-matrix representation of the model. Therefore, it is proposed the assessment of the effectiveness of energy efficiency and energy conservation management based on the assessment of the discriminant vector in accordance with the management results.

Summary

Conceptual model of energy conservation management can be used to control other types of resources, such as informational resources. Its simplicity allows creating simple algorithms that implement the management and monitoring mechanisms of management actions. Conceptual model can be used to simulate the behaviour of living organisms, which also extends the range of its practical applications.

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