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Methods of decision making in the energy management system

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ABSTRACT: The article deals with the problems of energy saving and increasing the efficiency of using fuel and energy resources, tasks and methods of decision making in the energy management system. The problems of finding the optimal solution in the process of making decisions of the energy management system, as well as methods of rationing resource costs, solving problems of optimal planning, operational accounting, control and regulation of consumption of fuel and energy resources in the production process are given. Mathematical models of the decision support system of the energy management system are proposed.

KEYWORDS: Classification, Data Mining, Machine Learning, Predictive analysis, Social Networking Spam, Spam detection.

I.INTRODUCTION

Theoretical provisions of the theory of decision making and the development of decision support systems in energy management processes based on intellectual data analysis are reflected in the works of A.B.Petrovsky[1],E.A.Trakhtengerts[2] andD. Power[3]. It is worth mentioning the works in the field of energy saving and energy management of such foreign scientists as A.I.Dovgyallo[4], T.H.Gulbrandsen[5], P. O'Callaghan [6] and others.

However, in fact, the task of making decisions in energy management systems (EMS) is difficult to formalize and poorly structured, and in connection with this, it is possible to identify the emerging scientific and technical support problem in making managerial decisions in EMS.

At the current stage of the economy development, the fuel and energy resources (FER) of the industrial enterprise are strategic in terms of its viability and are in line with such types of resources as human, production and financial.

Efficiency of FER use at the enterprise influences the profitability of its operation, being one of the levers for managing its competitiveness. Despite the evidence of this fact, at the current stage, the management infrastructure of many enterprises does not include means for effective control, accounting and analysis of consumption of FER.

II. STATEMENT OF A PROBLEM

The problem of energy saving and increasing the efficiency of the use of FER is now becoming one of the priority directions for the development of enterprises and companies of the fuel and energy complex working in the production sector. EMS is the basis of any program to improve energy efficiency and rational management of energy conservation. EMS is a complex of interrelated and interacting tasks on the formation of energy policy and goals for increasing energy efficiency, as well as the creation of processes and procedures to achieve these goals.

III. THE CONCEPT OF THE PROBLEM DECISION

When implementing the EMS's functional tasks, the decision-making process (DMP) is carried out to develop and implement tasks aimed at achieving economic performance. DMP - a key process that affects the quality of products or services, the strategy of enterprise development. The problem of decision making will be considered in the search in the state space. In general, the problem is formulated as follows: an initial state or subset of such states, a final state or a subset of such states (possibly implicitly via some restrictions) and a set of rules for transforming states are given. It is required to find a sequence of transformation rules, possibly satisfying certain requirements (optimality or admissibility), which allows you to convert the initial state to the final one. If the desired sequence must satisfy the requirements of optimality, then we have the problem of finding the optimal solution if the admissibility requirements are the problem of finding an admissible (satisfactory) solution [7, 8].

The decision-making task (DMT) is determined by a set of

$$\text{DMT} = (S, S_p, S_i, S_f, R, C) \qquad (1)$$

where S is the set of states (situations), called the universe, S_p is the subset of possible (permissible) states $S_p \subset S$, respectively $S_p \cap S$ is a subset of impossible (inadmissible) states; $S_i \subset S$ is a subset of the initial states; $S_f \subset S$ - a subset of finite, or target states; $R: S \to S$ is a finite set of transformation rules, each rule $R_i \subset R$ is a function realizing the mapping $R_i: S_i \to S$, where S_i is the domain of R_i. It is believed that the rule R_i is applicable to the state $s \subset S$, if $s \subset S_i$; C is the set of criteria for estimating the solution found [9]. We will assume that states are described by the final words of a language and can express both structured and unstructured concepts. When developing a production program in EMS, any quantitative, qualitative, temporary and other changes in the production process necessarily entail changes in the corresponding driven material processes: an increase or decrease in the volume of extraction, processing, sale of marketable products, change in production times, etc., and also require appropriate changes in the quantity and timing of the supply of raw materials, materials, energy resources, in increasing or decreasing the number of workers for certain professions, qualifications and etc. Increasing the efficiency of production processes in EMS is dependent on the choice of optimal management decisions. The mathematical formulation of the problem of choosing optimal solutions in general form is as follows. Let there be some set of possible solutions $\{\overline{X_i}\}$, where $\overline{X_i}$ is a vector of dimension a; a is the number of characteristics of the solutions. We assign a serial number to each solution, as a result of which we obtain a one-dimensional set $X = \{X_1, X_2, \dots X_n\}$, where n is the number of possible alternative solutions. Then each *i*-th solution can be associated with a numbered point X_1 in an a-dimensional space, which is described by a vector of characteristics.

$$\overline{S_i} = (S_{i1}, S_{i2}, \dots, S_{in}),$$

$$S_y \in \widetilde{S_j}; j = 1,2, \dots, a. (2)$$

where $\widetilde{S_j}$ is the set of possible values of the j-th characteristic.

Let some restrictions on the characteristics of the solution be imposed, which, in a general form, can be written:

$$A(S_1, S_2, \dots, S_j, \dots, S_n) \geq 0,$$

$$B(S_1, S_2, \dots, S_j, \dots, S_n) = 0. (3)$$

It is required to choose a solutionX_i from the set X satisfying conditions (2) and having an extremal value of some criterion which, in general, is a function of the characteristic

$$F(X_i) = f(S_{i1}, S_{i2}, \dots, S_{in}) \to extr. \, (4)$$

Further we will assume that the minimization of the criterion is required, since in the case of maximization it is always possible to construct an equivalent criterion whose minimum corresponds to the maximum of the original. Then we can write

$$F(X_i) \to min, X_i \in X. (5)$$

Mathematically rigorous methods of multi-criteria choice of optimal solutions, are currently underdeveloped [10].

A successful solution to the problem of choosing alternatives from the set of solutions is possible in the presence of a suitable integral optimality criterion. In the field of EMS in terms of such criteria, the following technical and economic indicators are usually used: production costs (materials, raw materials, energy resources, etc.), cost, profit, level or

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coefficient of profitability, etc. At the same time, there is no common opinion on the question of what the criterion of efficiency of production should be, and whether there is a universal assessment that allows to give preference to this or that variant of management in the process of the multifaceted activity of the enterprise. The most common criteria for minimizing these costs and an adequate criterion for the maximum net profit characterize onlythe absolute magnitude of the effect. However, in a number of cases it is advisable to evaluate the effect in relation to the costs that caused it. Consider, for example, the production process of the oil and gas industry.

The production process of the oil and gas industry can be viewed as a multipolar system with various inputs and outputs. The production function of the technological cycle of EMS, i.e. the dependence of their outputs on the inputs can be written in the following form:

$$Q_i = F(X_i, L_i, R_i) \qquad (6)$$

where X_i - technological inputs, representing energy resources, raw materials, materials, etc. *i*-th stage of the production process; R_i - means of labor (equipment, installations, etc.); L_i - personnel involved in production; Q_i - output of the production process.

Each stage of the production process, as well as the output, are multicomponent, i.e. vector quantities:

$$X_i = \begin{bmatrix} x_{i1} \\ x_{i2} \\ \vdots \\ x_{in} \end{bmatrix}; R_i = \begin{bmatrix} r_{i1} \\ r_{i2} \\ \vdots \\ r_{ik} \end{bmatrix}; L_i = \begin{bmatrix} l_{i1} \\ l_{i2} \\ \vdots \\ l_{im} \end{bmatrix}; Q_i = \begin{bmatrix} q_{ir} \\ q_{ir} \\ \vdots \\ q_{ir} \end{bmatrix}.$$

we introduce the coefficients

$$a_{ij} = \frac{x_i}{q_i}; b_{ij} = \frac{l_i}{q_i}; \ h_{ij} = \frac{r_i}{q_i}; (7)$$

determining the cost of the *i*-th resource X_i, L_i or R_i for the production of the *j*-th product unit. The set of these coefficients is conveniently represented in the form of the following matrices:

$A = [a_{ij}]$ - material costs for the *i*-th production process;
$B = [b_{ij}]$ - labor costs for the *i*-th production process;
$H = [h_{ij}]$ - production capacities of the *i*-th production process.
In this case, the linear production function can be written in the form of matrix relations:

$$X_i = A_i \times Q_i; \ L_i = B_i \times Q_i; \ R_i = H_i \times Q_i; \qquad (8)$$

The purpose of planning production activity is to achieve a certain balance between production and the consumer, which is expressed in the compilation of balance equations describing production models. Each type of product Q_i, produced by production units of the oil and gas industry, is consumed at a certain intensity. To ensure the production of products with the required intensity, the costs of the means of production are required in the amount:

$$L_i = \sum_{i=l}^{n} l_i = \sum_{i=l}^{n} b_i q_i; \ R_i = \sum_{i=l}^{n} r_i = \sum_{i=l}^{n} h_i q_i. (9)$$

The objective function of the task is to maximize the volumes of oil and gas production that ensure the maximum satisfaction of the needs of the national economy in the production of the oil and gas industry with minimal costs for their production.

Wherein

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$$X_i = \sum_{j=1}^{J} X_j \leq \sum_{j=1}^{J} X_j^p; \; L_i = \sum_{k=1}^{K} L_k \leq \sum_{k=1}^{K} L_k^p; R_i = \sum_{n=1}^{N} R_n \leq \sum_{n=1}^{N} R_n^p. \quad (10)$$

where X_j^p - estimated (normative) costs of the i-th type of energy resources, raw materials, materials, etc. on production; L_k^p - the estimated (normative) needs of the k-th type of means of labor for the production of products; R_n^p - calculated (normative) quantities of the nth specialty of engineering and production workers; $Q_{\text{ГП}}^{\text{н}}$ - the main task of the unified mathematical model of the production processes of EMS is to obtain the maximum volume of high-quality commercial products with minimum expenditure of energy resources - ER.

As an objective function of this task, one can take the relationship of energy resources to the volume of output.

$$F(X) = \frac{ER_s}{Q_s} \rightarrow min(11)$$

whereQ_s is the volume of oil and gas of the s-th production stage; ER_s - costs of energy resources of the s-th production stage; $s = 1 \div S_s$ production stages.

IV. CONCLUSION

Thus, by choosing a single criterion and using the developed unified mathematical model, it is possible to control and manage the indices of the production volumes and the energy costs of each stage of the production system separately.

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