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# Minimization of energy production management consumptions

*I U Rakhmonov*[1], *V Ya Ushakov*[2], *A M Najimova*[4], *D A Jalilova*[1], *F B Omonov*[3]

[1] Tashkent state technical university named after Islam Karimov, Tashkent, Uzbekistan
[2]Tomsk Polytechnic University, Russia
[3] Termiz branch of Tashkent state technical university named after Islam Karimov, Tashkent, Uzbekistan
[4] Karakalpak State University

**Abstract.** The article discusses the issue of organizing management of a constantly operating object distributed in space and developing arbitrarily, while the organization of management should be optimal according to the criterion - the maximum return (income) on the invested funds (equipment) and the raw materials used. An energy system with well-known engineering concepts is used occasionally as an example. Particular attention is paid to the issue of the reliability of such an object, its significance for the state economic mechanism. The article provides a specific sequence for formulating the control goal based on parametric (measuring) information.

## 1 Introduction

In technical systems, the control task is to maintain some adjustable parameters (for example, the frequency and voltages of nodes in power systems) at the level of required values, and the regulation itself is carried out on the basis of the so-called measurement information. The fundamental question is whether there is a connection between the canonical type of information and its measuring, parametric form. In our opinion, such a connection should be sought by analyzing the value characteristics of information [1-3].

The value of information depends entirely on its reception, i.e. from the consequences of its perception by the receptor (in particular, by an automated controlled power system). The value of information was the subject of research by a number of scientists - A.A. Kharkevich, M.M. Bongard, R.L. Stratonovich, B.N. Petrov and others. The commonality of their concept lies in the statistical approach to information, and the most specific interpretation of the value for the conditions of further use of information for management should, apparently, recognize the formulation of MM Bongard [4-5].

$$V = \log_2(P^{'}/P), \tag{1}$$

where V is the value of information,

P and P '- the probabilities of achieving the goal before and after receiving information.

If the entropic measure of information itself, determined by Hartley or Shannon (through the probabilities P and P '), is an unambiguous and universal quantity, then this universality does not extend to the concept of the value of information (1), if only due to the fact that the effect of achieving the goal in different control systems it can be different (incommensurable), and the very analysis of the value of information outside the connection with its receptor becomes abstract [9-14].

In complex technical systems, which include energy systems (ES), the goal of control can be considered to be the achievement of a certain state that is optimal according to some predetermined criteria (in particular, economic). Note that such an optimal state is unique for an ES at each moment of time. Any “moving away” from the optimal state can be estimated by the corresponding damages (E), and the “approach” to the optimum (from the “optimal” state) - by gains similar in meaning and value (E). In particular, damages and gains may well be purely economic. The very distance from the optimum can be expressed in terms of the deviations of the controlled parameters from their "optimal" (corresponding to the system optimum) values, i.e. through parametric (measurement) information.

Having determined the optimum of the system, i.e. Having designated the purpose of control, we concretized the use of parametric information (control parameters), the very meaning of the information and the method of its measurement, which is fully consistent with the approach. Using now the concept of the effect of system control, we will find a connection between the parametric information defined above and information according to Shannon, i.e.

between information "for management" and canonical information [6-8].

We will describe the state of the ES near the optimum by some linear economic characteristic, which is a function of the set of controlled parameters $\pi$:

$$Э = f(\pi_1^{'}, \pi_2^{'}, ... \pi_j^{'}, ..., \pi_m^{'}) = \alpha_1\pi_1^{'} + \alpha_2\pi_2^{'} + ... + \alpha_j\pi_j^{'} + ...\alpha_m\pi_m^{'}, \quad (2)$$

where Э is the current (actual) value of the economic indicator of the ES operation;

$\pi_j^{'}$ - current (actual) values of control parameters;

$\alpha_j$ - weighting factors (statistical, regression - in particular).

The considered state will be considered sufficiently "close" to the optimal one, at which the ES functions most economically (with the economic indicator $Э_o$):

$$Э_o = f(\pi_1^o, \pi_2^o, ... \pi_j^o, ..., \pi_m^o) = \alpha_1\pi_1^o + \alpha_2\pi_2^o + ... + \alpha_j\pi_j^o + ...\alpha_m\pi_m^o \quad (3).$$

Here $\pi_j^o$ is the parameters of the system that determine its optimal state are called optimal.

The assumption that the current state of the ES is close to the optimal $Э_o$ is necessary to comply with the linearity conditions of the problem, i.e. the invariability of the coefficients $\alpha_j$.

Let us consider a situation when all but one control parameters have their optimal value, and the j-th parameter has its current non-optimal value $\pi_j^{'}$. We denote the deviation of this parameter from the optimal one by

$$\pi_j = \left|\pi_j^{'} - \pi_j^o\right| \quad (4)$$

Obviously, this will also determine the deviation of the economic indicator of the ES Эj from its optimal value:

$$E_j = Э_j - Э_o = \alpha_j = \left|\pi_j^{'} - \pi_j^o\right| = \alpha_j\pi_j \quad (5)$$

For the sake of brevity $E_j$, we will call it the effect of regulation of the ES by parameter $\pi_j$. If a parameter $\pi_j$ can be in n specific discrete states $P(\pi_{ji})$, then the resulting efficiency $E_{j\Sigma}$, as is known, can be calculated as the sum:

$$E_{j\Sigma} = \alpha_j \sum_{i=1}^{n} P(\pi_{ji})\pi_{ji} \quad (6).$$

Analyzing the structure of expression (2), we come to the conclusion that the system-wide ($E_{ES}$) effect of regulation can be obtained by summing the effects of regulation by individual components, i.e. it has the additivity property:

$$E_{ЭС} = \sum_{j=1}^{m} \alpha_j \sum_{i=1}^{n} P(\pi_{ji})\pi_{ji} \quad (7).$$

Since the sum (7) completely repeats the properties of the term x (6), for simplicity we return to the analysis of the j -th term. Note that when passing from the case of a discrete change in the parameter $\pi_j$ to its continuous change, expression (6) will change:

$$E_{j\Sigma} = \alpha_j \int_{o}^{\pi_{j\max}} P(\pi_j)\pi_j d\pi_j \quad (8)$$

As it follows from (5), $E_j$ = 0 for the optimal value of the parameter $\pi_j^o$, i.e. at its very specific value, the likelihood of reaching which with targeted regulation $P(\pi_j^o) = 1$. Recall that it can be interpreted as an optimization effect if the ES passes from a suboptimal state to an optimal one, or as damage from sub optimality - if the reverse transition takes place. The optimal state should be considered as completely ordered, the entropy of which is equal to zero [18-24]. The entropy of a disordered state is known to be related to the probability of this state and, for our example, can be represented as follows:

$$H_j = \sum_{i=1}^{n} P(\pi_{ji}) \log_2 P(\pi_{ji}) \quad (9)$$

and for the continuous case

$$H_j = -\int_{o}^{\pi_{j\max}} P(\pi_j) \log_2 P(\pi_j) d\pi_{ji}. \quad (10)$$

Let us recall the additivity property of entropy, which allows the entropy of a system to be calculated as the sum of the entropies of its individual elements, which for our example gives

- in the discrete case

$$H_{ES} = -\sum_{j=1}^{m}\sum_{i=1}^{n} P(\pi_{ji}) \log_2 P(\pi_{ji}) \quad (11)$$

- in the continuous case

$$\mathrm{H}'_{ES} = \sum_{j=1}^{m} \int_{o}^{\pi_{j\max}} P(\pi_j) \log_2 P(\pi_j) d\pi_j \quad (12)$$

The last formulas (9÷12) are known expressions for the Shannon information entropy, which is defined for a set of random variables. When the probability of a state changes from $P(\pi_j)$ to 1 (the system transitions from an optimal state to an optimal one), the change in information according to Shannon is equal to

$$I = O - \mathrm{H}'_{ES} = \sum_{j=1}^{m} \int_{o}^{\pi_{j\max}} P(\pi_j) \log_2 P(\pi_j) d\pi_j \quad (13)$$

It is this information according to Shannon that we use to transfer the ES from the suboptimal state to the optimal one, and at the same time the effect of $E_{ES}$ control is achieved. Naturally, practical regulation is carried out not according to Shannon information, but according to parametric (measuring) information, by minimizing parameters $\pi_j$ - sm (5). Obviously, there is some correspondence between these two forms of information, which can be revealed through the effect of regulation (control) [12-14]. Taking into account the property of the additive effect of system regulation noted above and the well-known property of additive entropy, consider the correspondence (= is the correspondence sign) of the effect and information using the example of one (*j*-th) parameter:

$$E_{j\Sigma} == I_j$$

or

$$\alpha_j \int_o^{\pi_{j\max}} P(\pi_j)\pi_j d\pi_j == \int_o^{\pi_{j\max}} P(\pi_j)\log_2 P(\pi_j) d\pi_j \qquad (14)$$

To simplify the analysis, we differentiate the right and left sides of expression (14):

$$\alpha_j P(\pi_j)\pi_j == P(\pi_j)\log_2 P(\pi_j) \qquad (15)$$

Comparing the right and left sides of expressions (14, 15) with respect to probability factors, we can conclude that they are affinely similar, i.e.

$$\frac{P(\pi_j)}{P(\pi_j)\log_2 P(\pi_j)} = idem \qquad (16)$$

The factor $\alpha_j$ on the left side of expression (14) can be regarded as a scale factor providing geometric similarity. The only element in (14) that does not have a similar one is the control parameter $\pi_j$. This means that, to within a certain constant (C), the parametric (measuring) information, on the basis of which the purposeful optimization control in the ES is carried out, corresponds to the information according to Shannon:

$$C\pi_j = I_j \qquad (17)$$

Note the validity of relations (14) and (17) for the boundary conditions. Let the ES with respect to the parameter j be brought to the optimum state. In this case $\pi_j = 0, \quad P(\pi_j) = 1, \quad \log_2 = P(\pi_j) = 0, \quad I_j = 0$, the right and left sides of expressions (14) and (17) are identically equal to zero. This means that in the optimum state there is no (and no need!) information for further control. Consider another example - some parameter $\pi_\nu$ does not affect the formation of the economic effect of management, i.e. its coefficient $\alpha_\nu = 0$ or we are dealing with useless information. In this case, the definition of the goal has not been formulated in relation to this ferry, therefore, from the standpoint of ES control, the parameter value can be any. It is known that the probability of any value of the parameter is always equal to, $I(P(\pi_j) = 1$ a $\log_2 1 = 0$, i.e. there is no information for control $I_\nu = 0, \quad C\pi_j = 0, \quad \text{т.к.} \quad C = 0$, regulation on this parameter should not be performed [15-17].

The presence on the left side of expressions (14) and (17) of a physically measured parameter, according to which regulation is directly carried out, is natural in the sense that a transition from abstract, conical information to concrete, physically measurable is necessary. An important conclusion following from what has been considered is that such a "bridge" between the conical form of information (according to Shannon) and its measurable, parametric form exists for predetermined conditions and lies in a certain constant C [25-35].

## 2 Conclusions

Thus, when fixing the method of measuring and using information (for control purposes) and when determining the control goal as achieving a certain (optimal) state of the controlled object, the Shannon information corresponds to the measurement, parametric information (or vice versa) up to a constant. Fixing the way of using information logically leads to the question of the effect of its use, of its value from the standpoint of management. If information according to Shannon is a factor for determining the throughput of channels for transmitting information to an automated dispatch control system, then the determining factor in the organization of the control itself is its value. In this regard, it is legitimate to talk about the development of information aspects of management, about the construction of management systems that are adequate to the processed information. In theoretical terms, it is required to substantiate the "information" methods of management, the development of information management theory.

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