The Model of Energy Distribution

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***Abstract*— The task of developing decision models for the distribution of energy resources in a city divided into districts is considered, taking into account the population size, the number of substations, the number of consumers, and their needs.**

Keywords— information approach; model; modeling of morbidity; making decisions; system; system analysis; theory of systems

I. Introduction

The article considers one of the tasks of energy resources management – the problem of resource allocation in the city, divided into districts. When solving this task, it is necessary to take into account the number of districts, the population number, the number of substations, the number of consumers, their needs, the indices of unmet need, calculated on the basis of the current provision of services, the requirements of state and territorial standards of population provision various kinds of energy resources, etc.

Thus, the problem of distribution of energy resources in the city belongs to the class of multicomponent, multicriteria problems with a large initial uncertainty. At the same time, it is important to constantly monitor the state of energy supply, promptly and reasonably make decisions on adjusting the volume of services and their types.

In this connection, the task was to select a method for modeling and an algorithm that would allow the development of decision-making models for the choice of the type of energy resource to be supplied on the basis of an analysis of the need in specific city conditions divided into regions.

To solve the problem, an analysis of the modeling methods was carried out and a multilevel model based on the information approach proposed by was proposed. A.A. Denisov [4, 5].

II. Rationale Selecting System Modeling Methods based on Classification of Systems And Problems

Various classifications of systems and problems solved by means of system representations were offered: in complexity and magnitude, in the form of the displayed object (technical, biological, economic, etc. systems); by the type of scientific direction, used for their modeling (mathematical, physical, chemical, etc.). The analysis of classifications is carried out.

In the theory of decision-making, a classification is made according to the degree of uncertainty (the first column in Table 1).

In the classification of G. Simon and A. Newell, a grouping of systems and problems was proposed on the basis of structurization (well-structured, poorly structured and unstructured).

By analogy with this classification, Temnikov proposed the separation of systems according to the degree of organization – well-organized, poorly organized or diffuse and self-organizing (the third column in Table 1). Different classes of problems and systems require different axioms and modeling methods [3] (examples are given in the right column of the Table 1).

Table 1 Classification of Systems and Problems

Signs of classification			
The degree of uncertainty	***The degree of structurization***	***The degree of organizing***	***Axiomatics***
With sufficient certainty	Well-structured	Well-organized	The axiomatics of Euclid (Eudoxus), Aristotle
With indeterminacy	Poorly structured	Poorly organized	Axiomatics of Probability Theory and Mat. of statistics
With great initial unconstraint	Unstructured	Self-organizing	Axiomatics of the Theory of Sets, Mat. Logic, Regularities of the Theory of Systems

Different axiomatics and modeling methods are required for different classes of problems and systems [3] (examples are shown in the right column of Table 1).

This concept allows us to choose the modeling methods in decision-making in the systems of organizational management: for problems with sufficient certainty, well-structured, belonging to the class of well-organized systems, the methods of classical mathematics based on the Euclidean axioms and Aristotle’s formal logic are applicable. For poorly organized problems and systems statistical methods are appropriate.

For a class of problems with great uncertainty, characteristic for self-organizing and developing systems, methods and models based on dialectic logic and special methods of systems theory that combine means of activating intuition and the experience of decision makers and methods of formalized systems representation are needed.

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In the development of the idea of multi-level structures by M. Mesarovic [6] and proposed in the 1970s. A.A. Denisov theory of the information field [4] and its discrete variants [5] proposed a generalized model of resource allocation, which allows the development of decision-making models for the distribution of energy resources, taking into account the specific features of specific territorial entities.

III. The Substantiation of the Model

A generalized model based on which it is proposed to develop formalized models for specific situations is shown in Fig. 1.

The methods for implementing the stages of the model are in the following sections.

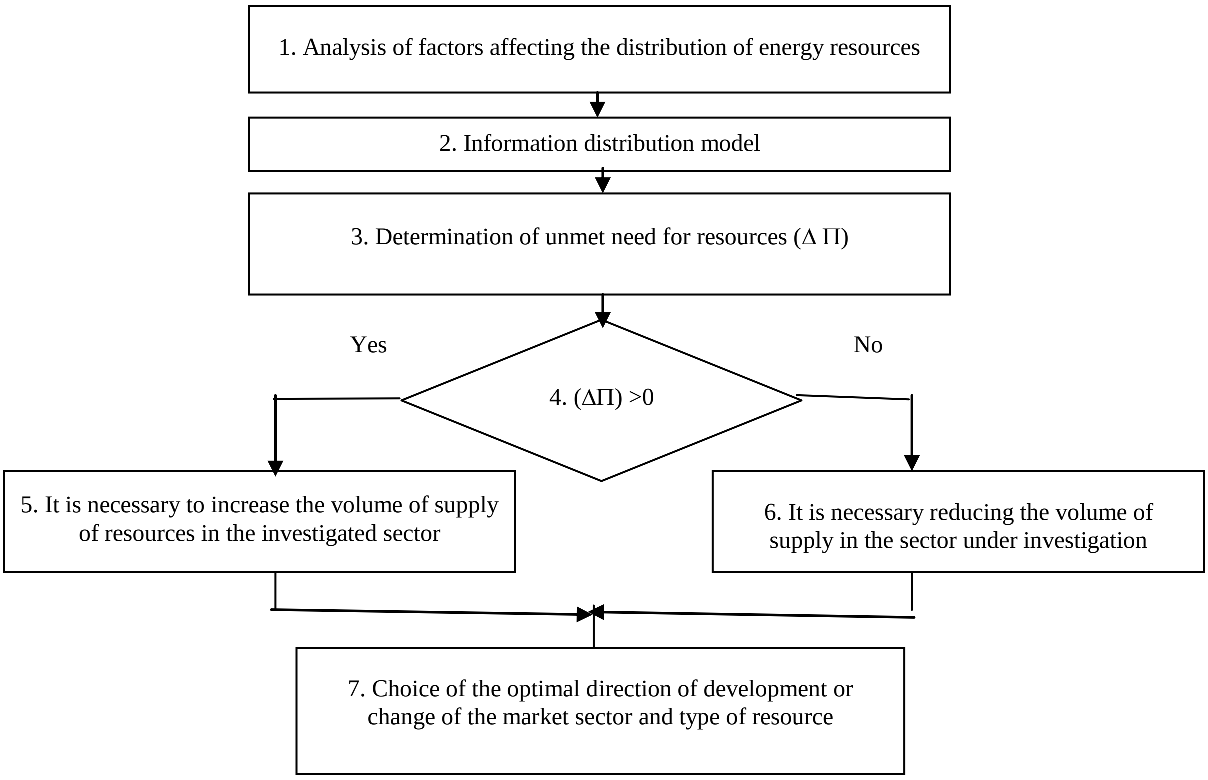

Fig. 1. A generalized model

IV. Anaplise of Factors Influencing the Distribution of Energy ResourceSH

The main factors affecting the situation in a city divided into districts are:

$$\varphi = < \varphi_1, \varphi_2, \varphi_3, \varphi_5 >,$$

where φ_1 – number of districts, φ_2 – population,, φ_3 – number of substations, φ_4 – number of consumers.

The main integral indicator is the unmet need for resources, calculated on the basis of the current security of the population, as well as the requirements of state and territorial standards for the provision of the population with various types of energy resources.

As quantitative criteria, two indicators can be introduced: the amount of energy resources and the number of substations. The location of urban substations is based on the principle of gradation, taking into account the zoning of the city. In the city there are three main levels: citywide, district level.

In these conditions, in order to conduct a multifactor analysis of the situation using formalized information models, it is required to apply methods that allow for taking into account the uncertainty, fragmentation and unreliability of the initial information. Based on the analysis of the factors that influence decision-making, we investigate the possibilities of developing a formal information model.

V. Development of the Formal Information model of Analysis of needs In energy resources

The formal information model of the analysis of the demand for services is developed on the basis of the joint use of structuring methods that allow to separate the initial uncertainty when choosing the type of services for more visible parts, the methods of studying the multi-level hierarchical structures of M. Mesarovic providing the possibility of a multilevel representation of the “layer” type model, and the information approach A.A.Denisov, which allows to bring heterogeneous criteria (quantitative and qualitative) to unified information units, which helps to compare these criteria and obtain estimates of the need for various types of services used for comparative analysis.

When developing an information model, the following information about the modeled system should be taken into account: the whole city is divided into m administrative districts (k = 1,…, m). Substations supplying services are divided into types, and the areas in which they are located. The whole list of services of the city is an array (i = 1, ..., v). To analyze the scope of the i-th energy service, we will make a sample of the substations rendering this service. To conduct segmentation as a segment, you can choose the k-th administrative district (k = 1,…, m).

For the analysis of the energy services segments we will use information models based on the assessment of the provision of energy services of the i-th species of one inhabitant of the k-th district H^i_k.

$$H^i_k = J^i_k / n^i_k, \qquad (1)$$

where J^i_k means information about the energy service of the i-th type in the k-th district of the city, measured in relative units; n^i_k is a population of the k-th district of the city, which is provided with the service of the i-th type.

In this study we will use the information indicator (J^i_k), which is calculated by the following formula:

$$J^i_k = A^i_k / \Delta A^i_k, \quad \ldots\ldots\ldots \qquad (2)$$

where ΔA^i_k – the minimum quantity of energy services of the i-th species in the k-th area, which is of interest to the consumer, which determines the unit of measure A^i_k. ΔA^i_k is accepted equal to one within the framework of this study.

Then the situation at a specific moment can be described using the idea proposed in [1]:

$$\begin{aligned}
H^i_1 &= f(H^i_{11}, H^i_{12}, H^i_{13},\ldots H^i_{1k},\ldots H^i_{1s},\ldots H^i_{1m}),\\
H^i_2 &= f(H^i_{21}, H^i_{22}, H^i_{23},\ldots H^i_{2k},\ldots H^i_{2s},\ldots H^i_{2m}),\\
H^i_3 &= f(H^i_{31}, H^i_{32}, H^i_{33},\ldots H^i_{3k},\ldots H^i_{3s},\ldots H^i_{3m}),\\
&\ldots\\
H^i_k &= f(H^i_{k1}, H^i_{k2}, H^i_{k3},\ldots H^i_{kk},\ldots H^i_{ks},\ldots H^i_{km}),\\
&\ldots\\
H^i_m &= f(H^i_{m1}, H^i_{m2}, H^i_{m3},\ldots H^i_{mk},\ldots H^i_{ms},\ldots H^i_{mm}) \qquad (3)
\end{aligned}$$

The set of dependencies (3), reflecting the interconnection and interdependence of all elements of the information model, can be interpreted for this task as follows: H^i_1, H^i_2, H^i_3,... H^i_k,... H^i_s,... H^i_m is resources endowment to provide the i-th energy services in the k-th area of the city (k = 1,…, m).

Consider the security of the i-th type service in the k-th district

$$H^i_k = f(H^i_{k1}, H^i_{k2}, H^i_{k3},\ldots H^i_{kk},\ldots H^i_{ks},\ldots H^i_{km}), \qquad (4)$$

where i – type of service; H^i_{kk} – k-th district's provision of the i-type service; H^i_{ks} – change in the providing of the k-th district.

The total provision of one inhabitant of the k-th district by the service of the i-th type H^i_k is defined as the algebraic sum of the elements:

$$H^i_k = H^i_{k1} + H^i_{k2} + H^i_{k3}\ldots + H^i_{kk}\ldots + H^i_{ks}\ldots + H^i_{km}, \qquad (5)$$

where m is a number of districts; H^i_{ks} is the change in the provision of services of the i-th type to one inhabitant of the k-th district; H^i_{kk} is provision of services of the i-th type to one inhabitant of the k-th district.

VI. Model of Definition of Energy Services Satisfaction with the Types of Services and City Regions

The model for determining the provision of services should be based on the following conditions: the city is divided into m districts, in each s-th district of the city (with the total population n_s) m^i_s substations providing energy services of the i-th species to the population of all districts of the city are registered. The substations are characterized by the substation parameter J^i_{sl} and their distribution by area.

Generalized formula for calculating the population's security H^i_{ks} has the form:

$$H^i_{ks} = \sum_{l=1}^{m^i_s} \frac{J^i_{ksl}}{n_k}, \qquad (6)$$

where J^i_{ksl} – characteristic of the l-th substation in the s-th district for providing energy services of the i-th species to the population of the k-th district; n_k –total population of the k-th district; m^i_s – the number of substations in the s-th district for rendering the service of the i-th species.

Formula for computing J^i_{ksl} has the form:

$$J^i_{ksl} = X^i_{ksl} * J^i_{sl}, \qquad (7)$$

where J^i_{sl} – the characteristic of the l-th substation in the s-th district for rendering the i-th type service; S^i_{ksl} – coefficient, showing the share of the l-th substation in the s-th region for provision of services for the provision of energy resources of the i-th species to the population of the k-th district.

For the coefficient S^i_{ksl} the following condition must be satisfied:

$$\sum_{k=1}^{m} S^i_{ksl} = 1 \qquad (8)$$

Thus, the formula (5) for calculating the resources endowment of the i-th kind of population of the k-th district will have the form:

$$H_k^i = \sum_{s=1}^{m}\sum_{l=1}^{m_s^i} \frac{S_{ksl}^i * J_{sl}^i}{n_k} \qquad (9)$$

The algorithm for determining the supply of energy resources is shown in Fig. 2

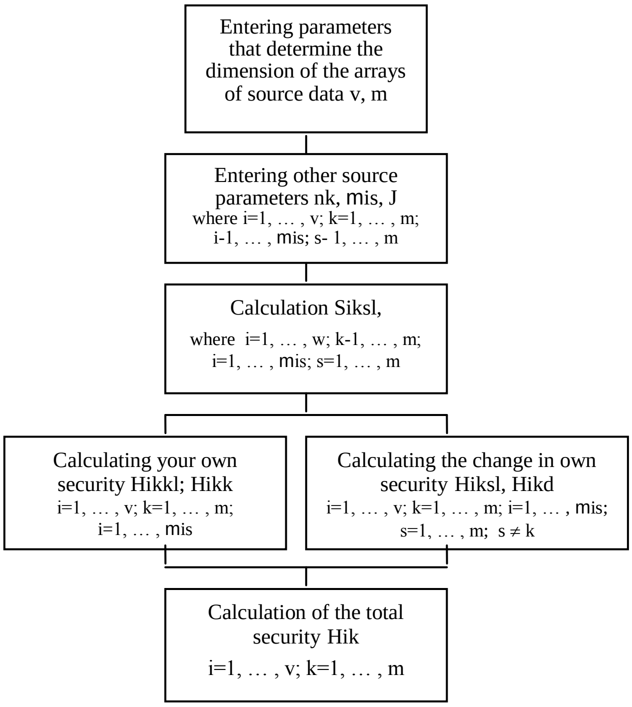

Fig. 2. Algorithms for determining the security energy resources

The description of the formal information model includes the characteristics of input, calculated and output parameters. The set of input parameters consists of the parameters that determine the dimension of the arrays of initial data: the number of services (v), the and other input parameters: the number–number of city districts (m) of substations distributed by regions and types of energy services (m_s^i, where i=1,…,v; s =1,…, m), by population by area (n_k, where k = 1,…, m) and the characteristics of substations providing this type of service, distributed by area and type of service (J_{sl}^i, where l = 1,…, m_s^i; i = 1,…,v; s = 1,…, m).

The set of calculated parameters consists of an array of coefficients that show the share of the l-th substation in the s-th region, to provide energy services of the i-th species to the population of the k-th district (S_{ksl}^i, , where l=1,…m_s^i; i=1,…v; k=1,…m; s=1,…m).

The proposed information model allows us to determine our own provision of services to the population of the city's districts and its changes due to the interference of substations in other areas.

Deterministic estimates are used in this model. It is possible to use the probabilistic estimations proposed in the assessing the degree of–information theory of A. A. Denisov: appropriateness of the analyzed components of the systems under study, which make it possible to obtain a generalized estimate in multicriteria problems with heterogeneous criteria; based on the information evaluation of the potential (significance) of the H_i component [3, 5]:

$$H_i = - q_i \log (1 - p_i'),$$

where p_i' – probability of achieving the goal when using the estimated resource; and q_i is probability of using the resource.

By applying jointly a probabilistic and deterministic method for estimating H_i, a comparative analysis of the estimates over a period of time [7, 8].

CONCLUSION

The models considered can be used to make decisions when choosing the type of energy supply and the market sector based on an analysis of the demand within the city, divided into districts, to determine its own provision of services to the population of the city's districts and its changes due to the interference of substations in other regions.

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