THE DEVELOPMENT OF HOUSING-AND-COMMUNAL SERVICES OF POWER SUPPLY SYSTEM IN SAMARA REGION

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In the article the author considers the problems of the development of housing-and-communal services power supply system in Samara region. The methods of evaluating the housing-system activity and the model for the managing its development are suggested for solving problems in this sector of economy.

The transformations in the economy of our country including housing-and-communal services (HCS) led to the situation that nowadays heat and electric energy supplying practice of HCS is based on the both unprofitable and expensive technologies. This can be explained by power shortage in Russian power economic environment equipment became obsolete; there is the discrepancy between economic-organizing mechanism of energy-supply system and modern qualifying standards to HCS from consumers. Besides, there is a problem expressing itself in the lack of metrics, characterizing the development of a brunch and allowing estimating the efficiency of HCS objects energy supply system. The lack of estimation procedure doesn't let us form a pattern for energy-supply system development and reduce the costs on HCS qualitative functioning in general and flatten out the rates.

The condition analysis of existing HCS system in Samara region showed a lot of problems affecting the development and efficiency of HCS energy-supply system. The main problems of communal services subsystem in Samara region are denominated by the shortage of investments in development and updating of the objects producing and distributing energy; by low efficiency of the fuel and energy resources used by HCS enterprises; by the absence of the mechanisms optimizing the fuel consumption and energy-saving technologies used on the territory of Samara region[1].

The economic characteristic and analyses of condition of existing energy complex in region in the sphere of energy supply for population and energy consumption by industrial and social sectors presents the following: The energy supply power shortage from centralized sources; The big volume of the losses in the electric and heat networks because of the technical condition and imperfection of electric and heat energy accounting system, also because of a long distance between the energy sources and the energy consumers etc[2].

Today the energy and heat supply practices are provided by the power center of Samara thermal power plant: from sub plant "Pokhvistnevo-I" 110/35/10 kV, sub plant "Pokhvistnevo-II" 110/35/6 kV and sub plant "Julia" 35/6 kV. The heat supply practice is provided by the heat energy production by 6 boiler houses using gas and distribution of heat energy through the heat networks with heat carrier represented by hot water with T=70/95C. The length of these heat networks is 21.5 km in double-pipeline system. The housing heating in Venera village is made by the boiler house of "Energoneft" enterprise through the heat networks of "Pokhvistnevenergo" enterprise with the length 1.2 km.

The hot water supply network is developed slowly because of 100% housing supplying with gas and installation of individual water heaters, especially in old individual buildings of housing areas.

The "Pokhvistnevenergo" enterprise annual necessity in quantity of energy: electric energy 46.3 million kW-h, heat energy (production) - 95.8 thousand Gcal considering that fuel, energy and water consumption for heat energy production and distribution makes: 11713.3 thousand gas cubic meters, 3133.95 thousand kW-

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h of electric energy, and 45966 cubic meters of treated water. The annual volumes of bought electric energy by public corporation (PC) counts 46.3 million kW-h, realization of usable electric energy distribution counts 33.6 million kW-h, the electric energy losses in distribution networks with voltage 10, 6, 3 and 0.4 kV count 8876 thousand kW-h above-standard losses. But still there is opportunity of electric energy distribution to detached consumers in terms of extra electric energy production.

For solving the problem of optimization we used the method of dynamic programming (DP). This method (co-called Hamilton-Jacobin-Bellman method) is devoted to the search of optimal control for complex systems, including the problems of planning, resources distribution, supplying, solution of game theory situations, making of algorithms for solving problems, etc.

DP has more unique character than the Pontryagin's maximum principle. So, we used this method because energy supply system is very complicated and consists of several subsystems, each of them should be optimized. The optimization problem has many stages and factors, and all this concerns to DP method, because in the basis of this method the special principles of optimality, determining the strategy of optimal control search.

This principle is formulated this way: optimal control doesn't depend on the prehistory of the process changing system state, but determined by its state in period under review. This principle sets demands to following system movement, from present period up to the ending of control process. Using this we can state that the search of optimal control with this method goes from the process ending to the beginning. On the basis of this search there is the rule saying that every management stage needs the increase of objective function should be maximal. Thereby the DP method solves the several optimization problems through the searching of the optimal control on every process stage. In other words, the general optimization problem in DP method is divided into several small optimization problems[3].

We reveal the transporting component and optimize it using the DP method. The above-suggested economic model of power conservation by following restrictions: Minimization of conveying costs; Multifuel capability; Cogeneration of energy formation process; Minimization of the energy sources number, with the view of the decreasing their total cost; Minimization of energy power losses during the distribution from a source to a consumer.

Now we make a model of optimal energy supply for consumers using this DP method. We use this method on the last stage, when the optimal states of each energy supply system components will be found. At first we should name the main stages of the DP method economics model making.

1) Dividing the problem into stages. Each stage should be not very small and not very big. On the Picture 1 we can see all the stages of energy moving from a supplier to a consumer. On the 1st stage the fuel supply is made. On the 2nd stage every energetic object produces energy. On the 3rd stage the energy distribution to consumers according to energy distribution terms begins.

2) The choosing of variables, characterizing the state of model-based process before every stage, and the revelation of the restrictions. In our case this restriction will be the reliability of energy supply.

3) The detection of management stages X_i, $I = I...m$ and of the restrictions, i.e. the range of acceptable managements X.

According to the 1st stage, before the solving problem using DP method, we should distribute the amount of the produced energy to the consumers according to their demands. We can do this using the solution of co-called transportation problem. And then we should set the following restrictions:

Fuel consumption $\rightarrow$ min

Energy losses by production $\rightarrow$ min

Energy losses by distribution $\rightarrow$ min

The number of consumers $\rightarrow$ max

The number of power plants $\rightarrow$ min

The problem efficiency index will be designated as W, and the efficiency indexes for every stage - j_i, $i = 1...4$.

If W possesses the property of additivity, then we can write down

, (1)

where j_1 - the efficiency of fuel supply stage; j_2 - the efficiency of energy production stage; j_3 - the efficiency of energy distribution stage; j_4 - the efficiency of energy consumption stage.

Fig. 1. **Stages of energy moving**

Variable X_i, on which the efficiency on a stage i, depends and therefore the whole efficiency is called stage management, $I = I...m$.

The process management in general (X) is called sequence of stages management (commands vector) $X = (x_1, x_2, ... x_i, ... x_m)$.

In our example the most important stage is the stage 3 (the stage of energy distribution), so we should consider it in details.

We are to use two-step mechanism for the optimization of this stage, solving the transportation problem first and then optimize using the DP method.

The following factors are necessary to perform these problems:

- the capacity of energy produced by the equipment;

$W_П$ - the capacity of energy consumed by population;

R - the total distance between the generating equipment and consumers energy. Meanwhile

$$R = \sum_{i=1}^{n}\sum_{j=1}^{m} r_{i,j} \qquad (2)$$

where r_{ij} - the particular distance between the generating equipment and energy consumer; $I = 1...n$; n - the number of generating equipment; m - the number of energy consumers.

Meanwhile

$$W_n(R) \to W_э, \qquad (3)$$

We will take into consideration the cost of transferred energy from i-consumer to j-supplier C_{ij} and will find the loss (expenses), taking into consideration the request in the energy need of a particular consumer W_c, with a formula

$$P = C_{ij} \cdot W_c \cdot R_{ij}, \qquad (4)$$

where C_{ij} is the cost of transferred energy of W_c content on the distance from source i to the consumer $j(R_{ij})$.

Then we need to examine the functional for optimizing objective effectiveness function (the efficiency of the region electricity supply system functioning tends to max). The additivity is one of the reasons of DP (dynamic programming) application. The energy-supply system is complicated one. We need to solve it optimizing every step. We determine the efficiency of every step - one of the constituent according to functional

$$F = f(W, R, P). \qquad (5)$$

Thus, the application of optimal control theory can be scientific base of the consumers' optimal energy-supply mechanism. The optimization mechanism is the combination of the economic-mathematical modeling in the form of transport problem and dynamic programming, which allow determining the optimal composition of the functions' totality, describing the area consumers' energy-supply.

The number of mini-heat station is determined by the demanded energy $W_э \cong W_п$, where $W_п$ depends on R and depends $W_п$ on $R = \sum_{i=1}^{n} ri$. (6)

Then $W_n(R) \to W_э$. (6)

We choose the Samara region to calculate the model confirmations:

We need to know: m - the number of boiler houses; n - the number of consumption objects; The distance from i-supplier to j-consumer; The loss (p) for 1km; The cost of energy transferred from the supplier to consumer; We will perform calculations according to data of Pokhvistnevo town; Today there are six boiler houses in Pokhvistnevo. They have a summary heating efficiency of 52 Gcal/h on an average; We suggest the using of two mini- heat stations with a summary efficiency of 62 Gcal/h. It is proved by solving the transport problem.

Thus, we introduce the strategy of the development evaluation of the HCS energy-supply system presented on the picture 2. The given strategy is a procedure, which includes a set of rules, algorithm according to which we can estimate the development of the HCS energy-supply system. The suggesting strategy consists of four interconnected stages. On the first stage the condition of HCS in terms of indicators correspondence to the environment is estimated. As a rule the controlled indicators are compared in dynamics and the problems of the existing branch condition are revealed. On the second stage the possible courses of system development through the improvement of some factors are analyzed. On the third stage the correlation of factors and their final influence on the whole test subject is disclosed on the base of these and other factors. On the fourth stage directly the development of energy-supply of HCS system is designed. We should describe every stage more detailed.

On the first stage it is necessary to estimate the branch condition on the particular territory. And the basic indicators, describing the level of HCS condition should be revealed. We defined the following indicators: level of physical depreciation of the basic HCS funds, the investment volume in this branch, the expenditure level for the basic funds exploitation, the level of gross regional product energy intensity, the HCS part in the pattern of consumption of heat and electric energy.

The next stage is connected with the analysis of the HCS energy-supply system development. On this stage there are the following important indicators: as the number of generating equipment in the region, its technical condition level, the capacity level of the HCS energy-supply system, the technical state level and the length of electric nets between the producer and consumer, the annual output size of the electric energy and the annual purchase of the electric energy with a New Wholesale Market of Energy and Capacity (NWMEC), the annual output size of heat energy, the level of fuel utilization factor, the energy loss level on the production and distribution of the energy stage, the heat and electrical energy cost price level.

On the third stage factor analysis of the energy-supply system is carried out with a purpose of the basic factors detection, which finally influences the heat and electrical energy cost price. It is necessary to define the following: to analyze the factors, which influence the development of the energy-supply system; to systematize the factors and their scores; to detect the influence of every factor on the cost price level of the heat and electric energy in the region; to detect the factors, which have a great effect on the resulting indicator; to make the models of the interconnection of the most significant factors.

On the last stage the HCS energy-supply system development is designed. The fourth stage is based on the previous three and is defined with the following actions: the designing of networks, which provide the HCS energy-supply system development; the detection of the generating equipment optimal number on the territory with taking account of the needs; the effective placement of the generating equipment model development; the management of the HCS energy-supply system algorithm creating; the calculation of the cost efficiency indicators; the assessment of the system departure from the given development stage; the designing of the correcting actions for the departing factor lowering.

Thereby, this strategy of the development evaluation of the HCS energy-supply system can be used for any branch of economics on the particular territory.

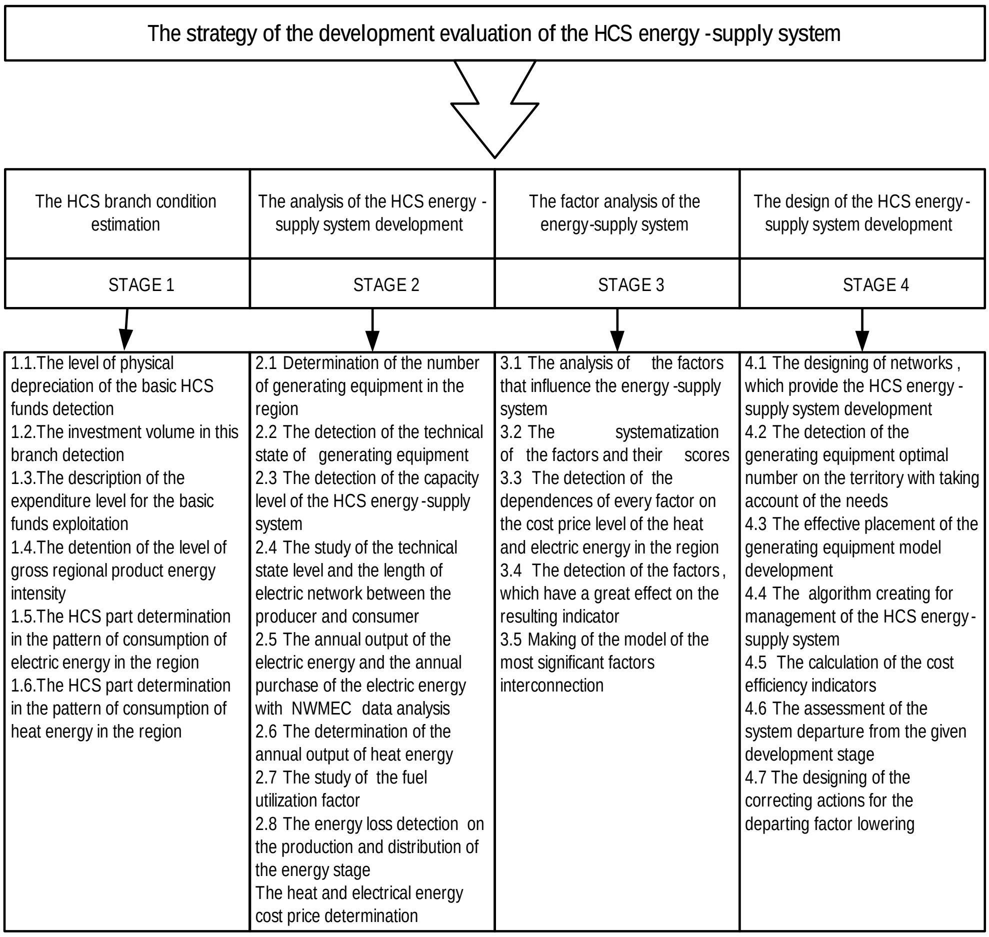

Fig. 2. **The strategy of the development evaluation of the HCS energy-supply system**

The described above strategy is directly connected with the model of the development management of the HCS energy-supply system, presented on the picture 3.

We revealed the constituents of every presented subsystem. Under the mission subsystem (1) we understand the set of missions, in compliance with which the management of the HCS

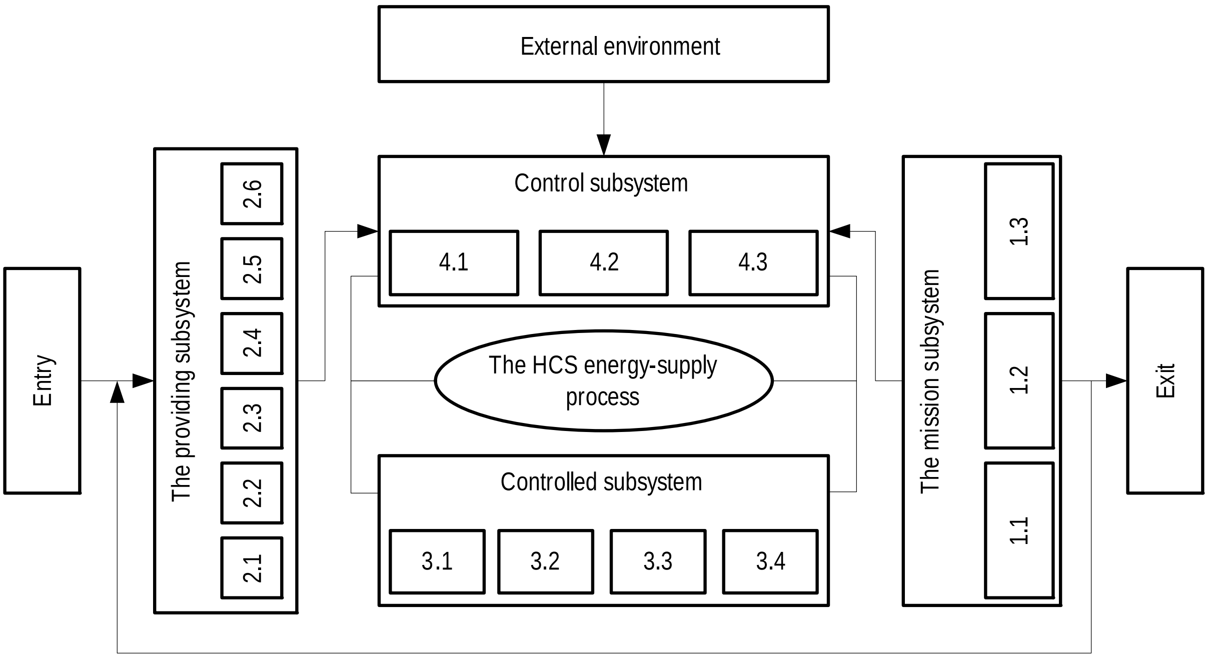

Fig. 3. **The model of the management of the HCS energy-supply system**

energy-supply process is realized. Every mission has its own evaluating mechanism of achievement. The feedback allows evaluating and regulating of the managerial mechanism by timely correcting actions. The mission of subsystem includes: the maximal use of electric and heat energy with the minimal expenses (1.1), the development of the HCS energy-supply system (1.2), the adaptation of the system to the external environment (1.3).

The providing subsystem (2) includes the methodological support (2.1), information support (2.2), legal support (2.3), financial provision (2.4), staffing (2.5), and organizing-technological support (2.6).

The controlled subsystem (3) includes marketing research (3.1), the HCS objects of energy-supply (3.2), the creation of electric and heat energy (3.3).

The control subsystem (4) includes the control of the HCS energy-supply (4.1), the development and the acceptance of managerial decisions concerning the development of the HCS energy-supply system (4.2), the coordination of the arrangements, which concern the realization of the managerial mechanism by the HCS energy-supply system (4.3).

It is necessary to note that the both worked out strategy of the HCS energy-supply system development evaluation and the model of the management of the HCS energy-supply system are the recommendations for the Samara region HCS energy-supply system development with a purpose of the heat and electrical energy cost price lowering by energy conservation.

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