UDC 519.7:519.85

O.Y. Churina, candidate of sciences, engineering
(National Aviation University, Ukraine)

Innovative management of an energy-efficient complex electric power system

In this work, the issue of methodological support for increasing the energy efficiency of electric power systems is considered. An analysis of complex socio-technical systems is proposed for modeling the energy efficiency of electric power systems. Optimization issues of energy supply in electric power systems are considered. It is noted that the design of ergatic control systems is based on evolutionary modeling.

I Introductory

Methodological support for assessing the priority of improving energy efficiency by type of industrial activity is determined by the following initial factors: the complexity of the structure of the industrial complex, different values of different types of industrial activity, different quantitative values of energy intensity. Analysis of these factors in the process of assessing the energy efficiency of industrial activities will establish the priority of energy efficiency. Therefore, it is expedient to develop methodological support for the information system for decision support in the electricity system. The tool of strategic planning is a strategic map, which is a way of modeling strategy. This process allows you to set and manage goals and indicators, that is, to visualize the causal relationships between the elements of the strategy. In the process of developing a strategic map, it is advisable to determine the following elements: strategic goals and prospects, targets and their quantitative values, the establishment of cause-and-effect relationships. Regarding the development of a strategic energy efficiency map, it is worth noting that energy efficiency characterizes all components of development of the region: economic component, environmental component of energy efficiency, which is derived from the economic component, as well as social component [1].

II Mathematical modeling of innovative management of the complex electric power system

Simulation modeling methods implement an algorithm for reproducing the functioning of the power system in time. Thus in the literature it is offered to apply the following methods of simulation modeling: discrete - event modeling, network concepts, system - dynamic modeling, cognitive modeling. Regarding the modeling of energy efficiency of industry in the region, a method of system dynamics is proposed, which reflects the processes of functioning of complex socio-technical systems. Based on the method of system dynamics, it is proposed to carry out the process of forecasting the increase of efficiency in the industry of the region, taking into account the extensive and intensive types of its development. According to the extensive type of development, the energy efficiency of the power system is increased due to expanded production and modernization of technical and technological base [1]. According to the intensive type of development, the intensity of consumption of raw fuel and energy resources is expected to decrease. Thus, the main factors in the choice of energy sources are technical and economic problems, the solution of which

is carried out at the enterprise level. The optimal choice of energy source is determined by the technical purpose and the final cost of useful energy, the cost of supply and distribution of energy. It is also necessary to analyze this process in environmental and commercial aspects, which allows the implementation of an energy management system. Thus, energy management is a complex hierarchical system, which includes management of both the process of energy production and the process of energy consumption. At the same time, the process of energy saving is a component of energy management, which involves assessing the energy efficiency of non-traditional and renewable energy sources. Efficient energy consumption can be ensured by joint solution of such tasks as security of energy supply, legislation and regulations, environmental issues [2]. Improving energy efficiency will help increase the reliability of the energy supply process, the optimal solution of environmental problems. It is proposed to develop the energy saving process in the following areas: analysis of the region's energy needs, development of information base of energy saving technologies, analysis of traditional alternative and non-traditional energy sources, energy audits of electricity supply systems (EPS). The process of normalization of energy consumption is carried out. The norm of specific energy consumption is the maximum allowable value of energy consumption under certain production conditions. The process of solving the problem of normalization of energy consumption is the basis of practical energy conservation. Depending on the degree of aggregation, energy consumption rates are classified as individual and group. Individual cost norms are taken into account at facilities, group cost norms are formed at enterprises.

Thus, in the process of normalization of energy consumption requires solving the problem of establishing individual standards of specific energy consumption in the power management system. Optimization of energy processes in the hierarchical power system involves meeting various criteria for optimal electricity consumption. Such optimality criteria are: minimum losses, minimization of instantaneous current values, uniform energy consumption, elimination of reverse energy flows. The criterion of minimum energy losses under the conditions of its transfer from the energy source to the load satisfies equation [3]:

$$\frac{u(t)}{i(t)} = \frac{U^2}{P} = const.$$

This equation corresponds to the coincidence of the shape of the instantaneous voltage $u(t)$ and the current $i(t)$ and reflects the implementation of Ohm's law at resistance, which is independent of frequency and time. The current value in the power system is minimal. The criterion of minimization of instantaneous current values limits the maximum value of instantaneous current in the power system, which provides protection of electrical equipment. By

$$I_{max} \geq \frac{u(t)_{max} * P}{U^2}$$

where $u(t)_{max}$ is the maximum value of voltage during the period T, this criterion may coincide with the criterion of minimum energy loss. The criterion of optimality, which ensures uniform energy consumption from the source - generator during the period of operation of the EPS is satisfied in EPS, the process of power consumption

in which is described by the equation $p(t) = P$, $t \in [0, T]$. That is, the instantaneous power function is a time-constant value. The degree of uniformity should be assessed by integral and instantaneous characteristics. Regarding the construction of integrated characteristics, it is necessary to analyze the components of instantaneous power - the energy of the power system node

$$W_{kc} = \int_0^{\frac{T}{2}} |p(t) - P| dt$$

fluctuating around the average level, as well as the energy of the active element of the consumer

$$W_{ka} = \int_0^{\frac{T}{2}} |p_a(t) - P| dt,$$

oscillating around the mean level, where $p_a(t)$ is the instantaneous power on the active element. These components of instantaneous power should be characterized by the degree of equilibrium of energy fluctuations in the power system:

$$\varepsilon_{kc} = \frac{PT}{PT + W_{kc}},$$

as well as active energy in consumers

$$\varepsilon_{ka} = \frac{PT}{PT + W_{ka}}$$

Instant description

$$\delta_p = |p(t) - P|_{max}, t \in [0, T]$$

simulates the maximum deviation of the instantaneous power from the average value. The criterion of optimality, which satisfies the condition of eliminating reverse energy flows in the power system, provides optimization of the power consumption process in EPS, which requires to exclude reverse energy flows from the load to the energy source - the generator [3].

The classical methods of synthesis of control systems are based on the mathematical apparatus of integro - differential calculus. Artificial neural networks, as well as genetic algorithms for their operation, are an innovative direction in the modeling of ergatic control systems. The design of ergatic control systems is based on evolutionary modeling. Evolutionary modeling is a field of mathematical modeling, which is a superposition of computer modeling methods, heuristic programming methods, which are based on genetic algorithms, artificial neural networks, fuzzy logic.

Innovative management of hierarchical EPS is a search for a palliative optimal solution. Palliative optimal decision is made in the process of multi-purpose planning under the condition of fuzzy information. It is advisable to use methods of fuzzy mathematical programming. Then the task of multi-purpose planning is the task of minimizing vectors under the condition of fuzzy information.

The mathematical model of the problem of fuzzy multi-purpose planning for the

development of ergatic power system with fuzzy parameters are:

$$\min f\,(x,\tilde{a}) = \{f_i(x,\tilde{a}_i)\}, i = \overline{1,k}$$

by

$$x \in X(b) = \left\{x \in E^n \middle| g_j\left(x,\tilde{b}_j\right) \le 0, j = \overline{1,m}\right\},$$

where x - n - measurable vector of variables;

$\{f_i(x,\tilde{a}_i)\}, i = \overline{1,k}$ – a set of mutually contradictory objective functions;

$\tilde{a}_i, \tilde{b}_j, i = \overline{1,k}, j = \overline{1,m}$ are vectors of fuzzy numbers;

$\{g_j(x)\}, j = \overline{1,m}$ is a set of functions of problem constraints;

X is the area of constraints.

The objective functions in this model are vectors. Fuzzy parameters of this control model determine the search for α - palliative optimal solution [4].

In the intelligent ergatic power system, electricity generation is carried out in the process of operation of intelligent means of diagnostics of electrical equipment, systems of integration of renewable energy sources, distributed generation under the condition of ensuring the reliability of EPS, improving electricity quality. During the operation of the electrical distribution network, its controllability and reliability are increased. Power electrical equipment, protection systems and automation operating on the basis of microprocessor technology, innovative information technologies are used. Modern intelligent power system management systems provide flexible adaptive qualities in terms of their topology and parameters. The development of innovative electricity is carried out in conditions of uncertainty and multi-criteria. At the same time, it is expedient to investigate the extremization of target functionals in the search for solutions of optimization electric power problems on the basis of fuzzy mathematical programming methods. Heuristic programming methods used in the process of mathematical modeling of intelligent power systems involve a fuzzy choice of options for acceptable solutions of multicriteria optimization of power problems. In order to find solutions to these problems, it is necessary to construct membership functions of indicators of variants of admissible solutions, as well as to construct membership functions of indeterminate values of optimality criteria, to determine the set of Pareto - effective options. As a result, this leads to a reduction in the sample of alternative solutions or to finding the optimal solution to the problem of power optimization.

III Conclusion

The energy efficiency of innovative electric power engineering is based on evolutionary modeling, which is a superposition of heuristic programming methods and computer modeling methods.

References

1. Afanasiev M. V. Strategy for promoting energy efficiency of the industry in the region: theoretical and methodological aspects of formation: monograph / M. V. Afanasiev, T. I. Salashenko. : View. HNEU, 2014. - 284 p. (in Ukrainian)

2. Energy management / Y.V. Dzyadikevich. - Ternopil: Ekonomichna Dumka, 2010. - 295 p. (in Ukrainian)
3. Tonkal V.E., Novoseltsev A.V., Denisyuk S.P. Energy balance in electrical networks. – K.: Nauk. Dumka, 1992. - 312 p. (in Russian)
4. T.Terano. Applied fuzzy systems. -M.: Mir, 1993. - 368 p. (in Russian)