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IOP Conf. Series: Journal of Physics: Conf. Series **803** (2017) 012174 doi:10.1088/1742-6596/803/1/012174

Intelligent Energy Systems As a Modern Basis For Improving Energy Efficiency

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Abstract. This work presents data on the share of energy costs in the cost structure for different countries. The information is provided on reducing the use of energy resources by means of introducing the intelligent control systems in the industrial enterprises. The structure and the use of such intelligent systems in the energy industry are under our consideration. It is shown that the constructing an intelligent system should be the strategic direction for the development of the distribution grid complex implying the four main areas for improvement: intellectualization of the equipment, management, communication and automation.

1. Introduction

Modern Russian economy is extremely energy intensive. The share of energy resources costs in the cost of the production structure in Russia is on average 1.7 times higher than those in China, 7 times higher than in the U.S. and 12 times higher than in the EU countries. The situation in the power sector is no exception.

We see the solution to this problem in the introduction of intelligent systems to control the use of energy at the industrial enterprises. In modern literature, this process is called "intelligent systems" or is similar in the meaning to the concept "intellectual energy." However, despite the clear description of the boundaries of the object of research, most scientists cannot reach a consensus what exactly this concept means.

To deal with this issue, we turn to the history. Particularly, sixty years ago a scientist, D. McKay (1951), introduced the concept of self-managing machines (such term as "artificial intelligence" did not yet exist). By his definition, the self-managed systems were the systems that were classified according to how they carried out the following general functions:

• reception, classification, storage and transmission of information;

• reaction to the changes in the environment, including the provision of the information about the state of the machine itself;

• deductive reasoning based on the set of assumptions or presuppositions and learning.

2. Methodology

In case of the definition suggested by D. McKay, learning includes monitoring and control of one's own purposeful behavior. All the above-mentioned features are certainly typical for a modern intellectual system including the ones in the sphere of energetics [1].

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In terms of technology, the most interesting and informative is the definition of a system given by academic P.K. Anokhin: “The system is a complex of selectively involved components which interaction and relationships take on the character of joint action of the components on getting a focused useful result” [2]. The “focused useful result” here can be seen as the goal of the operation of the system. Such definition of the system connects it with the purposeful activity. The author had the privilege of working under the leadership of P.K. Anokhin in the bionics laboratory in 1965-1968.

3. Discussion of Results

Intelligence in terms of technical systems should be viewed as a combination of the ability to predict the medium with the ability to select an appropriate response from a variety of alternatives based on the result of the prediction and chosen goals. It seems meaningful to define intelligence in terms of behavior of the system (live or artificial) seeking the objective and to measure the degree of its intelligence according to the adequacy of its decisions. In the absence of an objective, decision-making is pointless and the term “intelligence” has no meaning.

In this article, intelligent technical systems should include technical systems, which having a few goals of functioning (and perhaps able to generate these goals!) choose the most suitable objective depending on the environment predicting the behavior of the environment and its own state. It is the latter definition, in our opinion, that is of practical value to the developers of the modern intelligent systems including the energy industry.

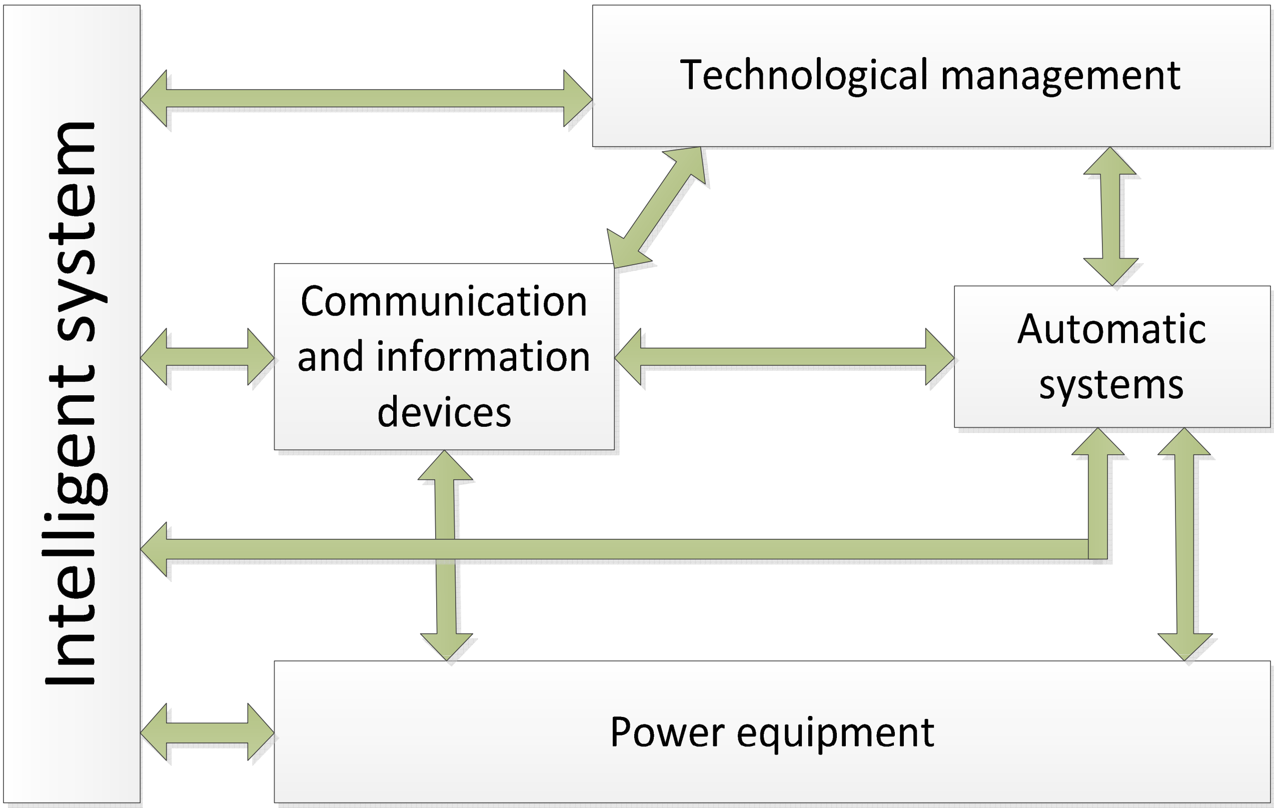

Figure 1. Organization of intelligent energy system networks for improving energy efficiency.

Let us consider the elements for the improvement of the intelligent systems in the energy sector and, in particular, in the intelligent systems. Building an intelligent system should be the strategic direction for the development of the distribution grid complex (fig. 1) implying four main areas for the improvement [3, 4]:

•intellectualization of the power equipment and technology for the electricity transmission and distribution;
•intellectualization of the technological management;
•intellectualization of the specialized communication and information devices;
•intellectualization of the automated accounting systems and custom load management.
The concept of intellectualization should promote the following functional properties of energetic (fig. 2):
•provide self-recovery in case of emergency perturbations, moving from the control of the perturbation to preventing an accidental damage of the network elements;
•develop motivation for the active behavior of the final consumer;
•provide resistance to the negative influences, including enabling information and energy security;
•ensure the security of the energy supply and the necessary quality of electricity in the different price segments as well as the transformation;
•cover a variety of types of electrical power plants, electricity storage devices (distributed generation) and optimal integration of the generating and accumulating capacities in the power system, provide the connection using the standardized procedures of the technical connection and introduction of the "micro-energy-systems" at the users level;
• provide monitoring and control over electric power transmission to the consumer on condition that electric power losses are minimized at all stages of its generation and distribution and cost for the final consumer;
• provide stability and reliability of electricity supplies to external and internal consumers of the energy system;
•optimize the management of the production facilities, moving to the remote control operation and modernization of the production assets in order to increase the efficiency of the fund management and improve their reliability and repair.

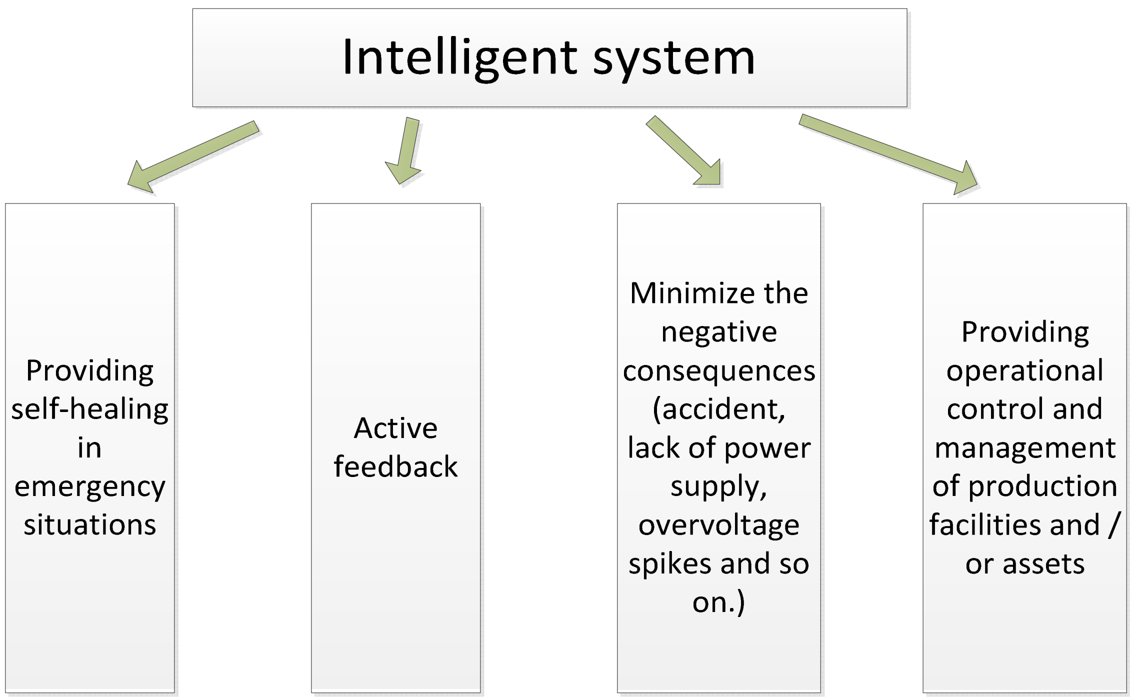

Figure 2. Influences of intelligent system

4. Conclusion
The introduction of the intellectual electroenergetics in Russia will allow obtaining not only technological effects, but also direct economic ones. The simulation results of the changes in the

development parameters of the intellectual electroenergetics in Russia for the period of up to 2030, conducted in the Institute of Energy Researches of Russian Academy of Sciences (IER of RAS), show that the transition to the innovative variant of the development of Russian energetics on the basis of intellectual technologies will be accompanied by the essential reduction in putting into operation of new power stations and the net entities connected with them for power output. This will provide the reduction in the volume of investment in the basic capital assets by almost 2 trillion rubles by 2030.

The additional effects will amount up to 1.5 trillion rubles due to the reduction in the expenditures on the fuel, reduction of the conditionally constant costs at lower rates of putting into operation of power stations, and the reduction in savings from economic value of the greenhouse gas emission.

Thus, the total economic effect in the case of intellectual energetics development in Unique Energetic System (UES) of Russia before 2030 can equal 3.5 trillion rubles. However, its value must be compared to the investments, which are necessary to spend on the mass introduction of new technological means and control systems at users' areas, in the distributing complex, in UNPN (Unique national power network), generation, in the circuits of technological and commercial dispatching.

At that, in the current economic situation, when Russia is under conditions of external constraints (sanctions) and a high exchange rate of a ruble relatively dollar and euro, it is hard to talk about mass application of foreign high technologies in the home energy market. This fact can lead to a rapid increase of prices for electric power for the final consumer, and, consequently, to the increase of the prices for Russian goods and services. The only way out that suggests itself in this situation is development of domestic technologies of intelligence energy systems, for which there are all prerequisites in different branches of industry, for example, metallurgy (see [5]-[6]), information technologies, instrument-making and etc.

Therefore, even at pessimistic estimation, the capital investment into intellectualization of UES of Russia will be fully compensated by the obtained effects, and at lower estimation of the cost of the implementation of IES program with AAN (intellectual electro-energetic system of Russia with the actively adaptive network), the effects will exceed the capital expenditures by almost 1 trillion rubles. In this case, the value of the net effect after 2030 will accrete additionally by approximately 1 trillion rubles every five years over the period of the aftereffect of the investment decisions on the development of the intelligence energetics made earlier.

Thus, the introduction of the intelligence energy systems in Russia will allow establishment of favorable conditions for the introduction of the intelligence systems into the operation of the industrial enterprises, acting as a peculiar incentive factor for the application of the intelligence systems in power engineering, providing quick payback of such projects, and, finally, an increase in the power efficiency of the Russian industry up to the level of the developed countries.

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