SMART CONTROL IN THE RUSSIAN ELECTRIC POWER SYSTEM

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Abstract: The paper describes creation of the intelligent electric power system of Russia on the base of the concept of intelligent energy system with active&adaptive network. Main requirements, goals, and technologies of the intelligent electric power system are listed. The features of the system that appear in the Unified national electric grid are considered. Special attention is paid to the structure and problems of control system. Intelligent electric power system should provide a qualitatively new level of the efficiency of the electric power industry operation and development, improve system security as well as quality and reliability of electricity supply to consumers.

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1 INTRODUCTION

A totally novel approach was suggested to make the transition to a qualitatively new level of technologies and control of Russia's Unified power system. The main goal of this approach is implementation of intelligent technologies in the Russian power industry to ensure an innovative breakthrough in development of the industry, and to increase the efficiency, reliability and security of its operation.

In 2010 the concept of Intelligent Electric Power System with Active&Adaptive Network (IES AAN) was developed by the JSC "R&D Centre for Power Engineering" by the order of the JSC "FGC UES" responsible for development and operation of the main electric networks in Russia. The concept of IES AAN stipulates that all subjects of the electricity market (generation, grid, and consumers) take an active part in the processes of electric power transmission and distribution. Electric power consumers as a part of IES AAN should become its leading component. Transmission and distribution networks, which are passive now, will turn into active components, whose parameters and characteristics will become flexible according the operation requirements of the entire system.

2 INTELLIGENT ELECTRIC POWER SYSTEM WITH ACTIVE&ADAPTIVE NETWORK

The goals of intelligent electric power system include (Voropai, 2011):

- In electric networks:
  - Power quality control;
  - Peak load shaving in electric network;
  - Creation of an alternative to reconstruction of the network infrastructure in the network "bottlenecks";
  - Creation of an alternative to expansion of the network infrastructure for electricity supply to remote and isolated areas;
  - Reduction of power failure time, and the time it takes to eliminate the failures;
  - Reduction of expenses for the network infrastructure maintenance, and its automation;
  - Operation and emergency control of the grid.
- In electricity consumption:
  - Reduction of electricity costs;
  - Provision of continuous energy supply;
  - Improvement of power quality;
  - Use of infrastructure for smart houses and electric cars;

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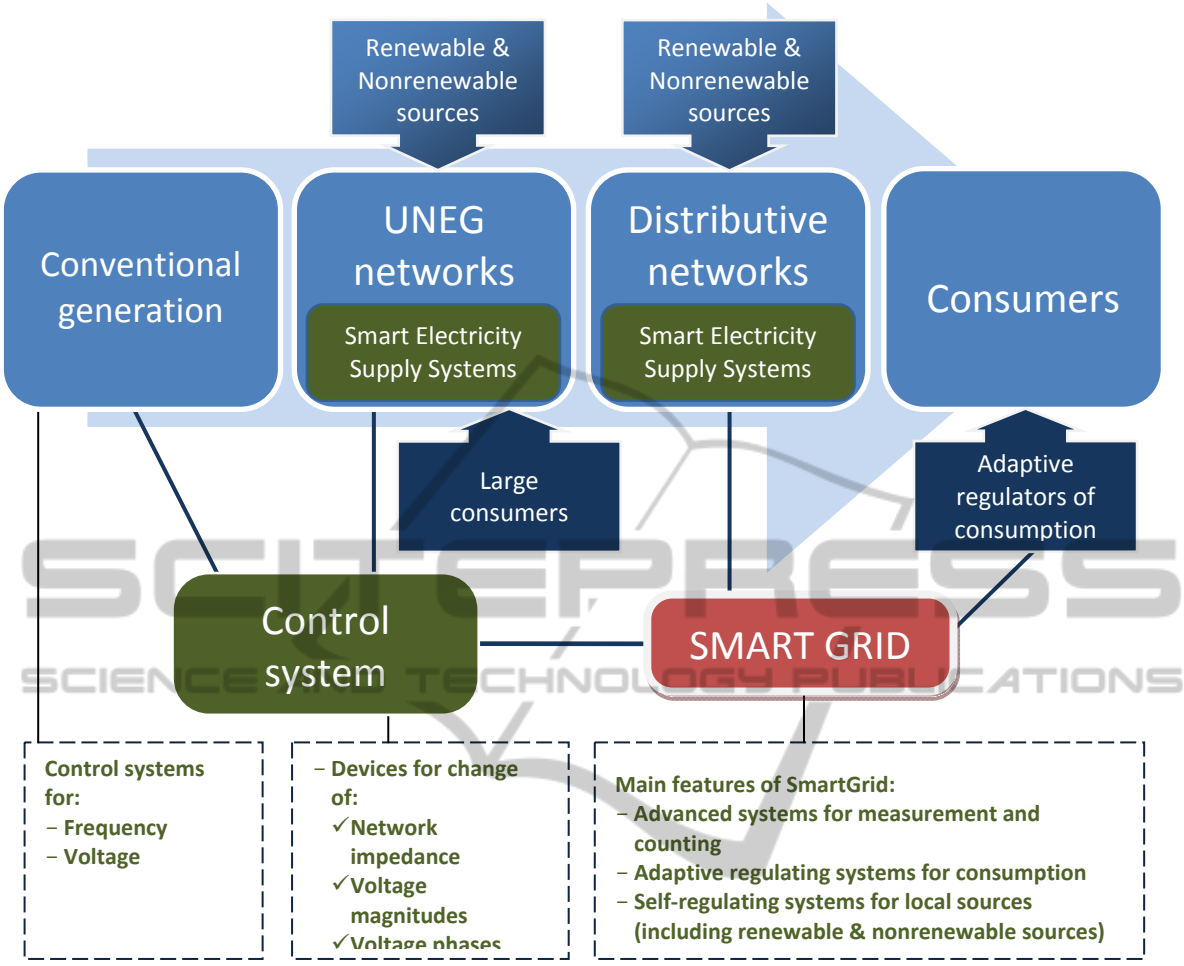

Figure 1: IES AAN technological infrastructure.

- Integration of consumers with their own micro-generation.

- In generation:
  - Maintenance of frequency;
  - Increase in available capacity;
  - Integration of variable generation sources, including wind turbines and mini-cogeneration power plants (mini-CPP);
  - Creation of an alternative to construction of generation capacities for electricity supply to remote and isolated areas.

Intelligent electric power system (Fig. 1) represents a customer-oriented electric power system of new generation which should provide high-quality, reliable and efficient services for electricity consumers through flexible interaction among all types of generation, electric networks and consumers on the basis of cutting-edge technologies and a single hierarchical system of control.

The unified national electric grid (UNEG) carries out backbone functions and includes power segments grids[1], electricity supply systems (ESS), the bulk transmission and international grids.

At formation of IES AAN, the UNEG components of different voltage levels should contain the devices changing impedance of the grid elements and voltage (both magnitude and phase) at various points of the grid. Possibilities of combining alternating and direct (lines and back-to-back stations) currents as well as modern devices of short circuit currents limitation in powerful switching equipment will be widely used.

Current ESSs represent a set of units for providing the consumers with electricity. They are formed both within the frames of UNEG, and on the base of distributive networks (Fig. 1).

ESS structure can include sources of electric

[1] Following the IES Concept the "power segment" is a set of control areas with the common (or similar) principles of electricity (and/or power) balancing.

power, electric power transmission, distribution, and transformation devices, various auxiliary devices and constructions (power plants and feeding lines of regional power systems, transmission lines, substations and distribution devices).Within the IES AAN framework one of the smart ESS's key functional characteristics is the motivation of active behavior of the end-consumer which is understood as a consumer possibility to independently change the received electricity volume and functional properties (level of reliability, quality, etc.) according to the balance of the requirements and possibilities of a power supply system, using the information about prices, electricity supply volumes, reliability, quality, etc.

3 CONTROL SYSTEM OF IES AAN

The problem of efficient control of created IES AAN for today, whose urgency and importance have been confirmed by recent large man-caused failures, is among the most important scientific and technical problems. With the availability of an effective control system IES AAN can provide reliable interaction between consumer grid units of different functions, and generators, using uniform principles and the common information-technological platform.

The structure of IES AAN control (Fig. 2) should be formed on the basis of the following principles:

1. At construction of IES AAN a control system realizing operating functions with a high degree of automation is a key link.
2. IES AAN control systems should have the uniform (coordinated) principles of management regardless the form of property and hierarchical level.
3. When combining the local and system functions of management, the relations between controls of generation, networks, and load-controlled consumers should be traced explicitly.
4. Information support of control systems should provide a possibility to control parameters and transit signals into control loops in real time.
5. The software of control systems should be realized in two time modes: on-line and off-line to trace and control both normal (optimization of conditions) and abnormal (prevention of overloaded and liquidation of pre-emergency conditions) EPS operation, and also to have possibility of adaptation to changing situations.
6. The communication systems included in the control loop should provide high speed and reliability of information and control signals transfer.

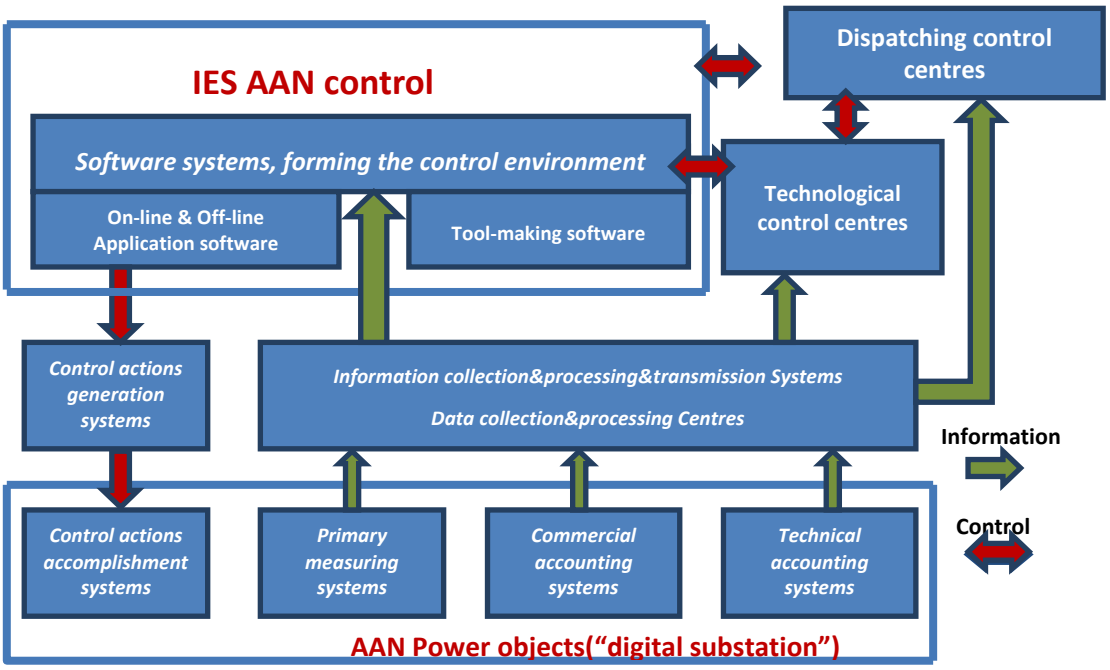

Figure 2: The functional structure of IES AAN control.

The modern IES AAN control system should provide the solution of the following problems:

- Control of IES AAN operation conditions and parameters;
- Control of settings, parameters and conditions of active-adaptive devices and technological objects of IES AAN;
- Control of routing and transmission of the electricity and power on the basis of active–adaptive algorithms;
- Monitoring of a technical state, operation and reliability of IES AAN basic objects;
- Monitoring of a technical state of auxiliary technological systems;
- Planning and development of an IES AAN technological complex;
- Power quality control;
- Provision of technological safety and control of IES AAN and its objects in emergency situations;
- Estimation of situations and forecasting of their development for decision-making;
- Technical support and operation of technical objects and facilities of IES AAN;
- The commercial and technical account of the electricity and power;
- Information interaction in a hierarchical network of IES AAN dispatching and operating structures;
- Information security of a control system.

For the effective solution of IES AAN control problems on-line in the conditions of incomplete information on parameters of EPS and disturbances, the use of uniform principles of control and qualitatively new kinds of techniques and technologies is necessary, including means and systems of:

- Control and regulation of active and reactive power with application of power electronics;
- Limitation of short circuit currents;
- Electricity storage;
- Forecasting and intelligent analysis of emergencies;
- Support of operative decisions, generation of recommendations and control actions on localization and liquidation of failures;
- Control and analysis of a technical state and a residual resource of the technological equipment;
- Availability of high-speed, completely integrated, bilateral technology of communication and commutations between IES subjects for interactive interchange of information, energy, and monetary flows between them in real time;
- The intelligent account of the electricity and control of power consumption.

4 CONCLUSIONS

The further development of IES AAN provides:

- Design and the subsequent application of new types of power equipment giving active properties to an electric grid (on the basis of power semiconductors, new kinds of materials, including high-temperature superconductivity and so forth);
- Creation of new means and systems of relay protection, automatic operation and emergency control devices, and equipment diagnostics;
- Creation of new systems and means of accounting energy resources;
- Design of control systems for substations of new generation;
- Improvement of existing hierarchical systems for coordination and control of power flows and frequency regulation, for automated control of generation, IES AAN fragments (power segments), and the integrated control systems of higher level, as well as design and implementation of new ones;
- Provision of a new quality of monitoring and protection of networks against external contingencies (lightning, icing, wind effects, wires sagging etc.);
- Monitoring of parameters of reliability and quality of electricity transmission services.

Finally creation of IES AAN should provide a qualitatively new level of efficiency of electric power industry development and functioning, raise system security and, the main thing, quality and reliability of electricity supply to consumers.

REFERENCES

Voropai N. I., 2011. *Intellectual electric power systems: the concept, a condition, prospects*//Automation and IT in power engineering, 2011, №3. With. 11-15. [in Russian]