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ELECTRIC POWER

TRANSMISSION AND DISTRIBUTION

Special issue, February, 2014

Power supply control of Olympic sites in Sochi

Integrated technical regulatory base of power engineering

Grid energy storage at UES power sites

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ELECTRIC TRANSMISSION AND DISTRIBUTION POWER

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Dear readers of the special issue of the magazine “ELECTRIC POWER. Transmission and Distribution” devoted to the 4th International Smart Grid Exhibition-2014 which will be hosted in Japan.

International cooperation on the further development of electric power systems, including the improvement of energy efficiency and energy saving technologies, as well as the use of renewable and non-conventional power sources and new high-tech solutions, is becoming more important. The extension of ties in this area is one of the main aspects of economic cooperation between Russia and Japan. The Embassy provides full diplomatic support to promote bilateral dialogue on energy issues. In cooperation with Japanese partners a number of projects, primarily in the Russian Far East, are under way.

Such significant events as the 4th International Smart Grid Exhibition-2014 are effective platforms for deepening contacts between specialists in electric power from different countries. This contributes to a common understanding of promising trends in this sector, development of the exchange of information on the energy policy and the situation in markets for energy, as well as the shared search for technical solutions. I am confident that partnership in electric power field both bilaterally and multilaterally will make a significant contribution to the strengthening the energy security in the Asia-Pacific region.

I would like to extend my wishes to organizers, participants and guests of the 4th International Smart Grid Exhibition-2014 for a successful and effective work, facilitation of business relations and development new joint projects.

Ambassador Extraordinary
and Plenipotentiary
of the Russian Federation
to Japan

E. Afanasiev

Dear participants of the 4-th International Exhibition on Intelligent Networks (4th International Smart Grid Expo 2014)!

The integrated power grid of Russia undergoes serious changes directed to the overall improvement of its effectiveness, the provision of reliable and uninterrupted power supplies to consumers through upgrading and improving the reliability of the network, its priority technology development, as well as the formation of an effective and reasonable tariff policy and investment attraction. However, the achievement of the strategic objectives set by the industry depends, in the first instance, on the development and application of the new high-performance technical solutions that meet modern requirements for reliability, quality, safety and availability in current activities. A key role in this regard plays development and implementation of effective (intelligent) power grid control systems. As is well-known, it is impossible to achieve optimal operation of the system by increasing the reliability and efficiency of its individual elements. The development and implement of integrated solutions that take into account all factors and aimed at fulfilling the full range of tasks is required.

That is why, the role of major international events like the 4th International Smart Grid Expo 2014 organizing joint work of a wide range of professionals, providing the possibility of a visual reference with the latest developments of leading scientists and engineers, and encourage the formation of new optimal solutions respecting the interests of the majority is invaluable.

For the same reason, I consider it extremely important issue and circulation among wide range of international experts such a specialized magazine as “ELECTRIC POWER. Transmission and distribution” publishing not only information on the latest developments in the management of the grid complex, but also scientific, analytical and educational articles to promote the exchange of views and information on the latest developments in a reader-friendly form and setting without permanent separation from production activities.

I wish all the participants of the event successful work, new discoveries and new interesting acquaintances.

Committee Chairman
of Energy State Duma
of the Russian Federation

I. Grachev

Greeting to organizers, participants and guests of the
«World Smart Energy Week»

On behalf of the Ministry of Energy of the Russian Federation welcome the organizers, participants and guests of the world week of smart energy, "World Smart Energy Week"

Today, more and more attention is paid to the development of intelligent energy, the development of innovative, energy-efficient and cost-effective technology solutions, renewable energy, smart grids, green energy in construction and housing and public utility sector. Participation of the Russian delegation headed by the Ministry of Energy of Russia in the World Smart Energy Week is a sign of dynamic development of the trend in Russia.

Tokyo as a host city for the Conference is symbolic for Russia in the shadow of memorandum on cooperation in the energy sector aimed at strengthening energy security in the Asia-Pacific region, development of mutually beneficial trade and economic relations, exchange of technologies, cooperation in the area of energy infrastructure operation and maintenance and implementation of bilateral agreements, signed this year between the Ministry of Energy of the Russian Federation and the Ministry of Economy, Trade and Industry of Japan.

I'm convinced that participation of the Russian delegation in the World Smart Energy Week will give further impetus to the development and strengthening of international cooperation, attract the attention of a wide range of professionals, contribute to further improvement and innovative development of the Russian fuel and energy complex.

I wish all the participants, organizers and guests of the World Smart Energy Week fruitful and successful work, achievement of targets set.

Official secretary,
Deputy Minister of Energy
of the Russian Federation

Yu. Sentyurin

MINISTRY OF ENERGY
OF THE RUSSIAN FEDERATION

Multiagent technology — a new approach to a common technological infrastructure management

The development strategy for the Unified National Electric Grid (UNEG) approved April 3, 2013, as one of the ways to ensure long-term reliable, quality and affordable energy to consumers, involves creation of a smart energy system with an active-adaptive electric power grid — grid of new generation, customer-oriented and based on multi-agent management principle of operation and development. This approach seems reasonable in terms of the need for a unified technical policy, availability, reliability, efficiency, viability and sustainable development of power systems related to critical infrastructures.

Andrei CHEREZOV (Андрей ЧЕРЕЗОВ),
Deputy Minister of Energy, the Russian Federation

WORLD EXPERIENCE

Wide development of digital communication and information technologies has made it possible to tighten regulations for production efficiency and transition to an economy based on knowledge and high technologies. Today new requirements for adaptability of support infrastructure are specified under changing conditions to maintain reliability of industries.

Conventional schemes for distributed infrastructure management are built in a hierarchical manner. This approach, together with the development of process control systems increases the number of elements of technological systems, their dynamism, mutual influence which entail the need to control multiple parameter modes, element and environment state. A need for technology management in an uncertain and incomplete information environment appears.

The growing complexity of creation and maintenance of a large-scale information management systems as well as the threshold of possibility to collect, provide integrity and efficient processing of information necessitate to overhaul and adjust management systems.

In the modern information environment security issue becomes critical, since the intrusion to management process can result in serious consequences.

Response to global challenges was rethinking of management principles and their focusing on the broader use of the possibility of self-organization, which was reflected in the new technological approach — multi-agent systems, modern conceptual direction of informatics, emerging at the intersection of automata theory, complex systems and artificial intelligence. Primarily they found use in the organization of complex socio-technical systems, and critical infrastructure, for which the criteria of reliability and survivability are in the first place.

This type of system has the following characteristic properties:

- adaptability to changes in the environment, structure and state of the control object;
- self-development;
- agent self-decision fastness;
- high survivability systems;
- the ability to modify as parameters as the structure of management system directly in the course of its operation;
- reducing dependence on human factor.

In the power industry this direction began developing since the advent of Smart Grid ideology. In addition to ongoing R&D by such major companies as Siemens, ABB, IBM, Cisco Systems, and others, there are already examples of real multi-agent systems for solving variety of practical problems in power management in the United States, Japan, India, China, the European Union.

■ Japanese developed a multi-agent system for the safe operation of the switching equipment. The system includes Facilitator-Agents, Equipment-Agents and Switch-Box-Agents. They monitor the operational status, service time and the use of equipment elements. Switch-Box-Agents represent the breakers or groups of breakers, carrying out operations to reconfigure the main circuit of the switchgear substation.

■ The European market offers PowerMatcher (Sweden) multi-agent system for optimizing power distribution. The system contains a number of agents, devices, endpoints representing consumers and service agents that participate in the auction mechanism for buying and selling electricity. The PowerMatcher pilot is implemented as a control system for the Danish city Hoogkerk power grid.

■ A number of U.S. and Canadian networks use distributed multiagent system IntelliTEAM II (S & C Electric Company, USA) to control the distribution network recovery after failures.

■ In Australia at the demonstration site “intelligent building» CSIRO Energy Centre deployed multiagent system GridAgents (Pacific Controls, USA) in order to automate power management. Also with the implementation of the system in Manhattan electricity network ConEd (Consolidsted Edison) an objective to integrate “smart building” management system and the distribution network control was achieved.

IEEE is working on the standardization of multi-agent systems, IEEE PES MAS working group is elaborating standard requirements applied to the electric power industry.

We can state that this trend is at the forefront of research, development and pilot implementation in power industry and thus forms the mainstream of future energy technologies in general.

TECHNOLOGY DEVELOPMENT CHALLENGES IN POWER INDUSTRY

In addition to the advantages of multi-agent approach already described a substantial interest in it in the unified power grid is associated with problems of technological development of the industry.

With the growth of small and alternative energy, distributed generation there are new elements of the system — active consumers and “digital energy” customers, technologies based on energy storage systems (high power rechargeable batteries, electric cars, etc.). As a result of liberalization of the electric power industry different energy facilities were owned by entities pursuing different objectives and define specific requirements to operation of these facilities.

All this raises challenges to adapt electric networks to consumer demands, to task-oriented development and unified technological management.

The primary task for distribution networks is to overhaul the architecture of process control systems from the unidirectional power flow architecture of distribution networks to bidirectional.

The following challenges emerge into prominence for the bulk power complex: improvement of control response, efficiency and capacity of network equipment under possible abrupt-changing loads. In the long term problems of energy system functioning and development will be addressed more and more through the development of information and communication technologies and new approaches related to production management.

All of the above trends and solutions are important to Russia. Understanding this, JSC FGC UES in 2010 prioritized transition to smart grid in its strategy to innovation and technological development. For the Russian power industry due to its characteristics intellectualiza-

Table. Process control issues

Technology	Issues	Application
Synchronized and phasor measurements technology	• The complexity of operating model and switching circuit maintenance to obtain real time parameters • Low observability and data inconsistency • Coordination of remote backup protection	• Definition of real time operating parameters of adjacent network elements • Online calculation of generator load characteristics • Determination of trajectory and mode change in normal and emergency conditions • Implementation of a fundamentally new starting elements for emergency control • Realization of high precision traveling wave fault location algorithms on the wave principle • The implementation of new types of unit relay protection with absolute selectivity without need to agree the settings and the opportunity to work at one end of the line
Wireless sensor tags technology	• Manual collection of information on the operation of the equipment and power transmission lines • Electromagnetic compatibility • The need to deploy a low-cost and effective monitoring and Diagnostics systems • Security and staff errors • Electricity theft	• Automatic asset management systems • Self-organizing MESH network sensors to monitor parameters of the equipment • Line objects and substation monitoring and diagnostics system • Staff work with the identification tags, access levels, augmented reality • Realization of indicative self-organizing networks to measure operating parameters in low and medium voltage networks • Development of high-reliability accounting and control system
Optical measurement technologies	• Nonlinear characteristics and low accuracy of electromagnetic devices characteristics • Low electromagnetic compatibility • Hardware robustness, material intensity of use • Mode constraints	• Creation of digital sensors, current and voltage transformers • The use of standard 61850 flexible technologies to implement digital substation • The use of devices for a whole range of measurements, the RP, EA, accounting and quality control • Creation of digital bus to reject copper lines between
Semantic technologies	• The complexity of manual assembly and maintenance of the process model • Different architecture • The problem of uniform standardization • Complexity of disembodied data integration • Necessity to work with multiple applications of different vendors	• Provision of automatic assembly and network topology testing and formation of process model • Automatic evaluation and network clustering into management zones based on connectivity and mode • Development of standard CIM classes entailing spreading agent range and use of their data and functions • Educate and configure networks to generate data streams and minimal ways of delivery • Creating applications for processing and collecting poorly structured information

tion of all network management as the basis of the common technical policy and the availability of utility infrastructure is feasible.

Under "intellectualization" must be understood not just improvement or even deep informatization of individual units and subsystems but new effective "digital" organization of data and equipment management at all stages of the life cycle that require a rethinking of the processes and approaches to ensure effective organization and technology.

The Table below shows the results of important technologies applied in power grid.

Multiagent approach involves solution of the following groups of tasks:

- creation of self-organizing technology information collection systems;
- creation of structured IT environment;
- development of a package of interacting data processing applications;
- implementation of adaptive systems for technological control and regulation.

Objectives of the first three groups are currently well-proven and widely used in the information field, which is reflected in the implementation of such concepts and methods of work as self-organizing "cellular" MESH radio access network, RFID-technology, GRID-and Cloud-Technology, Data mining.

Creation of process control systems of a new type is a problem related to energy security. Here there are no ready answers from related fields and only successful analogy can be used and only mathematical and analytical framework can be developed including those on the basis of multi-agent approach.

In general, the use of power engineering decentralized management is not something new. Speed requirement processes in power have always determined the need for extensive use of local control with overall coordination through set parameters (settings) and algorithms of automatic devices.

So a relay system with mutual redundancy, automatic load shedding system and voltage regulation system with local regulators, etc. were built. In the meantime reconfiguration and local regulator resetting process is related with long-term analytical tasks and parameterization process operations.

This often becomes the cause of power system disturbances, but because of a long cycle of adaptation schemes to operation conditions, network diagram is often far from optimal in terms of reliability or losses control. Also this fact can be a critical constraint in the implementation of active network elements which altering the electrical network parameters lead to changes in load flow, short circuit currents, which require real-time adjusting of local regulators settings.

Creation of an extensive system of centralized adjustment of relay protection and control devices settings faces a huge informational, process problem; moreover, this approach is extremely vulnerable to outside interference.

It should be also noted that to adopt appropriate and sustainable solutions a huge number of technological parameters characterizing equipment state should be delivered to the control center, as well as standardization of information transmitted from objects of different legal status is needed. This work is extremely time consuming and costly, and in some expert estimates — impossible in principle.

An alternative target-oriented approach is the use of a system adaptive to the on-site management mode logic. At each of the objects need to update the scheme-mode model of the adjacent zone, and global coordination is carried out under coordination of behavior strategies of individual agents representing the interests and objectives of the network elements and objects within the information and physical interaction through the electrical environment. By physical interaction is meant a calculated definition of local measurement adjacent objects state using the current scheme-mode model and the further implementation of control actions.

Multiagent approach allows a much wider use of new measurement technologies and facility management. For example, the use of devices synchronized phasor measurements in centralized systems management requires the transfer of large data flow to the control center.

Substation agents can process and use measuring instantaneous values of voltage and current in full for more accurate recovery of mode dynamics and trajectories of change, sharing with other facility agent only subscription samples related to electrical connectivity and mutual influence.

MULTIAGENT CONTROL SYSTEM DEVELOPMENT

Currently pilot projects on network intellectualization are implemented in East and Siberia IPS.

For the energy cluster "Elgaugol" included in East IPS and elected as one of the first "pilot" a multi-agent control system has been developed, the first stage of which is aimed to realize the function of voltage and reactive power control. In addition to providing targeted functionality, this system is intended to demonstrate the possibility of:

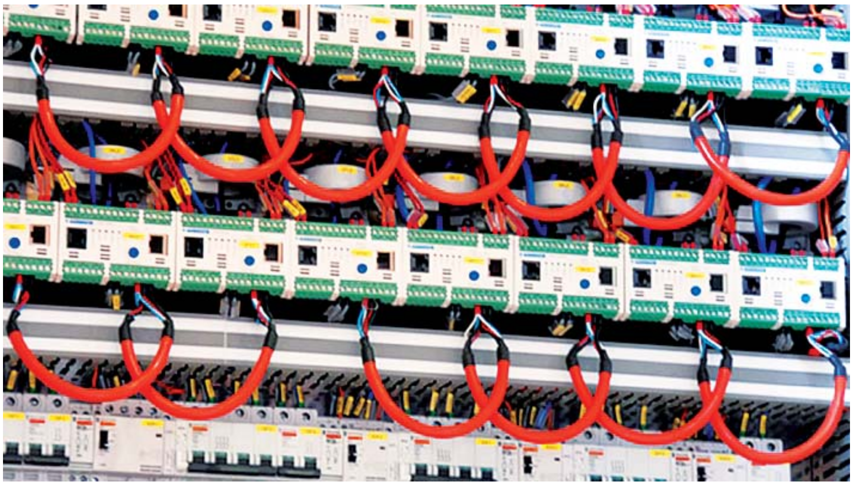
- reliable operation of control system at weak ties;
- "zero redesign" of control systems in restructuring of an energy cluster (in particular, the emergence of new substations);
- easy integration of various control systems, including systems of different generations;
- implementation of open source solutions that provide access to third-party development or modernization of control systems.

One of the project tasks is to define the zone of effective and efficient sharing of traditional and multi-agent systems. Multi-agent systems do not fully replace the existing systems of process control, but supplement them by automating those activities that used to make operating personnel and control system support engineers. Therefore, the pilot multi-agent system was tasked with voltage level optimal control of several substations, while the tasks of operational planning are dealt with at the network control center. According to expert assessment, fulfillment of voltage regulation tasks will permit to generate more accurate requirements for auxiliary systems and subsystems of agent-based environment to ensure the integration into the existing system of centralized management. From a hardware perspective the substations are equipped with redundant head-end equipment with specialized software running on FIPA standards. It supports standard methods

of agent-to-agent interaction, with the coordinator agent agency network, and also provides access to communication with external systems.

Multi-agent system to interact with external information environment employs the most common information exchange standards — Common Information Model CIM, IEC 60870-5-104 for communication with control center information systems and IEC 61850 for communication with substations systems.

Solving the problem of optimal voltage control substation agents receive from the network control center ranges within which they are able to change their voltage substations. Based on the given ranges, facility modes and load assessment, admissibility of modes including single faults on adjacent sites, and based on history of application of management strategies and technical status of own devices, agents form and transmit commands and settings to automatic control system of (auto) transformer OLTCs and substation reactive power compensation means.



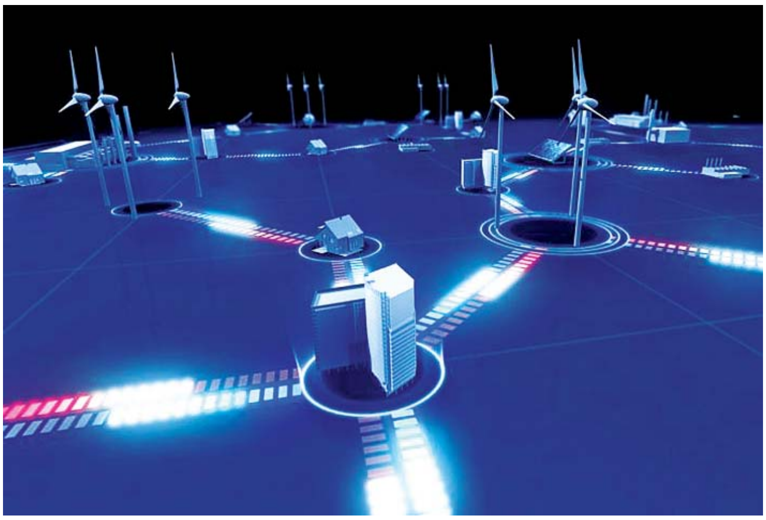
Today the most actively studied issue is sustainability in obtaining optimal solutions from group of agents in terms of commands execution delays and mode changes, nonlinearities inherent to electric networks, asynchronous execution of commands at different objects. To ensure the stability of the solutions the introduction of additional feedback, selection of optimal behavior of agents and strategies that currently is one of the basic questions of the study and to the development and testing of technology will be required.

Such a control system is planned to develop and test at JSC FGC SEC ground to the end of the year, and in 2014 providing that the results are satisfactory to evaluate the implementation at “Elgaugol” power cluster.

FURTHER STEPS

In backbone networks is promising to use multi-agent voltage control in power supply of abrupt load changing extended objects, which include electrified transport systems, such as pipelines and railways. Even more significant is potential of multi-agent approach in the intellectualization of distribution networks, where the factors that require new approaches to management are expressed at the most. In particular the possibility to implement the approach to automate the supply of industrial parks, distributed generation control, demand and production assets is under discussion. Due to the integration of companies in the Russian power grid complex, developments resulting from the innovative activity of JSC FGC UES can be used in IDGC projects.

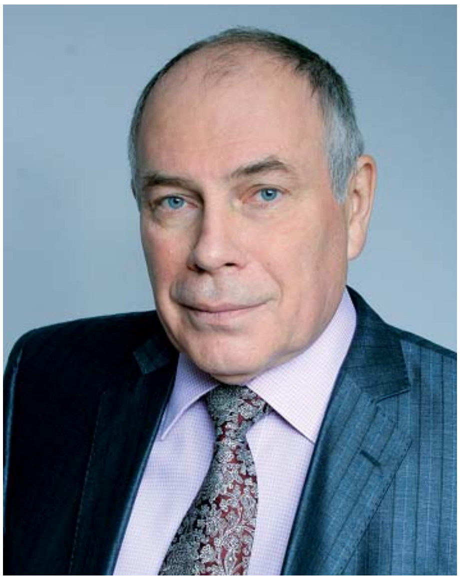
Currently, a reference architecture that will specify the technical requirements for control systems and interfaces, interaction, and also form the agent foundation classes is under development. Polygon, i.e. system to support solution life cycle for the intelligent network that will provide researchers and developers with access to knowledge bases, test models, simulations of different control systems is created. To attract a wide range of researchers and developers to the aforementioned problems all-russian competition for innovative projects and developments in the field of smart energy “Energoproryv” started. This contest will form a community and ecosystem actors capable and interested in the creation of new generation process control systems.



For all who want to develop and discuss together these issues Internet sites Grid2030.ru and Gridology.ru operate. It is worth to note an important task and the need to create accessible and understandable terms and definitions in the field of intellectual energy. This is especially due to the multi-agent technology and new information technologies in general, where there are still no established terms despite the fact that information technology is steadily stepping in our technological realities.

Implementation of the above initiatives, development and implementation of new systems based on open architectures and multi-agent approach rank high on the list of medium-and long-term goals of Russian grid development.

Development of Active-adaptive networks



Head of the laboratory «Intelligent Energy» JIHT RAS, Deputy Chairman of the Architectural Committee for creation of smart grid at joint scientific and technical council of JSC UES FGC and Russian Academy of Sciences Vladimir DOROFEEV (Владимир ДОРОФЕЕВ) tells about features of smart energy-architecture system with active-adaptive network and necessary conditions for its implementation.

— Vladimir Valerianovich, now you are a member of the Architectural Committee for creation of IPS AAN, whose work is focused on the development of reference architecture of active-adaptive network (AAS). At the same time, both abroad and in Russia continues to develop the concept of creating an "intellectual grid", or Smart Grid. What is the difference between AAS ideology from Smart Grid ideology?

— FGC UES in Russia for the first time, set fundamentally new approach to modernization of the technology base of domestic power system. The first step in this direction was the elaboration of a concept for development of intellectual power supply system with active-adaptive network (IPS AAS).

The preparation of this document involved the analysis of work carried out in that regard. It should be noted that up to now developments conducted in different countries have no unambiguous interpretation for the term Smart Grid. However, the ideology of this development has been primarily focused on creating control systems within the local electricity distribution level of domestic nature of the controlled load and maximum inclusion in these systems of alternative and renewable energy sources with emphasis on energy saving. Recently, however, a number of countries — United States, China, South Korea and Europe — carried out works beyond the local systems to create interfaces for their integration into the centralized power grid, as well as to develop general management systems including the use of multiagent control principles.

The Russian approach to new technology is based on creating conditions enabling the integration at all levels — from the FGC to distribution networks — of active elements that change the network parameters depending on the situation in power grid, creating terms for connected to customer networks (generation and consumers) providing the most complete and efficient transport of electricity between them. This is a more complex task, requiring both multiparametric substantial modernization of the primary power equipment and the creation of a fundamentally new management system that responds to the situation in real time. Moreover such a system is based on the enormous information flows and modern high-speed and secure communications systems. In general, we are talking about creating energoinformational system of a new type, unifying new energy technologies, modern distributed control systems and telecommunications. This type of energoinformational system creates the possibility of new market mechanisms in the relationship between suppliers and users of electricity, providing them with the most efficient use of this resource. All of this together is called an IPS AAS.

One of the first steps towards the practical implementation of this ideology was the establishment of the joint scientific and technical Council of JSC FGC UES and the RAS Architectural Committee on development of intellectual energy. The Committee in addition to representatives of these organizations includes representatives of generation, consumers, local networks and developers of IT technologies. The Committee established expert working groups, specialized in different directions, to provide agreed decisions on building IPS AAS architecture, which meets the interests of all actors involved in the production, transmission, distribution and consumption of electricity. On the basis of the proposals of the expert working groups the Architectural Committee should take a decision on the overall architecture of the system to move: the road map, including the development of pilot projects of energy fragments, pilot projects of separate united energy systems (in particular, East IPS) and further steps towards creating entire IPS AAS of Russia.

— Could you explain what the IPS AAS architecture is and what exactly should the Architectural Committee agree on?

— The concept of system architecture has its roots in the development of different kinds of computer systems, primarily built on the principle of parallel computing in order to improve the performance of the overall system. With the development of information technologies providing transfer, processing and use of information for various purposes, this concept has slightly extended including not only computing, but also various types of communication channels and data throughput with the definition of ways they interact with distributed computing systems. Today when developing complex systems the notion of their architecture is critical when determining the principles of construction and future operation of the system during its design.

Reference architecture should be universal providing different classes and categories (users) of the future system with maximum comfort to include their own current processes and give an idea of the possible transformation of these processes in the future under various conditions in user and external environments.

In developing the IPS AAS ideology the architecture concept of this system includes presentation of a unified description of the conceptual model specifying objects in the system, interfaces between these objects and services presented to processes participants supported by the system. Architecting the IPS AAS as energy-system should include three basic elements: the architecture of power engineering systems, architecture of information and communication interactions including control systems and architecture of economic relations between actors in the power market.

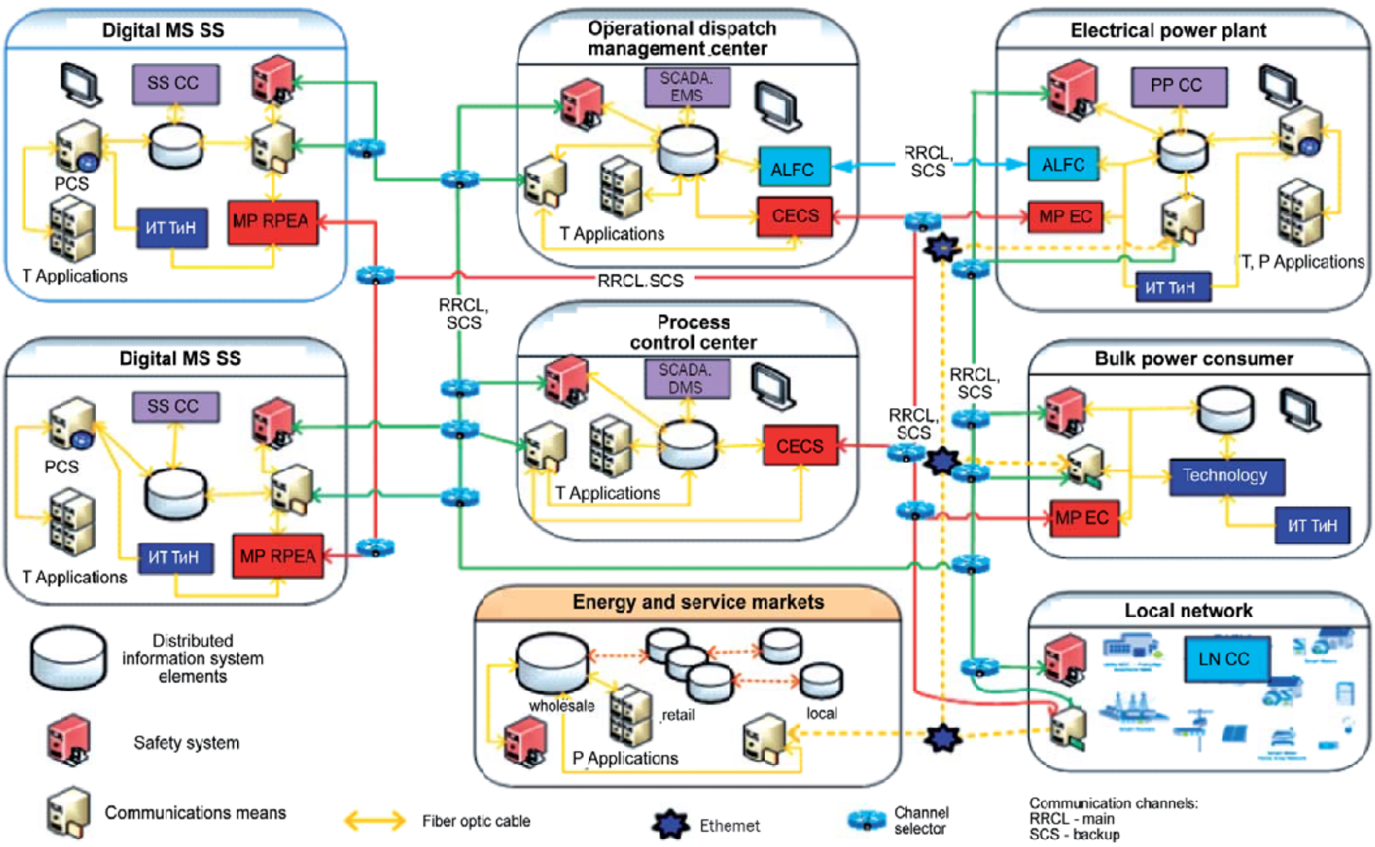
As I've already said the Architectural Committee consists of experts from many organizations interested in the fact that the future energy system meets their requirements, in some cases contradictory, to access and use of energy supplied by grid. The harmonization of the positions of various parties through architectural view of IPS AAS is the main objective of the Architectural Committee.

The most difficult is the communications architecture that connects all IPS AAS subsystems; so the figure illustrates an out-line scheme of this architecture.

— When do you schedule to complete works on unification "smart grids" architecture and the development of appropriate standards?

— The developed concept defines a strategic vision of the future energy system, all work to create the smart

Fig. IPS AAS extended communications architecture



grid — a complex and controversial process. Many of the tasks require major scientific and engineering study and reasoning. Some decisions in the course of this work may be deemed non-viable (infeasible or low-tech), there may be new ideas or ways to solve. Now, for example, there is a discussion about the advantages and disadvantages of centralized and distributed control systems and their possible combinations (the optimal allocation of authority) to create IPS AAS control system. The choice of this decision will condition many subsequent steps. In general, the work on the creation and coordination IPS AAS architecture will be completed by the end of 2014.

If we talk about standardization, the creation of such a system is impossible without coordinated decisions based on the huge number of standards. In this regard it is necessary to use existing and emerging international standards, take part in the work of recognized organizations such as the International Electrotechnical Commission (IEC), the International Telecommunication Union (ITU), the National Institute of Standards and Technology (NIST) and others. In addition, a number of standards should be developed by Russian specialists, in particular linking CIM-power system model with market procedures for building the single information space for IPS AAS technology.

— What effects will be achieved in the implementation of such an ideology?

— Given the complexity of the future energy system its effectiveness can not be evaluated by conventional methods. Comparison of the current state of the system by a particular range of parameters, including those mentioned by you, as well as today user satisfaction (or dissatisfaction) with the same parameters and assessment for 2025—2030 IPS AAS, especially at this stage, when all solutions are not developed and tested yet, is only possible in the representation of qualitative or expert assessments.

With that said, it should be noted that the flexibility of the transmission system in conjunction with the implementation of the market mechanism of electricity transmission services will permit to identify the most efficient transport routes increasing their use (load) factor and, conversely, to abandon heavily loaded and unused connections. The effect of such solutions can be evaluated by the two constituents:

- reduce electricity transmission losses to 30% of the current level;
- reduce direct investments to the power part of the power system up to 20%.

It should be noted that the cost of a system creation is primarily related to capital investments in automation and control systems, and their value is commensurate with capital investments savings.

It is possible to cite estimates for other indicators including the improvement of reliability due to more efficient operation of automation and control systems, as well as active participation of electricity consumers in the process, but I'm not going to call specific numbers, because it requires even more serious study.

I want to give you one example. If you go back 10—15 years ago, you remember, what was the connection? Mobile communications devices only began to emerge. At that time, one could not even imagine how in today's life we cannot do without them. Whether it was possible then to evaluate the effectiveness of such solutions and the tech boom (various services) around the mobile communication systems? Implementation of the IPS AAS is to a great extent an analogue of such a solution.

— The speed and success of implementation of any "smart grid" architecture in workflows of network companies are directly dependent on the readiness of core network equipment, as well as the existing devices and systems to manage this equipment. We know that more or less prepared for such events are UNPG facilities only. If we talk about the distribution networks, willingness of major tie-stations and medium voltage networks in large cities can be considered. All other network objects before implementing automation devices will likely require reconstruction and modernization, and this huge investment, which will stretch over years. With this in mind, at what levels, highlighting what stages and in what timeframe "smart grid ideology" could be introduced in Russian power industry?

— Your question is discussed at different levels and constantly posed as follows: "And if we are not ready today to receive significant effects, is it worth doing this? Or maybe develop the network as they did before? After that the power system, available in Russia was created by certain canons and is one of the most powerful in the world". But the situation is such that the power system equipment because of its age still requires replacement. Therefore, when determining the directions of modernization and development it is essential to determine what power system will be result of these works. The concept of IPS AAS development is the answer to the question and establishment of its architecture is the first real step to design. The technical requirements to the system, its elements (power facilities and the equipment installed), as well as to the systems of control and information create for the developers an understanding what kind of equipment and systems will be in demand and what should be their characteristics, including cost. One of the key conditions is that equipment installed at the facilities must have the functionality corresponding to new working conditions of the power grid, and the cost of it should not only exceed but also be cheaper than the existing equivalents. Of course, the power grid is being equipped with many new items: a modern accounting system, automation and information systems, cybersecurity etc. These systems require additional capital costs (estimated), which should not exceed the amount of savings of needed investments to the power part of the grid.

If we talk about the readiness of the power system, both at the level of the UNPG and at the level of the distribution networks, the assessment expressed in your question is not quite accurate. UNPG objects are prepared for implementing IPS AAS not so much physically, but ideologically, in view of the fact that the Federal grid company was the first to create the ideology for the new energy system. Its practical realization at such major and capital-intensive projects, such as the substations and transmission lines in the UNPG, really requires major capital investments. But even the availability of funds does not determine everything. For example, even the design process requires a lot of regulations to be revised, as well as qualified staff of designers and builders who is ready to implement new solutions. However, objects that allow to talk about the first real steps towards the creation of IPS AAS at UNPG level have already begun to appear. 500 kV Beskudnikovo substation equipped with the innovative asynchronous compensators, allowing a wide range of reactive power regulation of the leading to reduction of losses, improving the reliability of the power system (stability during severe disturbances) and the maintenance of power quality indicators may serve as an example.

In distribution networks creation of IPS AAS is closer to existing foreign counterparts — the Smart Grid — many of its elements are already available on the market. In addition, individual objects of distribution networks, of course, are not in any degree comparable with the UNPG capital-output ratio. But here comes the scaling factor, when significant efficiency can be achieved at mass application of new solutions, which in turn requires considerable expenses. In this case, it is very important to select objects for pilot projects to demonstrate the effectiveness of the decisions taken. For the distribution networks such objects can be areas of electrical networks, for example, in large cities, where new large-scale construction and energy-saving solution are implemented. In these circumstances it is necessary to interact with the urban and municipal authorities for the approval of the new energy regulatory framework.

I would like to point out that only the systems approach for choosing the sequence of steps at implementing decisions on creation of IPS AAS can have a significant impact on both economic and socio-political spheres, when broad mass of users of such a system become aware that there is no other way. That is why the choice of pilot projects and their launch should be approached very carefully. Creation of a unified network infrastructure Russian Grids allows to find objects for pilot projects that comprehensively implement the whole chain of relations: generation (network connections), bulk networks (UNPG), distribution networks (distribution zone) and electricity consumers. The first such a large-scale pilot project on implementation of IPS AAS was conceived within East Unified Power System. This zone was chosen due to its relatively small (relative to other UPS) size and the diversity of primary, including unconventional power sources. Today, the work is aimed at its implementation.

For testing and simulation of new technological solutions, primarily control systems based on new principles (multiagent systems) R&D Center at FGS UES creates an IPS AAS network control center test area.

Basic solutions and technologies proved-out, it is planned to transfer them to the East UPS pilot sites with subsequent replication at other sites and interconnection in the unified system.

In general, the whole work package will be completed by 2020. Its trial operation should confirm the effectiveness of decisions, and then, from about 2022, it will be possible to speak about the mass replication of solutions and in the period 2025—2030 the Russian energy system as a whole should get a new quality. By the way, their foreign counterparts in the full version are scheduled to be completed in about the same period.

— Foundation for implementation of "smart grid" ideology needs to be built now. Taking into account relevant promising solutions, not only network equipment should be developed, but process of training should be organized. In what way is work with employees of networking companies, equipment manufacturers, educational institutions organized?

— Today, in my opinion, JSC UES FGC is one of the few companies in the Russian energy sector to pay serious attention to the training of personnel in general and for new energy in particular. The company has signed cooperation agreements with leading universities in Russia engaged in training on practically all aspects of the industry “Electric energy”. These programs do not include only organization of training for young specialists at the undergraduate and graduate levels, but also competence gap closure for key personnel of the company. The competition called “Energoproryv” (“Breakthrough to the future”) aiming at the search for promising ideas, projects and teams of young professionals and academics has just completed. The competition attracted more than 60 teams from various cities of Russia who presented their projects. As a member of the competition committee I can note the high interest in the theme of the contest. Many projects and ideas were aimed at the realization of smart control systems and creation of equipment for intellectual energy. Especially interesting was the project of an educational nature, presented by the team of Yekaterinburg and aimed at education of future energy specialists from schooldays, and cultivating energy saving basics from childhood.

On June 20 in St. Petersburg at the St. Petersburg International Economic Forum (SPIEF 2013) awarding ceremony for the winners of the National Youth Competition “Energoproryv” for high-tech innovation and development projects was held.

Thank you very much for the interview! We will watch with interest the further development of active-adaptive grid philosophy construction.

Interviewed by Ekaterina GUSEVA

Directions for development of intelligent network in Russia

Vladimir SOFIIN (Владимир СОФЬИН),
JSC Rosseti Head of the Department
of technological development and innovation

Smart Grid technology widely acknowledged in the world has become an integral part of the electrical networks of many utilities from all continents. Certainly, intellectualization of networks will mark a new stage in the development of energy sector and will provide a response to the new challenges of socioeconomic development of countries. However, focus issues for different countries varies greatly and depends on many factors. This is the lack of cheap energy, the growing attention to environmental aspects of network operation, the task of transferring large capacities at significant distances with minimal losses, increased energy efficiency and reliability.

To date, the most perspective directions of development of the Smart Grid technology are the following:

- smart metering systems for power billing;
- management and integration of RES in the network based on technology of virtual power plant;
- DMS/OMS systems;
- f lexible transmission lines.

In electric networks operated by JSC Rosseti Smart Grid technology is designed to provide given parameters on reliability and quality. This is an opportunity for networks to automatically engage in a single information space for data exchange and mode control in which all the players of today energy market: generation systems, consumers, marketing companies and adjacent power systems are present.

The idea of Smart Grid integration, first and foremost, is based on the principles of economic feasibility and efficiency of decision making. This should be a golden mean between functionality, reliability and price.

Smart Grid technology development drivers in Russia

Today Russia is not experiencing an acute shortage of energy resources as well as objective problems with CO2 emissions. Drivers for Smart Grid development in Russia differ from drivers of other countries. First of all, the following important tasks are set for JSC Rosseti:

- reduction of losses including transmission of electricity over long distances;
- improving reliability of electricity supply to consumers;
- increasing observability and intellectualization of the network in order to increase efficiency in the use of grid assets;
- enhancement of automation level.

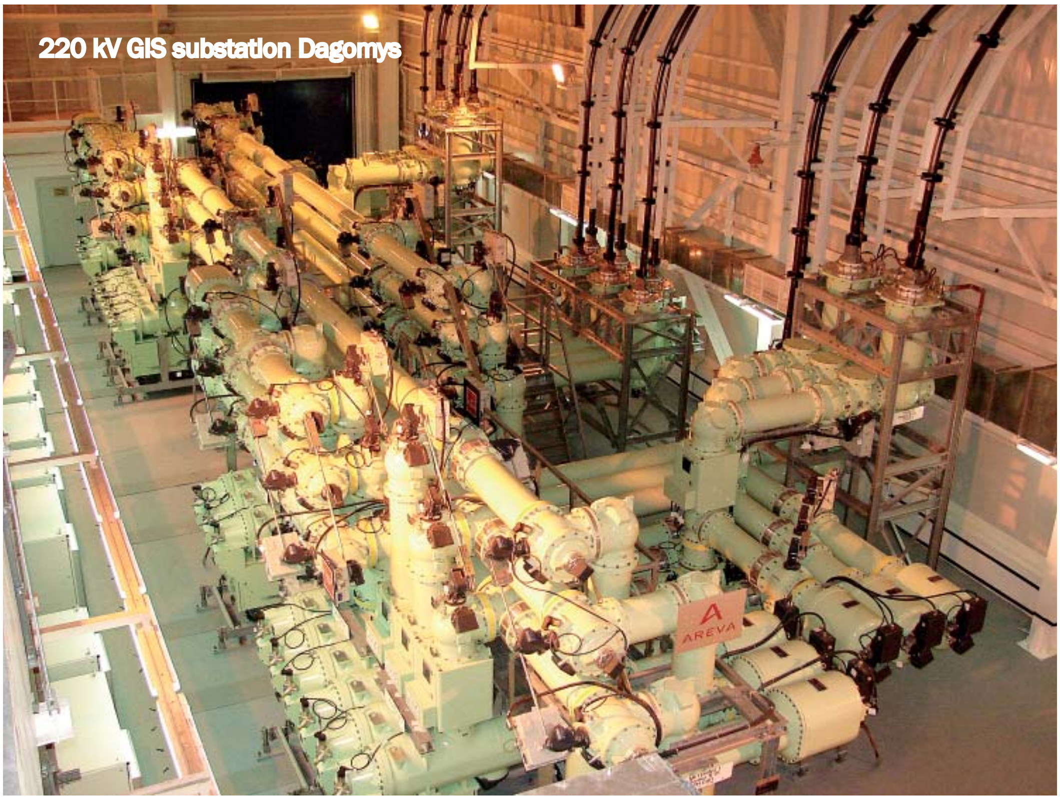
For development of the power grid of Russia is insufficient to copy foreign technologies and models of Smart grids. Today it is necessary to choose, adapt and develop the solutions that will bring the desired effect while maintaining and further enhancing the performance of reliability, quality and efficiency of electrical networks.

The term «smart grid» represents a qualitatively new state of networks which allows to:

- change parameters and network topology in real time according to current regulatory conditions, excluding the emergence and development of accidents;
- integrate into the network all types of energy generation, including small scale generation and all types of users from households to large industry;
- ensure better market opportunities for the infrastructure by mutual provision of a wide range of services by market entities and infrastructure;
- minimize losses, improve system self-diagnosis and self-restoring, provided that the conditions of the reliability and quality of electric power are maintained;
- integrate grid and information infrastructure to create an all-mode control system with full-scale information support.

The first priority in the development of smart grid in the bulk power system is increasing observability, creating automated systems and control centers for operating modes and topology control, post-disturbance element self-restoring, optimal loading of the network taking into account the reserves of power and demand, as well as the rapid integration of consumers and generation into the network. In power distribution system is more important to create an intelligent infrastructure for end users with power management, localization and self-restoring of damaged elements of the network. An important criterion for the next generation system operation is ensuring cybersecurity.

Within the development of the Russian Federation integrated power grid concept a unified Rosseti technology policy and innovation policy were adopted. These documents will help realization of the Smart Grid technology through implementation of innovative



220 kV GIS substation Dagomys

products and advanced technical solutions of domestic and foreign manufacturers.

Key technologies

One of the defining challenges to be addressed for integrating Smart Grid technology is cybersecurity of power networks.

In order to reduce the risk of cyber-attacks on the power grid control system a vertically integrated comprehensive system of information security is created and successfully operates.

In addition JSC Rosseti participates in the establishment of a State system for detection, prevention and elimination of computer attacks consequences on information resources of the Russian Federation.

In particular in the North Caucasus Federal District and in the Sochi power district JSC Rosseti jointly with SC Rustech develop a comprehensive automated system for security management. This system could be the basis for building a security system for the entire integrated power grid of the country, as well as other systems of critical infrastructure.

Digital technology testing (digital relay protection devices and Emergency Control Automatics, automated billing and power quality control systems), i.e. Smart Grid, is carried out at JSC Rosseti "Digital substation" site. A fully digital 220 kV substation "Nadezhda" (Yekaterinburg) is planned to be put into operation in 2015.

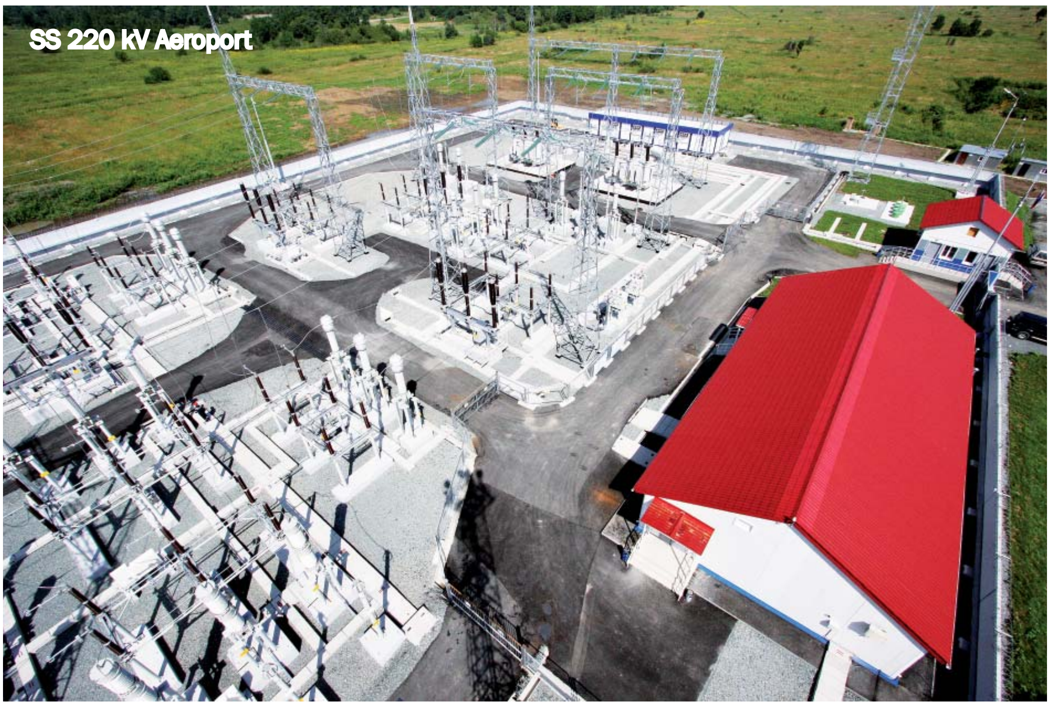
Another important project launched by Group of companies Rosseti is installation of series compensation devices (SCD) which increases OL capacity. A pilot site for the project was 500 kV OL Primorskaya GRES — Chuguevka 2 and Primorskaya GRES — Dalnevostochnaya (East). After installation of the device OL capacity will increase from 70 MW to 280 MW (depending on the technologies applied).

Another interesting technology is phase-shifting. Control of power in the transmission lines may be carried out by changing voltage phase angle at the ends of lines. The application of such device is planned for 220 kV OL Barabinskaya — Tatarskaya — Voskhod (the device will be installed at SS 500 kV Voskhod), which would increase the line capacity from 23.2% in 2020, up to 32% in 2025.

Special attention is given to technologies to increase the flexibility and reliability of the network. To date, a number of projects, including R&D has been realized:

- static VAR compensators are installed at SS 500 kV Novoanzherskaya, SS 500 kV Zarya, SS 220 kV Afipskaya, Krymskaya, Slavyanskaya. They provide increased power quality and system stability, improvement of capacity to 20—30% (Siberia, South);
- static compensators: installed at SS 400 kV Vyborgskaya. Compensators provide capacity increase to 20 MW in repair mode of synchronous compensators, 40 MW at emergency tripping/repair of 330—400 kV OL (Northwest);
- controlled shunt reactors are installed at SS 500 kV: Tavricheskaya, Barabinskaya, Irtysh, Nelym and many other substations to provide voltage stability, VAR flow optimization, enhanced power transmission capacity (Urals, Siberia);
- asynchronized compensator at SS 500 kV Beskudnikovo. It provides power capacity improvement to 20—40 MW. Reduction of power losses by 8% of total value (Moscow).

Distribution networks include the following projects: creation of infrastructure for use of electric transport in the city of Moscow, recloser implementation, development of smart power billing systems in many cities of Russia (installed about 1.2 million meters of today), implementation of OMS/DMS system, creating a Smart grid comprehensive project in the IC Skolkovo (Moscow region).



In addition, the Rosseti Group of companies is implementing a comprehensive project Smart City. In this case synergy effect is possible only in the case of interaction with related industries, enterprises of housing and communal services, State and municipal government agencies, as well as with the direct participation of energy consumers.

Development of science and technology

Rossetti conducts network intellectualization in close cooperation with Russian scientists, designers and manufacturers of equipment. In the past year the innovation process involved groups of more than 30 organizations: academic and industrial research institutes, design, production and research organizations and higher education institutions.

Currently the following innovative projects are under implementation:

- direct current link at SS 220 kV Mogocha to provide communication between asynchronous IPS of East and Siberia;
- 220 kV current limiting device on the base of special reactor and explosive switches at SS 500 kV Kaskadnaya;
- development of resistivity bridge harmonic filter prototype for HVDC SS 400 kV Vyborgskaya;
- creation of digital substation test site and elaboration of new innovative technologies before integration into existing power facilities, including the identification of key technical decisions and requirements the today substations should meet;
- creation of infrastructure for electric transport in Moscow and Moscow region;
- innovation cluster «Elgaugol» — 220 kV substations group control center to optimize current modes of transit. Project is scheduled for completion in 2015.

Rossetti actively cooperates with leading foreign companies in the following fields:

- research in the EU power systems and the development of techniques to improve overhead lines capacity in backbone networks;
- development of technical proposals for the application of compound insulators at 110—500 kV substation and overhead lines;
- creation of a monitoring system for hot-spot control of 110—220 kV overhead lines technical condition on the basis of temperature transducers;
- creation of intellectual property management system;
- within the framework of the project for construction of the federal testing center in Russia;
- within the framework of the project for construction of testing ground and creation of a prototype for digital substation hardware-software complex, solutions of various foreign companies are implemented.

SS 110 kV Laura

Social and environmental aspects

State policies aimed at curbing the steep rise in tariffs make companies looking for internal reserves in terms of efficiency gains. This situation is also a signal to suppliers of equipment and technologies for power industry to control prices for electrical products and equipment.

Achieving this task is possible only through a transition to a new technology pattern of electric power industry based on an innovative approach, the application of highly efficient equipment and effective business processes. Widespread introduction of energy management in companies with high proportion of energy costs is under way (primarily metallurgical and oil and gas sector), it allowed to reduce electricity consumption cost by 10%.

Creating intelligent network is impossible without development and taking into account requirements for the development of green energy, environmental safety and energy efficiency improvements in protection of the environment and conserving natural resources. Smart grid should be a decline in the share of expenditures of natural resources by 5% annually.

Main effects Rosseti expect from introduction of the newest technologies in networks are enhancing the quality of life of consumers, optimizing energy resources and ensuring the international integration of the unified power system of Russia into power systems of other countries.

Responding to Needs of the Present, With a View to the Future

At present, a multitude of energy sales organizations of various sizes operate in the territory of Russia. The largest of them were traditionally formed on the basis of former AO-Energos in the reformation process of RAO UES of Russia. They enjoy certain advantages, but most still remain to be relatively young establishments having to fight for the consumer and for their right of existence. Today we are talking to Sergey SHABAIDAKOV, General Director of JSC "Pervaya Sbytovaya Kompaniya", the organization which renders packaged high-quality services to its customers and which has rightly won their confidence.

— Sergey Alexeyevich, please tell us first about your company. When was it established and what does it engage in?

— "Pervaya Sbytovaya Kompaniya" was established on December 30, 2003, and in 2004 it obtained the status of a wholesale market entity to supply electric power to consumers. As a result of power industry reformation consumers got the right to choose any electric power supplier that will offer them the most favourable terms in accordance with the rules of electric power wholesale and retail markets. One of these independent suppliers is JSC "Pervaya Sbytovaya Kompaniya".

We supply, at contract prices, electric power to our consumers that meet certain requirements (the energy sales organization has, according to all the contracts signed with consumers (buyers) on the retail market, the total connected capacity of power receiving equipment not less than 20 MVA on condition that in each cluster of supply points it equals or exceeds 750 kVA and commercial metering systems are implemented). We also provide services on installation of automated information and measuring systems for commercial power metering (AIMS CPM) at customers' facilities.

— JSC "Pervaya Sbytovaya Kompaniya" is now one of the largest sales companies in Belgorod Region. Besides services traditionally provided by organizations of the sector, the company actively engages in such fields as energy audit, energy consulting and installing electric power metering systems. Please tell us how successful these directions of the company's activities are at present? Who are your main customers?

— Following adoption of Federal Law 261 of November 23, 2009 "On energy saving and increasing energy-efficiency" the direction of energy audit has become top-priority not only in our company but in the power industry, as a whole. We have conducted inspections of the largest industrial and agricultural enterprises in Belgorod, Kursk and Volgograd Regions. We analyze almost all parts of enterprises' production processes, which enables us to define and develop measures for reducing energy consumption rates of production processes as well as for reducing losses and expenses.

Apart from energy audit, our company renders services in the field of installing and commissioning AIMS CPM. In 2013 our company installed about 200 metering devices

as components of commercial power metering systems implemented at the largest industrial, agricultural and utility enterprises in Belgorod Region.

— Which of the projects in this field do you consider to be the most successful? What are their main performance indicators?

— We have conducted many energy inspections of different enterprises and every single of them can be called successful. Since we use an individual approach to every energy inspection, take into account all peculiarities of production processes and, most importantly, offer certain programs of energy saving which include: saving energy resources by optimizing production processes, reducing losses by improving supply schemes (electric power, gas and heat supply) and saving energy resources by introducing new technologies.

Implementing electric power metering systems allows our customers to save about 15—20% of electric power costs thanks to more beneficial rates, which they can choose only after installing respective metering devices. Besides, now they can monitor real-time hourly electric power consumption and correspondingly adjust operation modes of their production works, for example, by carrying out the most energy-consuming production processes when electric power is the cheapest (at night).

— Issues of increasing energy-efficiency in existing power supply schemes are closely related to issues of reducing losses in power grids, increasing quality of electric power supplied to the consumer, etc. These problems can be solved only on condition of close cooperation with power grid companies. What does JSC "Pervaya Sbytovaya Kompaniya" do in this direction? Are there any problems with interaction and mutual understanding? Do you have any suggestions on how the situation can be improved?

— The matter is that power grid companies themselves are interested in implementation of automated systems of commercial metering, in order to be able to more accurately meter power and capacity transmitted through their grids. Therefore, even if any problems in interaction with power grid companies in terms of metering arise, they are solved routinely. One should also pay attention to the fact that metering devices installed by specialists of JSC "Pervaya Sbytovaya Kompaniya" enable monitoring of electric power quality, due to which our customers and representatives of power grid companies can monitor the condition of equipment of power grids and eliminate all disturbances in operation of grids within the shortest possible time. Deterioration of electric power quality can lead to significant changes of operation modes of power receivers and, consequently, to decreasing capacity of operating mechanisms, deterioration of quality of products, shortening of service life of electric equipment and rising probability of accidents. Therefore, electric power quality monitoring is one of the priority functions of electric power metering systems we create.

— There are several contradictory points of view on interoperation of power grid companies and power sales companies. There are even suggestions on introducing amendments to legislation in order to provide for combining power grid and sales activities within one company. What is your opinion on the issue? Which operation scheme is the most effective and beneficial for grids, sales and consumers?

— As regards suggestions on combining power grid and sales activities within one company, such ideas may have some ground, however, they contradict the changes in the Russian power industry which took place within the framework of its reformation. Combining sales and power grid activities is getting radically back to what we had 10—15 years ago and at present it is hardly rational as it impedes the fulfillment of the key task of reformation, i.e. competition between energy sales companies, which we now have.

On the other hand, impact of grids on different aspects of sales business remains to be substantial and often is of a clearly discriminatory character in relation to sales and end consumers of electric power. Our company, being a wholesale market entity and an electric power supplier for a number of large consumers, interacts with grid companies not only as a consumer of their services on electric power transmission, but on a range of related issues as well, for example, organizing commercial metering for electric power consumers, coordination of clusters of electric power supply points on the wholesale market, electric power quality, etc. The problems we face most often concern quality of supplied power, uninterrupted power supply, organization of metering and different compliance procedures.

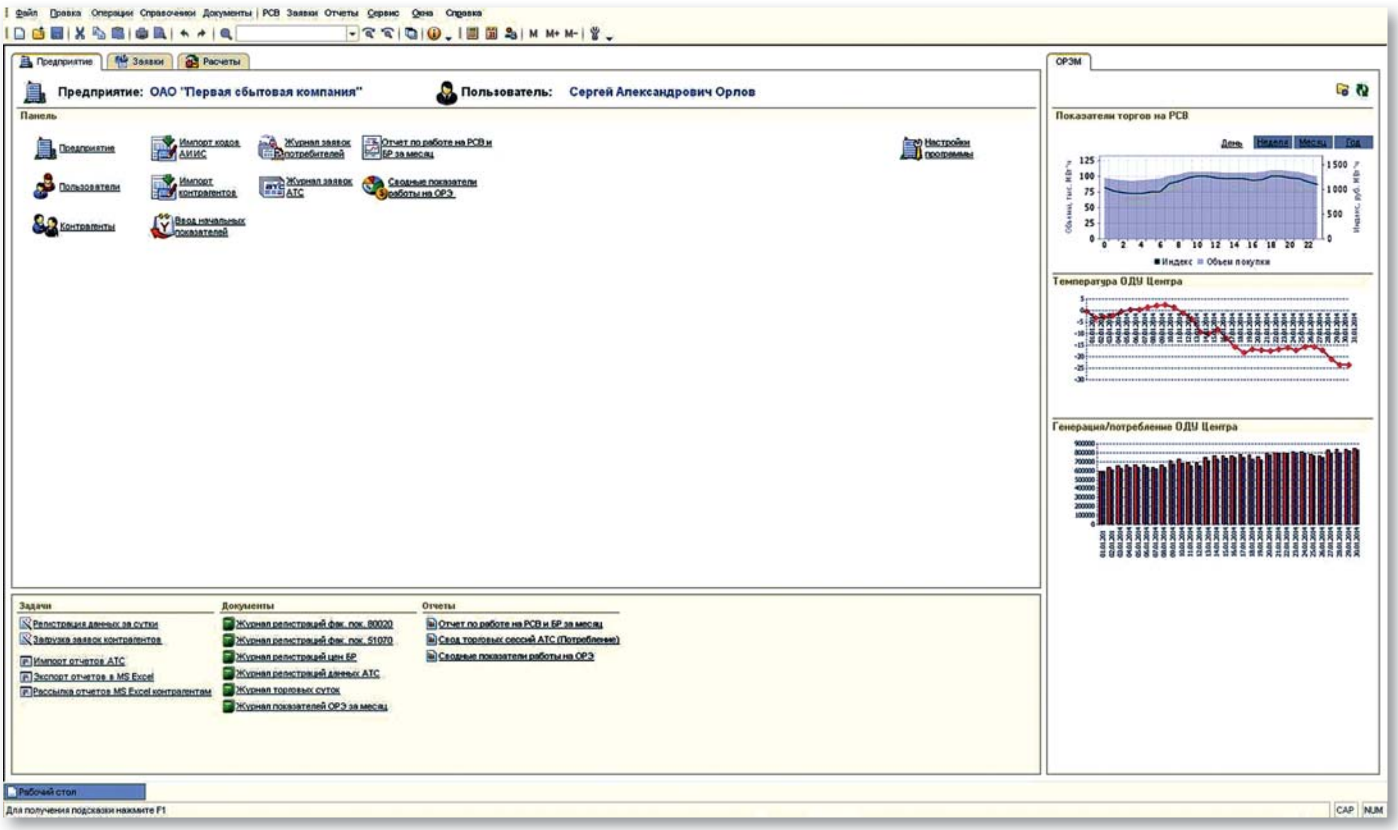
Thus, the way I see it, the solution to the problems lies not in changing the existing legislation radically once again and combining all kinds of activities in power industry, but in introducing small changes in activities of grid companies, improving quality and transparency of services provided by power grid organizations.

— Let's go back to your current activities. One of the services you provide is creating automated systems of electric power metering. Such services are rendered by many organizations. What is the advantage of your systems?

— Indeed, at present we design and install automated information and measuring systems of commercial power metering (AIMS CPM) which meet the requirements of the electric power and capacity wholesale market (EPCWM). The service includes the whole range of works starting from purchasing equipment and ending with obtaining the Certificate of Compliance of AIMS CPM with Technical Requirements of EPCWM, i.e. we implement turnkey projects. Highly qualified personnel of JSC "Pervaya Sbytovaya Kompaniya" have great experience in designing, commissioning and maintaining AIMS CPM. The main advantage of our metering systems is their competitive prices. All equipment and components used in AIMS CPM are supplied directly from manufacturing plants, which makes the final cost of the system cheaper, provides for its highest performance in terms of reliability, service life, etc. The apparent benefit of our systems is that all our consumers can monitor consumption of their enterprises from any place of the world. It requires only Internet access, which is not a problem nowadays. In many cases we finance creating automated systems of commercial power metering to the rate of 100%. It is beneficial both for us as power suppliers and our consumers.

— Do these metering systems have a possibility of integration with other automated technological systems (automated process control systems, supervisory control and process control systems, communication systems, etc.)? With which systems is it possible and to what degree?

— AIMS CPM systems of JSC "Pervaya Sbytovaya Kompaniya" operate with Alfa CENTER software package, which is based on the principles of the client-server architecture and Oracle database management system (Oracle DMS). Therefore all automated technological systems based on Oracle DMS can be integrated with our AIMS CPM. AIMS can take readings of devices for metering other energy resources (steam, gas, water, heat) and even meters engaged in the technological process. These functions can be used both directly for comprehensive metering of resources and as an "auxiliary tool" for metering namely electric power. In addition, integration of AIMS CPM with automated process control systems of enterprises makes it possible to perform: peak-shaving of electric power consumption, indirect



diagnostics of equipment based on power consumption parameters; calculation and maintaining energy-efficient operation modes of mechanisms.

— Does the system's upper level have any possibilities for analysis and forecasting of events and indicators? Is there any possibility of integration with systems of financial and economic planning of the enterprise?

— Our AIMS CPM systems can integrate with software products developed on the platform "1C: Enterprise". They enable consolidating information obtained as a result of execution of metering and billing functions, keeping it in retrospective, generating various kinds of reports, developing trade strategies and analyzing operation performance on EPCWM and retail electric power market.

Automation makes it possible to reduce the time required for carrying out the activities within the framework of fulfillment of financial obligations/ requirements of signed contracts, to reduce the number of routine operations executed by personnel, to reduce the risk of errors in primary and reporting documents and, consequently, to improve the quality of interaction with counteragents.

AIMS CPM data enable creating the "Personal Account", which is an access point to limited personified information and is intended for providing services on remote working with documents, consumption data, obtaining billing data as well as paying for power supply services to customers of energy sales companies, enabling the customer to work with documents on the remote basis (filing requests for introducing amendments to agreements), displaying data of actual consumption, contracts and additional agreements to contracts, metering points and consumers' metering devices, prices of guaranteed suppliers and costs of electric power and capacity on EPCWM.

— How do you carry out operation, ongoing and warranty maintenance of metering systems? What additional services associated with metering systems does JSC "Pervaya Sbytovaya Kompaniya" render to its customers?

— In JSC "Pervaya Sbytovaya Kompaniya" it is the AIMS CPM department that deals with operation and maintenance of metering systems. Ongoing maintenance involves replacement and restoration of the installed equipment, updating and maintenance of AIMS CPM software. We undertake to provide warranty maintenance within 12 months following the commissioning of the system. Should the guarantee period expire we offer post-guarantee maintenance of systems. In addition, we render consulting services during modernization of AIMS CPM.

— Which direction in the power industry, in your opinion, will be leading in future?

— I believe that the future of power industry lies with virtual power stations.

This system provides for digital monitoring of renewable energy sources and coordinates their operation with consumers' needs. Speaking figuratively, by means of the system small "pieces" of power are packed into a large packet in which they are delivered to the consumer at the proper time.

The idea lies in interconnecting all power producers by means of an information system, which will enable coordinating and adjusting functioning of the whole energy system.

Now we are forming a working group which will develop a project on creating a virtual power station. We will make all efforts to use best practices of our foreign colleagues and introduce our own ideas in this project.

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Cooperation in the field of intelligent energy

Interview with Takeshi TANAKA, Show Director, World Smart Energy Week

— The 4th International Exhibition "INT'L SMART GRID EXPO" is held within the scope of the World Smart Energy Week together with other events like the exhibition of rechargeable accumulator batteries (Battery Japan), exhibition of hydrogen and fuel components (FC Expo), exhibition of solar system (PV System Expo), exhibition of environmental-friendly construction (Eco House & Eco Building Expo), exhibition of solar power generation (PV Expo), exhibition of wind power (Wind Expo), exhibition of processing technologies (Enetech Japan). How does INT'L SMART GRID EXPO relate to these events? Are they competitors?

— Such a format of showcasing of world industry and energy modern achievements in the field of intelligent networks is chosen not accidentally. Each of the events within the World Smart Energy Week allows professionals of relative skills and directions the most in-depth studying of selected topics, to build dialogue with a range of experts dealing with the same issues and the same interests.

At the same time all the exhibition shows complement each other, creating a unified information space around the «Smart grids» topic. This allows specialists in various areas of energy meet and discuss with other professionals related cross-border issues and generate balanced technical solutions, build business relationships.

The proposed concept is maximally comfortable for heads of enterprises operating in the field of «Smart grids». Depending on the objectives pursued, the leaders are able to get an integrated view of prospects for the development of this trend, to visit as quickly as possible all interested exhibitors, to hold business talks with the participation of all the parties concerned or delve into the discussion of a specific problem.

Thus, all shows presented at the World Smart Energy Week work to achieve a common outcome: provide all persons concerned with necessary information on prospects for the development of «Smart grids», facilitating the establishment of business connections and the promoting best ideas and technologies in the field.

— In recent years many exhibitions and business events are held under «Smart Grid» and «Smart Energy» marks. What is unique about INT'L SMART GRID EXPO in Tokyo?

— Recently the subject of «Smart grids» is extremely popular. However, despite the similarity of names, our observations show that the thematic content of exhibition and business activities carried out by various organizers differs. We believe that the reason for such differences in the first place lays in the lack of unanimous understanding in professional circles of Smart grids ideology, various degree of readiness of the power grid to implementation of this ideology and the differences in the development of appropriate technologies. Many experts and energy industry specialists who have a thorough knowledge of the structure and features of the existing power grid believe that the implementation of the «Smart grid» ideology is related to the automation of production processes and building a corresponding management system. Accordingly, given these views and the interests of the participants, many events on the smart grid ideology are devoted to the development of information and communication technologies in the energy sector.

In our view, the «smart grid» ideology is much broader than general organization of process control automation system in a single grid. The latest world trends in the power sector define direction of development for power system interconnections; building an effective system of energy resources exchange and overall strengthening energy security. To solve these fundamental problems power system automation, no matter how intelligent it is, is not enough. It requires an examination of a set of technologies aimed to achieve these goals.

That is why the World Smart Energy Week invites all visitors to get an integrated view on the issues of smart grid building. Our show not only covers the IT/communication technologies and services, it covers other important segments such as wind power, PV, hydrogen & fuel cells and rechargeable batteries. Also what's unique about our World Smart Energy Week is that the individual 8 shows are independently all world class/Asia's leading specialized B-to-B shows.

— What are the main objectives of INT'L SMART GRID EXPO holding? What results do organizers expect to obtain?

— Our main aim is to support the business between exhibitors and visitors and contribute to further development of the industry through our show.

We believe this will be achieved by the following factors:

- increase in the number of smart city projects implemented by various countries, regions subsequent dissemination of best practices on a global scale, taking into account regional peculiarities;
- raise awareness of energy companies specialists about the features and capabilities of technology and equipment for the construction of «smart grids», which in turn will create conditions for increasing the number of purchases of products and technologies and, consequently, their distribution;
- increase in the number of partnership established between exhibitors and visitors.

— Many global companies that establish trends in the industry for years to come take part in the exhibition and business events. Do they expect world premiere of new developments (equipment, technologies) in the field of smart grid construction during the 4th International Exhibition "INT'L SMART GRID EXPO"?

— INT'L SMART GRID EXPO is annually gaining popularity, gaining credibility among professionals and experts of Energy and Industry. It is expected that the INT'L SMART GRID EXPO — 2014 will bring together over 1,510 exhibitors from more than 30 countries. Total number of visitors of the exhibition will exceed 80,000 people.

We certainly hope that the exhibition would be a strategic and effective platform for the development of new products and technologies. A lot of promising new technologies in virtually all areas of the development of «smart grid» were presented at the 2013-year exhibition. Most of them were highly appreciated by experts in this field and received a lot of recommendations for further improvement.

At INT'L SMART GRID EXPO — 2014 you have the opportunity to meet with well-known world-class companies that will present to the participants their latest developments and the results of many-year perfection of known technologies; and with debutants, in the course of communication with which you may change your view on the now traditional notions of intelligent networks. In any case each of exhibitors and visitors will find and open a lot of interesting and new, and will become a full member of the expert community in the field of building smart grid.

— What business events are scheduled during the exhibition and what are most special of them, in your opinion?

— The list of World Smart Energy Week events is very long and is formed so as to satisfy interests of almost any exhibitor. Each of the thematic platforms holds a lot of events it would take too much time to make a full enumeration of it here. Besides I draw your attention that the exhibition is visited by many organized delegations of various countries, each of which has its own program of business events. To navigate through all this variety we recommend using the official guides, information posted on the official website, as well as the services of on-site staff and help desk working directly with the exhibitions.

— Generally speaking, the conception of the term «Smart Grid» is different in countries and companies. Does INT'L SMART GRID EXPO set the objective to support unification and standardization processes in this field (terminology, concepts, data communication protocols, etc.)?

— Given the global trends which we talked about above, the solution to the issue of standardization in the field of «smart grid» is indeed one of the main tasks. We respect the open competition so we would like to leave it up to the industry professionals to develop the unification/standardization. We try to contribute by putting the best efforts to provide the best platform and environment to carry out the business negotiations.

Innovation Suite of IT-Systems to Control Power Supply of Olympic Venues in Sochi

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The first-of-its-kind suite of IT-systems designed to control power supply in Sochi was commissioned in September of 2013. Information systems of the Power Supply Control Centre (PSCC) of Sochi energy region were designed according to the special order of JSC "FGC UES", part of JSC "Russian Grids" Group of Companies. The project was implemented within the framework of an agreement on interaction signed between JSC "FGC UES" and Rostec Corporation. The direct project contractor was CJSC "RTEC", part of Rostec Corporation. The large-scale high-tech project was implemented within a short time. The period from development of technical solutions to commissioning of the system at PSCC of Sochi energy region was less than half a year.

The main task of PSCC is monitoring and analyzing the general and operational situations at power facilities involved in external power supply of Olympic venues and infrastructure facilities in Sochi, as well as organization of interaction and coordination of efforts of all entities. PSCC is to ensure efficiency and justification of the taken decisions through introduction of innovative technologies, analysis and visualization of information that is critical for situational control of operation both in normal operating and emergency modes.

PSCC implements a suite of three integrated basic information systems, which includes the Decision Support System (DSS), the main and redundant SCADA Systems.

The main tasks of PSCC suite of information systems are the following:

- monitoring of general and operational situations. Regular preparation and reporting of monitoring results in accordance with provisions of the Regulation on the control of power supply of Olympic venues and principles of interaction between organizations supplying power to Olympic venues during preparation for and holding XXII Olympic Winter Games and XI Paralympic Winter Games 2014 in Sochi;
- real-time situational analysis and assessment for facilities supplying power to Olympic venues in Sochi region;
- coordination of actions of organizations operating Olympic venues in case of accidents and emergency situations in external power supply networks of these venues;
- interaction with regional and federal authorities, structural subdivisions of EMERCOM of Russia, personnel of grid companies and companies providing back-up power supply of Olympic venues.

The PSCC decision support system is designed for constant comprehensive and real-time situational monitoring and, ultimately, for increasing efficiency and justification of decisions. DSS is designed for creating conditions for individual and joint work of operating personnel of substations, field crews and PSCC personnel both in normal operating mode and in emergency situations.

PSCC DSS is based on QuaSy-DSS platform; its methodological basis is formed by innovative smart technologies, including methods of ontological modelling, the concept of systemic situational analysis of activity, experientology as the direction providing for structuring, organizing, accumulating and translating of experience, as well as the language of structured messages. This was the actual foundation for automation of processes of collection, processing, statistical analysis and visual display of information about current activities of organizations supplying power to Olympic venues, including maintaining electronic operating documentation by PSCC personnel.

PSCC DSS provides for fulfillment of the following functions:

- receiving, storing, displaying and preliminary analysis of regular data flows in-coming as structured messages (basic real-time information) from workplaces of PSCC on-duty operating personnel generated on the basis of the power engineer's language of structured messages;
- receiving, conversion, analysis of regular flows of well-structured messages, their classification and submission of operational situation reports to various levels of decision-taking in order to create a coherent view of the objectively existing situation;

- maintaining and actualizing of the database of power facilities (substations and transmission lines) in accordance with the coordinated information profile of equipment with the respective list of attributes;
- maintaining a database of subjects of activity on the basis of a task-oriented classifier of subjects of activity in order to facilitate decision-taking and organizing activities of DSS users;
- maintaining, storing, developing and direct practical use of databases of terms, syntactic rules, typical word combinations and autosyntax rules for maintaining PSCC operations logs;
- visualization and structured description of electric circuit diagrams of substations and transmission lines;
- design, development and visualization of models of organization of the enterprise's activities and decision-taking with possibility of their further conversion into database objects;
- organization of PSCC personnel's activities through automation of the PSCC operations log maintenance process;
- displaying of geoinformation data through interaction with the regional GIS-node installed in PSCC;
- maintaining a database for emergency backup equipment in Sochi region;
- monitoring of movements of emergency and repair crews with the use of mobile systems and real-time map display;
- monitoring of operating vehicles with the use of mobile systems and real-time map display;
- integration of all three systems, exchange of information related to emergency situations and unplanned outages irrespective of its nature.

The DSS system includes 12 subsystems (modules).

1. QuaSy DSS: Message server — Message server subsystem.
2. QuaSy DSS: Monitoring — Situational monitoring subsystem.
3. QuaSy DSS: Objects — Subsystem of registering and maintaining of electric power facilities (objects of activity).
4. QuaSy DSS: Subjects — Subsystem of registering and maintaining of entities (subjects of activity).
5. QuaSy DSS: PLSM — Subsystem of support of the power engineer's language of structured messages.
6. QuaSy DSS: ConFrame-Electric — Subsystem of development, visualization and actualization of electric circuit diagrams related to the database of electric power facilities.
7. QuaSy DSS: ConFrame-BI - Subsystem of development, visualization of models of the enterprise's activity organization by tasks.
8. QuaSy DSS: NCS OL — Subsystem of maintaining operations logs of the network control center:
   - QuaSy DSS: OL — NCS (for PSCC);
   - QuaSy DSS: OL — NCS (for MSAC — mobile situational analysis center);
   - QuaSy DSS: OL — NCS (for ODS — operating and dispatching services);
   - QuaSy DSS: OL — NCS (for DN — distribution networks);
   - QuaSy DSS: OL — NCS (for MPC — main power consumers).
9. QuaSy DSS: SS OL — Subsystem of maintaining substation operations logs.
10. QuaSy DSS: FC OL — Subsystem of maintaining operations logs of field crews.
11. QuaSy DSS: PMIT (power engineer's mobile individual terminal) — Subsystem of organizing data communication (structured messages) by means of personal communication devices of substation operating personnel.
12. QuaSy DSS: PSIT (power engineer's stationary individual terminal) — Subsystem of organizing data communication (structured messages) by means of stationary automated workstations of the operating personnel.

MESSAGE SERVER

Designed for collecting, storing, displaying and preliminary analysis of regular data flows in-coming as structured messages (basic real-time information) from mobile and stationary automated workplaces of operating and dispatch personnel generated on the basis of the power engineer's language of structured messages.

The flow of structured messages is organized on the basis of the power engineer's language of structured messages (PLSM), which is a specific instance of the Language for Organizing Common Activity LOCA. It should be emphasized that an integral part of PLSM is strict use of dispatchers' names of facilities and equipment, which are correspondingly stored in the integrated database. Structured messages are generated by operation, maintenance and administrative personnel by means of operations logs (OL). They can also use

CJSC "Russian Telecom Equipment Company" (RTEC) is the Russian private-public company established in 2007 by a resolution of the Government of the Russian Federation as a joint enterprise of Rostec State Corporation and a group of high-tech IT-companies with the aim of designing and manufacturing in Russia of trusted telecommunication equipment and communications systems. RTEC is a part of JSC "Ruselectronics" Holding.

JSC "Ruselectronics" is a group of enterprises specializing in designing and manufacturing of electronic equipment, electronic components, electronic materials and equipment for their manufacture, as well as microwave and semiconductor devices. The holding company was founded at the beginning of 2009 on the basis of the same-name state holding operating since 1997.

Fig. 1. Multi-window interface for monitoring PCSS messages

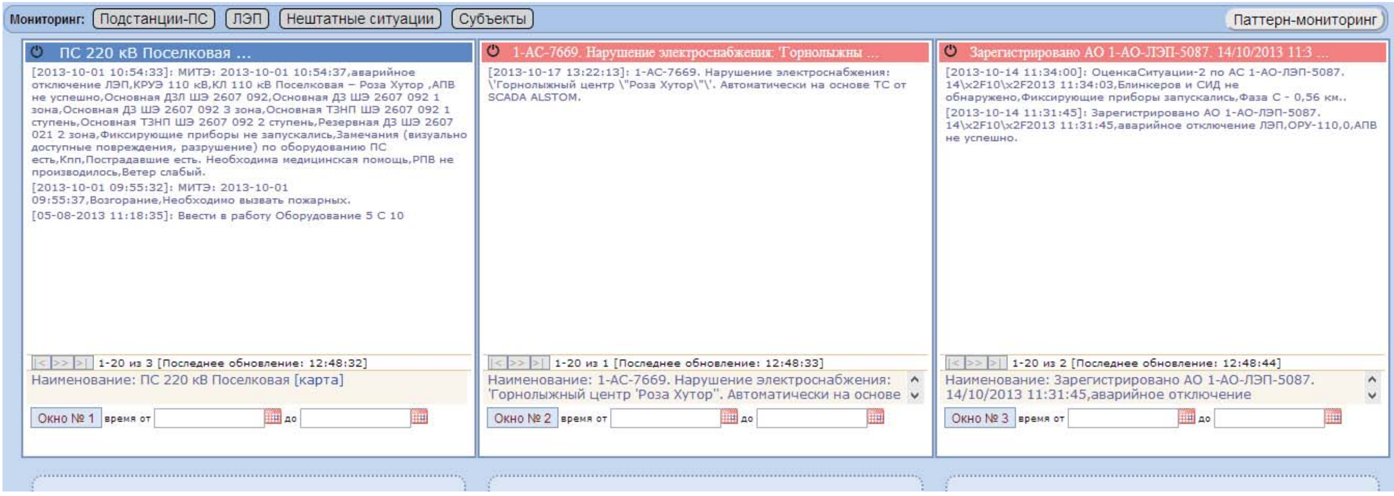
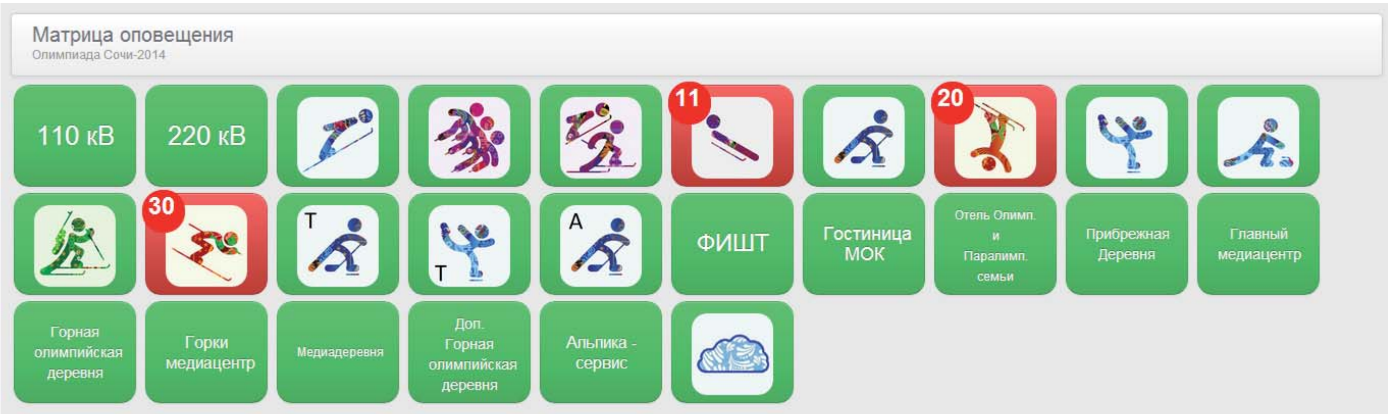


Fig. 2. Iconographic matrix of management notification



power engineer's stationary individual terminal (PSIT) and power engineer's mobile individual terminal (PMIT), the operating personnel of substations, network control centres, operating dispatch groups and field crews are equipped with. OL, PSIT and PMIT are organized into a network structure which can be controlled by transforming it, when required, into a hierarchically organized system of sources of flow structured information.

The situational monitoring subsystem provides collecting, converting, analyzing and visualizing of regular flows of well-structured messages in-coming from the message server subsystem, their classification and submitting operational situation reports to various levels of decision-taking in order to have a full view of the objectively existing situation. Examples of graphic interfaces are shown in Fig. 1—2.

The subsystem of registering and maintenance of power facilities (objects of activity) is designed for maintaining and actualizing of the database of power facilities (substations and transmission lines) in accordance with the coordinated information profile of equipment with the respective list of attributes.

The subsystem of registering and maintaining subjects of activity is designed for maintaining a database of subjects of activity on the basis of a task-oriented classifier of subjects of activity. Used for decision-taking and organizing activities of DSS users.

The subsystem of maintaining the power engineer's language of structured messages (PLSM) is designed for maintaining, storing, developing and direct practical use of databases of terms, syntactic rules, typical word combinations and autosyntax rules during automation of processes of organization and communication of messages from communication devices and stationary automated workstations of the operating personnel, as well as for maintaining operations logs of substations, field crews and the joint operations log of the Substations Group Control Centre.

CONFRAME-ELECTRIC

The tool for visualization and actualization of electric circuit diagrams related to the database of electric power facilities.

It is a graphic modeling tool for designing electric circuit diagrams of electric energy systems. Provides visualization and structured description of single-line electric circuit diagrams of substations. Enables creating and maintaining databases of electric circuit diagrams, distribution devices, connections, elements of their components, including description of required attributes, as well as correlating electric circuit diagrams and their elements with corresponding objects of databases displaying their structured description. A Web-oriented tool making it possible both to conduct its integration into any Web-application and use it as a separate stand-alone application. An example of the interface is shown in Fig. 3.

CONFRAME-BI

A graphic modeling tool for designing, developing and visualization of models of organization of the enterprise's activity and decision-taking by decision-makers, with a possibility of their further conversion into objects of databases. Includes tools for creating classifiers, taxonomies, mereotopologic task trees and describing activity organization models. Implemented for visualization and structured description of models of enterprises' activity and decision-taking by means of ConFrame tools. Enables developing classifiers, taxonomies for subjects (entities) and objects of business activity, building mereotopologic task trees, structuring business activity relations, correlating them with corresponding databases. Provides a possibility of creating and visualizing models of organization of the enterprise's activity by tasks, designing and describing well-structured models of infrastructure space and timing. A Web-oriented tool making it possible both to conduct its integration into any Web-application and use it as a separate stand-alone application.

OL

A subsystem of maintaining operations logs of the network control centre. The principle of using OL is described in detail in the joint work by A. Badalov, D. Gvozdev, V. Pelymsky, B. Shvedin.

PMIT enables arranging data communication (structured messages) by means of communication devices (tablets) of the operating personnel of substations. Provides a possibility of generating and communicating messages with the use of information profiles of equipment of certain substations or transmission lines.

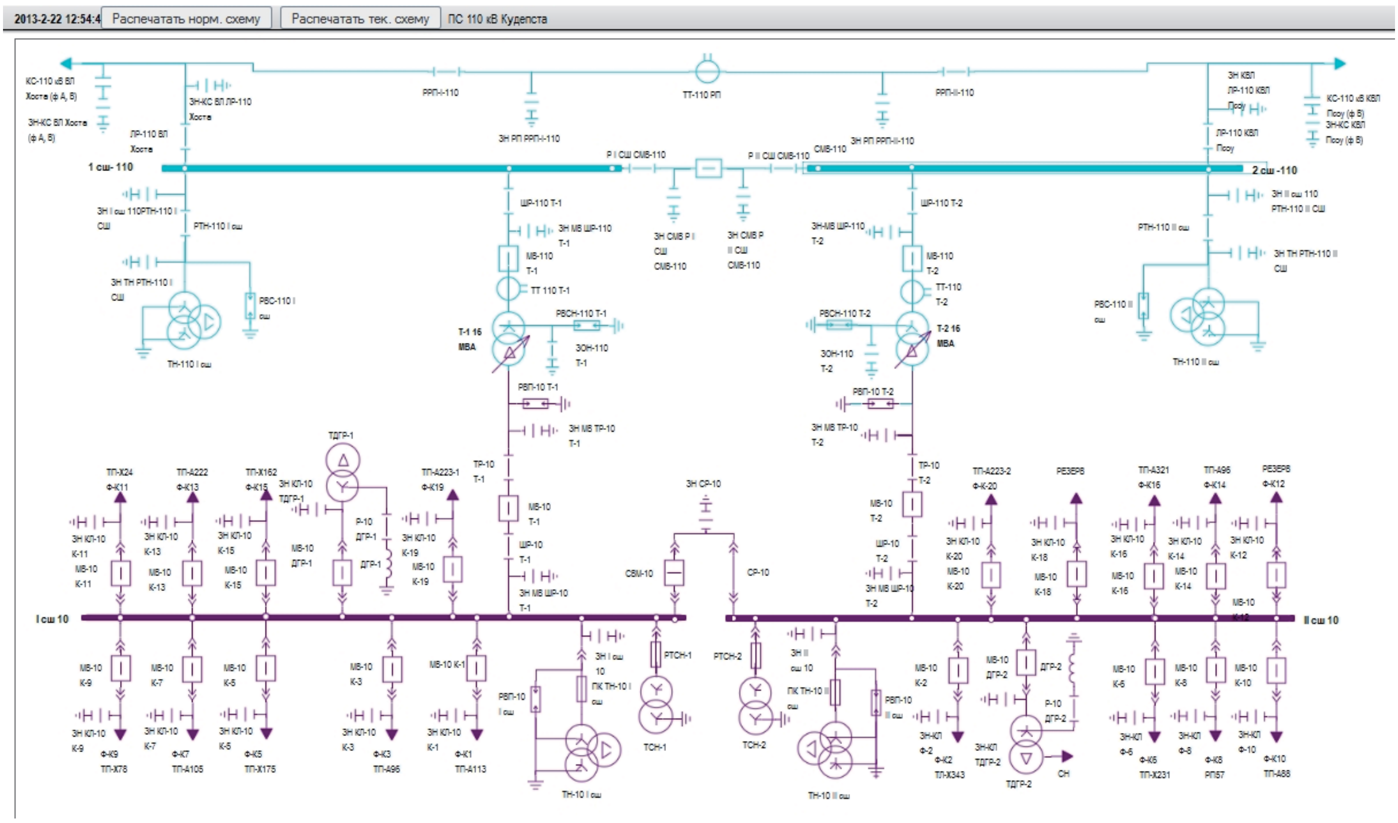
Messages are generated in the dialogue mode with the use of autosyntax in accordance with the specified algorithm.

The substation operating personnel was offered a dialogue-based model of situational analysis (DMSA), which made it possible to significantly reduce personnel's mistakes in stress conditions. An example of the interface is shown in Fig. 4.

CAPABILITIES AND TECHNOLOGIES OF GIS-BASED VISUALIZATION

DSS makes it possible to work with geoinformation data. Data of external GIS-systems can be imported into DSS GIS-system. All data are consolidated and by means of integration services are sent to adjacent SCADA-systems. In addition, integration services enable real-time displaying of data, reports, diagrams from DSS of the Joint Situational Analysis Centre on a geographic map.

Fig. 3. Electric circuit diagram of "Kudepsta" Substation 110 kV



Also, the GIS-subsystem receives information about the location of operating vehicles and crews. DSS interface enables easily navigating the map with all available objects to be supervised within the framework of the PSCC IS project. A fragment of basic DSS interface with the GIS-underlay is shown in Fig. 5.

During implementation of the project they used the logic of displaying monitoring areas according to their significance for the power supply of the region. In order to provide full visualization of monitoring areas and depending on the level of significance each of the areas is highlighted on the map with a certain color (the traffic lights rule). Green color means 'less significant', yellow — 'significant' and red — 'most significant' (Fig. 6).

The main SCADA provides monitoring and displaying diagrams and operation pattern of Sochi energy region of Kuban energy system as well as condition of the equipment (main SCADA-1). For the first time in the Russian electric power industry they commissioned the SCADA-EMS e-terraplatform system by Alstom.

Fig. 4. Dialogue-based model of situational analysis (DMSA) for on-duty personnel of "Laura" Substation 110 kV. Selection of emergency type

It should be emphasized that SCADA-EMS, built on the basis of the equipment database following IEC (CIM) standards, was integrated for the first time in the Russian electric power industry, too.

The flow of the manipulated telemetry is strictly attached to the equipment database and supported by it.

Special attention should be paid to the e-terravision technology (SA - situational awareness). It is the first-time integration of the given solution, which is innovative for the world practice, in Russia.

The redundant SCADA Syndis was supplied by "Mikronika" Company. The virtual concentrator (central receiver-transmitter station), an innovative tool enabling programmatically organ-

Fig. 5. Fragment of PCSS basic interface map. Tracking operating vehicles

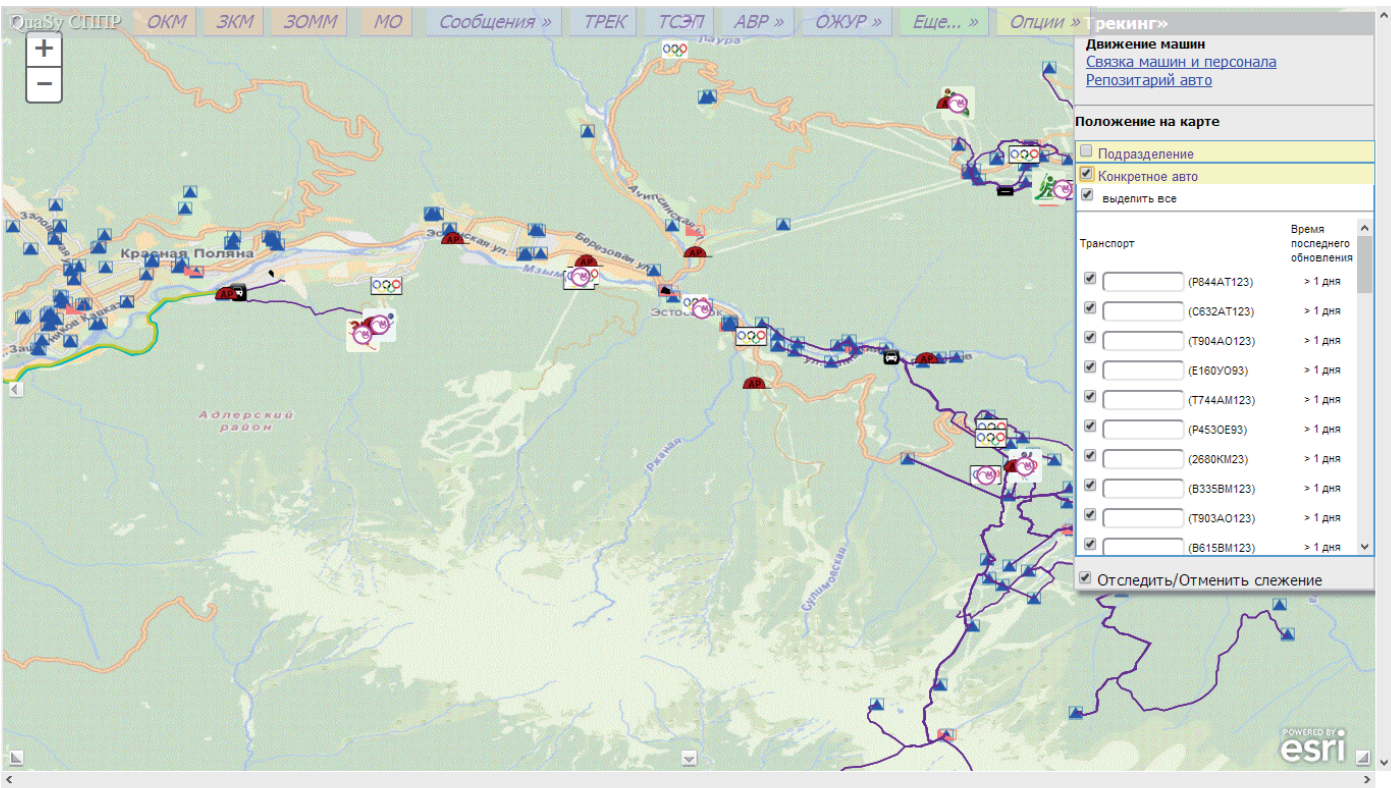
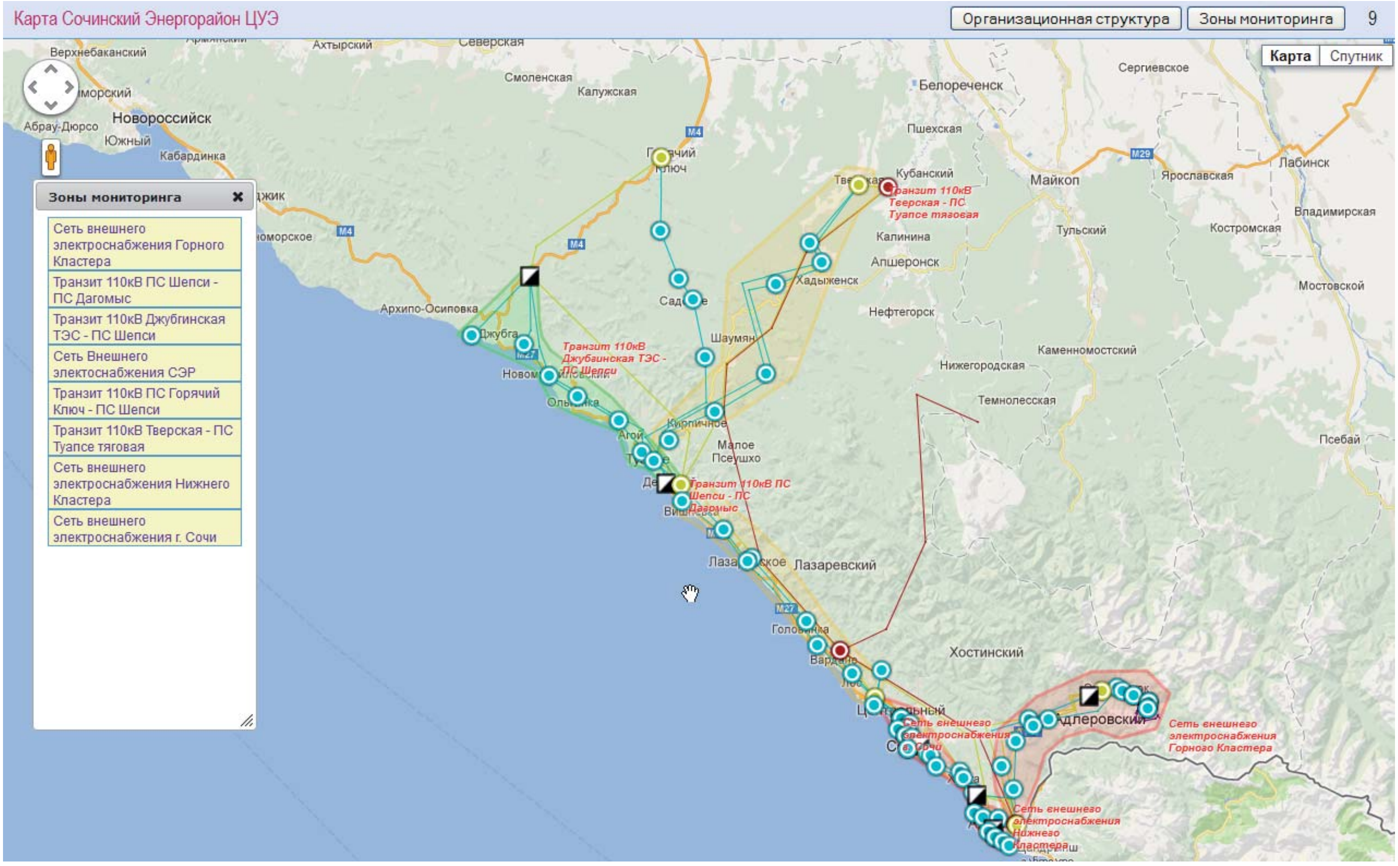


Fig. 6. Interface for monitoring areas



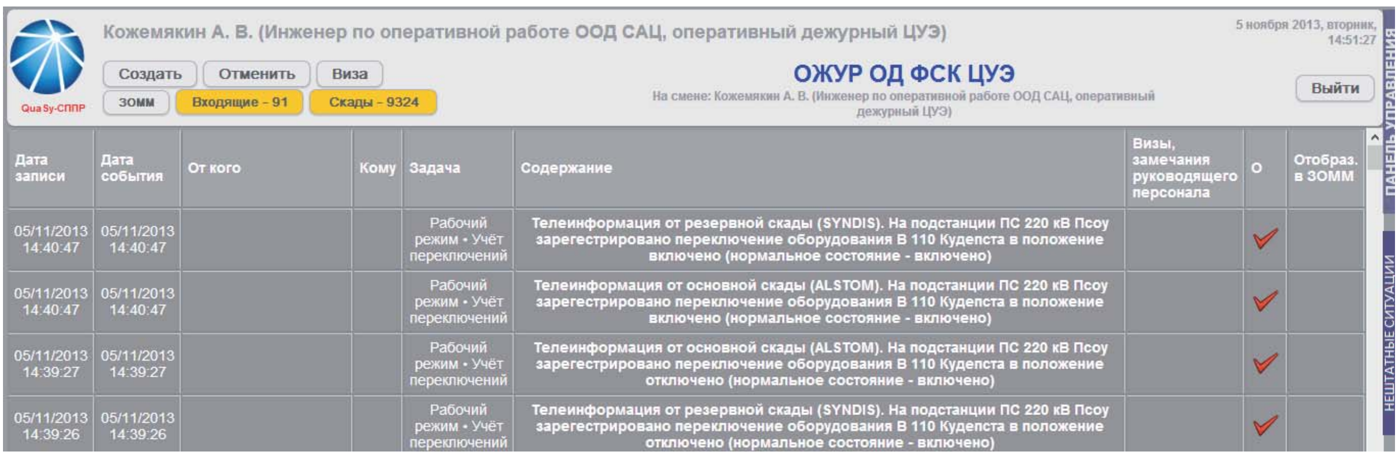
izing the telemetry flow, was used for the first time. Also, integration of the redundant SCADA and DSS was carried out. The redundant system provides monitoring and displaying diagrams and operation pattern of Sochi energy region of Kuban energy system as well as condition of the equipment.

For the first time the PCSS project implemented the technology of semantic integration between SCADA-EMS e-terraplatform and QuaSy DSS by using the QuaSy ConFrame-Electric Federator tool. The semantic integration was carried out with the use of the semantic ID generator for all equipment, as well as for the full telemetry flow. Thus, each telesignal and telemetering had not only its address, but also its semantic ID.

For the purpose of integration with SCADA Syndis only internal IDs of the system itself were used. In case of manual control of switching equipment the respective signals were sent from DSS to the main and redundant SCADA systems, like from a single source. On the other side, telesignals generated in the main and redundant SCADA systems were received by DSS for analysis.

Fig. 7 shows the PCSS on-duty engineer's working interface, which clearly demonstrates the way teleinformation is received from SCADA Alstom and SCADA Syndis.

Fig. 7. PCSS on-duty engineer's OL Interface. Integration of DSS, SCADA Alstom and SCADA Syndis



Process level development strategies

Dmitry UKRAINSKIY (Дмитрий УКРАИНСКИЙ), Leading Engineer,
Alexander ZHUKOV (Александр ЖУКОВ), Director General,
TERMA-ENERGO LLC leading engineer

A few years ago the terms "smart grid" or "digital substation" could be used only by young enthusiastic specialists as something very far.

But interest in smart grid inevitably grew, pro-active research, testing and development were carried out, and today the Government has made several strategic documents determining energy development in Russia. "Policy objective will be creation of intelligent electric grid complex with active-adaptive power system — new generation customer-oriented network based on the multi-agent control principle on the basis of mass balanced implementation of modern technological tools and solutions in the complex", as set out in "Development Strategy of the of electric grid complex." Thus, all the approved government documents directly refer us to creation of "Smart grids" in Russia, where digital substation are the key part.

In correspondence with IEC 61850 «Communication Networks and Systems in Substations» a digital substation has three levels:

- process level;
- bay level;
- station level.

The station and bay levels are the most widely covered and elaborated by Russian and foreign enterprises. These levels are responsible for control, monitoring, storing and distribution of data. Process level is not paid so much attention to, although it is responsible for collection of primary analog and discrete data, that is, primary information. This includes current and voltage, presence or absence of voltage, busbars and transformer temperature, cables insulation resistance and other signals. Some of the most important decisions are made basing on this information, so it must not be forgotten that modernization and development of sensors collecting primary information in substations is very important.

Digital sensor high-voltage test (35 kV).

Our company has secured its place in the market and established itself as a manufacturer and supplier of quality components for power industry, such as voltage detectors, voltage arc protection devices equipped with fiber-optical sensors, voltage dividers, and others. Also, our company develops and manufactures various products for 6—35 kV electrical equipment using epoxy compounds (post and entrance insulators, busbars). To do this TERMA-ENERGO LLC uses latest 3D technology for insulator and injection moulds design as well as modern equipment and technological processes acquired from the world leaders in this field, such as Hübers, Vogel, Hedrich, Huntsman. This combination allows TERMA-ENERGO to maintain high product consumer-grade.

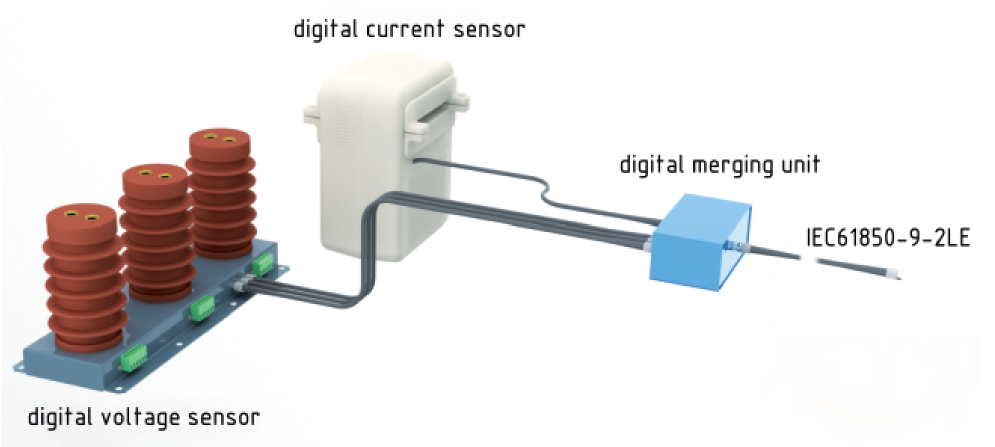
Development of modern element base and the adoption of new international standards provided a good opportunity for our developers to use innovative approaches to gathering primary information necessary to create advanced digital substations. Based on the existing problems in the world experience in running the digital stations, a clear understanding and concept to establish a harmonized set of devices for collecting primary information has been generated. Today it is one of the priority directions of TERMA-ENERGO activity. This primarily concerns acquisition of current and voltage data for commercial accounting and protection.

Contrary to popular belief about the preferential use of digital optical transformer at the substation process level we should not forget that such transformers are most appropriate and effective at high and extra high voltages. While at medium and low voltages due to their high cost and low sensitivity these transformers are not effective.

On the base of lengthy research our company has been successful in developing high accuracy current and voltage sensors outputting digital optical signals of currents and voltages measured in real time. Workable specimens were obtained and test results proved their effectiveness.

Current sensor consists of a specially designed high-precision, high-speed and jam-protected analog-to-digital conversion board and original measuring elements. All of this is placed on high potential side, does not require insulation and additional power source. Thus, only an extra strong dielectric fiber optic cable with two optical fibers providing galvanic isolation is routed to low potential side.

The first fiber transmits billing current values of 0.2s accuracy [1] / 256 samples/cycle; the second fiber transmits 10p accuracy [1] current data /80 (90) samples/cycle for relay protection units.



The current output signal ratio for relay protection device is 8000% of rated primary current. Operating temperature range is -40° to +85° C. The rated primary current is up to 5000 A.

Overall dimensions and weight of the current sensor is relatively small and can be commensurate with the classic measuring current transformer for 0.66 kV voltage. Therefore, mechanical strengthening of high-voltage bus to install the sensor is not required. Dimensions and weight almost do not change under the increase of the rated current within 10—110 kV voltage class. As for the cost of the current sensor, it is a sequence lower in comparison with cost of transformer based on optical laws and commensurate with cost of classical measuring current transformers starting from 10 kV voltage class.

Currently voltage sensor has an accuracy of 1%, and operates within -25 º — +50 º C temperature range. This sensor features a smaller dimensions and lower cost compared to existing measuring voltage transformers, it has no DC magnetizing and resonance phenomena inherent to classical voltage transformers. Work is underway to increase the accuracy of the sensor to class 0.2 [2] for use in commercial accounting of electric circuits. Digital output is similar to the output of current sensor.

To work on IEC 61850 standard these current and vol-tage sensors require digital Merging Unit, capable of receiving input digital optical signals and form a group digital stream protocol per IEC 61859-9-2LE standard. Using only digital signals, the accuracy of the information received is maintained as digital optical signal carrying information from the transformer is not affected by electromagnetic interference and, in addition, there is no analog-to-digital conversion, which inevitably introduces additional error. Moreover, lack of an analog-to-digital conversion greatly simplifies Merging Unit and reduces the dimensions.

In accordance with policy we seek to identify and work through the most weaknesses and continuously engaged in the development of sensors to collect other valuable information except for current and voltage. The next device to be launched into serial production will be a tool for online measurement of insulation resistance of cable lines. Due to constant connection of the device to high voltage, the time available for the measurement of this parameter takes about 5 minutes as opposed to the currently existing devices that perform the same task. The output signal may support GOOSE-messages.

Feasibility studies undertaken suggest that the cost of our equipment during the transition to serial production will not exceed the cost of conventional solutions and will provide a number of technical advantages:

- improving measurement accuracy and information transfer reliability;
- simplicity of design, operation and maintenance;
- unified platform data exchange (IEC 61850);
- high noise immunity;
- high fire explosion and ecological compatibility;
- digital signal in real time;
- absence of saturation and ferroresonance;
- small size and weight of the primary equipment;
- reduction in the number of copper cable connections, number of devices, as well as more compact arrangement.

So, due to the advent of IEC 61850 standard unified data exchange platform made a reality transfer of information using innovative devices, including digital current and voltage transformers. However, a number of questions remains to be solved and full integration of these technologies providing smooth operation needs a joint effort of manufacturers and developers operating in the field of digital substations. Our company is open for cooperation.

LITERATURE:

1. GOST 7746-2001 “Current transformers. General specifications”
2. GOST 1983-2001 “Voltage transformers. General specifications”.

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Application of Grid Energy Storages in Power Systems

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INTRODUCTION

Development priority of modern intelligent electric systems (IES) is to improve reliability of power supply, energy efficiency and environmental friendliness. Fulfillment of these tasks is often complicated by electrical network issues such as high equipment congestion, heavy losses and lengthy outages due to network accidents, complexity of RES-integrated network control due to intermittent power profile they generate.

One of the best ways to solve these problems is the use of energy storage systems.

To date, several types of storage devices are used with different ways of storing energy and technical characteristics: pumped storage power plants, compressed air energy storages, flywheel energy, supercapacitor energy storage systems etc. This article focuses on one of the most rapidly developing and promising directions for energy — grid energy storage systems based on batteries (BESS).

The basic structural components of BESS are batteries, bidirectional inverter to convert the current during battery charging and discharging as well as a system for monitoring, control and protection of BESS elements. Until recently one of the most studied and practically mastered were BESS with lead-acid batteries. However, in recent years application of other types of batteries, for example, sodium-sulfur, nickel salt, lithium-ion is actively developing. Increased interest in such batteries is conditioned by the fact that compared with lead-acid they usually have higher specific characteristics and longer service life.

Depending on the functions performed BESS can either be connected directly to the low voltage network (0.4 kV) or to a higher voltage network through a power transformer. BESS primary modes of operation are:

- electric power storage mode in which the storage consumes energy from the network for battery charging;
- output mode when BESS supplies previously stored power to the grid.

BESS APPLICATION IN POWER GRID SYSTEMS

Currently in Russia and abroad active research and practical implementation of BESS for different solutions are conducted:

Fig. 1. Daily load profile leveling by BESS

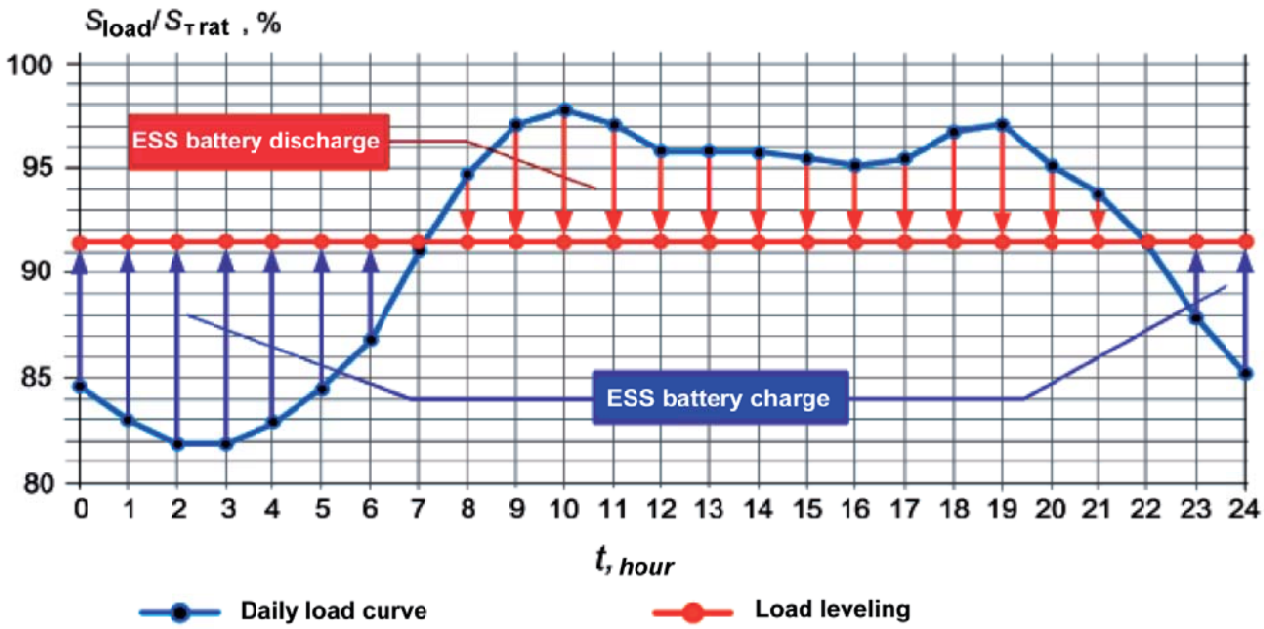
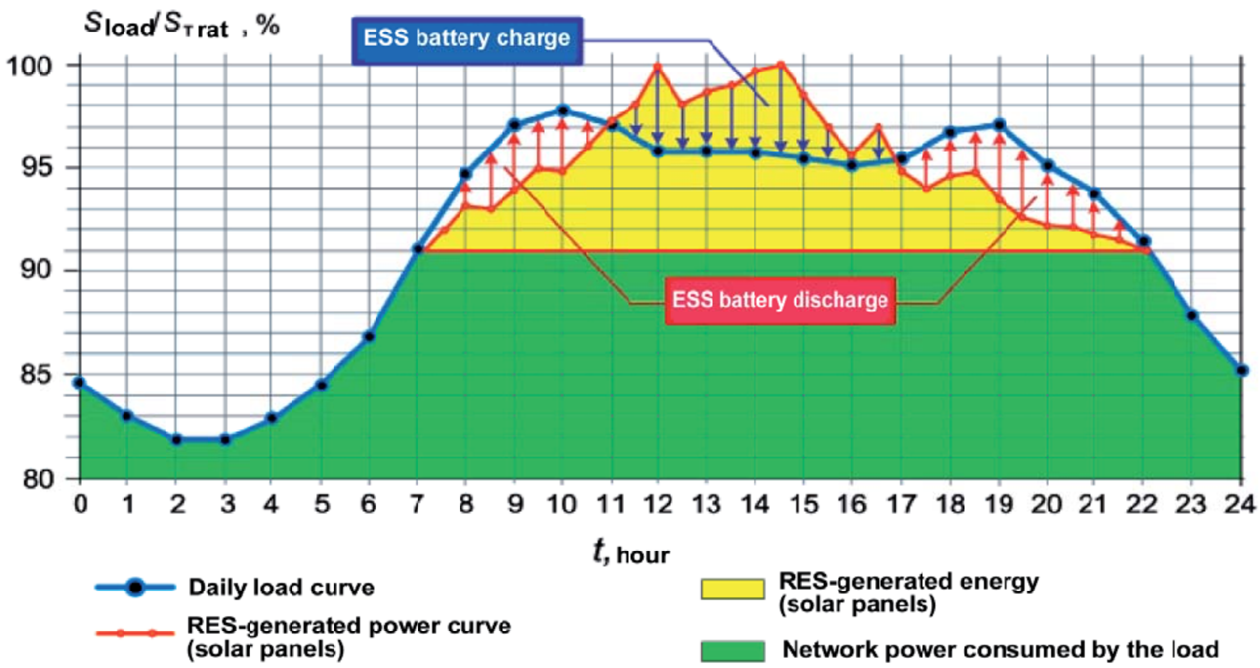


Fig. 2. Example of daily load curve and power in the network with distributed solar generation



- reduction of peak load, daily load curve leveling;
- renewable energy power curve balancing;
- customer and auxiliary systems backup power supply;
- reduce losses and improve power quality in the electrical network;
- network frequency regulation.

REDUCTION OF PEAK LOAD, DAILY LOAD CURVE LEVELING

Reducing peak load and daily load curve leveling are historically the first tasks to be solved with the use of battery-based ESS.

Back in the 80s several pilot projects in Germany, Japan and the United States were implemented where BESS on the base of lead-acid batteries were applied for the solution of these problems. To level the daily load curve in the hours of the low night demand (Fig. 1) BESS enters into battery charge mode and operates as a three-phase load, during peak demand it goes into a power output mode and supplies active and reactive power to the network.

In recent years this area of application is becoming increasingly important, as it allows to solve several important problems:

- partially unload the substation (SS) overloaded transformers, which potentially allows to connect them to an additional load
- to reduce the power and voltage losses in electrical network when using BESS as electricity supplier by reducing the value of the power transmitted along the feeders from substation to the customer by the amount of power received by the customer from BESS;
- maintain customer voltage required by regulatory documents during daily peak load.

RENEWABLE ENERGY POWER CURVE BALANCING

Renewable energy sources actively implemented abroad usually generate intermittent power curve. This in turn complicates the tasks of prediction power values generated by them and network mode control to which they are connected. To balance power generated by renewable energy sources BESS are successfully used. In excess generation mode BESS goes into battery charging mode, with a lack of power generated by renewable energy sources BESS outputs power to customers.

In the autonomous power supply systems based on renewable energy the use of BESS allows to power the customer even when renewable energy sources do not produce the amount of power necessary for the customer. Fig. 2 shows an example of the daily load curve electric network with a high degree of distributed solar generation. In this case, the use of renewable energy in the daytime allows to unload supply substations.

BESS is used to reduce solar power fluctuations while the value of power consumption from the network remains unchanged.

Fig. 3 shows an example of consumer daily load profile powered by independent source based on solar panels, wind turbine and BESS. In this case BESS is targeted to produce load supply under the shortage of power generated by the autonomous power supply system.

To date the leading foreign battery manufacturers offer different types of batteries to be used in BESS for RES. This is primarily a high capacity sealed lead-acid maintenance-free batteries made on GEL technology (less AGM) focused on the cycling and having compared with lead-acid batteries of other types are less self-discharge and having increased resistance to deep discharge. In recent years renewable energy is increasingly used BESS based on sodium-sulfur, nickel-salt and lithium-ion batteries. In comparison with lead-acid batteries benefits of its use are higher charge/discharge cycle, the possibility of deep discharge, the best mass and dimension parameters, but their operation is conditioned by more complex control system of batteries.

CUSTOMER AND AUXILIARY SYSTEMS BACKUP POWER SUPPLY

Nowadays to provide backup power to consumers of low energy needs battery-based BESS are used very widely. The market offers a number of solutions, mainly on the basis of lead-acid batteries, allowing autonomous electricity supply to consumers with relatively low load by earlier charged batteries from the network.

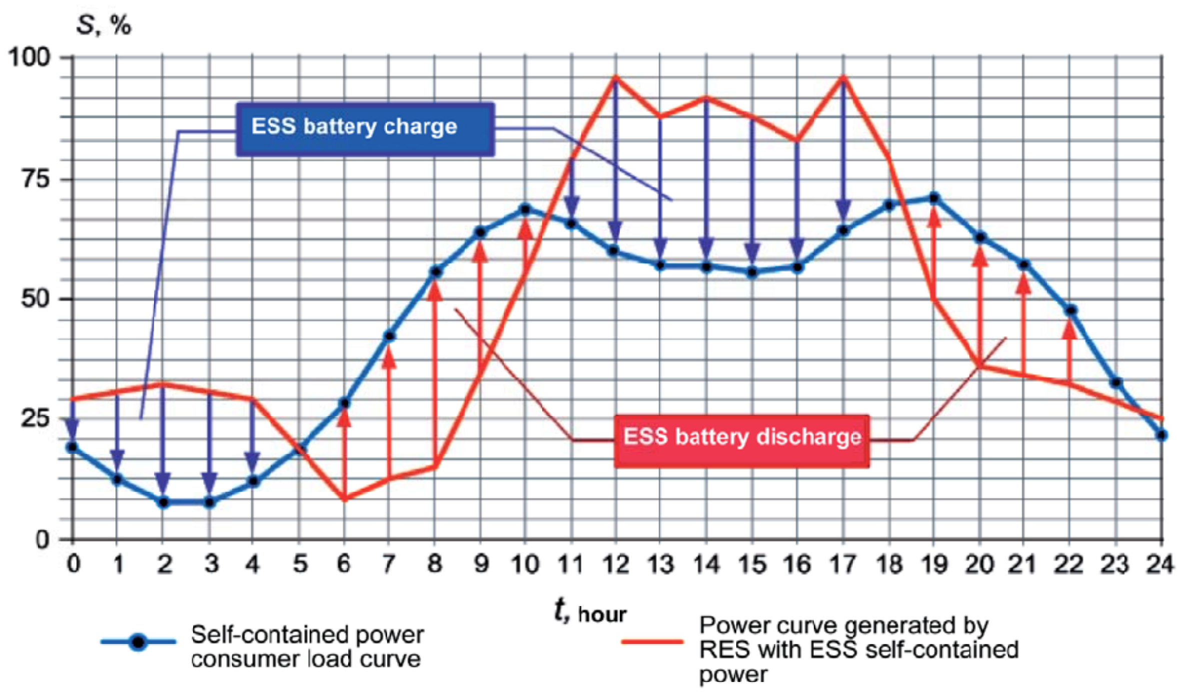
Application of BESS to provide backup power to consumer groups of high equivalent wattage is currently implemented in a number of projects abroad. This direction is promising, but the high cost of batteries restricts mass use of battery-based BESS to solve this problem. An example of a successful implementation of BESS in the distribution networks are projects of the U.S. company American Electric Power (AEP) carried out with the financial support of the U.S. Department of Energy. Within the framework of these projects by 2010 in Texas and West Virginia five large BESS of total power 11 MW and 75.4 MWh energy storage capacity are used for backup power applications as well as maintain a stable level of power at sharp increase in electricity demand. Also as part of the project “Community Energy Storage” 80 BESS of 25 kW/25 kWh each on the basis of lithium-ion rechargeable batteries are under construction and targeted to provide backup power for consumers.

BESS application for auxiliary systems backup power supply at a complete loss of the external power supply is an important direction of energy storage devices utilization that will improve the reliability of electricity supply to customers. This direction is successfully developed abroad and since recently — in Russia. One of the first BESSs in our country to provide backup power for substation auxiliary power supply were installed by JSC UES FGC in 2010 at 220 kV “Psou” SS (Sochi) and in 2011 at SS “Volkhov-Severnaya” (St. Petersburg).

REDUCE LOSSES AND IMPROVE POWER QUALITY IN THE ELECTRICAL NETWORK

Utilities are facing a number of challenges such as equipment congestion, assets degradation, non-optimal configuration of the distribution networks, etc. which lead to increased losses in electric networks and reduce the quality of electricity. To improve the situation various technical measures usually requiring significant time and material costs are taken: disaggregation of existing power networks, construction and commissioning of new supply substations and adjacent sections of the network, the use of booster transformers, reactive power compensation devices, etc. One of the operational decisions to these issues is to integrate BESS into distribution networks.

Fig. 3. Example of daily load curve and power when customers are supplied from a BESS autonomous RES



16 MW lithium-ion energy storage used to regulate network frequency. BESS is installed by AES Energy Storage in Jonson -city, New York.

Control system used in BESS bidirectional inverters allows to adjust BESS input and output power factors. Due to this the storage can be used as a reactive power compensation device. BESS application for reactive power control helps to maintain voltages at electrical network nodes specified by regulatory requirements, to reduce the voltage and power loss in the power grid as well as improve the load power factor.

When BESS is used to output energy to network the active power transmitted from substation to BESS site decreases also leading to power losses and voltage reduction in these parts of the network.

Thus, application of the BESS in distribution networks can improve the quality of voltage, to provide the required voltage to consumers in daily peak load and delay the necessary measures for the reconstruction and modernization of electrical networks.

NETWORK FREQUENCY REGULATION

Another important area of BESS application is to regulate frequency of the network. In this case BESSs connected to the mains can be used as active power spinning reserve or as an additional load. In case of network frequency reduction BESSs can be automatically or by the system operator transferred to output active power into the network until the frequency returns to the specified range or BESS is discharged to an acceptable value. With frequency increasing BESS can be switched into charge mode to increase the power load on the network. Abroad pilot projects on the use of BESS for frequency regulation have been implemented since the 80s. Currently this area is becoming increasingly important due to the increasing share of distributed generation based on renewable energy which power curve is often intermittent and difficult to forecast, and limited control under the deviations at mains frequency.

CONCLUSIONS

Abroad BESSs are considered as one of the key components of modern IPS. With more sophisticated network topology, increasing power load, growth of distributed generation and renewable energy the implementation of BESS is becoming increasingly important. Today BESSs are successfully applied to solve a number of problems: reduce maximum and daily load curve leveling, balance power curve generated by renewables, backup power service to consumers and auxiliary systems, reduce losses and improve power quality in the electrical network, regulate frequency in the electric networks etc.

Modern energy storage technology and power electronics allow to develop BESS with high specific characteristics and long life. One of the major factors hindering the implementation of BESS remains their high cost, which is primarily determined by the cost of battery. Despite this, thanks to wide functionality, the use of network energy storages to address energy challenges is very promising.

Pilot project for grid energy storage application in Unified National Power Grid (UNPG)

Creating intellectual electric network is a global trend. Work in this direction has been successfully carried out in many countries. In order to implement a number of elements that will provide UNPG with new properties it is necessary to create a technological basis, involving international experience, and to ensure in-home development and production of the state-of-art electrical equipment. One of these elements is Energy Storage Systems (ESS) based on high power batteries.

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Application of energy storage systems based on lithium-ion batteries is a revolutionary solution both in terms of convenience (mobility, compact size, environmental, etc.) and in terms of their impact on the planning and power industry efficiency.

For the normal functioning of the unified power grid of the country strict observance of parity between generation and consumption of power at any given time is required. The feasibility of using ESS is the ability to store electrical energy generated by power plants in excess during minimum load hours and its subsequent output to the network during peak hours. This provides a more uniform loading of generating facilities during the day and not to withdraw a number of power plants at night.

Moreover the use of ESS creates conditions for optimal network infrastructure.

In order to manufacture innovative equipment and develop new cooperation OAO "UES FGC" at the SPIEF 2010 signed a Memorandum of Understanding with company Enerl which meant the creation of a network energy storage system based on high-power lithium-ion.

In 2011 JSC "FGC UES" in conjunction with "Mobile GTPP" (100% subsidiary) embarked on a project on installation of GESS at UNPG facilities. The analysis selected two spots for possible deployment of GESS — 220 kV "Psou" substation in Sochi and 220 kV "Volkhov-Severnya" substation in St. Petersburg.

Implementation of these projects was approved by the Ministry of Energy (Protocol of 14.11.2010 № 414 pro).

Batteries bank installed at "Psou" substation.

GESS COMPOSITION AND FUNCTIONS

GESS on the base of high-power batteries consists of the following:
• bank of batteries;
• battery control and monitoring system;
• converter equipment;
• switching devices.

Each grid energy storage system at SS "Psou" and SS "Volkhov-North" consists of 5 containers: 3 containers with batteries, 1 container with conversion equip-

Parameter	Value
Battery capacity, megawatt hour	2.5*
AC rated power, megawatt hourMВт	1.5**
AC voltage current, three-phase, 50 Hz, kV	0.4 +10%
Phasor power factor	>0.95 subject to adjustment to +/- 0.95 (reactive power output)
Harmonic components	<5% THD (total harmonic distortion)
Long-term overload capacity	125% of rated value
DC maximum design voltage, V	DC 1180 V
DC voltage range, V	DC 720—1180 V
DC voltage ripple, %	< 2
Response time +1 to-1 MW, ms	< 20***
Inverter efficiency, %	> 95
System efficiency under double inversion, min, %	88**
Max stray load losses, %	<2 of rated power
Max limit charge/discharge rate (coefficient C)	2 C****
Rated inactive load, %	<1 of rated power
Charge/discharge cycle life	1600
Utilization factor (defined as the ratio of hours per year when the plant is ready for operation to the total number of hours per year (8760 hours), min:	
• for first 6 months of pilot operation	0.96**
• for the following year of the pilot operation and every year of commercial operation	0.96**

Notes:
* at the end of life cycle.
** Warranty parameter
*** Inverter response under frequency control mode C coefficient defines charge/discharge current relative to battery rated capacity, i.e. 2 C means current when the battery is fully discharged in 0.5 hour.

ment and 1 container with switching equipment and system control equipment. Given the particular sites for the installation, the SS "Psou" containers are mounted in two tiers, and the SS "Volkhov-North" four containers arranged in a row. Each container is equipped with its own air conditioning and fire extinguishing systems and freely dismantled wheelbase so to be quickly transferred to any suitable location along conventional roads without special agreement with Road Patrol Service. GESS has the following characteristics presented in Table.

Energy storage system at SS "Psou" and SS "Volkhov-North" can be in one of the six internet-preset modes.

1. "Availability for island mode" — forced (by the system operator) transfer of the inverter into voltage controlled mode for rapid (within 400 ms) transfer of the system into "island mode."
2. "Island mode" — dedicated load operation under loss of both substation auxiliary power supplies. "Frequency control mode" — network frequency maintenance by GESS load shedding or increase.
3. "Power peak smoothing mode" — house load peak shaving, i.e. GESS power output during maximum consumption and consumption during under-consumption.
4. "Real-time dispatch mode" — ESS dispatch control in the whole operation range of ESS.
5. "Charging" Mode — mode of maintaining appropriate levels of charge (if none of the modes are selected).
6. "Island mode" and "Availability for island mode" are inverter voltage control modes and the rest modes of operation are inverter current control modes of operation.

Choice of lithium-ion batteries is rooted in a number of advantages over batteries with a different chemistry including the most convenient structure of rechargeable cells allowing to create any required battery capacity and voltage range, wide range of admissible discharge currents allowing to use batteries for a wide range of applications in the energy sector, a greater number of cycles of use, high specific power consumption permitting to create compact and powerful energy storage systems and environmental friendliness.

EQUIPMENT TESTING

In 2011 specialists of JSC «FGC UES» jointly with OJSC "Mobile GTPP" and JSC "R&D Center at FGC UES" elaborated and approved Program and methodology and timeframes for energy storage systems testing.

The program included a number of parameters including frequency measurement of the output voltage when working with one or two inverters, measurement of the output voltage distortion factor, determining the efficiency of inverters, definition of the transitional variation of output voltage and inverter voltage recovery time, study on the modes of operation as a power backup source in frequency control mode, in load shaving mode, charge and discharge from the substation auxiliary board. It also included checking the functioning of the storage in "back-to-back" mode, stability analysis for side-by-side operation of two inverters and determining the overall efficiency of the energy storage.

Based on the successful results of the test it was decided to modernize the equipment in terms of ESS hardware protection improvement, as well as finalization of the interface and installation of additional control panels for the operational staff of the substation.

During commissioning and testing of energy storage systems the training of personnel of substations with issuing appropriate certificates were carried out, a set of operating and maintenance instructions were developed.

By now all energy storage systems test completed and Rostekhnadzor permission for putting ESS into operation received.

ESS field of application:

- together with or instead of the mobile gas turbine power plants (MGTPP);
- together with or instead of diesel generator sets;
- oil and gas facilities;
- railway facilities;
- peak load power-consuming industry;
- regions of Russia, where there is no centralized power supply (distributed generation);
- RF renewables (wind power stations, tidal power station etc.);
- network frequency maintenance;
- an alternative to construction of generating capacities and/or expansion of network infrastructure for supplying electricity to remote areas;
- essential backup power supply;
- infrastructure development for electric vehicles.

CONCLUSIONS

As a result of field test experiences of energy storage systems based on 1.5 MW/ 2.5 MWh energy storage capacity main operating modes have been successfully explored and serviceability in the following modes has been confirmed.

Quality improvement. ESS can be used to improve power quality in case of short-term disturbances in the network.

Reliability Improvement. ESS can be used to provide uninterrupted power supply before start of redundant power supplies (1—10 seconds). In case of outage for more than a few seconds ESS is able to generate enough power to ensure its continuity, correct deenergizing of equipment and/or transition to electricity production in the territory of the customer. ESS can ensure uninterrupted power supply during the time sufficient to remedy the outage.

Network power supply reliability improvement. This function is featured by capability to improve the reliability of power supply to the network side of the meter. To implement this function a combination of ESS and diesel generator set to compensate short-term power interruptions and to ensure reliability in case of long-term outages can be used.

Improvement of reliability of power supply to a consumer. The main task of this function is to improve the reliability of power supply to commercial and industrial consumers. To implement this function a combination of ESS and diesel generator set to compensate short-term power interruptions and to ensure reliability in case of long-term outages can be used.

Sustainability enhancement. To maintain stability of the power system during large disturbances caused by its failures that can be cleared by switchgear tripping, transmitted power should be significantly below the limit defined by the static stability. It is known that the maximum capacity at which static stability is maintained during small disturbances is called a limit of static stability. ESS on the base of large capacity batteries can be used on the DC side to provide of static and transient stability.

Load curve leveling. Load tracking is to ensure balance of power generation and consumption in a given part of the network. ESS is suitable for realization of load curve functions as it can quickly and widely change the values of the output power, naturally designed to track falling and increasing loads. When the load is falling, ESS charges, when the load is increasing, ESS discharges.

Power and frequency balancing. Power and frequency balancing (network load balancing) is intended to compensate short-term fluctuations of generated power and frequency. ESS usage for frequency stabilization can significantly increase the performance of existing regulators.

Voltage regulation. One of the main tasks carried out by ESS is to maintain voltage at a given level by generating or absorbing reactive power. To stabilize the voltage using ESS is to compensate the reactive resistance network to ensure the required indicators of sustainability. Using ESS as a voltage regulator reduces the possibility of voltage sagging and power outage occurrence. This feature is essential during peak loads.

Due to the impossibility of reactive power transmission over long distances under implementation of the function, distributed ESS, placed at the load lumping, become of particular importance.

JSC FGC UES continues to work on the development of network energy storage units and determine the most effective places to install them.

Five-container ESS. Aeriai view.

Integrated Technical Regulatory Framework at the Heart of Electric Power Industry Development

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TECHNICAL REGULATORY FRAMEWORK AT PRESENT

Nowadays Russia is one of the world's major producers of electric power (more than 230 GW). The unified energy system (UES) of Russia includes about 600 power stations with generation capacity of over 5 MW each.

However, notwithstanding such a great capacity of the energy system, Russia's GDP energy intensity amounts to 0.4 tons of fuel equivalent per USD1000 versus the average world index of 0.19 tons of fuel equivalent, while the energy intensity of products is 3—4 times as high. Comparing to developed countries, the structure of Russian GDP is characterized with a lower share of services (including transport and communications) and takes a traditionally modest part in the domestic household sector of economy, according to the level of per capita power consumption. Electric power available per worker in processing industry of Russia is 29.3 thousand kWh, in the USA — 45.9, in Finland — 98.3.

The wear-out rate of heat generating facilities and heat systems of thermal power stations continues to increase. About 68% of heat supply networks have been in operation for more than 25 years.

The electric power industry implements a significant number of outdated and redundant technical regulatory documents and standards developed both in Soviet time and the operating period of JSC "RAO "UES of Russia". Their status is ambiguous as some documents fulfill a role of recommendations, while others have not undergone the established procedures for incorporation into the legislation of the Russian Federation. Thus, the issues of legitimacy of industry-specific technical regulatory documents (TRDs), having no mechanism of adopting general industry standards and financing of their development and no TRDs establishing requirements to reliability, safety and energy efficiency of electric energy systems and electric energy facilities are quite urgent at present. These issues are of special importance in connection with establishment of market relations, Russia's joining WTO and participation in integration processes in post-Soviet regions (CIS, the Customs Union and EurAsEC).

The problems become worse with Russia's lagging behind the European Union and USA in the field of standardization: many Russian standards are more than 30 years old, the degree of harmonization of national standards in the field of electric power industry with international and European standards is, on average, 24% (in Germany it is over 90%; in EC — over 70%). The industry has no system of technical regulation and standardization. There is no coordination of works on creation, integration and supervision of compliance with TRD requirements. The TRD structure is imperfect. Work on establishing a modern set of terminological standards adopted in the world practice hasn't still been completed. Insufficient attention is paid to development of national standards, regulations and rules for UES design, construction, control and operation. There are no modern standards for implementation of devices and instruments in test and measurement procedures at all stages of the system's lifecycle. The existing low level of standardization negatively affects UES control, technology discipline and responsibility, which leads to accidents and failures in the system's operation.

At present the electric power industry primarily implements standards of organizations (SOs), with each power company developing its own SO with no regard to the industry's general interests. National standards which could bridge the gap are almost never developed, which increases the risks of accidents and failures of UES equipment. A target program of standardization in the direction of system intellectualization, integration of innovative products, implementation of unified and standard processes by means of network modeling hasn't been developed yet. All this has negative consequences for industry management, synchronization of works, cost increases and extension of terms for works completion. The industry has still not integrated effective sets of standards: PDPPS (product development and pilot production system), CALS-T (information support), which are widely implemented in defense sectors of industry. One can state that the industry has no due regard to issues of metrological support, which is essential for ensuring reliability, quality and safety.

EU STRATEGIC POLICY OF SUPPORTING INNOVATIONS THROUGH STANDARDIZATION

European standardization organizations (CEN, CENELEC, ETSI) consider standardization to be an integral part of scientific research and developments:

- results of research projects are invaluable for standardizers;
- research projects should be provided with information about standards that already exist or are in the process of development;
- standardization-related activity itself can give rise to the need in additional research (for example, developing required methods of tests and measurements of products).

The Technical Boards of European CEN and CENELEC have created the working group STAIR. This joint strategic working group deals with complex issues of standardization, innovations and research, in order to:

- provide recommendations in the field of the strategy for CEN and CENELEC Technical Boards concerning the integrated approach to scientific research, innovations and standardization;
- take into account the uniformity of the European Commission's policy in the field of scientific research, innovations and opportunities for making standards as effective as possible;
- offer decisions for transferring results of research projects into standardization providing the following:
    - standards enable popularizing innovative products and services, while winning trust of industrial users and consumers, and make a significant contribution to establishment of a large-scale market;
    - standards provide consistency and compatibility of products and services, due to which end users benefit from price reductions;
    - standards raise the quality of products, enabling implementation of advanced technologies and methods, while simultaneously considering safety and ecology aspects;
    - standards support export through elimination of technical barriers in trade on the single European market and on a global scale;
    - European standards support European legislature. Referring to standards, the industry can meet legislative requirements related to launching high-quality products onto the market;
    - standardizers establish general rules not only for providing conformance of products to safety and ecology requirements, but also for the companies to use these purposes as basic components in the fields of safety, protection of consumers and environment;
    - standards provide access to 500 million EU consumers. European standards conform to international standards (ISO, IEC, ITU telecommunications sector) to the maximum possible extent.

In this connection standardization is the best means for rapid launch of innovative technologies and products onto the market; it simplifies the lifecycle of an invention starting with development of its idea and ending with its introduction onto the global market; it is an essential tool of innovative business, scientific research and developments.

Standardization is particularly effective in adapting the new knowledge acquired during research to market needs in the following fields:

- nomenclature/terminology and classifiers;
- metrology;
- measurements and methods of reliability, quality and safety tests;
- energy efficiency and resource saving;
- transformation of products, processes and systems with due regard to intellectualization;
- functional and technical consistency.

In respect of the adopted new technologies, the standards which are supported by innovation-fostering policy (with due regard to terms of intellectual property) are key tools for ensuring technical applicability and market access. Thus, standards transfer innovative technologies into merchantable products and offers.

Research carried out in a number of EU countries (Germany, France, Great Britain) showed that, on the national economy scale, the joint effect of conducting works on standardization with due regard to implementation of international and European standards (ISO/IEC/ CEN/CENELEC) makes up more than 1% of the gross domestic product (GDP). Experience of foreign EU companies shows that each euro invested in standards gives profit of up to 20 euros. In Great Britain the contribution of technological transformations in GDP amounts to about 50%, while the contribution of standards directly in technological transformations amounts to more than 25%. According to experts, Germany derives standardization-related economic benefit of about 18 billion euros annually.

HARMONIZATION OF STANDARDS AS AN EFFECTIVE PATH TO UES DEVELOPMENT

Russia's joining WTO, establishment of the single economic and information space within the Eurasian Union and CIS, development of economy of regions in the Far East and on western borders of the Russian Federation create new opportunities for business. In this connection, creating mechanisms and tools of state support for establishing the modern regulatory framework of the industry is of special importance. Facilitation of processes of development and implementation of Russian national and sectoral standards, harmonized with international and European standards, will allow the level of standards' harmonization to increase to 70% by 2020 and, correspondingly, Russia's GDP energy intensity to decrease by more than 5%.

It should be emphasized that, in conditions of Russia's membership in WTO and establishment of the single economic and technology space in CIS and EU, there should be development towards establishment of a single, continent-wide electric power market, i.e. introduction, among countries of the European Union, Russian Federation and CIS, of a market-based effective load management synchronization mechanism using standards, regulations and rules harmonized with international and European standards. Analysis showed that fulfillment of such aims, first of all, requires implementation of measures on:

- establishment of a single basis of integrated and harmonized statutory and technical regulations and standards, including terms and definitions, market rules of electric power trade development, competition and investments based on non-discriminatory access to grids;
- integration of systems and programs of development of CIS-EU grid infrastructure with regard to ecology requirements and implementation of low-carbon power generation and renewables;
- creation of a common system operator;
- creation of conditions for mutual investments into development of grid infrastructure, construction and modernization of power generating facilities in Russia and EU;
- activation of work of Russian technical standardization committees and their participation in international technical standardization committees in ISO and IEC;
- development of cooperation between JSC "Russian Grids", JSC "SO of UES", JSC "FGC UES", on the one part, and ENTSO-E, on the other part;
- establishment of a joint regulatory legal and technical centre (Centre) promoting the development of a unified transcontinental sustainable energy system.

Herewith, the main tasks of cooperation of Russia, CIS and EU in the electric energy sector are ensuring UES reliability, efficiency, quality and safety and responsibility of electric power suppliers in respect of consumers. Such a single integrated policy based on mandatory implementation of uniform statutory acts, technical regulations, ensuring compliance with standards requirements will enable effective fulfillment of the tasks set, and in Russia — great reductions in energy intensity of GDP and products.

INTEGRATION AND SYNCHRONIZATION OF PRODUCTION PROCESSES

In the world practice UES primary development is carried out towards its intellectualization in all aspects and at all stages of production and engineering processes, including generation, transmission, distribution and management with implementation of a complex automated integrated functional system, including monitoring, metering, supervision, analysis, self-diagnostics, revealing deviations and self-control of indicators. In this case the lifecycle is described as an aggregate result of processes taking place from determination of needs of the society (consumers) in innovative (or modernized) system products and services to transition to a higher level of UES development caused by development of the society and changes of generations of equipment and technologies.

As it was demonstrated in a number of research papers, one of the essential and fundamental features of UES intellectualization is integration of standards in the field of electric-power industry with standards of information and telecommunications technologies, communications and metrological support. Without this integration it is impossible to create a technology platform — a regulatory technical configuration (architecture) of UES with real-time synchronization of processes throughout all stages of the system's lifecycle (from R&D, construction and operation to transition to other scientific technology generations of development of devices, equipment, substations and the system, as a whole).

It should be underlined that at present works on standardization in the field of Smart Grid in Russia involve specialists of 16 technical standardization committees (TCs), while there are 27 TCs in the International Electrotechnical Commission (IEC). EU countries have already developed many directives and regulations binding EU countries to fulfill requirements of standards specified in the directives and regulations. IEC has a working group (IEC SG) made of experts from 14 countries who develop sets of standards including protocols of interaction of devices in Smart Grid systems. Therefore it is necessary to use the experience of international committees and EU and, first of all, to carry out harmonization of national standards with existing international and European standards. A common trend of

UES intellectualization is development of sets of standards and other TSDs, integrating a multitude of smart digital computational, communications technologies and electrical architectures, as well as related established regulations and procedures, processes and services, which in functional and informational aspects should be compatible, synchronized in processes of design, construction, modernization and operation of UES components. Such a smart system will differ from others in flexible integration, self-diagnostics and self-control; it will be able to reflect technical, social and organizational needs in a sustainable, information-protecting smart grid with regard to confidentiality of consumers, who should be provided with an opportunity of collecting, metering, analyzing, implementing, processing, storing, communicating and deleting their information, which will enable rendering various complex services. Provision of such services requires comprehensive integrated standards relating to safety and protection of personal data. At that we should mention that the configuration (architecture) of a smart grid in accordance with the lifecycle should provide innovations in a way for solutions launched, for example, in 2019 to interact with devices of the previous generation, for example, of 2014, with regard to results of adequate analysis and monitoring of UES operation.

The practice of designing, building, operating, modernizing and developing UES and its facilities, in particular, demonstrates that one of the essential components of economic efficiency is synchronization of construction and engineering works with regard to required metrological support throughout the lifecycle of UES development and modernization, which can be implemented by means of corresponding integrated sets of standards and measures:

- first of all, to develop and create, in the field of electric power industry, an effective framework of statutory and technical regulations and rules based on national standards harmonized with international and European ones with regard to Russian peculiarities;
- secondly, to systematically improve the following regulatory methods based on implementation of national standards:
  - monitoring of metal structures and concrete structures with use of modern regulatory methods of measurements and analysis;
  - testing of UES equipment and facilities;
  - regulatory scheduling of repair and modernization works;
  - regulatory technical and economic assessment of situations and risks;
  - implementation of effective sets of standards of PDPPS, CALS-T, network modelling, etc.

Implementation of these measures will require introduction of corresponding amendments into a number of laws and by-laws of RF, including:

- the Federal Law “On Technical regulation” of 27.12.2002 № 184 as amended in 2002—2012;
- the Federal Law “On Electric Power Industry” of 26.03.2003 № 35 as amended in 2012;
- the Federal Law “On the Federal Contract System” № 44 with the aim to establish mandatory requirements to reliability and security of the system, electric power quality, energy efficiency similarly to the way it was done in USA Federal Laws and EU Directives and regulations;
- monitoring information should be orderly kept in a base of standards and regulatory data with the aim of storing and analyzing statistics and implementing it in calculation of risks with the use of respective regulatory technical methods.

Herewith, one should lay emphasis on an important direction, which is creating integrated sets of standards for analysis and assessment of risks throughout the system’s lifecycle, particularly for risk assessment at the stage of UES operation with the aim of solving problems related to security of development of smart grids and satisfying energy consumers’ needs with regard to economic efficiency.

Analysis showed that modern integrated sets of national standards should, first of all, include standards which establish:

- rules and regulations of technology design, construction and operation of facilities with development of type-design practices and unifica-

Fig. 1. Integrated system for synchronization of production processes in UES

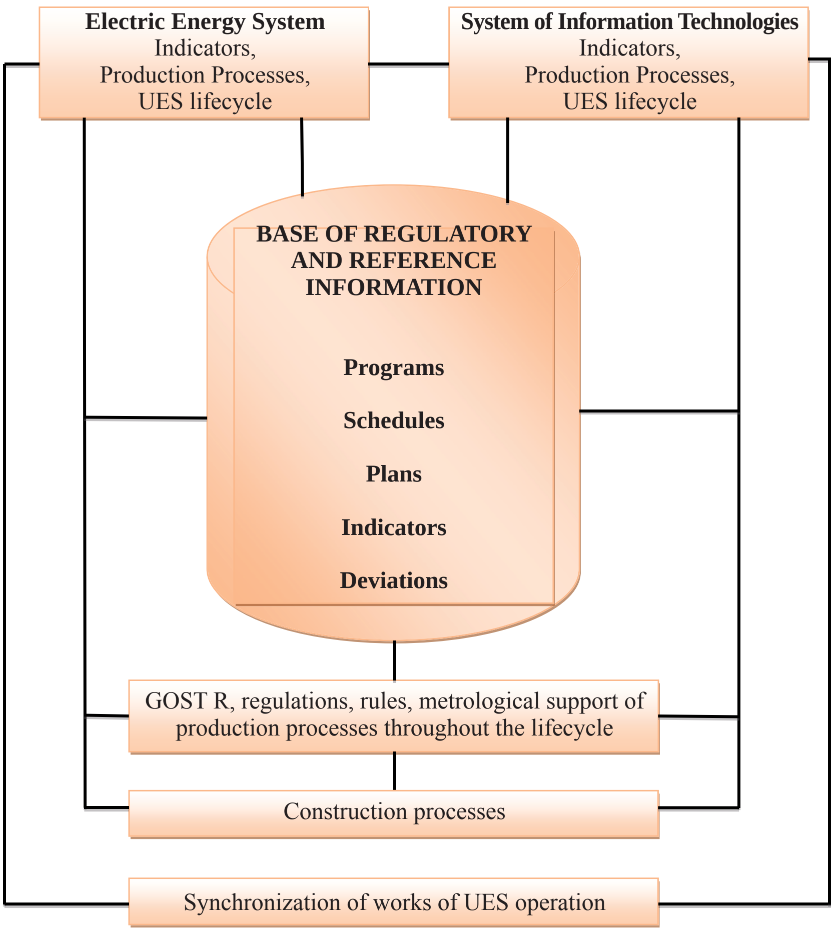
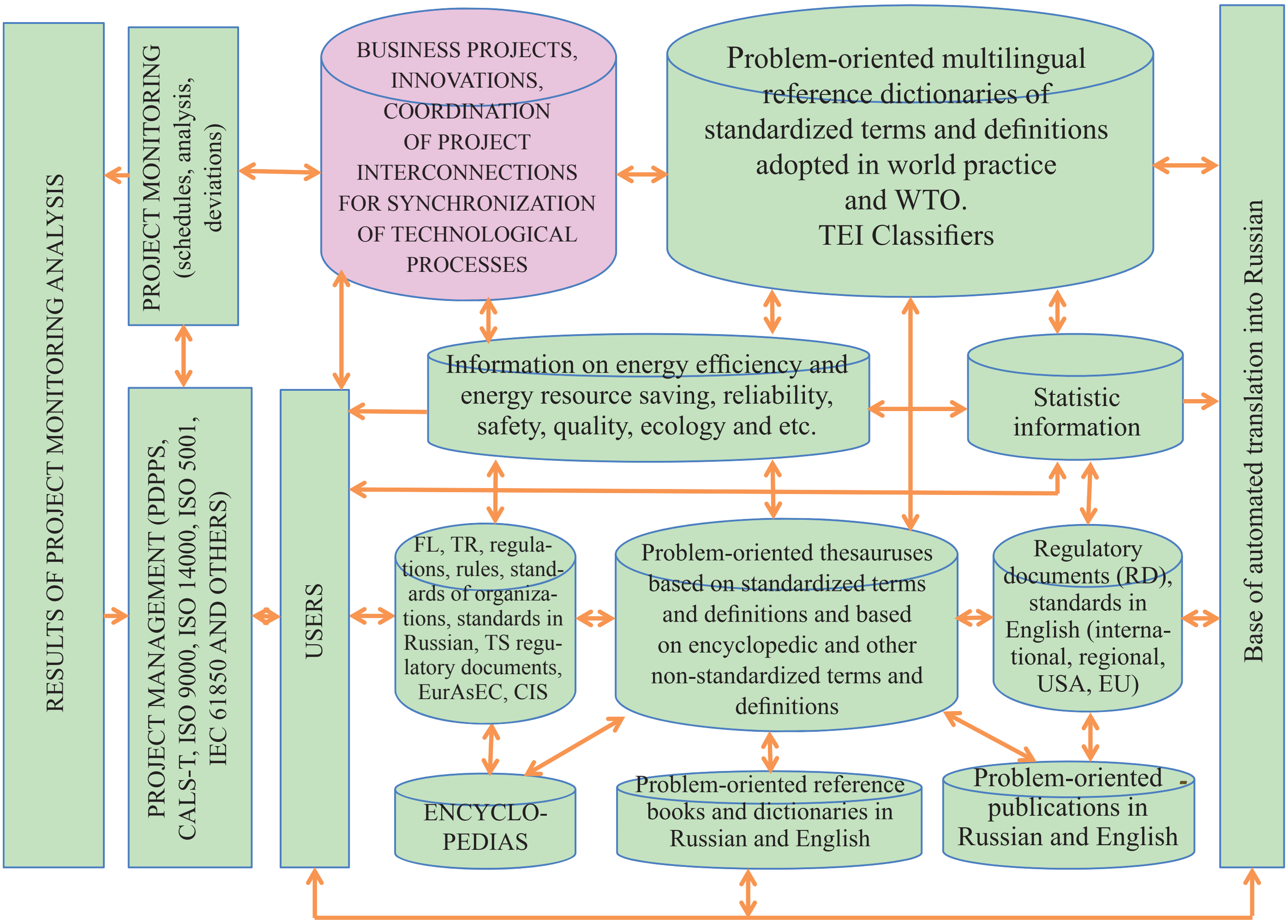


Fig. 2. Model integrated base of knowledge as well as regulatory and reference information for project management



tion of technical solutions, synchronization of organization of construction and modernization of facilities with regard to supplies of complex technical products in plant-tested large-scale units;

- rules and regulations of UES dispatch control;
- rules and regulations of scheduling and conducting repairs of facilities based on regular monitoring and diagnostics of the condition of facilities, as well as prompt situational analysis:
  - methods of testing facilities, devices and equipment, particularly during acceptance tests of public procurements;
  - rules and regulations of public procurements meeting mandatory requirements of technical specifications of Russian consumers in respect of reliability, quality, energy resource saving, safety and environmental performance;
  - rules and regulations for safety, reliability, quality, energy efficiency, resource saving and ecological requirements of construction and operation of facilities and UES, on the whole;
  - automation systems of control of technological processes with the use of international and European standards.

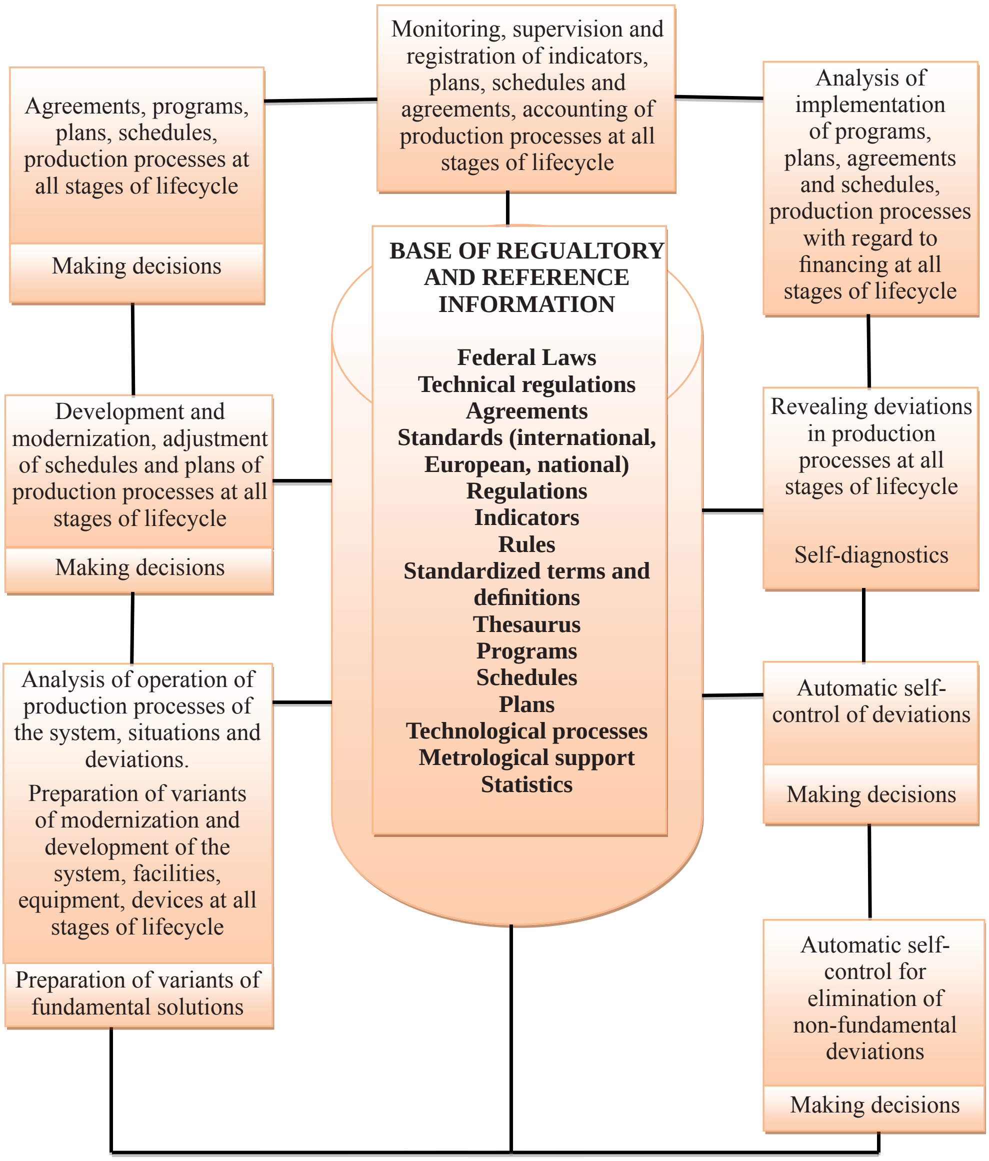
Advanced modern and effective integrated sets of standards should include standards for combined electric power and heat production and specific fuel consumption of energy facilities.

MANAGING UES DEVELOPMENT BY MEANS OF INTEGRATED REGULATORY KNOWLEDGE BASE

The above mentioned problems and their solutions also concern the public utilities sector, the share of which amounts to about 50% of all electricity consumption. Despite the fact that the volumes of residential housing construction in recent years have sharply increased, the tariffs for the population have correspondingly increased and will increase not only because of growing prices for oil and gas, but also because of irrational spending of fuel and energy resources and absence of a systematic approach to construction of industrial, residential and other social amenities buildings.

The main problem is that there is no single systematic approach to regulation in the public utilities sector. This explains predominance of industry-wide standards-creating — builders create their own standards and so do power engineers. This is especially true for the most

Fig. 3. Integrated functional system of UES control and development at all stages of technological processes throughout UES lifecycle



work-consuming and expensive part of construction — the engineering one — which is created and modernized throughout the lifecycle of facilities. In this regard it is essential to ensure efficient synchronization of builders' and power engineers' work with consideration for required development of methods of scheduling, test and measurement processes with the use of a modern regulatory framework of standards, rules and practices.

There exist sets of standards the implementation of which will enable effective management of both projects and operation processes. Carrying out systematic works requires use of a modern set of standards for the system of energy efficiency management (ISO 50001), which, by means of energy policy, can determine the algorithm of actions with the aim of achieving the goals set.

One of the essential standards of the industry is the fundamental standard IEC 61850, which includes standards for peer-to-peer communication and client-server communication, for designs and configurations of substations, for test methods, as well as standards specifying ecological and design requirements. A distinctive feature of IEC 61850 standard is that it gives an opportunity to various manufacturers of equipment for the power industry to build integrated compatible devices. Implementation of the integrated standard IEC 61850 makes it possible to reduce spending on design and installation of information networks.

IEC 61850 standard was used in developing GOST R IEC 61850-3-2005 "Communication Networks and Systems in Substations". The present standard can be applied to substation automation systems (SAS) and describes the communications between intelligent electronic devices (IED) and respective system requirements, establishes requirements to communication networks, in particular to their quality, as well as requirements to the environment, power supply sources and recommendations on compliance of the requirements to other standards and specifications for substation automation systems.

Taking into account the above mentioned, the systematic methodical approach under consideration based on integration of sets of standards can be shown with charts in Fig. 1—3. For instance, Figure 1 shows the scheme of an integrated system providing for synchronization of production processes in UES, which demonstrates close interconnections between builders, power engineers, IT-specialists by means of standards, regulations and rules, metrological support and a base of regulatory and reference information. Implementation of such an integration scheme is of special importance during modernization and development of UES and its separate components towards system intellectualization.

Fig. 2 shows a model of an integrated corporate base of knowledge as well as regulatory and reference information for users (power engineers, IT-specialists, builders and metrologists) using references, codes and standards, various regulations, including building codes and public health regulations and standards, rules, standardized terms and definitions, classifiers of technical and economic information (TEI), non-standardized (new) terms and definitions. It is demonstrated for business project management that the interconnection between projects and their management are carried out by means of synchronization of technological processes with implementation of existing integrated sets of standards, including PDPPS, CALS-T, ISO 9000, ISO 14000, ISO 50001, IEC 61850 and others, as well as analysis of statistics of various deviations of planned programs and schedules.

The conducted analysis was used for drawing a scheme of an integrated functional UES control and development system with regard to intellectualization at all stages of technological processes throughout the UES lifecycle presented in Fig. 3. In such an integrated UES development management system an essential feature is the need in constant monitoring and prompt analysis of development of international and European standardization with the aim of efficient implementation of foreign experience enabling reducing money and time expenditure on development, creation and development of facilities, devices and other components of UES.

Another important peculiarity of such a system is existence of various states of intelligence levels and development of UES units and elements, in connection with which it is necessary, while planning works, to develop models of configuration (architecture) of equipment generations, each of which will determine a mechanism of UES development management in space and time with regard to changes of equipment generations (Fig. 4).

PRIORITY DIRECTIONS OF MEASURES FOR DEVELOPING UES INTEGRATED REGULATORY TECHNICAL FRAMEWORK

Analyzing the state of the problem makes it possible to determine the following priority directions of UES regulatory framework near-term development:

- activating work of Russian standardization committees and ensuring their interaction with technical committees of international and regional standardization bodies;
- facilitating rates of interstate standards development ensuring compliance of products to requirements of technical regulations;
- harmonization of state supervision rules and procedures, including methods of assessing risk of harm done by dangerous products;
- establishing responsibility of the manufacturer (supplier) as regards safety and reliability of products launched onto the market, certification bodies and test laboratories — as regards accuracy of results and sufficiency of the conducted assessment of compliance;
- bringing requirements to products and related processes to compliance with international standards and achievements of science and technology in the field of electric power industry;
- developing standards identical to ISO/IEC/EN standards, with regard to assessment of readiness of the industry and test framework for their implementation;
- coordinating works on forming proposals for actualization of lists of standards with the aim of complying with requirements of technical regulations;
- increasing the level of harmonization of national standards with international and regional standards;
- reducing terms for developing standards, including developing preliminary standards;
- developing uniform rules and procedures confirming compliance of products to requirements of technical regulations;
- preemptively developing standards ensuring innovative development of electric power industry, including building smart grids;
- actively involving business community in the process of development of national standards;
- forming a single system of professional training and evaluating competence of experts of certification bodies and laboratory personnel.

In conclusion, it should be noted that, in conditions of establishment of the Single economic space and Russian Federation's joining WTO, improvement of the industry's integrated regulatory framework is an efficient tool of UES further development.

Fig. 4. Change of generations of systems, scientific/technical complexes and facilities