Management and development of digital technologies in the electric power industry of Russia

D I Zimnukhova, G A Zubkova, D E Morkovkin, P V Stroev and A A Gibadullin

1 State University of Management, 109542, Russian Federation, Moscow, Ryazan Avenue, 99
2 Financial University under the Government of the Russian Federation, 125993, Russian Federation, Moscow, Leningradskiy Avenue, 49

E-mail: 11117899@mail.ru

Abstract. The article is devoted to the development of digital technologies in the electric power industry of Russia. It is proved in the work that in recent years the issues of the industry’s transition to a qualitatively new development path, which, according to the authors of the study, should be based on the introduction of digital technologies and smart grids in the electric power industry, have become relevant. The study presented the main advantages of the Smart Grid system, which are self-regulation of the electric power industry and maintaining stability and reliability in the long term. At the same time, it was revealed that the transition to digital technologies requires the industry to form a new asset and production unit management system related both to the superstructure and the creation of new energy complex management elements. At the same time, it is expected that the introduction of Smart Grid will increase the economic, environmental, social and technological effect both for the industry and for the national economy as a whole. At the end of the study, conclusions are drawn from the results of the work done.

1. Introduction
In the Russian Federation, in recent years, the volume of consumption of electric energy has been increasing, while consumers pose new challenges for the industry related to ensuring the efficient operation of equipment, reliable and uninterrupted power supply to consumers, and a high-quality supply of electric energy. All this is caused by the transition of industrial enterprises to innovative and digital technologies, the shutdown of which can lead not only to economic consequences, but also destroy the built national economic and military system of the state. Of course, these requirements require the search for new mechanisms for their satisfaction and the transition to new conditions for the functioning of the electric power industry.

In the electric power industry, not only new tasks are being formed, but also the number of systemic problems that are associated with increased wear of equipment, a high proportion of electric energy losses, accidents and equipment failures, etc., is increasing. According to recent expert estimates, more than half of the equipment is used outside the park’s resource, and the total depreciation of production capacities reaches 50%, while there are no prerequisites for improving the industry’s efficiency and switching to new technologies [1-4].
In our opinion, one of the directions that allows us to improve the management system of the electric power industry, and, as a result, increase its efficiency, is the technology of the industry switching to Smart Grid.

2. Materials and methods
The purpose of this study is to analyze the conditions for the management and development of digital technologies in the electric power industry of the Russian Federation. To achieve this goal, the following tasks:

- conduct a comparative description of energy systems;
- determine the positive effect of the use of digital technologies in the electricity industry.

The study used methods of factor, historical, statistical, logical, comparative, economic, and mathematical, system analysis and a method of expert assessments that allowed the authors to solve the tasks.

3. Results
One of the promising directions for the introduction of digital technologies is Smart Grid, which is an automated system that transfers electric energy from the manufacturer to the consumer and is able to independently monitor and distribute electricity flows in order to achieve maximum energy efficiency. Thus, Smart Grid allows you to maintain a balance between demand and supply for electricity in real time [6].

Compared to existing power grids, Smart Grid has a completely new features and capabilities that can solve a number of problems facing energy companies in Russia.

In the framework of the Smart Grid concept, to achieve maximum effects from their application, the following unique functional properties are distinguished:

- self-healing in emergency situations. To ensure reliable and high-quality energy supply, it is necessary to maintain the state of all elements of the energy system at a certain level by switching to the management of preventive emergency recovery [5].

Within the framework of a self-healing power system, it is assumed that the maximum possible failures are minimized by collecting data and smart devices that implement special methods and decision-making algorithms [5].

The indicators obtained from the devices will allow not only a complete diagnosis of the equipment condition, but also an assessment of the probability of failure or accident, to predict possible failures in work, and also to formulate an algorithm of necessary actions for personnel [5].

Thus, Smart Grid provides the integration of various devices of the electric power industry, in order to achieve the stability of the entire industry and maintain the reliability of all power equipment;

- modeling of processes of active consumer behavior. In an energy system based on Smart Grid, it becomes possible to create conditions where the end user can adjust the volume of purchase of electric energy depending on the cost of electric energy and supply volumes in a specific period of time. This property of the power system is mainly aimed at smoothing the peaks of energy consumption, which will lead to minimization of the costs of energy companies for operating costs, in particular, the use of inefficient power units with high specific fuel consumption [5].

Peak consumption can be regulated through online applications provided by utilities or energy providers, through which consumers can control their energy consumption. In addition, consumers with their own sources of generation will be able to act as sellers, selling their surplus to end consumers [5];

- resistance to negative influences. This property assumes the existence of special methods to ensure the stability and flexibility of all elements of the power system, preventing accidents in advance and restoring the system in accordance with energy security requirements. To create sustainability, devices such as automatic switches, intelligent systems for monitoring and monitoring the state of
equipment will be used which will adapt to changing environmental conditions and reflect external threats. Thus, a Smart Grid-based power system will help deter, prevent and detect detrimental effects on the network and other elements [5];
- expanding the market for electricity and capacity for the final consumer. Free access to the markets of electric energy and the capacity of individual consumers, which have their own source of generation by increasing the capacity of networks, as well as the development of distributed energy, will contribute to the development of a competitive environment in the markets and optimization of the work of electric companies [5];
- optimization of asset management. The use of information obtained from equipment and sensors, and company databases will optimize the operating modes of the power system; improve the operation of equipment, which will significantly affect the reduction of system costs, as well as costs associated with maintenance and repair [5; 7].

Thus, based on the foregoing, a comparative analysis of the existing energy system and a system based on the Smart Grid concept can be carried out (table) [5-6; 8-10].

| Table 1. Comparative characteristics of energy systems. |
|--------------------------------------------------------|
| **Existing energy system**                          | **Smart Grid Based Energy System** |
| One-way communication between elements or its absence | Two way communication              |
| Centralized generation; complex integrable distributed generation | Distributed generation              |
| Accident response                                     | Accident Prevention Response        |
| System crash susceptibility                           | Systemic accident prevention        |
| On-site equipment verification                        | Remote equipment monitoring         |
| Limited power flow control                            | Power Flow Management               |
| Inaccessible or late information on final tariffs for industrial consumers | The rate is formed in real time |

It can be seen from the table that the energy system using the Smart Grid concept is more manageable and maneuverable, and the end user has not only the ability to consume electric energy, but also manage his own demand.

4. Discussion

However, the application of this concept cannot be implemented without the use of special technologies:

- information management systems. An automated data processing system - ADMS, which combines the subsystems responsible for managing distribution networks (DMS), supervisory control and data collection (SCADA), emergency shutdown management (OMS), and also a geographic information system (GIS) can act as an information management system.) This system will allow you to store, quickly analyze large amounts of information and immediately respond to possible accidents and blackouts, the data of which will be sent to the server of the power grid companies from digital substations and systems for the automatic elimination of accidents on power lines. Thus, the use of the ADMS system will effectively and efficiently solve operational problems at energy facilities, analyze the operation of the energy system, and optimize and control the operation of electric networks [6; 11-12];
- digital substations. Digital substations are substations with a high level of automation, and carry out their work and information exchange between the connecting elements of the substation in digital format [13];
- automation systems for the processes of eliminating the accidents of air (cable) networks. These systems include automatic sectioning, switchgear, and short-circuit sensors. Emergency
response systems will independently identify and localize the accident site, significantly reducing the time required for the repair team to go out and carry out repair work, as well as reduce interruptions in power supply;

- intelligent metering and energy monitoring systems. Automated information and measuring system for commercial accounting of electricity (AIIS KUE) is designed to collect and transmit telematic mechanics signals and automated commercial accounting of electricity [14].

At the same time, the development of digital technologies in the energy industry has the following positive effects:

- Reducing the operating and operating costs of electricity companies, which are achieved thanks to the technological features and functions of smart grids:
  - in the event of an emergency, the monitoring system for the state of the power system automatically cuts off the power supply to the damaged section of the network, and also localizes the scene of the accident, significantly reducing the time it takes for the repair team to find and fix the malfunction;
  - the monitoring system will allow you to monitor in real time the condition of the equipment that is part of the power system, thereby reducing the risk of overloading it and creating all the conditions for the transition from scheduled maintenance to repair according to condition;
  - the introduction of new intelligent distribution networks will reduce losses in the transmission of electricity by optimizing production and achieving a balance in the power system [13; 15].

- Ecological effects. States around the world are trying to solve the problems of environmental pollution by tightening legislation and standardizing the volume of emissions of carbon and other harmful substances into the atmosphere. The use of Smart Grid will reduce the volume of pollutant emissions thanks to the functions of demand management for electric energy in order to reduce power consumption during the peak load, which is covered by energy-wasting power [16].

- Improving the efficiency and reliability of power supply by ensuring absolute observability and controllability of the electric network, as well as the automatic detection of emergency outages and their remote response, which will reduce the volume and duration of emergency situations.

- Increasing the share of renewable energy and distributed generation. The introduction of Smart Grid technology will simplify the access of industrial and residential consumers to distributed generation sources by increasing the adaptability of the power system [5].

To date, mainly electricity is supplied from centralized sources of generation at a predetermined load, which greatly complicates the supply of electricity from distributed sources [5]. In this case, the integration of monitoring and control functions based on Smart Grid allows for stable operation of the network, as well as facilitating control of bilateral electricity flows and the functioning of renewable energy sources [5].

In addition, the use of distributed generation based on renewable sources not only saves consumers costs by purchasing low-cost energy, but also provides the opportunity to sell surplus electric energy.

- Economic effects. Thus, all of the above possible effects from the implementation of Smart Grid ultimately boil down to an increase in economic efficiency achieved by:
  - saving money on the construction of new generating capacities to cover the increase in load;
  - reduction of fuel costs at thermal power plants and, accordingly, fees for the emission of greenhouse gases and carbon;
• reduction of the predicted maximum load for consumers in demand management, which will allow to regulate and reduce peak loads;
• decrease in the level of redundancy of power by increasing the reliability and uninterrupted power supply;
• reduction of the share of electric energy losses in the conditions of using digital and innovative technologies [17].

Of course, the transition of the electric power industry to digital technologies requires the restructuring of the entire system of functioning of the industry, the creation of additional subsystems and changes in the working conditions of individual industry organizations, however, such a transition will allow the electric power industry to take a qualitatively new path of development and provide additional positive effects, as for the industry, and the economy as a whole.

5. Conclusion
Thus, as part of the study, an analysis was made of the effects of using Smart Grid in the electric power industry, which include the possibility of self-preservation, self-monitoring and self-healing of the energy system in the event of external and internal disturbances. At the same time, in order to switch to new conditions for the functioning of the industry, it is necessary to form new subsystems to ensure the implementation of digital and intelligent networks in the electric power complex, which, in the future, should provide economic, environmental, social and technological effect for the national economy.

References
[1] Kamchatova E Y, Vasilieva A V, Lyasnikov N V, Dudin M N and Vysotskaya N V 2018 Energy saving management in urban economy and industry International Journal of Civil Engineering and Technology 9 6 1423-9
[2] Gibadullin A A et al 2019 IOP Conf. Ser.: Mater. Sci. Eng. 537 042031
[3] Gibadullin A A et al 2019 IOP Conf. Ser.: Mater. Sci. Eng. 537 042065
[4] Zakharov V N, Linnik V Y, Linnik Y N and Zhabin A B 2019 Classification of coal seams by features of geological structure and characteristics of breaking Mining Informational and Analytical Bulletin 5 5-12
[5] Kobets B B and Volkova I O 2010 Innovative development of the electric power industry based on the Smart Grid concept (M: IAC Energy)
[6] Gomonov K G 2015 Prospects and economic efficiency of the implementation of intelligent energy networks in Russia and in the world Vestnik RUDN. Series Economics 2 25-35
[7] Gibadullin A A, Pulyaeva V N and Yerygin Y V 2018 The need for a digital substation during the digitalization of energy International Youth Scientific and Technical Conference Relay Protection and Automation, RPA p 8537223
[8] Boeva E Yu, Kunikeev B A and Shchegolev N L 2015 Prospects and problems of implementing Smart Grid in Russia Engineering Bulletin: electronic scientific and technical journal 09 543-51
[9] Pulyaeva V N et al 2019 IOP Conf. Ser.: Mater. Sci. Eng. 537 042033
[10] Sazanova S L, Sharipov F F and Dyakonova M A 2019 Spatial Economics, Geopolitics, and Marxism. Marx and Modernity: a Political and Economic Analysis of Social Systems Management A collective monograph. Edited by Marina L Alpidovskaya, Elena G. Popkova. A Volume in Advances in Research on Russian Business. Information Age Publishing Inc 651 pp 279-88
[11] Loskutov A A 2015 Development and research of the topology of intelligent urban distribution networks of medium voltage (Samara: Samara State Technical University)
[12] Gibadullin A A, Bortalevich S I and Yerygin Y V 2019 Dynamic Invariance of the Electric Power System Advances in Economics, Business and Management Research 47 299-302
[13] Smart Grid. Smart Networks. Intelligent power networks URL: http://www.tadviser.ru/index.php/Article:Smart_Grid_(Smart_Nets)

[14] Gavrilovich E V, Danilov D I and Shevchenko D Yu 2016 «Smart grids» Smart Grid - a promising future for the energy industry in Russia Young scientist 28 (132) 55-9

[15] Morkovkin D E et al 2019 IOP Conf. Ser.: Mater. Sci. Eng. 537 042064

[16] Kiseleva S P and Makolova L V 2019 Environmental-oriented management of agricultural enterprises and training for personnel for the secondary resource business sphere in the conditions of digital economy E-management 2 2 7-15

[17] Sozontov A, Ivanova M and Gibadullin A 2019 Implementation of artificial intelligence in the electric power industry E3S Web of Conferences 114 01009