Engineering solutions in the field of digital transformation of the electric power industry

A A Gibadullin¹, E V Ryabinina², D E Morkovkin², Sodikov K A³, P V Trifonov², M A Kirpicheva² and A D Kokurina⁴

¹ State University of Management, 99, Ryazan Avenue, Moscow, 109542, Russian Federation
² Financial University under the Government of the Russian Federation, 49, Leningradsky avenue, Moscow, 125993, Russian Federation
³ Tajik National University, 2, Lohuti street, Dushanbe city, 734025, Republic of Tajikistan
⁴ National Research University Higher School of Economics, 20, Myasnitskaya Ulitsa, Moscow, 101000, Russian Federation

E-mail: 11117899@mail.ru

Abstract. In the framework of this study, engineering solutions in the field of digital transformation of the electric power industry are analyzed. In the work, the main advantages of the introduction of digital technologies in the electric power complex were identified. The study presents measures that will allow the full transition of the electric power industry to digital solutions in the field of ensuring the reliability, stability and security of the energy sector. At the end of the work, the simplest typical architecture of digital control of the electric power complex was presented.

1. Introduction

Currently, issues related to the need to switch to innovative and digital technologies are being updated not only at the national, but also at the corporate level. The transition to digital technologies will provide certain advantages to the enterprises of the electric power complex, will not only increase the reliability of the power supply, the stability of the energy system, the safety of the functioning of the electric power complex facilities, but will also reduce the capital and operating costs associated with the implementation of engineering projects and their maintenance [1-3].

The digital transition in the electric power industry of Russia is aimed at providing digital infrastructure, namely, electric networks, substations, relay protection devices and automation and other electric power equipment [4]. Internationally accepted protocols and engineering decisions are transformed into Russian electric power facilities, among which are IEC protocols, Smart Grid technologies, Industrial Internet of Things and other design decisions [5-6].

At the same time, Russia has just begun the process of transforming industry into digital technologies, which today requires scientists and engineers to search for new design and engineering solutions that will ensure a qualitative and quantitative transition of the industry to digital technologies [7-9]. In this regard, the authors of the study decided to conduct an analysis of engineering solutions in
the field of digitalization of the electric power industry and present mechanisms that will allow the formation of standard design solutions aimed at digitalization of the electric power industry in Russia.

2. Materials and methods

The purpose of the presented study is to evaluate engineering and design solutions in the field of digitalization of the electric power complex and to develop technological solutions to ensure the transition to digital technologies in the electric power complex of Russia. The following tasks were formed:

- Evaluate engineering and design solutions in the field of digitalization of the electric power complex;
- Offer typical technological solutions that ensure the transition to digital technologies in the electric power industry.

The scientific research was built based on an assessment of engineering and design solutions of various organizations implementing the use of information and switching technologies in order to manage objects of various industries. In the work, scientific methods were used that made it possible to reveal the goal and solve the proposed problems.

3. Results

The concept of digital transformation of the electric power complex should be based on the interaction of objects of the electric power complex, infrastructure equipment, information, and analytical tools that can ensure the reliability, stability and security of the power system and electric power facilities [10-11].

Engineering solutions in the field of the electric power complex should be based on several stages of achieving the final goal related to the transition to digital technologies. These solutions include:

- Analysis of the state of the facilities of the electric power complex, assessment of the reliability and safety of the energy system, identification of factors affecting the stability of the system;
- A system for adjusting the functioning of the system, taking into account the conditions for reliable, stable and safe functioning of electric power complex facilities;
- Prevention of reducing the level of reliability, stability and security of the system, due to decisions made by artificial intelligence or operational personnel [12-14; 15].

Such a structure of digital control of electric power industry facilities will make it possible to achieve the necessary level of reliable operation of electric power facilities by introducing technical and cost-effective devices and equipment, by creating a continuous system for monitoring, evaluating and predicting the state of equipment. At the same time, monitoring will reduce the number of unforeseen equipment failures and failures, eliminate technological irregularities, reduce the time of restoration of power supply, optimize capital and operating costs of production, increase the efficiency of monitoring the condition of equipment and operating modes, and reduce energy losses.

An integrated approach to the implementation of digital technologies will ensure the safety of electric power facilities, namely:

- Ensuring anti-terrorism security;
- Ensuring physical security;
- Ensuring technological safety;
- Ensuring information security [15-18].
In addition to the positive aspects from the introduction of digital technologies in the electric power industry, there are also problems that the industry may encounter in their implementation. Among which we can single out the high cost of digital technologies, the lack of the necessary standards and rules of digitalization, the development of new mathematical models to predict the technical condition of equipment, the need to upgrade or replace switching equipment, the absence of data exchange protocols, and the lack of common requirements for information and switching equipment for preserving and data transfer and the need for the development of new information security technologies [19-20].

Thus, in Russia the necessary uniform rules for the transition to digital technologies of the electric power complex and the rules for the functioning of the new system have not been formed.

4. Discussion
It is advisable to design the design of a digitalization system for the electric power complex on the design and development of technical regulations for the introduction of numbers in the industry. Of course, the Russian electric power complex cannot be quickly and without significant costs transferred to digital control mode, since it is necessary to carry out preparatory measures related to assessing the readiness of the industry to switch to digital solutions, searching for and adopting appropriate protocols and standards for the operation of equipment and the entire energy system, translation electric power equipment from one control mode to another control mode, etc. In this regard, we will present measures aimed at digitalizing the technological processes of the Russian electric power complex [15; 21-23]:

- Adoption of standards and protocols to ensure the transition to a digital network;
- Preparation of the technical policy of electric power enterprises under new conditions for the functioning of the industry;
- Adoption of unified legal regulations related to the creation of software and electronic systems;
- Comprehensive design for the process of technical re-equipment and modernization with the aim of introducing information and communication technologies and creating a data collection and processing system;
- Installation of intelligent control systems, accounting and quality control of electricity, voltage at input elements;
- Creation of new communication channels and information transfer;
- Introduction of smart technologies for the supervision and control of equipment;
- Development of a system and program for the development of common centers for managing networks and systems;
- Creation and transition to standard digital systems of all objects of the electric power network and systems;
- Integration of a digital energy system with small generation facilities, creation of an electric energy storage system and management of other energy systems.

Thus, one can imagine the simplest typical scheme of digital control of electric power facilities (figure 1) [15].

The presented simple architecture of control systems is similar to the well-known and used principles of managing various objects [24-26]. A similar concept should be built on the creation and use of information and switching infrastructure connected to the Internet, equipment, protection systems, automation, sensors and other devices of the electric power industry, which will make it possible to make decisions and manage energy infrastructure facilities offline.
5. Conclusion
Thus, the study revealed that the digitalization of the electric power industry will achieve the stability, reliability and safety of the energy system. It was presented in the work that the basis for digitalization of the electric power industry should be the analysis of the functioning of the electric power industry, the adjustment of decisions made and the prevention of adverse situations in the electric power industry. At the same time, digitalization will ensure physical, informational and technological security and anti-terrorist protection of electric power complex facilities. The study proposed a typical architecture of digital control of the electric power complex, which will allow:

- Create a single administrative center for managing technological modes of operation of electric power facilities;
- Optimize the workload of operational personnel;
- Develop and introduce Russian technologies in the field of digital management into the production process;
- Increase the level of management and remote decision-making on the main issues of the functioning of the electric power complex;
- Improve the reliability, stability and safety of electric power facilities;
- Reduce operating costs for the management of electric power facilities.

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