Assessment of the level of stability and reliability of the electric power complex

A A Gibadullin
State University of Management, 99, Ryazan Avenue, Moscow, 109542, Russian Federation
E-mail: 11117899@mail.ru

Abstract. This study is aimed at assessing the level of reliability and uninterrupted power supply to consumers. The concept of the reliability of power supply to consumers, which should contain the properties of persistence, uninterrupted operation, durability and maintainability, was presented. In addition, the study analyzed reliability indicators, as a result of which it was revealed that the number of accidents is reduced, however, qualitative indicators, including the number of disconnected consumers, average power outages of consumers and the time of outages, are increasing. At the end of the study, the authors proposed a causal relationship model that affects the reliability and uninterrupted power supply to consumers.

1. Introduction
The electric power complex of Russia is one of the largest in the world, which is combined into a single energy system, including power plants, electric systems and networks, substations, switchgears and elements responsible for the supply of energy to the final consumer. The complex took a rather long period, for example, in 1920, the State Plan for Electrification of Russia was adopted and then, until 1941, the industry developed stable indicators, even exceeding the tasks set. In the 50s of the 20th century, the potential of the Soviet electric power industry was created, and in the 60-70s, the existing power plants were built and put into operation, an integrated power system was created and the basic principles of the functioning of the electric power complex were formed.

During the period of Russia's transition to market relations, the electric power complex also underwent a transformation, as a result of which competitive and monopolistic activities were singled out and new companies were formed in the industry that are privately owned and independently responsible for the operation of electric power facilities. At the same time, during the transition to innovative and digital technologies, the work of highly efficient production and various types of activities that ensure human life, issues of reliability and uninterrupted power supply to consumers come to the fore, which requires the complex to provide the required amount of requested load with electricity [1].

The main construction of electric power facilities producing electric energy today was carried out about half a century ago. Despite the fact that developed countries have already repeatedly switched from one type of production to another, the electric stations created in the Soviet years are operated in Russia. This situation causes a number of negative consequences for both industry and consumers, for example, equipment has a high level of wear, a high share of energy consumption, low efficiency and installed capacity utilization, low innovative and technological development of electric power facilities.
and others Problems. Thus, these negative factors can adversely affect the reliability and uninterrupted power supply, which, as a result, can violate not only the stability of the entire electric power system in Russia, but also exacerbate the internal and external situations of the national economy.

2. Materials and methods
The main goal of the work is to assess the reliability and uninterrupted power supply to consumers. The following tasks were formed in the work:

- determine the property of reliability and present its elements;
- present a causal relationship model that affects the reliability and uninterrupted power supply.

The work used data from line ministries and state statistical agencies, and the scientific methods used allowed us to solve the research tasks.

3. Results
The reliability of the electric power complex is an essential component of the national economy, the violation of which can lead to adverse consequences for the types of economic activity. The reliability property meets a number of characteristics, which includes the following main components:

- persistence - this is the property of an object to function for a long period of time, while not losing the assigned properties and characteristics in time;
- uninterrupted operation - this is the property of an object to continuously operate at a given operating mode of equipment;
- maintainability - this is a property of an object that allows you to restore or technically change individual elements or units of equipment in order to maintain the future operation of the equipment;
- longevity is a property of an object that ensures continuous operation of the equipment from the beginning of its commissioning to the end of the equipment’s park life.

Thus, the reliability of power supply is a complex property that includes many elements, the preservation of which ensures the stability of the functioning and development of the electric power complex. Of course, a change in these properties negatively affects the entire system, and as a result, disrupts the power supply to consumers, which can lead to production stoppage, mass rejection of products, worsening of the living conditions of the population, changes in the operation of individual city systems, etc.

However, despite the fact that reliability is a complex technical system, and maintaining the integrity of this system ensures the stability of power supply and the entire energy system, there are problems associated with ensuring the reliability of power supply to consumers.

For an objective analysis, we consider the indicators characterizing the cessation of power supply to consumers (figure 1) [2-3].

From the presented figure it can be seen that the number of mass power outages during the period under review is generally decreasing, however, despite this, quality indicators are increasing. So, for example, from 2017/18 to 2018/19, the number of power outages decreased from 37 to 19 cases, and the average number of disconnected consumers increased from 16,920 thousand to 24,070 thousand people. Thus, a decrease in the number of outages is not an indicator of an increase in the reliability and uninterrupted power supply to consumers.

Next, we consider the average power outages of consumers and the duration of outages (figure 2) [2-3].
Advanced technologies in the fuel and energy complex

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Figure 1. Cessation of energy supply to consumers in the heating season (from November to March).

Figure 2. Average power of disconnected consumers (MW) and duration of outages.

The figure shows that the duration of the outages has a changing curve, which, in general, decreases during the period under review, and the average power outage of consumers, although it has decreased, is insignificant.

In order to ensure reliable and uninterrupted power supply at the state and corporate level, measures are being taken to preserve the power supply to consumers, which are associated with updating and modernization of production facilities, carrying out diagnostic and repair measures, restoration and technical impact on electric power facilities. At the same time, not all of these factors are components in violation of the reliability of power supply to consumers, in this regard, the formation of a causal relationship model in which to present factors affecting the provision of uninterrupted power supply to consumers is relevant [4-5].
4. Discussion
We will form a model of causal relationship affecting the provision of reliable and uninterrupted power supply to consumers (figure 3).

![Model of Causal Relationship](image)

**Figure 3.** A causal relationship model that affects the reliability and uninterrupted power supply to consumers.

The presented model contains weather factors, changes in consumer load level, equipment wear factors and other factors affecting the reliability and uninterrupted power supply.

Today, activities in the field of improving the reliability and uninterrupted power supply are taking place in certain areas of activity, for example, electric networks monitor the glades, and the System Operator of the UES of Russia monitors the load level and, if necessary, can use non-operated production capacities. However, in the opinion of the researchers, the problems associated with improving the reliability and uninterrupted power supply must be solved systematically, namely, to ensure the management of the factors presented in the model and to carry out activities aimed at preventing the development of negative factors affecting the electric power complex.

5. Conclusion
The study was devoted to assessing the reliability and uninterrupted power supply to consumers. In the framework of this work, it was revealed that reliability has a number of properties - it is the maintainability, uninterrupted operation, durability and maintainability of the system, the interconnection of which ensures the safe and stable operation of the energy system. In the work, indicators were analyzed that affect the reliability of power supply, as a result of which it was revealed that the number of accidents has been decreasing in recent years, but their negative consequences are increasing. At the end of the study, a model was proposed to ensure the reliability and uninterrupted power supply, which should be considered as a single system and to carry out holistic management of negative factors.
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