Monitoring the technical and technological state of electric power complex facilities

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Abstract. The presented study is devoted to monitoring the technical and technological state of electric power complex facilities. As part of the study, the basic principles of monitoring and examining the state of equipment were analyzed, the process and procedure for monitoring the status of equipment and structures of the electric power complex were examined. The work analyzed the periods of preparation for the heating season of the Russian electric power industry, as a result of which it was revealed that the number of violations at electric power facilities was increasing, and the equipment of the federal districts was not fully prepared for the heating season by the readiness index. The work revealed that for almost all indicators of heat supply, water supply and sanitation, the number of violations and incidents during the heating period is increasing. At the end of the study, measures were presented that will ensure the stability and reliability of energy supply to consumers.

1. Introduction

The electric power complex of Russia is a systemic industry that ensures the functioning of production capacities, the defense capabilities of states, the creation of new types of goods and technologies, and the life of humanity. Modern electric power industries in all countries of the world were formed at the end of the 19th and beginning of the 20th centuries, when the first power plants were built, new methods of generating electric energy were created, mainly using peat, coal and fuel oil. In many countries, the electric power industry made energy transitions associated with the rejection of non-renewable resources and the transition to nuclear energy, and then another transition was made from nuclear energy to renewable energy [1].

The Russian energy potential was formed in the postwar years, when the main power plants were built, the country’s energy system was created, and the principles of the functioning of the electric power complex and the conditions for the development of the electric power industry were formed [2]. However, the use of technologies and equipment that were created back in the Soviet period does not give the industry the necessary reliability, stability, security and uninterrupted operation, which, of course, reduces the efficiency of the electric power complex as a whole.
At the same time, problems related to the moral and physical deterioration of equipment, an increase in the environmental load on the environment, a decrease in the efficiency of individual capacities, the continued use of non-renewable resources, etc., have been exposed in the electric power industry [3]. It is worth noting that the electric power industry operates according to various load schedules, as a result of which, during the heating period, the electric power complex must be ready for peak consumption of electric energy and maximum heat energy generation, to ensure uninterrupted electric and heat supply of the resource for end consumers. As a result, the electric power complex must meet all the requirements of the federal authorities and, if necessary, in an operational mode, change the operating modes of electric power facilities in order to ensure reliable and uninterrupted electricity and heat supply to consumers.

2. Materials and methods

The purpose of the study is to monitor the technical and technological state of the objects of the electric power complex. The following tasks were presented in the study:

- To analyze the technical and technological state of electric power facilities during the preparation for the heating season and the operation of facilities in the specified period;
- To offer recommendations on achieving sustainability and reliability of energy supply to consumers.

The study used statistics from the Ministry of Energy and other state authorities. Among the methods that were used in the work, we can distinguish statistical, logical and comparative methods, the method of system analysis and other approaches and methods.

3. Results

Monitoring the status of various complex technical devices is carried out daily, while in individual companies this is done with digital devices that collect, analyze, process information, make decisions or transfer information flows to operational dispatch personnel. Another way to monitor the condition of the equipment is the work of the operational and repair personnel, who manually inspects the equipment and decides on the future functioning or emergency repair.

Inspection and monitoring of buildings, equipment and structures is carried out with the aim of [4]:

- Assessment of the technical condition of the equipment for the purpose of further repair or reconstruction;
- Assessment of their further trouble-free operation and the possibility of restoring equipment to its original characteristics;
- Monitoring of objects and identification of structural changes as a result of hard work of the equipment;
- Assessing the condition of equipment, especially electrical networks and systems, as a result of natural and climatic effects;
- Monitoring the condition of canned equipment located on a forced idle time, various restrictions, the planned equipment reserve and various types of repairs;
- Diagnostics of equipment operated outside the park resource;
- Diagnostics and monitoring of capacities that is in constant operation and under the influence of various factors.

Thus, the examination and monitoring of the technical condition is carried out in order to determine the operating conditions and the possibility of further use of the equipment to perform production processes.

The process of inspection and monitoring of equipment includes the following steps [4]:

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• Determination of volumes and parameters of the investigated object, the acquisition of the necessary means of technical equipment diagnostics;
• A detailed determination of damage parameters and identification of factors contributing to their formation;
• Determination of the actual state of the structures of buildings and structures that ensure the operation of an electric power facility;
• Determination of the level of actual load and impact on the analyzed objects;
• Assessment of the level of design efforts of structures exposed to various loads;
• Assessment of compliance of the equipment operation parameters with the specified characteristics;
• Assessment of the output parameters of electric and thermal energy;
• Monitoring the repair campaign, assessing the quality of repairs;
• Determination of the causes of defects and factors that have the greatest destructive effect and analysis of the causes of their occurrence;
• Registration of the final list of defects and conclusions about the possibility of further operation of these facilities.

In the electric power complex, the state of electric power facilities is constantly monitored, and at certain times, employees of state supervisory services are involved in order to conduct an independent survey and assess the current state of the equipment [5-6]. Such checks, as a rule, are associated with the transition to high-readiness modes of the electric power industry, for example, during the preparation of electric power facilities for operation in the autumn-winter period, major events, etc. Inspections related to the readiness of facilities for the autumn-winter period in Russia are held annually and mainly include inspections of facilities by the Federal Service for Ecological, Technological and Nuclear Supervision [7-9]. Such a survey allows you to identify the level of readiness of objects for work in the heating period and the possibility of sustainable heat supply to consumers. In addition, within the framework of this monitoring, it is possible to identify electric power facilities that are not ready for the heating season and issue an appropriate order to eliminate the detected defects and violations.

We will carry out a comparative analysis of the results of monitoring the progress of preparation for the heating season of electric power facilities in Russia (figure 1) [9-10].

![Figure 1](image_url)

**Figure 1.** Comparative analysis of the results of monitoring the progress of preparation, pieces.
From the presented figure, it can be seen that in the Russian Federation during the preparation for the heating season, about 20 thousand different examinations are carried out. At the same time, if the gross volume of violations for three years has decreased, the specific number of violations increases, for example, in 2017/2018 their number was 4.7 violations per unit, then in 2018/2019 - 4.1, and in 2019/2020 - 6.08. Thus, in relation to the previous year, in 2019/2020, the volume of violations increased by 50%.

The analysis of violations showed that the industry does not have any sustainable measures for updating, modernizing and replacing equipment, which, of course, in the heating season can lead to a sharp decrease in the supply of thermal and electric energy. Consider the main violations [4; 11-12]:

- Violation of the water treatment regimen;
- Operation of power equipment outside the park resource without taking measures to restore or carry out organizational and technical measures to extend the life of the specified equipment;
- Not carrying out test activities;
- Failure to carry out planned activities related to preparation for the heating season;
- Failure to carry out the repair campaign;
- Failure to comply with previously issued instructions of the relevant authorities in matters of ensuring reliable and uninterrupted operation of the equipment.

Thus, the presented violations can significantly affect the operation of power equipment in the heating period.

Consider the index of readiness of the constituent entities of the Russian Federation for the heating season (figure 2) [9-10].

From the presented figure it is seen that only the southern federal district is almost completely ready for the heating season, since this is due to the reduced period of the heating season. In the remaining federal districts, a different situation is observed, of course, mainly, it depends on weather conditions and temperature differences in the territories under consideration.

Next, we consider the number of accidents and violations during the heating period (table 1) [9-10].

It can be seen from the table that, in almost all indicators during the heating period, there is an increase in the number of accidents and incidents on the networks, which indicates the absence of
effective preventive measures that would reduce the number of accidents and incidents on the networks during the heating period [13-14].

Table 1. Number of accidents and violations during heating periods.

| Indicators | Heat supply | Water supply | Water disposal |
|------------|-------------|--------------|---------------|
| The number of accidents on networks in the heating period 2017-2018, units | 438 | 6413 | 7662 |
| The number of accidents on networks in the heating period 2018-2019, units | 397 | 6459 | 7987 |
| The number of incidents on the networks in the heating period 2017-2018, units | 17069 | 19310 | 12841 |
| The number of incidents on the networks in the heating period 2018-2019, units | 17196 | 21601 | 14207 |

Thus, we believe that it is necessary to propose measures to prevent an increase in the number of accidents and incidents on the networks during the heating period.

4. Discussion
Modern requirements for the inspection and monitoring of equipment and structures, which operates in a changing external and internal environment, require not only monitoring, but also proposing measures aimed at maintaining the equipment in a stable and reliable operation. In this regard, it is necessary to propose activities that will achieve the goal [15-17]:

- Creation of a system for continuous monitoring and inspection of equipment, including using digital technologies;
- Modernization of heating networks, the introduction of innovative technologies and energy transfer;
- Reducing the number of worn out and energy inefficient capacities that negatively affect the sustainable and reliable energy supply to consumers, and increases the number of accidents and incidents;
- The creation of a distributed generation system and the development of renewable energy, which will improve the reliability and quality of energy supply;
- Improving the model of electric energy flows and the relationship between seller and consumer;
- Formation of a research base for the creation of innovative and digital technologies of power equipment, including with the aim of reducing equipment imports;
- Optimization of generating capacities and creation of a system for the most efficient loading of production capacities;
- The formation and creation of a heat market.

Thus, maintaining stability and ensuring reliable energy supply to consumers, especially during the heating period, is of particular interest, since it is precisely in the autumn-winter period that any violations or accidents at electric power facilities can lead to significant industrial and economic consequences, as well as endanger life and the health of people living in the area. Of course, the policy in the field of monitoring, updating and modernization of heating networks must be carried out with the support and supervision of state and municipal authorities, which will achieve the planned indicators and ensure the necessary reliability and stability of energy supply.

5. Conclusion
The conducted study was devoted to monitoring the technical and technological state of electric power facilities, in the framework of which the conditions for monitoring and examining equipment were
determined. The analyzed indicators, reflecting the number of inspected objects and the number of violations, showed that in 2019/2020, on average, there were six violations per heating object, which is 50% higher than the previous similar period. At the same time, the readiness of electric power facilities for the heating season showed that not all facilities in the federal districts are ready for the heating season, and there is an increase in the number of accidents and incidents during the heating season. At the end of the study, mechanisms were proposed that could increase the level of technical and technological stability of electric power complex facilities.

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