Formation of a system for achieving sustainable development of the electric power complex

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Abstract. The article analyzes the influence of various factors on the electric power complex. The study showed that the internal factors associated with the condition of the equipment in operation have the greatest influence. The analyzed indicators indicate that during the periods under consideration, there are practically no changes associated with a decrease or increase in the number of accidents at stations and networks. At the end of the work, recommendations were presented to ensure the stability of the electric power complex, which should include long-term and short-term plans.

1. Introduction
The issues of achieving sustainable development of the electric power complex are relevant for any state and industrial system, since it is the electric power facilities that provide power supply to enterprises and organizations, preserve the country's defense capability and ensure comfortable life for the population. Any negative changes associated with the influence of external and internal factors on the electric power complex have a negative impact on all technological, operational and organizational processes occurring at electric power enterprises [1-2].

Any processes affecting the electric power complex can be divided into two components - these are external and internal factors. External factors include changes in the economy, politics, regulatory changes, the emergence of innovative and new engineering solutions, techniques and technologies, and more. Internal factors include various changes occurring within the system, for example, changes in the principles of management of electric power facilities, physical and moral obsolescence of production facilities, increased operating costs, reduced energy efficiency of production, lack of a policy to modernize and update production facilities, and much more [3-5].

In our study, we will not consider the factors that affect the electric power industry from the outside, since almost any change in the external environment, such as changes in the economic policy of the state, the introduction of new regulatory and legal rules for the functioning of the industry, pandemics and crises, cannot significantly affect the electric power complex. At the same time, changes within the energy system always affect the electric power complex and may lead to the destruction of the built system within the entire industry or individual electric power enterprises. Thus, we consider it necessary to limit our research only to internal factors and consider their influence on the state of the energy system [6].

2. Materials and methods
In this study, the aim of the work is to formulate a policy to ensure the sustainable development of the electric power complex. The work set the following tasks:
Analyze the indicators of the accident rate of the electric power complex;  
To formulate measures to achieve the stability of the electric power complex.

The study used scientific methods and approaches, and as an information base, statistical indicators, annual reports of government agencies and analytical reports of various organizations were used.

3. Results
The policy in the field of sustainable development of the electric power complex in Russia is formed at the national level and for each energy system its priorities are determined to ensure the supply of electricity to consumers, the reliability and uninterrupted operation of electric power facilities, the possibility of electricity flows between power systems, the operation of the wholesale and retail market and the policy in the field of modernization and innovative development of the electric power industry. At the corporate level, specific programs are being developed to implement the goals and objectives of the power industry development set at the federal level. But speaking about the policy in the field of sustainable development, it is necessary to take into account all the factors that determine this direction of development. Among the main groups of factors, it is advisable to highlight the following [5-8]:

- Financial stability;
- Resource and raw material supply;
- State and dynamics of development of the electric energy market;
- Share of intersystem flows;
- Level of environmental safety;
- The size of the export potential;
- The level of reproduction of fixed assets.

These groups of factors can be divided into a large number of components, which will ultimately lead to the determination of the causes of the emergence of certain negative factors that hinder and restrain the stable operation of the electric power complex. In our opinion, it is advisable to consider the last group of factors associated with the level of reproduction of fixed assets. It is advisable to include the following components in this group of factors, so we refer to the conditions for ensuring sustainable functioning [8-10]:

- Level of interchangeability;
- The level of physical wear and tear of fixed production assets;
- Volumes of capacity reservation;
- Equipment accident rate.

The factors that affect sustainable development include:

- The amount of state support;
- Dynamics of electricity consumption;
- The level of obsolescence of fixed assets;
- Dynamics of the introduction of innovative and digital technologies in the electric power complex.

Undoubtedly, the level of physical and obsolescence of equipment, the volume of capacity redundancy, the level of equipment accidents, and the amount of state support, the dynamics of the introduction of innovative and digital technologies in the electric power complex is influenced by the
condition of the equipment and the proportion of stops or equipment failures. In this regard, let us consider the volume of accidents at power plants and networks (figures 1 and 2) [11].

**Figure 1.** Emergency in electrical networks of 110 kV and above.

**Figure 2.** Emergency at power plants with an installed capacity of 25 MW and above.

The presented figures show that the number of accidents annually and monthly is approximately at the same level. This situation indicates that there is no policy at the state, regional and corporate level to ensure the sustainable operation and development of the electric power complex.
If we analyze the level of depreciation, commissioning and disposal of fixed assets in the electric power industry, then we can conclude that depreciation reaches 60%, and some production facilities are operated outside the park resource, which indicates an extension of the standard period of use of these capacities. If we consider in interrelation the indicators related to wear, retirement and commissioning, we can conclude that there is no renewal of production capacities in the industry, and the commissioning of new capacities occurs only due to the development of the energy system in new territories and the emergence of new consumers.

In this regard, we consider it necessary to propose mechanisms aimed at ensuring sustainable development in the long and short term.

4. Discussion
At the facilities of the electric power industry, measures are constantly being taken to maintain equipment in working order, however, we believe that at the state level it is necessary to develop certain criteria that should be applied at all energy facilities and be monitored by state supervisory organizations. It is advisable to divide such requirements into short-term and long-term perspectives.

In the short, term [6-9; 12-13]:

- Implementation of a policy on online monitoring of the technical and technological state of the main production facilities;
- Elimination of worn out and energy wasting capacities;
- Implementation of a policy to assess the condition of production facilities;
- Implementation of planned current, medium and major repairs;
- Reduction in the use of equipment in critical condition;
- Implementation of a policy to prevent the occurrence of shutdowns, failures and accidents at power facilities.

Long term [6-9; 12-13]:

- Develop a phased policy for the modernization and renewal of production facilities;
- To propose the conditions for redundancy and power flows in order to remove worn-out and energy-wasting capacities from operation;
- Development of a policy to increase the installed capacity utilization factor at efficient enterprises and to reduce the specific consumption of equivalent fuel at energy enterprises;
- Introduction of a policy to prevent physical and moral deterioration of production facilities;
- Carrying out a policy of transition to environmentally friendly and renewable energy sources;
- Development and implementation of innovative and digital technologies in the electric power complex.

Thus, we can conclude that ensuring the sustainable operation and development of the electric power complex must be carried out in the framework of the short and long term.

5. Conclusion
As part of the study, it was revealed that the electric power complex affects all areas of activity, because of which, ensuring its sustainability is a necessary task for the industry. The work revealed that there are external and internal factors that negatively affect the electric power complex, however, it was found that internal factors have the greatest impact on the electric power industry. The study presented a group of factors that ensure the stability of the electric power complex. It was revealed that most of the factors, in one way or another, arise due to the deterioration and accident rate of equipment, because of which, the indicators of accident rate at stations and in networks were analyzed. The presented indicators indicate that the accident rate does not change for several years and months,
therefore, mechanisms were proposed in the work to ensure the stability of the electric power industry in the short and long term.

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