The development strategy of the environmental safety of the electric power complex

A A Gibadullin¹, Gilts N E², Ju A Romanova³,²⁴, Ir N Romanova⁵ and Kh A Bahretdinova⁶

¹ State University of Management, 109542, Russia, Moscow, Ryazan Avenue, 99
² Reshetnev Siberian State University of Science and Technology, 660037, Russia, Krasnoyarsk, Krasnoyarsky Rabochy Avenue, 31
³ Institute of Market Problems at the Russian Academy of Sciences, 117418, Russia, Moscow, Nakhimovsky Prospect, 47
⁴ Moscow State University of Food Production, 115080, Russia, Moscow, Volokolamskoye Highway, 11
⁵ Smolensk State Agricultural Academy, 214000, Russia, Smolensk, Bolshaya Sovetskaya Street, 10
⁶ Tashkent Institute of Irrigation and Agricultural Mechanization Engineers, 100000, Uzbekistan, Tashkent, Kara Niyazov Street, 39

E-mail: 11117899@mail.ru

Abstract. Consideration of the environmental policy of the electric power complex is becoming relevant at the present time, since most of the power plants were commissioned more than 40-50 years ago, while technological modernization and updating of production capacity did not occur. As a result of the analysis, it was revealed that the growth in the production of electric energy is practically not observed, while the volumes of consumption of coal and gas in the production of electric energy do not change, the use of fixed production assets is increased, as a result of which the standard period of use of the equipment is exceeded. Emissions of pollutants are slightly reduced only by categories of solid waste and sulfur dioxide, emissions of nitrogen oxides do not change, and emissions of carbon oxides increase. The work proposed a mechanism for the development of environmental safety of the electric power complex, containing directions for monitoring the technical condition of power equipment, introducing technical and technological re-equipment of generation facilities, assessing the level of reproduction of fixed production assets, determining the resource dependence of generation facilities and measures for organizing and managing the production process.

1. Introduction
In recent years, the issues related to the need to preserve the environment and improve the environmental safety of energy facilities have become more acute. The construction of large power plants on the territory of the Russian Federation began as early as the 50-s of the last century, this period was marked by the emergence of new types of power plants, the placement of energy facilities near sources of raw materials and the development of the energy system of the national state [1; 2]. At the same time, during this period, the main source of fuel for power plants was coal, less often fuel oil,
and there were virtually no gas power plants. In recent years, power plants have begun to actively switch to the use of gas fuel - as one of the most environmentally friendly types of fuel, but the regions of the Volga region, Siberia and the Far East remain, where coal-fired power plants are still operating, which negatively affects the environmental situation in this area territory [3; 4].

Thus, the improvement of the environmental safety of modern power plants is currently not only relevant, but also the primary task of the electric power industry [5; 6]. The electric power complex is currently not only a branch of the national economy, but also a system forming element of the national economy.

2. Materials and methods
The present study is devoted to the development of the environmental safety of the electric power complex during the transition of the Russian energy industry to environmentally friendly and safe production of electric energy. To achieve this goal, we have proposed the following tasks:

- to analyze the ecological state of the electric power complex;
- propose mechanisms for the development of the environmental safety of the electric power complex.

The basis of the study was used methods of system analysis, statistical, factor, historical, comparative and logical analyzes, which allowed us to offer measures for the development of the environmental policy of the electric power complex.

3. Results
Let us analyze the electric power complex of the Russian Federation. Consider the indicators of the production of electrical energy in power plants of various types (figure 1) [7].

![Figure 1. Production of electric energy in Russia, billion kW*h.](image)

The presented figure shows the stabilization of the production of electric energy, most of which is produced by thermal power plants. It is worth noting that the historically established system for the production of electricity at coal-fired thermal power plants is economically beneficial, however, such power plants have a negative impact on the environment.

Let us analyze the consumption of fuel and energy resources in the production of electric energy. Analysis of the indicators suggests that the volume of natural gas consumption from 2010 to 2017 increases from 204 to 209 billion cubic meters, but the minimum amount of gas consumption was observed in 2015 and amounted to 194 billion cubic meters. The volume of coal consumption from
2010 to 2017 is reduced from 143 to 134 million tons, while in 2014 the power plants consumed only 127 million tons of coal.

Many studies in the field of technical and technological sustainability of power industry enterprises [8; 9; 10; 11; 12] show that in the industry there is a tendency to increase the service life of equipment. Most of the equipment is operated outside the park resource, at the same time, turbine units and boiler units that directly affect the environment have a maximum service life of 40 to 50 years. Of course, the operation of obsolete and physically obsolete equipment and the lack of a policy for the modernization of production facilities adversely affect the environment [13].

Further, it seems necessary to consider the emissions of pollutants into the atmosphere (figure 2) [7].

![Figure 2](image-url)

**Figure 2.** Emissions of atmospheric pollutants from stationary sources, fuel combustion (for generating electrical and thermal energy), thousand tons.

The figure shows that there is no steady tendency to reduce emissions of pollutants into the atmosphere, for example, emissions of solid substances into the atmosphere decreased by about 15% over the period under review, emissions of sulfur dioxide and nitrogen oxides have fluctuating curves, and emissions of carbon dioxide increased by 8%.

In order to solve the problems associated with the renewal of production capacities, attracting investment resources to the industry, and including improving environmental safety, in 2000 it was decided to reform the Russian electric power industry. In 2008, the restructuring of the industry was completed, which resulted in the emergence of generating companies whose production facilities are located in different federal districts and, as a rule, are in private management. Today, each company independently determines the main activities aimed at the development of the company, including the protection of the environment. Until the reform period, the industry was managed by the state-owned company RAO «Unified Energy System of Russia», which developed and implemented environmental safety measures at the national level. The Environmental Policy of RAO «Unified Energy System of Russia», developed in 2005, contained the main directions for increasing the environmental efficiency of energy production through:

- transition of electric power industry to renewable energy sources;
- energy saving and rational use of natural resources;
- development of research bases in the field of environmental policy and environmental protection in the electric power industry;
- adoption and implementation of preventive measures to eliminate negative environmental consequences;
- international cooperation in the field of environmental protection.
In general, environmental problems were proposed to be solved through technological modernization and decommissioning of outdated equipment, improvement of technological processes and the development of new ways of generating electrical energy.

As of today, generation companies independently deal with environmental protection issues, while their environmental policy does not always correspond to the environmental situation in the region. Companies include in the plan activities aimed at improving the environmental safety of the electricity industry, among which are:

- update and commissioning of highly efficient gas energy blocks;
- re-equipment of environmentally friendly samples;
- construction of new treatment facilities;
- increase fuel efficiency in the process;
- reduction of heat losses in order to reduce the impact of thermal radiation on the environment.

However, the above activities are more programmatic and focused on the long term. When considering environmental protection measures for a number of companies, two major areas can be identified:

- measures in the field of water protection, which consist in cleaning the water protection zone, reuse of wastewater, maintenance of sewage treatment plants, replacing filters and conducting monitoring measurements of biological resources;
- measures aimed at reducing emissions of pollutants into the atmosphere, carried out through technical re-equipment of power units, routine maintenance of ash collectors, reconstruction of gas and fuel oil pipelines.

Thus, the analyzed measures indicate the absence of effective and large-scale measures aimed at reducing the negative impact on the environment. A similar picture is observed in all generating companies, this is due to the fact that there are no effective approaches to the implementation of environmental policies at the national level and the reduction of financial resources from generating companies for the implementation of the developed measures.

At the national level, measures are also being developed to protect the environment, for example, improving environmental safety is considered in the context of updating and upgrading the entire electric power system. Developed by the Energy Institute G.M. Krzhizhanovsky in 2011, the program of modernization of the electric power industry for the period until 2020, provided for the cost of its implementation in the amount of 11.2 trillion rubles. The Energy Strategy of the Russian Federation, which is updated every five years, provides for the transition of the Russian energy industry to an innovative development path. At the same time, it is worth noting that the planned measures to upgrade and modernize production facilities do not occur due to the lack of financial resources both at the national level and at the level of generating companies.

4. Discussion
The objectives of the development of the environmental safety of the electric power complex of the Russian Federation should be the following:

- reduction of fuel consumption in the production of electric energy;
- refusal to use outdated equipment and technology;
- development of a more advanced technology for the capture of pollutants;
- transition from coal generation to renewable energy;
- development of innovative equipment and technology in the field of energy production.
In our opinion, in order to ensure environmental safety, it is necessary to envisage a set of measures related to monitoring the technical condition of power equipment, technical and technological re-equipment, assessing the level of reproduction of basic production assets, determining the resource dependence of generating facilities and developing organizational and management measures. It is advisable to realize the achievement of the environmental safety of the electric power complex in the interaction of all interested parties - these are state and regional authorities, generating companies, suppliers of resources and equipment, and consumers of electrical and thermal energy. Imagine a scheme to ensure the environmental safety of the electric power complex of the Russian Federation (figure 3).

![Figure 3. Model of achieving environmental safety of the electric power complex.](image)

From the presented model it can be seen that it is reasonable to base the achievement of the environmental safety of the electric power complex on the factors of operation and development. The factors of operation include the monitoring of the technical condition of equipment and the level of reproduction of basic production assets, and the factors of development are the determination of the resource dependence of the electric power industry facilities, the introduction of technical and technological measures and the development of principles for organizing and managing the production process.

Thus, ensuring environmental safety is advisable to consider as a combination of factors contributing to the sustainable functioning and development of the electric power complex, which in the long term will create an opportunity to preserve the environment for future generations, but will also improve the technical and technological state of electric power facilities.

5. Conclusion
The formation and development of the modern electric power complex of the Russian Federation began in the Soviet years, the construction of generating facilities proceeded according to policy plans in order to meet the demand for electric energy of nearby settlements and industrial enterprises. After the collapse of the Soviet Union, the industry was taken over by a state-owned company that developed plans at the federal level, was able to concentrate financial and material resources on certain
projects, and had effective management functions. After the restructuring of the electric power industry, private generating companies were formed in the industry, and today they are unable to implement large projects, carry out large-scale modernization of production facilities and develop new innovative technologies. The data presented in the study testifies to a decrease in the technical and environmental sustainability of power industry enterprises, which is a necessary condition for the formation of mechanisms aimed at reducing the negative impact on the environment. The work proposed a model for achieving environmental safety of the electric power complex based on the factors of operation and development, which include directions for monitoring the technical condition of equipment, assessing the level of reproduction of basic production assets, determining the resource dependence of electric power facilities, introducing technical and technological measures and shaping the principles of organization and process control.

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