Geoecological Approach to Justification of Priority Directions for Reducing Negative Ecological Impacts during Implementation on the South Yakutia of Large Energy Projects in the Republic of Sakha (Yakutia)

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Abstract. The Republic of Sakha (Yakutia) belongs to the zone of the North, rich in natural resources. Distinctive features from other territories are extremely severe climatic conditions, unfavorable both for the population and for the intensive development of industry, construction, transport, and agriculture. Under current economic conditions it is necessary to intensify the development of fuel and energy resources as well as their export which leads to the peaking of environmental problems including environmental pollution. The most significant contribution to this process is made by the fuel and energy complex which determines the urgency of carrying out theoretical developments to minimize the consequences of disturbing the ecological balance of territories of industrial development. This requires a comprehensive geoecological approach involving a systematic study of the relationships between both natural and man-made objects, elements and processes necessary for the most complete analysis of possible changes in nature and their consequences. Based on the application of the geoecological approach, a methodological scheme has been developed that provides a comprehensive study of various fuel and energy complex objects as part of the complex, functionally unified geotechnical system "Energy Object - Environment" in the North which is based on geosystem analysis and the concept of geotechnical systems. Studying the interaction of large power facilities in South Yakutia – the Neryungri TPP, the Elga coal complex and the project of the possible Kankun HPP with the environment as a part of various industrial geotechnical systems, analysis and assessment of technogenic impacts, changes in natural complexes and natural and social consequences, assessment of the degree of environmental stability to technological impacts can form the basis for the development of geoecological directions, differentiated by landscape complexes and ranked by the levels of nature conservation. With that the specific activities are determined by the landscape and ecological specifics of each landscape area and modern regional nature management.

1. Introduction

The fuel and energy complex is one of the sources of environmental pollution. Of 10.3 million tons of pollutants released into the atmosphere from stationary sources of the fuel and energy complex of the Russian Federation, 2.9 million tons are mining operations, of which 2.6 million tons belong to the extraction of fuel and energy minerals. Despite the achievements in the use of alternative energy
sources, the dependence on traditional sources remains extremely high: 40% - TPP (gas); 28% – TPP (coal); 21% – HPP and PSP; 11% – NPP [1]. Therefore, energy and environmental safety is the most important component of Russia's national security and one of the main tasks of modern energy policy [2].

The Republic of Sakha (Yakutia) belongs to the zone of the Far North which is rich in natural resources including fuel and energy resources. Distinctive features from other territories are extremely harsh climatic conditions that are unfavorable both for the population and for the accelerated development of industry, construction, transport, and agriculture.

At the same time, modern economic conditions necessitate the intensification of fuel and energy resources development, as well as their export which leads to increased ecological problems including environmental pollution.

This determines the actuality of theoretical developments to minimize the consequences of violation of the ecological balance of territories of industrial development in the Republic of Sakha (Yakutia). This requires a comprehensive geoecological approach which is a combination of geographical and ecological approaches and involves a systematic study of the relationships between both natural and man-made objects, elements and processes that necessary for the most complete analysis of possible changes in nature and their consequences. In general, this approach leading to the identification and assessment of the consequences of man-made impacts on the environment is based on the study of the following processes: the impact of economic activity on the environment; changes in the environment; the consequences of impacts that affect natural and social conditions [3]. This approach also allows adequately justifying the selection of areas of geographically differentiated environmental measures, strictly linking them to a specific geo-ecological situation [4].

In accordance with this, a methodic scheme was developed for studying the interaction of energy objects with natural systems as part of geotechnical systems to justify the geoecological directions for reducing the negative impact of major energy projects in the Republic of Sakha (Yakutia) on the example of energy facilities in South Yakutia: the Neryungri GRES, the Elga coal complex and the project of the possible Kankun HPP.

2. Methods and approaches

The theoretical basis of the article is the principles of the geoecological approach expressed in the methods of geosystem analysis and geotechnical systems that provide a comprehensive identification of territorial and industrial contradictions in the interaction of power structures with the environment.

In geosystem analysis, the environment is considered as a system formation consisting of a set of natural components combined in the form of geosystems (landscapes). A characteristic feature of the method is the relationship and the interdependence of the environment components and the possibility to make connections between them and the regularities of their anthropogenic changes [5].

The bases of the concept of geotechnical systems that allows considering human economic activity as interacting natural and technical systems are considered in the works of the Institute of geography of the USSR Academy of Sciences [3-6]. The study of the relationships and the structure of this interaction makes it possible to predict the anthropogenic transformation of natural components, find optimal solutions for optimal operation of technological equipment and structures, as well as provide adequate environmental technologies that minimize the impact on the environment [7].

3. Discussions and results

The purpose of the article is to develop geoecological directions for reducing the negative environmental impact of major energy projects in the Republic of Sakha (Yakutia) in South Yakutia.

Having said so the following issues were solved: the study of technological features of the interaction of various geotechnical systems "Energy facility – the environment" with the natural environment and their structure to identify the mechanism of their functioning and the relationships between the subsystems; the development of a system of indicators of integrated assessment of the interaction of energy facilities with the environment according to the scheme: impacts - changes -
consequences; the justification of environmentally safe criteria for the interaction of complex objects with the environment; the assessment of the geosystems stability degree to anthropogenic impact; the assessment of anthropogenic changes in geosystems and negative consequences in natural and socio-economic environments; the development of geocological directions for reducing the negative environmental impact during the realization of major energy projects in the Republic of Sakha (Yakutia) on South Yakutia – the Neryungri GRES and the Chulman CHPP, the Elga coal complex and the project of the possible Kankun HPP.

Neryungri GRES and Chulman CHPP. Technological features of influence on the environment are studied by considering their interaction as geotechnical systems "Heat and power resources – the environment" and the main channels of communication with the environment in the atmosphere, hydrosphere, and lithosphere are established. The influence of atmospheric precipitation on the underlying surface: snow, vegetation and soil covers - is studied; the composition and amount of wastewater entering watercourses, their change and impact on the chemical composition of natural waters are determined. The zoning of the GRES-CHPP impact area was performed according to the intensity of atmospheric emissions, wastewater and landscape changes; the areas of active and permanent impact zones, density and concentration of pollutants for an each object were calculated. The degree of stability of geosystems is estimated by factors that ensure the self-cleaning and the restoration of the soil-plant complex (biological productivity, conditions of heat and moisture supply), as well as by the cryogenic component (temperature, ice content of rocks, nature of permafrost distribution) [8].

Elga coal complex.

As a result of its consideration in the form of a mining geotechnical system "Coal mining complex – the environment" and determining its structure, the directions and intensity of influencing factors of the coal complex on the environment, as well as the nature of changes in geosystems and the degree of evaluation of their transformation are revealed.

The study of the complex impact on the environment is conducted: the types, a direction, the magnitudes of anthropogenic impact on the components of natural systems; functional and causal relationships between them are identified; the assessments of the degree of stability and the anthropogenic variation of surrounding geosystems are obtained; a map of environmental zoning is compiled which shows the principles of environmental measures due to the structure of geosystems, their stability and the degree of anthropogenic changes, as well as environmental measures differentiated by landscape and specified in a set of their types and directions [9,10].

Thus, it is determined that landscape-forming factors that are subject to altitude-zone differentiation determine the stability of natural complexes. The natural complexes of the Elga coal field development zone under study are generally characterized by a relatively low degree of resistance to man-made impacts and are relatively stable, relatively unstable and unstable to man-made impacts.

As a result of the assessment of the degree of geosystems anthropogenic variability, it follows that the territory as a whole is characterized by the focal development of the industrial development zone. At the same time, the highest degree of variation is typical for the locally located mining territory confined to the bald mountain and sparsely wooded landscapes. The average degree of anthropogenic variation is peculiar to mountain valleys occupied mainly by reindeer pastures. Most of the mountainslope landscapes have a low degree of variation. It was found that the greatest change among the selected components of the environment is subject to soil cover, permafrost, geological environment, surface water, terrain; the least - air environment, groundwater, bottom sediments, hydrobiota, vegetation and fauna.

Kankun hydroelectric power station. As a result of determining the structure of the geotechnical system "HPP - the environment", a comprehensive assessment of the current state of anthropogenic changes in geosystems before construction and a forecast of their changes are made. The assessment of the current state includes an assessment of geosystems stability and the degree of their anthropogenic changes depending on the types of the territory economic use. To assess the degree of
stability, a number of permafrost and bioclimatic factors were analyzed. It allowed identifying four types of landscapes corresponding to different degrees of transformation. The types and intensity of future loads are determined to predict the directions and intensity of technogenic factors affecting the future hydroelectric power station on the environment, as well as the nature and the transformation degree of a reservoir and coastal geosystems. It is determined that as a result of the HPP construction, the territory constituting 63% of the land allotment will be severely and moderately disturbed. At the same time, more than 11% of geosystems will be completely transformed. As a result of flooding by the reservoir, more than 51% of natural complexes will be affected including the most biologically productive complexes of slopes on the Timpton river valley [11].

Thus, as a result of this work, a methodological scheme for studying the interaction of energy objects with natural systems is developed to justify the geo-ecological directions for reducing the negative impact of large energy projects in the Republic of Sakha (Yakutia) on the example of energy facilities in South Yakutia: the Neryungri GRES, the Elga coal complex and the project of the possible Kankun HPP [12] (Figure 1):

4. Summary
Based on the application of the geoecological approach, a methodological scheme has been developed that provides a comprehensive study of various fuel and energy facilities as part of a complex, functionally unified geotechnical system "Fuel and energy facility – the environment" under conditions the North which is based on the geosystem analysis and the concept of geotechnical systems:

- technological features of interaction of various geotechnical systems "Energy object – the environment" with the environment and their structures are studied to identify the mechanism of their functioning and connections between subsystems;
- a systematization of indicators for a comprehensive assessment of the impact of fuel and energy facilities of South Yakutia on the environment has been developed which makes it possible to group the information received, consistently study the processes of HPP impact, changes and negative consequences in the natural and economic spheres;
- the degrees of stability and anthropogenic changes in geosystems, as well as negative consequences in the natural and socio-economic spheres on the territories of fuel and energy facilities in South Yakutia are assessed;
- environmentally safe criteria for interaction of fuel and energy facilities with the environment and the principles of reducing their negative impact on the environment are justified;
- a method for obtaining geoecological directions for reducing the negative environmental impact of major energy projects in the Republic of Sakha (Yakutia) on the example of large energy facilities of South Yakutia – the Neryungri GRES and the Chulman CHPP, the Elga coal complex and the possible Kankun HPP is developed.

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