

ENERGY SECTOR OF THE BAIKAL NATURAL TERRITORY IN TERMS OF IMPACT ASSESSMENT ON THE ECOSYSTEM OF LAKE BAIKAL

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Abstract: The study deal with the functioning of energy objects in the Baikal natural territory and they impact on the ecosystem of Lake Baikal. It is shown that pollutants have a major impact on the atmosphere from where can spread over long distances and leached from the air to the water and soil surfaces. The role of energy sector of the Baikal natural territory in the impact on the lake ecosystem has been determined.

KEYWORDS: ECOLOGICAL ZONE, HEAT POWER PLANTS, SMALL BOILERS, BERNING THE COAL, AIR POLLUTION

1. Introduction

This study examines the functioning of energy objects and their influence on the elements of the environment: the atmosphere, water bodies, and soils. At the same time, the impact assessment of energy objects located in the Baikal natural territory is investigated.

The concept of the Baikal Natural Territory (BNT) is defined by federal law of Russia No. 94 of May 1, 1999 "On the Protection of the Lake Baikal" (as amended on July 14, 2008) and is worded as follows: "The Baikal Natural Territory is the territory that includes Lake Baikal, the water protection zone adjacent to Lake Baikal, its catchment area within the territory of the Russian Federation, specially protected natural areas adjacent to Lake Baikal, and the territory adjacent to Lake Baikal till 200 kilometers to the west and north-west from it"[1].

The borders of the Baikal natural territory partially cover three subjects of Russia: the Republic of Buryatia, the Irkutsk Oblast and the Zabaykalsky Krai. In general, the area of the Baikal natural territory is 386.2 thousand km², of which 57% is the territory of the Republic of Buryatia (97% of the republic's population lives in this area), 29% is in the Irkutsk oblast (where the population is 54%) and 14% - Zabaykalsky Krai (the population of this part of the region is 15.5%). Within the framework of the Law and in accordance with the Order of the Government of the Russian Federation No. 1641-p dated November 27, 2006 "On the Borders of the Baikal Natural Territory", ecological zoning is regulated [1-2] and three ecological zones are distinguished (Figure 1) [3]:

- the ecological zone of atmospheric influence is an area till 200 km wide to the West and North-West of lake Baikal, on which economic objects are located, which have a negative impact on the unique ecological system of the lake;
- central ecological zone - an area that includes Lake Baikal with islands, a water protection zone, and specially protected natural areas adjacent to the lake;
- buffer zone - the territory outside the central ecological zone, which includes the catchment square of Lake Baikal within the territory of the Russian Federation.

Zoning of the territory provides, above all, the regulation of anthropogenic impact on the lake Baikal ecosystem.

The character and scale of the impact of energy sector is connected with the flow of pollutants into the elements of the environment, their quantity and quality. In this study, enterprises generating electric and thermal energy are considered as energy objects. In general terms, pollutants from the burning of organic fuels enter the atmosphere from energy objects, and as rule heated clean water is discharged into water bodies. Impact on soils is connected with destruction of landscapes and the formation of a significant amount of waste (ash and slag), including the excretion of significant areas for their storage.

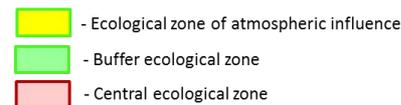


Fig. 1. Ecological zones of the Baikal natural territory

So, the greatest impact of energy sector to the natural environment arrive from the atmosphere, which gets a significant amount of harmful substances that can spread over long distances and areas, washed out of the air and deposited on the water surface and soil.

The impact assessment of the energy objects on the environment is carried out by using: statistical data, state reports on the ecological situation in the regions of the Russian Federation, annual reports on the activities of enterprises, and methods for determining emissions from boilers of different capacities approved by the Government of the Russian Federation.

2. Results and discussion

2.1. The ecological zone of atmospheric influence

The ecological zone of atmospheric influence is almost completely located on the territory of the Irkutsk Oblast (99% of the area), only in the northern part a small territory of the Severobaikalsky District of the Republic of Buryatia falls within the zone (or 1%) [4].

In this zone, enterprises of the Irkutsk-Cheremkhovo industrial region predominantly are predominantly located and in fact - in the five largest cities of the Irkutsk region - Irkutsk, Angarsk, Usolye-Sibirskoe, Cheremkhovo and Shelekhov. In these cities, 7 large-scale thermal power plants of PJSC Irkutskenergo operate year-round, from which about 200-250 thousand tons of pollutants enter the atmosphere in different years [5].

The contribution of all power plants of the atmospheric influence zone to the total emission of the five cities under consideration is estimated at 65-70%.

From the standpoint of energy sector, the negative impact on the Baikal natural territory, as well as the water area of the lake Baikal is associated not only with significant amounts of heat power plant emissions, but also with conditions of entry of impurities into the atmosphere. It does mean that an emission height from heat power plants is of more than 150 m, when pollutants enter outside the surface layer, and are involved in long-distance transport.

For the Baikal natural territory and the water area of Lake Baikal, three heat power plants of the cities of Angarsk and Irkutsk, which are located closest to the lake, can have the greatest negative impact to Baikal. The character of the impact of these three heat power plants is determined by the facts that:

- they are enough large, working on coal, that contributes to the formation of a significant amount of emissions - more than 50 thousand tons per year from each station;
- sulfur oxides prevail in emissions - up to 70% of the total volume of emissions;
- the height of the emission exceeds 150 m, respectively, pollutants come outside the surface layer of the atmosphere, entering into long-range transport processes.

The features of long-distance transport of pollution are determined by fact that winds of the west and north-west directions can bring to the southern part of the central ecological zone of the BPT and water area of the lake of harmful impurities from these three stations which located on the distance of 80 to 100 km from the lake Baikal. At the same time, the maximum load of heat power plants occurs in the winter period, and climatic and geographical features BPT are determined by the high frequency of anticyclones in the cold period of the year with low precipitation and stagnation situations, which significantly reduces the ability of the atmosphere to self-purification (2-3 times lower than the average Russia).

According to the long-term monitoring of the atmosphere and atmospheric precipitation, which is conducted year-round by the staff of the Limnological Institute of the SB RAS in the settlement of Listvyanka, gaseous emissions of large heat power plants enter into a long-distance transport and manifested as plumes in the coastal areas of the southern part of the lake Baikal. In recent years, concentrations of oxides of sulfur and nitrogen, which reach dozens and hundreds of $\mu\text{g}/\text{m}^3$ recorded at a permanent monitoring station of the atmosphere (in Listvyanka) and can cover large areas of southern Baikal, including the eastern shore [6, 7].

In the ecological zone of atmospheric influence, the assessment of wastewater discharges by energy enterprises was not carried out because the wastewater into the lake Baikal cannot receive. The situation is similar with production and consumption wastes, whose impact on the lake's ecosystem Baikal and adjacent territories in the context of assessing the contribution of energy sector from the ecological zone of atmospheric influence is not appropriate.

2.2. The central ecological zone

The central ecological zone adjoins directly to the Lake Baikal and has a special environment protection and socio-economic status. One third of the territory of the central ecological zone is occupied by specially protected areas: reserves (11.9 thousand km^2), national parks (12.9 thousand km^2) and wildlife preserves (0.8 thousand km^2).

The special status of the use of this territory is regulated by the federal law "On the Protection of Lake Baikal" and, in accordance with the Decree of the Government of the Russian Federation No. 643 of August 30, 2001 "On Approving the List of Activities Prohibited in the Central Ecological Zone of the Baikal Natural Territory" with changes of Government Resolution No. 186 of March 2, 2015. These resolutions prohibit certain types of economic activity, including the construction of coal-fired boiler houses, except for their major overhaul and reconstruction.

The power objects in this area include the Baikalsk heat power plant and numerous boiler houses of various capacities, of which 66 are coal, 15 are electric boiler houses, 9 are use wood, 3 are gas and

1 oil. In the structure of installed capacity of heat sources, coal-fired boilers occupy more than 90% [8].

It should be noted that electric boiler houses, as the most environmentally friendly, function only in the coastal areas of the Irkutsk oblast, which is explained by the acceptable level of electricity tariffs in the region. Among the energy technologies used, layer combustion of solid fuels has the greatest weight. The majority of boiler houses use boiler units with a capacity of up to 1 Gcal/h, in which flue gas cleaning is usually not performed or is not performed satisfactorily.

Due to the lack of statistical information, officially approved methods for calculating emissions of pollutants into the atmosphere by heat power plants and boiler houses of different capacities were used to assess the impact of energy objects on the atmosphere of the central ecological zone [9-11].

The total estimated emission from the boiler houses of the central ecological zone amounted to 24.5 thousand tons per year, and the share of small capacity boiler houses where flue gas cleaning is not performed accounts for 60% of the total emissions at a fuel consumption of 26% from the total burning fuel. More than 74% of the fuel is burned in 9 large boiler houses, but only 40% of total emissions into the atmosphere enter from them.

As a consequence of the predominant use of coal, in the composition of emissions (up to 80%) particulate matters are prevail, or so-called "black carbon". The distribution of emissions from boiler houses in the central ecological zone has two clearly expressed manifestations in the southern and northern parts of Lake Baikal: 12.4 thousand tons in the south, 1.75 thousand tons in the middle part of Baikal and 10.3 thousand tons - in the north.

It should be noted that at present there are no data, both official statistics and initial information for calculating emissions from heat sources of year-round tourist bases, as well as a number of small boiler houses that heat one building. In addition, for the central ecological zone, it is important to take into account emissions not only of energy objects, but also of private houses of settlements heated by coal and firewood.

According to official statistics, wastewater discharges into surface water bodies (rivers, streams) and directly into the waters of Lake Baikal in the central ecological zone is carried out only on the form of sewage discharges on special treatment facilities in large settlements: Slyudyanka, Baikalsk, Severobaikalsk. It is rather difficult to identify the contribution of wastewater discharges from large boiler houses operating in these cities. As for small capacity boiler houses, they have no direct wastewater discharge, only loss of coolant during the transfer of thermal energy to the consumer. And in terms of impact assessing the on the waters of Lake Baikal influences of small boilers can be neglected.

The impact assessment of industrial waste from the energy sector is not only related to the lands that have been excretion for storage and that have been removed from economic circulation (forest, steppe, agricultural), but also due to pollutants entering the environment elements from storage sites. The impact of waste occurs through the soil and the air: dusting, burning dumps, filtering of ash dumps. Ash and slag waste obtained by thermal transformation from the combustion of coal may have an increased concentration of various radioactive elements (uranium, radium, thorium, etc.). This is due to the fact that coal, as a natural sorbent, is capable of accumulating natural radioactive elements, and when burned, their content in ash and slag can increase 3-10 or more times [12]. The problem of radioecological safety of coal, fly ash (not captured in treatment equipment), as well as ash and slag waste and products from them are requires take special solution at the state level. It is necessary to conduct continuous monitoring of the content of radioactive elements of burn coal at all energy objects. In the new conditions of digitalization of the Russian economy, including the energy sector, the organization of such monitoring is just beginning. Comprehensive monitoring of the impact of energy sector will allow analyzing the situation not only in quantitative terms, but also in qualitative terms. In this study, the impact assessment of ash and slag waste from energy sector is still considered from the standpoint of their quantitative formation.

The calculation of the amount of ash and slag wastes was based on the recommendations [13, 14]. Ash and slag waste includes residues of unburned fuel in the furnace devices of boiler houses. For large boiler houses, the volume of captured solid (ash) particles in special catching devices, which are moved to the ash dumps or waste storage, is also taken into account.

The total amount of ash and slag waste from energy objects in the central ecological zone is estimated at 79-80 thousand tons annually. Territorially, the largest amount of ash and slag waste falls on the Slyudyansky district: city Baikalsk - 25.1 thousand tons/year and the city of Slyudyanka - 19.2 thousand tons/year, which are located in the southern part of Lake Baikal. In the northern part - the largest amount of energy sector waste is generated in the city of Severobaikalsk (22 thousand tons/year). From the calculations it is clear that it is in these settlements that large energy enterprises are located.

One of the problems of the heat generation of large cities and settlements of the central ecological zone that needs to be solved in the coming years is the filled of ash dumps. Thus, in the city of Severobaikalsk, expansion or construction of a new ash dump is required, since the existing one is almost full.

2.3. The buffer ecological zone

The buffer ecological zone covers 75% of the area of the Republic of Buryatia and 25% of the Zabaykalsky krai.

In total, from all stationary sources of the zone in 2017, 85.2 thousand tons of pollutants entered the atmosphere, of which 75.2 thousand tons - in the Republic of Buryatia and 10 thousand tons - from stationary sources in the Zabaykalsky krai [5]. Assessing the contribution of energy enterprises to this emission and the possibility, under certain meteorological conditions, to influence the lake's ecosystem, it should be noted that only large energy objects of the Republic of Buryatia have a "high" emission sources. In the Zabaykalsky krai, these are mainly small capacity boiler houses in rural areas.

The Ulan-Ude thermal power station -1, the Timlyuy thermal power plant and the Gusinoozyerskaya state district power station are referred to such energy sources in the Republic of Buryatia. Emission from these energy objects is estimated at 60-63 thousand tons/year (or 60% of the total emissions from stationary sources of the buffer ecological zone). Sulfur oxides are also predominant in the emissions of these stations [5].

In general, the buffer ecological zone is dedicated from the standpoint of the protection of water bodies, since the main inflow of water and the catchment area of the lake Baikal is located and formed in this area.

Sewage of large energy enterprises, as a rule, is characterized as regulatory clean warmed waters, however, when entering them into water bodies, they are capable of disrupting the hydrobiological and chemical composition of natural waters. Directly to Lake Baikal, wastewater from large energy enterprises of the buffer ecological zone does not flow. Accordingly, from the impact assessments of the on the lake's water area these wastewater are excluded. And also ash and slag waste and their storage due to remoteness from Baikal are excluded too.

3. Conclusion

As a result of a study for impact assess the of the energy sector of the Baikal natural territory on the lake's ecosystem Baikal was revealed that the main impact is related to the emission of pollutants into the atmosphere during the production of electrical and thermal energy. The total emissions coming from the energy objects of the Baikal natural territory is estimated at 280-300 thousand tons per year. That is comparable, and often higher than the annual emissions of some European countries. In general, the contribution of energy objects to the total emissions of the Baikal Natural Territory is estimated at 67.5%, (Table 1).

Table 1. Emissions to the atmosphere of the Baikal natural territory in 2017 by ecological zones and the assessment contribution of energy sector

Index	Ecological zone			total
	atmospheric influence	central	buffer	
Emission, total, thousand tons/year	301,8	24,5	85,2	441,5
among them: energy objects	210,3	24,5	64,1	298,9
Contribution, %	69,9	100	75,2	67,7

A specific feature of the energy sector of the Baikal natural territory is the use of coal as a fuel. At the same time, its combustion at large heat power plants located into ecological zones of atmospheric influence and buffer one is associated with the formation of a significant amount of gaseous emissions — sulfur and nitrogen oxides. Under certain meteorological conditions, such emissions can enter the southern and middle parts of Lake Baikal and later fall out in the form of acid precipitation. In turn, acidification in the elements of the environment leads to a change in the initial quality, as a rule, to deterioration.

In the central ecological zone, the sources of emissions are large and small boilers houses with a predominant emission of particulate matters. In quantitative terms, this emission is estimated at 24.5 thousand tons per year, but due to natural and geographical features, all these pollutants remain in the lake's ecosystem Baikal: will fall to the surface of the earth and the lake or be washed out with precipitation. Pollutants can have a synergistic effect (enhance the effect of various impurities), contribute to the formation of fogs, and in conditions of stagnation of the atmosphere forms smog situations, especially in winter time.

Along with the emission of pollutants into the atmosphere when coal is burned, ash and slag waste is generated, which must be stored and disposed of. At present time, it is important to organize the accounting of produce such wastes and their storage. In addition to, should be to establish a system of automatic continuous monitoring of emissions from existing enterprises around Baikal, including energy sector.

Recently, much attention has been paid to the creation of a unified integrated digital monitoring system of the Lake Baikal ecosystem. Such system will allow state monitoring of data of both a climatic and anthropogenic terms. In fact, this is a new level of organization of interaction with various services in the field of the protection of Lake Baikal, as well as the transition to the "Industry 4.0" platform.

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References

- [1] Federal law "On protection of Lake Baikal" (ed. of 14.07.2008) № 94-FL of 01.05.1999, Moscow, Russia, 1999. [On line]. Available at <http://www.baikalfund.ru/library/law/>. Accessed on: November 21, 2016.
- [2] Order of the Government of the Russian Federation No. 1641-p dated 11.27.2006 "On the boundaries of the Baikal natural territory". [On line]. Available at <http://www.tanhoi.ru/DOC/russia/1641r.pdf>. Accessed on: December 20, 2016).
- [3] Siberian Branch of the Federal State Budgetary Institution "Russian Federal Geological Fund" (FSBI "Rosgeolffond"). Available at <http://geol.irk.ru/baikal/>
- [4] State report "On the state of Lake Baikal and measures for its protection in 2012." - Irkutsk: Siberian Branch of the Federal State Budgetary Institution "Rosgeolffond", 2013.- 436 p.
- [5] State report "On the state of Lake Baikal and measures for its protection in 2017." - Irkutsk: ANO "Expert", 2018. - 340 p.

- [6] Obolkin V.A., Potemkin V.L., Makukhin V.L., Hodzher TV, Chipanina E.V. Long-range transfer of plumes of atmospheric emissions from regional coal-fired thermal power stations to the South Baikal water area. - Optics of the atmosphere and the ocean, Vol. 30, №1, 2017. Pp. 60-65.
- [7] V. Obolkin, T. Khodzher, L. Sorokovikova, I. Tomberg, O. Netsvetaeva & L. Golobokova. Effect of long-range transport of sulfur and nitrogen oxides from large coal power plants on acidification of river waters in the Baikal region, East Siberia. - International Journal of Environmental Studies, 2016, Vol. 73, No. 3. Pp. 452-461.
- [8] B.G. Saneev, I.Yu. Ivanova, E.P. Maysyuk, T.F. Tuguzova. Introduction of Environmental Measures in the Heat Power Industry of the Central Ecological Zone of the Baikal Natural Territory - Ecology and Industry of Russia, 2018. V. 22 №7. Pp. 20-25.
- [9] Method for the Determination of Gross Atmospheric Emissions of Pollutants from Boilers of Thermal Power Stations, (All-Union Thermal Engineering Institute (VTI), Moscow, 1998).
- [10] Method of Determining Atmospheric Emissions of Pollutants Produced by Burning Fuel in Boilers Having Capacity of 30 ton of Steam per Hour or Less Than 20 GCal per Hour, (Firm Integral, St. Petersburg, 1999). (<http://meganorm.ru/Index2/1/4294849/4294849657.htm>)
- [11] Methodical letter of SRI Atmosphere from 17.05.2000 № 335 / 33-07 "About carrying out of calculations by a Method of Determining Atmospheric Emissions of Pollutants Produced by Burning Fuel in Boilers Having Capacity of 30 ton of Steam per Hour or Less Than 20 GCal per Hour", (Firm Integral, St. Petersburg, 2000).
- [12] Ovseychuk V.A., Krylov D.A., Sidorova G.P. Natural radionuclides in coal and ash from coal-fired power plants - Coal, 2012. № 9. Pp. 96-97.
- [13] Sidelkovsky L.N., Yurenev V.N. Boiler installations of industrial enterprises: Textbook for universities. 3rd ed., Moscow. Energoatomizdat, 1988, 528 p.
- [14] Nazmeev Yu.G. Ash and slag removal systems of thermal power plants. Moscow Power Engineering Institute, 2002, 572 p.