

Energy industry of the Republic of Buryatia: current state and prerequisites for further development

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Abstract. The article contains the results of a study of the state of the fuel and energy complex (FEC) of the Republic of Buryatia. The role of fuel and energy complex in the economy of the republic is analyzed in the article. The main problems, the solution of which is necessary for further development of the industry, including energy security and low efficiency of heat and power production in the power system, are identified by the author. The tasks of development of transboundary interaction with the energy system of Mongolia are defined. Possible options for gasification of Buryatia were studied. To ensure increased energy security of the Republic of Buryatia and the efficiency of the Buryat energy system, the main activity is the continuation of the construction of Ulan-Ude Thermal Power Station-2. The necessity of actualization of the development strategy of the fuel and energy complex of the Baikal region based on the diversification of the fuel and energy balance due to gasification, the development of gas processing and gas chemistry, the use of non-traditional and renewable types of energy is substantiated.

1 The role of energy industry in the economy of the Republic of Buryatia

The energy industry provides the conditions for stable development of the economy and social sphere. The foundations of the energy industry in the Republic are coal industry, heat and electric power industries.

In the gross regional product, the share of the economic activity type named “Production and distribution of electricity, gas and water” (hereinafter – energetics) was 6.1% in 2016 (see table 1).

A quarter of industrial production of Buryatia is produced in the energetics. The share of energetics in the fixed assets of the republic was 17.1%. The share of energetics accounted for 16.9% of the turnover of organizations in Buryatia in 2016, and one of coal industry – 2.6%. In 2017, the shares of coal mining enterprises and energetics enterprises in tax revenues to the budget of the Russian Federation were 1.5%, and 6.8%, respectively.

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Table 1. Share of energetics in the main macroeconomic indicators, %¹

	Year					
	2006	2010	2013	2014	2015	2016
Gross regional product	5,9	4,5	4,8	4,9	5,2	6,1
Tax revenues	13,8	1,1	4,8	5,1	4,7	6,1
Manufacture of industrial products	33,3	23,9	21,3	21,0	19,8	24,8
Fixed assets	17,8	15,3	16,4	14,2	18,3	17,1
Investments in fixed assets	1,3	17,4	15,4	12,0	10,5	12,4
Number of employees	3,6	3,9	3,6	3,6	3,6	3,8

2 Energy industry of the Republic of Buryatia: current state and problems of development

2.1 Resource base

The resource base of the Buryatian energy industry is mainly represented by coal. 23 deposits of brown and hard coal are known on the territory of Buryatia, of which 13 are accounted for by the state balance sheet, and 6 are being developed. The balance reserves of coal are 2.6 billion tons. The largest deposits of black coal are Nikolskoie, Erdem-Galgataiskoe and Olon-Shibirskoie. The proved coal reserves of these fields are more than 1.1 billion tons, which currently sufficient to meet 50 years of production [1].

Large reserves of brown coal are contained in the Gusinoozerskoe and Zagoustaiskoie deposits. The western group of deposits, including the large-scale Akhalinskoye field, is located in poorly developed area.

The Republic of Buryatia has a significant hydropower potential with main located on the Vitim River, where it is possible to build large hydroelectric power stations with the generation of electricity more than 5 billion kWh. The energy potential of small hydropower in the basins of the Barguzin and Dzhida rivers is 30 MW and 11 MW, respectively.

Buryatia holds quite large renewable energy resources. The total daily flow rate of geothermal sources in Buryatia is estimated at more than 50 thousand m³/day. However, special studies are needed to use them in electrical and heat supply systems. The economic potential of solar energy, wind energy and logging waste amounts to 34 thousand tce, 130 thousand tce and 110 thousand tce, respectively².

2.2 Production and consumption of fuel and energy resources

The extracted coal is mainly used as fuel for the Gusinoozerskaya GRES and thermal power plants. A significant part of the coal mined at the Tugnui coal mine is exported to East Asian countries.

¹ The Republic of Buryatia is 95 years old: an anniversary collection / Territorial authority of the Federal State Statistics Service for the Republic of Buryatia. - Ulan-Ude, 2018. - 464 p.

² Strategy for the development of the fuel and energy complex of the Republic of Buryatia for the future until 2030. Moscow-Ulan-Ude. 2009. Approved by the Resolution of the Government of the Republic of Buryatia of May 15, 2009, No. 177.

In the Republic of Buryatia currently operate large coal companies - OJSC "Siberian Coal Energy Company" (OJSC SUEK), which includes the sections "Tugnui", "Buryat Coal Company", and LLC "Ugolny cut", LLC "Buryat Mining Company", LLC "Buryatugol", LLC "East Siberian Mining Company". Coal mining in the republic increased from 2386 thousand tons in 2012 to 3671 thousand tons in 2017.

The power system of the Republic of Buryatia (RB) includes power plants with a total capacity of 1,403.39 MW, including Gusinoozerskaya coal power plant – 1190 MW (84.8% of the total capacity), diesel power plants – 18.62 MW, solar power plants – 10 MW.

The total length of power transmission lines is 33,689 km, of which VL-500 kV is 340 km, VL220 kV is 2,496 km, VL-110 kV and below – 2693 km, VL35 kV is 26,450 km, the number of substations is 8995 units, including voltage 220 kV – 25 pcs. The peculiarity of the Buryat energy system (ES) is a high share of the main radial networks and low voltage distribution networks.

In the Republic of Buryatia there are two unconnected power districts - Southern and Severobaikalskii. The main electric grid of the power system of the Southern region is formed from power transmission lines and substations with a voltage of 110-220 kV. Electricity is supplied mainly from thermal power plants operating at local coal. The Southern power district of the power system of the Republic of Buryatia is connected with the ES of the Irkutsk oblast' and the Zabaikalskii krai through a 500 kV transmission line and a two-circuit 220 kV transmission line, and with the ES of the central region of Mongolia via a two-chain 220 kV transmission line.

The Severobaikalskii energy district is transitory and is connected with the ES of the Irkutsk oblast' and the Zabaikalskii krai. The main load here is electric traction of Baikalian-Amur Railroad and mining enterprises of Bodaibo District of Irkutsk Oblast'. There are no generating stations in the Severobaikalsk power district. Power supply is provided by a two-chain 220 kV transmission line "Ust-Kut-Severobaikalsk-Taksimo" from Irkutskenergo.

The unified fuel and energy balance of the Republic of Buryatia is presented in Table 2. On the whole, the Republic's electric power industry is in stagnation. The existing capacity of power plants allows to fully meet the republic's electricity needs, transfer the required amount of electricity to the Irkutsk Region and the Trans-Baikal Territory, and export it to Mongolia.

Table 3 shows the dynamics and structure of electricity consumption in 2013–2017. Electricity consumption of the republic has not yet reached the level of 1990 (5,886 million kWh), amounting to 2017. 5487.8 million. kWh, and in 2022 it is projected at a volume of 5565 million kWh.

The main consumers are transport and communications (35% of productive leave), power plants (10% of total consumption). The share of population consumption is high (22% of productive leave), the energy consumption in agriculture and forestry remains extremely low.

In the Republic of Buryatia there are no energy-intensive industrial consumers in contrast to the Irkutsk oblast', where, with a total consumption of 53,209.4 million kWh, the share of manufacturing industries is 56.4%. At the same time in Buryatia, there are significant losses of electricity in the networks (21% of total consumption), while in the Irkutsk EC they are twice lower (9.3%).

Table 2. Fuel and energy balance of the Republic of Buryatia for the period from 2013 to 2017³

Index		2013	2014	2015	2016	2017
Electricity production, mln. kWh, total		5 391,80	5 347,0	5745,86	5632,1	6273,3
Including:	TPP	5 389,90	5 344,9	5744,3	5630,3	6271,7
	DPP	1,9	2,1	1,6	1,8	0,7
	Other	-	-	-	-	0,9
Heat production, thousand Gcal, total		6 406	6 307	6 133	6 782	7025
Including:	TPP	2699,9	2 668	3 698	3 237	3803
	Boiler rooms	3704	3 637	2 433	3 544	3222
	Non-fuel	2,1	2	2	2	2
KPT, thousand tons of fuel equivalent, total		3 076,91	3008,6	3 011,09	3209,5	3400,5
Including:	Coal	EE TPP	1768	1753	1 812,03	1837,632
		TPP TPP	668,3	628,7	437,63	387
		Boiler rooms	509	500	644,34	938
		Total	2 945,30	2 881,7	2 894,00	3163
	Fuel oil	TPP	12,5	12,2	9,08	9,0
		Boiler rooms	94,46	87,2	82,42	12,416
		Total	106,96	99,4	91,50	21,50
		Diesel fuel	24,65	27,5	25,6	25

Table 3. The structure of power consumption in the territory of the Republic of Buryatia for the period 2013–2017

Power Consumption	million kWh				
	2013	2014	2015	2016	2017
Total	5484,0	5408,5	5363,8	5394,7	5478,8
Industry - total	750,8	722,8	755,8	637,8	559,8
Agriculture	19,3	20,6	17,7	19,9	18,8
Forestry	0,8	0,4	3,8	0,1	0,1
Fish-farming	1,9	1,6	1,2	0,5	1,2
Transport and communication	1165,8	1185,4	1177,7	1245,4	1304,4
Construction industry	40,9	38,5	37,9	37,5	30,3
Other industries	876,2	926,7	707,6	1011,9	1003,6
Population	940,0	957,4	881,6	872,8	815,0

2.3 The problems of heat and energy system

At the same time, there are serious problems in the energy system of the Republic of Buryatia. The most important issue is energy security. Due to the insignificant increase in electricity and heat consumption for more than 20 years, new capacities were not put into operation, they are also not envisaged in the current and future plans of energy enterprises, as well as in the “Scheme and Program for the Development of the Electricity Industry” (hereinafter referred to as the SPDEI) of Buryatia and the Russian Federation. This led to

³ Scheme and program for the development of the power industry of the Republic of Buryatia for 2018-2022. Approved by the decree of the Government of the Republic of Belarus of 28.04.2017 № 239-p.

problems in the electrical heat supply of Buryatia that significantly reduce energy security, efficiency and reliability of the energy system, raise tariffs for heat and electricity.

From the point of view of energy security, according to the studies carried out by Melentiev Energy Systems Institute Siberian Branch of the Russian Academy of Sciences (ISEM SB RAS) under the guidance of Corresponding Member RAS N.I. Voropaya [2], the Republic of Buryatia is in a pre-crisis state by two factors. The first is a high share of the Gusinoozerskaya State district power station (86% of the total installed capacity), the highest generating source in the republic. The commissioning of new power plants is required.

The second factor is the high depreciation of fixed assets of industry “Production and distribution of electricity, gas and water”, which reached 49.1% in 2016⁴. Every year the resources of the existing main equipment, electric and especially heating networks are reduced. Therefore, it is necessary to develop and implement a program for upgrading equipment at the Gusinoozerskaya GRES and other power plants, replacing the trunk and intra-district heating systems in Ulan-Ude.

The second problem of the development of the fuel and energy sector is the low efficiency of heat and power production in the energy system. Buryatia owns the highest tariffs for electricity and heat in the Baikal region and one of the highest in the Siberian Federal District. For example, the tariff for electricity for the population for the second half of 2018 in the republic is equal to 3.93 rubles per kWh, in the Transbaikalian Territory - 2.99 rubles per kilowatt-hour, in the Irkutsk Region – 1.06 rubles per kW·h; tariffs for heat energy are, respectively, 1616 rubles/Gcal, 1046 rubles / Gcal, 871 rubles/Gcal.

The reasons for low tariffs in the Irkutsk region are well known. First of all, it is a high share of power generation in hydroelectric power stations (75.77%), the cost of which is much lower than that produced by thermal power plants. In addition, the bulk of electricity in thermal power plants is generated by thermal consumption, which reduces the cost of both heat and electricity. The majority of large consumers of non-ferrous metallurgy, petrochemicals, wood chemistry, railway transport and others are connected to the electricity networks of 220-110 kv and are close to energy sources, which significantly reduces losses on transportation of electricity.

The power systems of the Republic of Buryatia and the Trans-Baikal Territory have much in common:

- almost the same level of consumption and production of electricity and heat;
- power generation at coal-fired thermal power plants with turbo-generators of 100 and 200 MW;
- backbone power lines 220 and 500kV;
- the main consumer – electric traction;
- extended power distribution networks with a voltage of 110–35 kV. etc.

The main reason for higher tariffs for electricity and heat in Buryatia than in the Trans-Baikal Territory is that in Buryatia, electricity generation for heat consumption is no more than 10%, and in the Trans-Baikal Territory – more than 50% of the total electricity production in the region. In the city of Ulan-Ude, with a heat load of 1300 Gcal / h, only 380 Gcal/h is produced using cogeneration at CHPP-1 with a capacity of 140 MW [3]. The use of cogeneration at the remaining heat load of 920 Gcal / h can ensure the production of at least 700 MW.

In 1980 the construction of Ulan-Ude CHPP-2 was started with the first stage being two heat-generating power units T-180/220 with a total heat capacity of 920 Gcal/h. Work on the construction of CHPP-2 was carried out with significant difficulties due to the weakness of construction organizations, and in the 90s construction financing was practically

⁴ Regions of Russia. Socio-economic indicators. 2017: P32 Stat. Sat. / Rosstat. – M., 2017. P. 578.

disrupted. In these circumstances, by 1995 four boilers of starting-peak boiler house were put into operation in order to prevent the failure of the heat supply of the city. At the same time, a significant amount of work has been done to develop the territory of the CHPP, construction of auxiliary facilities, external and internal communication lines, access roads and railways that practically ensure the launch of two power units.

Capital investments amounted about 10 billion rubles. Unfortunately, afterwards, the construction of the CHPP was stopped. Such amount of auxiliary and infrastructure facilities significantly increases the cost of heat generated at CHPP-2 at present and, of course, will reduce the amount of investment needed to commission power units at the power plant.

At present, the city's centralized heating system is performed by 136 sources of heat supply, including: from CHPP-1, CHPP-2 owned by JSC "Territorial Generation Company-14", 34 municipal boiler houses transferred into operation by OJSC "Ulan-Ude Energy Complex" and 100 departmental boiler rooms. The total installed heat capacity of heat sources is 1820.5 Gcal/h.

Central heating provided 82% of the area of residential buildings, CHPP-1 and CHPP-2 provide 61% of the city's heat load⁵. Low-rise buildings in suburban neighborhoods are mainly heated from individual sources of heat, using coal or, less often, firewood. The high cost of heat leads to the fact that even in the area of operation of Ulan-Ude CHPP-1 and CHPP-2, new small boiler plants are being commissioned using coal for heating of offices, retail and warehouse buildings, as well as residential quarters. This leads to the worsening of the ecological situation in the city.

The problem of protecting Lake Baikal is one of the key issues for the Republic of Buryatia. A significant part of the territory of the republic – 57.27 thousand km², is included in the Baikal natural territory (BNT), which introduced environmental restrictions⁶.

A significant contribution to the solution of problems arising in connection with the preservation of the ecology of Lake Baikal should be made by the electric power industry. First, it is necessary to find the most acceptable solution for energy and heat supply of the central ecological zone (SEZ) of Baikal. Among the energy objects, the largest impact on the natural environment of the coastal areas is provided by numerous heat sources: the Baikal Thermal Power Plant and more than 100 boiler houses of different capacities, of which 66 are coal, 15 are electric boiler houses, 9 are wood, 3 are gas and 1 is mazut. The total capacity of the boiler houses is 417.7 Gcal/h, including 288.8 Gcal/h in the Republic of Buryatia and 128.9 Gcal/h in the Irkutsk region. Within a year 295.1 thousand tons of coal are being burned, the emissions of pollutants reach 26.7 thousand tons, including 14.9 thousand tons in Buryatia and 11.8 thousand tons in the Irkutsk region [4].

It should be noted that the needs for fuel and, accordingly, the emissions of pollutants of individual housing, year-round tourist hosting premises, as well as small heat sources that heat one building and do not have their own heating networks, have not been estimated. There are a lot of such sources: in the territory of the Irkutsk region it is mainly electric boiler and electric heating devices, in the Republic of Buryatia – firewood, coal and, in rare cases, liquefied hydrocarbon gas are used for fuel. It is not possible to determine the documented expenditure of energy resources for these purposes due to private purchasing of fuel since without concluding contracts and therefore lack of statistical data.

Currently, more than 130 thousand people live in the central ecological zone of the Baikal natural territory (CEZ BNT) in 151 settlements. The calculations carried out by the

⁵ Heat supply scheme in Ulan-Ude for the period up to 2028. Approved. Decree of the Administration of Ulan-Ude from 03.11.2017 № 322.

⁶ State report "On the state of Lake Baikal and measures to protect it in 2015". Irkutsk: Siberian Branch of Federal State Unitary Enterprise "Rosgeofond", 2016.

authors show that on the territory of the CEZ BNT, 215,000 Gcal are consumed per year for individual heating, including 125,000 Gcal of heat in the territory of Buryatia. To produce this amount of heat, 102 thousand tons of coal, incl. 60 thousand tons in Buryatia, is needed. At the same time, emissions into the atmosphere will amount to 9 thousand tons, including 5 thousand tons in Buryatia, and the volume of ash and slag waste will reach 43 and 25 thousand tons, respectively.

The high level of anthropogenic pressure on the environment in the CEZ of the Baikal natural area determines the need for specific decisions on the development of the electric power industry taking into account environmental factors.

Another problem of the development of the energy sector in Buryatia, caused by the influence of the Baikal factor, is connected to the regulation of the water level in Lake Baikal and the interaction of the power systems of the Baikal region. After the construction of the Irkutsk hydroelectric power station was completed, a new hydrological regime of Lake Baikal was formed, which mostly depends not on natural factors, but on hydropower parameters of the Angarsk cascade of hydroelectric power stations [5].

Fluctuations in the water level in Lake Baikal in extreme low-water and high-water years have a significant negative impact on the socio-economic development of the Republic of Buryatia and the Irkutsk region and an ecological situation in the coastal areas. Thus, in 1982, as a result of prolonged low water and a decrease in the level of Lake Baikal, a sharp decline in electricity production occurred at the Angarsk cascade of HPPs. Thermal power plants could not compensate the loss of power, because the reserves of fuel and power of coal enterprises could not provide the necessary output as thermal power plants. In the conditions of an acute shortage of electric power in all regions of Siberia, the limits of its consumption, incl. vital objects, industrial enterprises, the railway traffic on the Trans-Siberian Railway was limited. The lack of proper interaction between power systems in the face of negative natural phenomena leads to significant economic losses.

The reduction of the anthropogenic pressure on the natural environment, of the CEZ BNT requires modernization of the boiler houses, introduction of new environmental technologies, and fuel replacement with environmentally friendly fuel types, including natural gas.

In the list of activities of the federal target program "Protection of Lake Baikal and socio-economic development of the Baikal natural territory in 2012–2020", measures were envisaged for the modernization of heat supply systems with transfer to environmentally friendly technologies in the territories of the subjects of the Russian Federation located in the Baikal natural territory, commissioning of 39 facilities with a total capacity of 325.33 Gcal/h with a decrease in the formation of ash and slag wastes. In fact, obsolete, worn-out boilers were replaced with new coal ones, which could provide only a slight decrease in the formation of ash and slag wastes and harmful emissions into the atmosphere. In our opinion, this type of modernization is unpromising.

Due to the mentioned above, it is more expedient to switch to electric heat supply of the territory of the CEZ BNT. Calculations show that (without taking into account the transfer of electricity for Baikalsk and the central boiler house in Severobaikalsk, which require a separate solution), a total of 418 MW and 731.5 million kWh per year are required for the CEZ of the BNT, 228 MW for the Republic of Buryatia and 400.0 million kWh per year*. On the territory of the Irkutsk region, 130 MW are required for boiler houses (21 MW already operate on electricity), 60 MW for heating individual buildings, a significant amount of which uses electricity. On the territory of Buryatia with the current tariffs for electricity it is impossible to do this.

* The calculations were carried out without taking into account the transfer of heating in Baikalsk to the city's electricity and the central boiler house in Severobaikalsk, for which a separate solution is needed

The resolution of the issue of setting electricity tariffs for the purposes of energy supply in the territory of the CEZ BNT, which would be competitive to coal (not higher than 1 ruble per kilowatt/hour) lays within allocating the necessary amount of electricity from the tires of the Angarsk hydroelectric power stations. For Buryatia 400 million kWh per year will be required with a maximum capacity of 228 megawatts, which is less than 1% of the Angarsk hydropower plant's output.

In our opinion, Baikal should "work" to improve the environmental situation in the CEZ BNT. The Ministry of Energy may well resolve this issue. The network infrastructure can provide electric heating for the Baikal coast. The southern part of the CEZ is supplied with a double-circuit power line-220 kV and a transmission line-500 kV, the northern part – with two-circuit power line-220 kV.

The fourth problem of the development of the fuel and energy complex in Buryatia is Mongolia's proposed construction of a hydroelectric power station on the Selenga River and its tributaries. This could pose a threat to the ecology of Baikal and the Baikal natural territory. According to the forecasts of the energy institute of the Mongolian University of Science and Technology by 2025–2030 electric load and power consumption of the Central Energy System of Mongolia (CES) will increase more than double and amount to 2000–2200 MW and 10 billion kWh, respectively. The prospective major consumers are ore dressing plants “Oyu Tolgoi” and “Tsagaan Suvraga”, a coal mine based on Taban Tolgoi coking coalfield, and an industrial park in Sainshand.

To meet the growing demand for electricity, it is planned to build thermal power stations on coal and hydroelectric power stations on the river Selenga and its tributaries [6]. At present, the Mongolian side has submitted a technical task for the regional environmental assessment of the Selenga and its basin and Baikal in the context of the Shuren hydropower plant construction project and the “Orkhon” hydropower and drainage project development for the World Bank. However, a feasibility study for four HPPs has already been developed. Their main characteristics are presented in Table 4.

Table 4. Hydroelectric power stations designed in Mongolia

Name	HPS Eghijn	HPS Chargight	HPS Orkhon	HPS Schuren
Port's height, m	95.7	60	90	65
Port's length, m	800	486.5	495	1200
Waterbasin area, km ²	125	43	60	203
Watere basin capacity, million m ³	4000	1090	700	3300
Installed power, MW	315	24.6	100	245
Electricity production per year, million kWh	500	116.6	219	900
Amount of investment, million USD	870.0	95.66	160	730.0
IRR, %	13	7.7	10	14.7
Payback period, years	15-20	15-20	13-16	10-13

Scientific research carried out by the staff of the ISEM SB RAS together with the Institute of General Experimental Biology of the SB RAS show that the construction of a hydroelectric power stations in Mongolia will undoubtedly cause considerable damage to the ecology of the basins of the river Selenga and the lake Baikal. Experts and participants of public hearings in Ulan-Ude noted the inexpediency and danger of the construction of the HEP on Selenga⁷.

⁷ <http://bau38.rpn.gov.ru/news/obsuzhdenie-planiruemogo-stroitelstva-ges-na-selenge-v-mongoli-sostoyalos-v-inc-so-ran-2>

The fifth problem of the development of the fuel and energy complex of Buryatia is related to the issues of power supply in the northern regions of the Republic of Buryatia, the Irkutsk Region, Zabaikalskiy region and the south of Yakutia. North of the Baikal region, adjacent to the Baikal-Amur Railway, is the only territory in Russia where electric power consumption is limited due to the backlog of the construction of the 500 kV transmission line Ust-Kut-Nizhneangarsk, one of the reasons for which are problems that arose in connection with the implementation of the Federal Law "On Protection of Lake Baikal" (a ban on the glades cut under power lines, the placement of high-power electrical substations in the CEZ BNT, etc.).

At the same time, the northern regions of the Irkutsk region, the Republic of Buryatia and the Zabaikalskiy region have great economic potential. This territory contains the richest deposits of minerals: gold, nickel, copper, iron, coal, asbestos, potassium, alumina, quartz, silicon, etc. In most fields reserves are approved, development licenses are sold, owners and enterprises for the operation and development are defined. All mineral deposits are located in the BAM zone, which significantly reduces the cost of transport communications. At present, a number of projects have completed a set of preparatory works, including the assessment of reserves in accordance with Russian and international requirements and the conduction of pilot industrial tests, as well as the preparation of feasibility studies.

The largest projects in the north of the Zabaikalskiy region are the establishment of ore mining and processing plants to develop the Udochkan copper field and the Chiney iron ore field in the Zabaikalsky region. In the Mui rayon of the Republic of Buryatia there is a number of large and promising gold fields, titanomagnetite ores, tin, beryllium, platinum, asbestos, and cement raw materials. Irokinodskoye and Kedrovskoye gold deposits are already in operation. In the north of the Irkutsk region there is the largest in Russia deposit of gold-bearing ores "Sukhoi Log", as well as there are other fairly large gold deposits - the Vysochaishee, Zapadnoe, Verninskoye, Chertovo Koryto, Nevsky. At the same time, the implementation of investment projects for the development of these mineral deposits is hampered by a shortage of energy capacities and a weak development of the electric grid infrastructure.

3 Prospects for the development of the fuel and energy complex of the Republic of Buryatia

3.1 Possible options for gasification of the Republic of Buryatia

The gasification and gas supply of republic can become an important direction of development of the fuel and energy complex of the Republic of Buryatia. The fuel and energy complex is one of the main polluters of the Baikal natural territory. The production and distribution of electricity, gas and water in 2008 accounted for 70.2% of air emissions of pollutants from stationary sources in the Republic of Buryatia⁸.

The gasification of Buryatia will dramatically reduce the negative technogenic impacts on the unique ecological system of Lake Baikal, as well as improve the social and economic situation in the republic.

In 2009, JSC "Gazprom promgaz" developed the General Scheme of Gas Supply and Gasification of the Republic of Buryatia and in 2016 it updated it (hereinafter referred to as the Gas Supply Scheme)⁹. According to the calculations, the demand for natural gas of the Republic of Buryatia is estimated at 2.8 billion cubic meters per year.

⁸ The Republic of Buryatia is 95 years old: an anniversary collection / Territorial authority of the Federal State Statistics Service for the Republic of Buryatia. - Ulan-Ude, 2018. - 464 p.

⁹ The General Scheme of Gas Supply and Gasification of the Republic of Buryatia OAO Gazprom Moscow 2009.

When carrying out the work, the following options for the development of the gas supply system of the republic are considered:

1) Autonomous gasification from LNG sources

As a source of liquefied natural gas (LNG), it is proposed to consider the construction of an LNG plant in the vicinity of the LNG plant in Skovorodino (the Amur Region).

– construction of 10 storage and regasification systems (SPCS) in 10 districts of the Republic of Buryatia for subsequent transportation through gas distribution networks to consumers;

– construction of 0.55 thousand km of distribution pipelines.

2) Combined gasification

Network gasification from the main gas pipeline "Power of Siberia" (Skovorodino-Chita-Ulan-Ude) and autonomous gasification from low-tonnage LNG plants for gasification of remote areas of the Republic of Buryatia:

– construction of 6 GDS and 5 SPCS for gasification of 86 hp;

– construction of 0.42 thousand km of gas mains;

– construction of 0.55 thousand km of distribution pipelines.

The calculation of economic indicators in the Gas Supply Scheme shows the non-competitiveness of the supply of natural gas with existing fuels – coal, firewood.

From the studies carried out by the ISEM SB RAS staff [9], it follows that in the prevailing price environment, the conversion to gas of boiler plants using fuel oil, oil and gas condensate, and also electric boiler houses is undoubtedly effective. Options for autonomous gasification were provided through the supply of LPG, LNG, and gasification of network gas during the laying of a large-diameter gas trunk pipeline (transit) across the Baikal region and a local regional gas pipeline. Gas prices for consumers for these options are listed in the table 5.

Table 5. The gas price for various scenarios of gasification, RUB / 1000 m³ (without VAT)

Region	Option			
	Gasification of LPG *	Export Gas pipeline	Gas network gasification (regional project)	LNG gasification
Irkutsk region	26300	3084-3964	3599-4813	15000-17000
Republic of Buryatia	14220	3589-4797	5113-7311	18000-20000
Zabaikalsky region	20690	4144-5713	7889-11893	20000-22000

According the ISEM SB RAS studies, it was determined that the economic indicators for transferring boiler houses to gas are determined by the price of coal over 1,300 rubles per ton (an economical price of gas is about 4000 rubles per 1000 cubic meters) [7].

Thus, among the listed approaches to the gasification of the Baikal region, the only option providing real gas supply prospects and prerequisites for increasing gas consumption is the laying of a major export gas pipeline of large diameter across the territory of the subjects of the Russian Federation in the Baikal region. This option can be implemented in the case of the construction of the second stage of the "Siberia Power" gas transmission system along the territory of the subjects of the Russian Federation in the Baikal region, and not along the route of the Eastern Siberia-Pacific Ocean pipeline.

In our opinion, the gasification of the Irkutsk region, the Republic of Buryatia and the Trans-Baikal region can provide great opportunities for improving the quality of life of the population. The transfer of boilers, thermal power plants, Gusinoozerskaya GRES, Ulan-Ude CHP, TEP of the Selenginsky Central Control Center and a number of industrial facilities will allow to reduce harmful emissions to the air basin and the catchment area of the lake by an order of magnitude. Baikal.

3.2 Prospects of development of the coal industry of the republic

Due to the fact that the proposed options for gasification of the Republic of Belarus are not feasible, coal remains the main resource base of energy. The main increase in coal production will be due to the development of the Nikolskoye coal deposit to 8 million tons per year.

It is necessary to increase the productivity of the Okino-Klyuchevskoye coal mine up to 2.5–3 million tons and build a railway line to the Harankhi station with a length of 30 kilometers. Coal production in the Republic of Belarus before 2030 should reach 15–20 million tons per year.

3.3 Prospects for the development of the electric power industry

To ensure increased energy security of the Republic of Buryatia and the efficiency of the Buryat energy system, the main activity is the continuation of the construction of Ulan-Ude CHPP-2. The most promising and economically feasible option is the installation of two T-180 heating units.

The commissioning of CHPP-2 capacities every year becomes more and more necessary and allows solving the following problems in Ulan-Ude:

1. The most fully meet the growing needs of the city in the heat.
2. To close a part of the average pressure of Ulan-Ude CHPP-1, small and medium-sized boiler houses in the city center and dismantle mentally and physically worn out equipment.
3. Increase the reliability of power supply to the city, reduce losses in networks.
4. Significantly improve the environmental situation in the city, as CHPP-2 will be equipped with the most effective treatment facilities and is located outside the contaminated zone.
5. Increase the energy security of the republic through the emergence of a second powerful source of generation and renewal of energy equipment.
6. The economic efficiency of electricity and heat supply of the city will be increased through the use of the effect of electricity generation on thermal consumption. There will be an opportunity to stabilize and reduce tariffs for heat and electricity [3].

The repeated appeals of the Government of the Republic of Buryatia to the Government of the Russian Federation and the Ministry of Energy of the Russian Federation on the completion of the construction of CHPP-2 have not been resolved due to lack of ownership of the owner (PAO RZD) and the refusal of the Ministry of Energy of the Russian Federation to commission heat-generating power units at CHPP-2 due to electricity surplus in Buryatia. This issue could and should be solved taking into account the forecasted growth in electricity consumption or the creation of a power reserve in the IPS of Siberia. SIPR electric power industry in Russia for 2017-2023gg. predicts an increase in electricity consumption from 210.091 billion kilowatt-hours in 2018 to 226.595 billion kilowatt-hours and a power increase from 31131MW to 33361MW, respectively.

To solve the issues of reducing harmful emissions from boilers and individual heating systems, by transferring them to electricity, additional capacity will be needed at power plants and network infrastructure facilities. The most effective is, again, the commissioning of power units at Ulan-Ude CHPP-2, since the maximums of electricity consumption and the production of it at the CHPP with the highest efficiency coincide.

It is necessary to ensure the construction of a 220 kV transmission line “Goryachinsk-Barguzin”. Due to the increase in the load and the increase in the category of consumers, the distribution networks and substations will need to be strengthened. Irkutsk and Buryat power systems are able to fully provide additional power generation and the necessary capacity. Due to the impossibility in the near future to provide grid natural gas, the high

cost of LNG and the lack of a gas distribution network, the provision of energy and heat supply to the coast due to electricity is seen as the most prepared, with an insignificant share of the hydropower plant produced at the Angarsk cascade. It is required to develop a program for the use of heat pumps, thermal water, wind and solar energy.

The transboundary interaction of the power systems of Buryatia and Mongolia should be strengthened through the construction of 500 kV transmission line "Gusinoozersk-Darkhan-Ulan-Bator". This will ensure the transmission of a sufficient amount of electricity and covering the peak loads of Mongolia instead of the hydroelectric power plants on the Selenga River and its tributaries. The threat of a violation of the ecology of the BPT and Lake Baikal by the World Heritage Site of UNESCO will be significantly reduced [8].

The solution of the problem of ensuring the supply of electricity to new consumers in the areas of prospective mining and processing of minerals in the north of the Baikal region is possible through the construction of the Mokskaya HPP with a Ivanovo counter-regulator with a capacity of 1 410 MV (Table 6). The implementation of this project is envisaged by the Strategy for the Development of the Far East and the Baikal Region [Dondokov et al., 2015].

Table 6. The gas price for various scenarios of gasification, RUB / 1000 m³ (without VAT)¹⁰

Indicator	Mokskaya HPP	Ivanovo counter regulator	Total
Power, Mw	1 200	210	1 410
Electricity generation, billion kWh·h	4,54	1,03	5,57
The cost of construction in the prices of III sq. M. 2012, billion rubles.	108,9	15,6	124,5

The emergence of a new generation source on the border of the Republic of Buryatia and the Trans-Baikal Territory will meet the long-term energy needs of the Baikal-Amur Mainline and adjacent territories. The total power of prospective consumers of this zone exceeds 1000 MW (see Fig. 3).

When designing the Mokskaya HPP, its location in the center of the prospective loads of consumers remote from the nearest sources of electric power generation over a distance of more than 1000 km was taken into account, including the Ust-Ilimskaya HPP in the Irkutsk region and the Neryungrinskaya GRES in the Republic of Sakha (Yakutia) [9].

The construction of the Vitim hydropower complex will also create an energy bridge between the united energy system of the Far East and the UES of Russia, ensure the energy security of the north part of the Baikal region, reduce electricity tariffs in the Republic of Buryatia and Zabaikalsky Krai, increase the possibility of more efficient regulation of the Baikal level and address the issue of electricity supply to Mongolia.

The commissioning of a large hydroelectric power plant with load control capabilities in cooperation with powerful thermal power plants assumes optimization of the operation mode of the energy systems of Transbaikalia and the Far East and large-scale export of electricity to the countries of North-East Asia.

The creation in the future of the Vitim cascade of HPPs will allow Russia to become the largest logistics operator, which will affect the supply of electricity to the Asian market. Unlike hydroelectric power plants located in densely populated areas, the advantage of the Mokskaya HPP is the lack of settlements, arable lands and cultural pastures at the site of the future reservoir.

¹⁰ Source: Feasibility study of the Moksky hydroelectric complex. St. Petersburg: JSC "Lengidropunkt", 1997, 338 p.

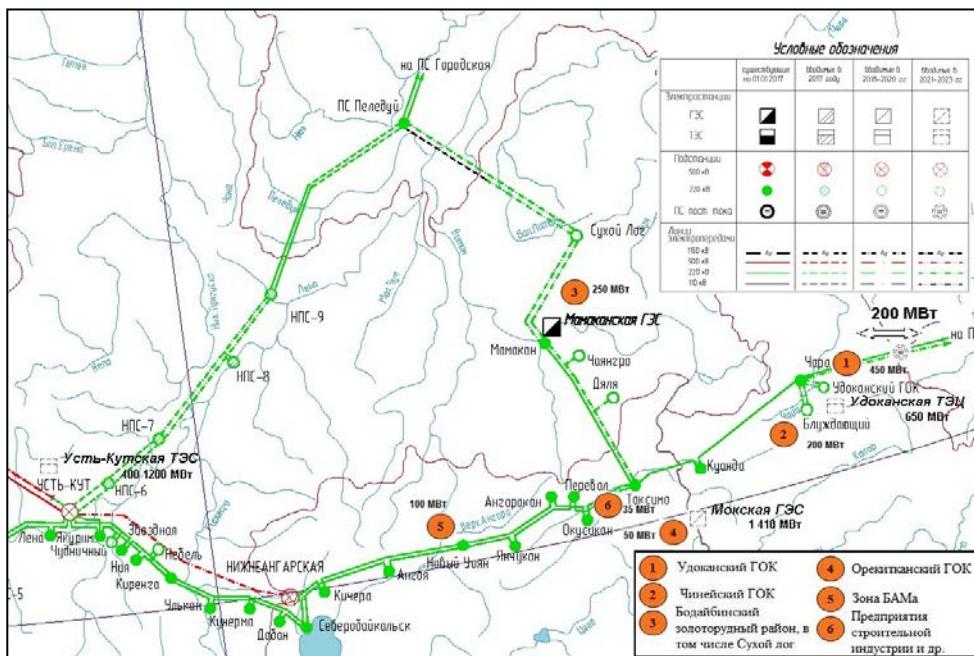


Fig.3. Scheme of power supply in the North of the Baikal region

The construction of a hydroelectric power plant will allow the introduction of flooded agricultural land in the Muya lowland, called the "oasis of Eastern Siberia". During the warm period, the climate is dominated by a humid and mild climate, due to natural seclusion, surrounded by high mountain ranges. In a natural greenhouse, cereals, fruit and berry crops, vegetables and even watermelons are grown. The urgency of the construction of the Mokskaya HPP for the Republic of Buryatia is due to the fact that the basin of the river Vitim is the only territory of the republic without the influence of the "Baikal factor", which limits the extraction of minerals and other types of economic activities.

4 Conclusions

1. The balance of power and electricity in the power system of the Republic of Buryatia is currently developing satisfactorily.
 2. In the near future, tensions in electricity supply will be maintained in the industrial hub of Ulan-Ude, the eastern regions of the Republic of Buryatia, the northern regions of the Republic of Buryatia and the Trans-Baikal Territory, in ensuring the traction load of the East European Railway and the ZABRD.
 3. A significant increase in the demand for electricity until 2035goda is possible when solving the problems of protecting Lake Baikal.
 4. Acceleration of the construction and commissioning of LEP-220 kV "Goryachinsk-Barguzin", 500 kV transmission line "Ust-Kut-Nizhneangarsk", "Gusinoozersk-Ulan-Bator" is required.
 5. Continuation of the construction of Ulan-Ude CHPP-2 is the fastest, most efficient and economical measure to cover the increasing thermal and electrical loads of the city of Ulan-Ude and the Republic of Buryatia and to solve environmental problems.

The need for the construction of CHP-2 is caused not only by local and local problems affecting the interests of a particular region, but also by the tasks of increasing the

reliability of power supply in the whole Republic of Buryatia, the Trans-Baikal Territory, Mongolia, and the Irkutsk Region.

6. To ensure the consumers of the BAM zone of the Republic of Buryatia and the Trans-Baikal Territory, the northern regions of the Irkutsk region and the southern regions of Yakutia, it is necessary to develop a scheme for the power supply of this node on the basis of the construction of the Moksky hydroelectric complex, taking into account the need to provide communication between the IPS of Siberia and the Far East.

7. It is necessary to update the strategy for the development of the fuel and energy complex of the Baikal region, taking into account the diversification of the fuel and energy balance due to gasification, the development of gas processing and gas chemistry, the use of non-traditional and renewable energy in the regions. In doing so, consider the ecological and economic advantages of laying a transit gas pipeline along the southern shore of Lake Baikal and the most populated areas of Buryatia and the Trans-Baikal Territory and Mongolia.

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