Importance of Hydrocarbon Resources in the Energy Supply of the Arctic Regions in Republic of Sakha (Yakutia)

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Abstract. The analysis of heat supply in the arctic regions of the Sakha Republic (Yakutia) is given. The Arctic regions include 13 regions of the Republic of Sakha (Yakutia), their territory occupies 52.56% of the entire territory of the republic. The delivery of fuel to the Arctic regions is fraught with large financial costs. They contain 155 sources of heat supply, out of which 83 work on solid and 72 on liquid fuel. The total fuel demand is estimated at 85.3 thousand tons of fuel equivalent per year, of which a large proportion, 96%, falls on diesel fuel. To solve the problem of energy supply of the population in the arctic regions of yakutia the role of potential local sources of hydrocarbons is shown. Conducting prospecting and discovery of projected hydrocarbon deposits in the immediate vicinity of potential consumers will significantly optimize the fuel and energy balances of the Arctic and northern regions of the Republic of Sakha (Yakutia). The oil and gas prospectivity of the territory under consideration is shown.

1. Introduction

The comprehensive socio-economic development of the Russian Federation’s Arctic zone provides for the improvement of the public administration system, the improvement of the indigenous population life quality and the social conditions of their economic activities in the Arctic [1-5].

Extreme climatic conditions, low population density, high resource intensity, focal nature of industrial and economic development and the dependence of livelihoods on the northern supply, low sustainability of ecological systems necessitate a constant presence and attention from the state. Indicators of socio-economic development of the Arctic and northern regions lag far behind the national average.

The electric power industry of the Republic of Sakha (Yakutia) includes a centralized and decentralized power supply zone. The centralized energy supply zone consists of three energy districts - West, Central and South. It covers 36% of the territory, where 85% of the population lives.

A significant part of the territory is located outside the grid area, mainly, these are northern regions with a large number of autonomous power plants. All diesel power plants operate on their distribution grids covering the territory of a separate village. The operation of power equipment is carried out in difficult climatic conditions, which leads to high costs for the maintenance of electrical grids, accelerated wear and additional costs.
2. Objects and research methods
The methodology of the study is based on a comprehensive synthesis and analysis of all available data from different years on the socio-economic situation of the Arctic regions of the Republic of Sakha (Yakutia). The theoretical and methodological basis of the study was the work of Russian scientists on the theoretical and practical problems of the heat and power balance of the republic. To obtain the results, methods of theoretical analysis of information sources, generalization and comparison of information on the issue under study were used. Comparative and statistical analyzes are carried out. Used tabular methods for presenting research results. The research information base was made up of materials from the Government of the Republic of Sakha (Yakutia).

3. Results and discussion
13 districts of the Republic belong to the Arctic and the North: Abyisky, Anabarsky, Allaikhovsky, Bulunsky, Verkhnekolymsky, Verkhoyansky, Zhigansky, Momsky, Nizhnekolymsky, Olenecksky, Srednekolymsky, Ust-Yansky, Eveno-Bytantaysky. Of these, 7 are completely beyond the Arctic Circle, and the territory of the other 6 districts crosses the Arctic Circle [6-7].

The above-mentioned northern territories of the Sakha Republic (Yakutia) are characterized by the unity of climatic, geocryological, or hydrographic and economic conditions. They are featured either by similarity or unity by the existing infrastructure and developed transport schemes. They are characterized by the unity of the mineral resource base and conditions for geological exploration, including for prospecting and exploration of mineral deposits, as well as for companies’ operations in the development of existing mining and oil and gas centers.

Given the above arguments, the unity of conditions for all thirteen north territories of the Sakha Republic (Yakutia) is quite obvious for the formation and implementation of their fuel and energy balances.

The above data is directly reflected in the formation and implementation of fuel and energy balances in various regions of Yakutia. For example, only in the southwestern and central and southern energy districts of the Republic local sources of energy products (oil, gas, coal) are currently used. In all other uluses, including in the arctic regions, mainly imported energy products (crude oil, diesel fuel, coal) are used to some extent.

In the Arctic and northern districts, the climate is very harsh, the duration of the heating period is 320-360 days a year.

In the north-eastern part of Yakutia, 68.16 thousand people live in 1620.6 square meters. m, which is respectively 7.07% and 52.56% of the total population and the entire territory of the Republic. The population density is 42.1 people per 1000 sq. Km. km (table 1) [8].

The total demand for petroleum products in the 13 uluses (districts) under consideration is 206,062 thousand tons, including 16,039 thousand tons of motor gasoline, 170,402 thousand tons of diesel fuel, 16,357 tons of jet fuel and 3,264 tons of lubricants (table 2) [9].

Delivery of fuel to consumers in the northern part of the Republic is associated with large financial costs, the magnitude of these costs is significantly influenced by the seasonality of transport links. The settlements, generally, are small and dispersed throughout the vast expanses of northern Yakutia. Fuel is burned in most cases in boiler stations with low efficiency. In the Arctic and northern regions of Yakutia, there are 155 heat supply facilities, of which with a capacity of up to 3 Gcal / hour are 52, from 3 to 20 Gcal / hour - 100 and from 20 to 100 Gcal / hour - 3. Of the 155 heat supply facilities, 83 work on solid fuel and 72 liquid (table 3) [10].

In addition to diesel fuel, oil and coal are consumed in the Arctic zone. Coal is burned only at the mini-CHP in Deputatsky. The total fuel demand is estimated at 85.3 thousand tonnes of fuel equivalent per year (table 4). A large proportion (96%) is diesel fuel. In accordance with the generation of electric and heat energy, the largest volumes of fuel consumption are accounted for by the Bulunsky, Yansky, Verkhoyansky electric networks (EN) and Zyryansky regional electric networks (DEN). The power supply of household consumers of all the Arctic regions is under the jurisdiction of the subdivisions of JSC Sakhaenergo [11].
Table 1. Average annual resident population and the area of the uluses of the north-eastern part of the Sakha Republic(Yakutia) on 01/01/2018.

| Districts | Population | % of the total population | Area | % to total number | Density, pop/1000km² |
|-----------|------------|---------------------------|------|------------------|---------------------|
| The Sakha Republic(Yakutia) | 964430 | 100 | 3083,5 | 100 | 312,8 |
| Abyisky | 4018 | 0,42 | 69,4 | 2,25 | 57,9 |
| Anabarsky | 3567 | 0,37 | 55,6 | 1,80 | 64,2 |
| Allaikhovsky | 2716 | 0,28 | 107,3 | 3,48 | 25,3 |
| Bulunsky | 8339 | 0,86 | 235,1 | 7,62 | 35,5 |
| Verkhneolomsky | 4123 | 0,43 | 67,8 | 2,20 | 60,8 |
| Verkhoyansk | 11352 | 1,18 | 137,4 | 4,46 | 82,6 |
| Zhigansky | 4222 | 0,44 | 140,2 | 4,55 | 30,1 |
| Momsky | 4073 | 0,42 | 101,8 | 3,30 | 40,0 |
| Nizhneolomsky | 4290 | 0,44 | 86,8 | 2,81 | 49,4 |
| Olenesky | 4072 | 0,42 | 318,1 | 10,32 | 12,8 |
| Sredneolomsky | 7499 | 0,78 | 125,2 | 4,06 | 59,9 |
| Ust-Yansky | 2813 | 0,29 | 55,6 | 1,80 | 50,6 |
| Total | 68159 | 7,07 | 1620,6 | 52,56 | 42,1 |

Table 2. The volume of demand for petroleum products in the districts.

| Districts | Total, ton | including: gasoline | diesel | gasoline | diesel |
|-----------|------------|---------------------|--------|----------|--------|
| The Sakha Republic(Yakutia) | 9834 | 874 | 7996 | 855 | 109 |
| Abyisky | 29869 | 301 | 29476 | 0 | 92 |
| Anabarsky | 6703 | 783 | 4694 | 1128 | 98 |
| Allaikhovsky | 16809 | 1128 | 13767 | 1554 | 360 |
| Bulunsky | 16007 | 1437 | 12774 | 1561 | 235 |
| Verkhneolomsky | 32796 | 3374 | 24981 | 3845 | 596 |
| Verkhoyansk | 8322 | 833 | 6870 | 515 | 104 |
| Zhigansky | 18383 | 1091 | 16029 | 1097 | 166 |
| Momsky | 13749 | 1217 | 11168 | 1051 | 313 |
| Nizhneolomsky | 3929 | 347 | 3490 | 0 | 92 |
| Olenesky | 15380 | 2360 | 9381 | 3361 | 278 |
| Sredneolomsky | 30822 | 1854 | 26838 | 1390 | 740 |
| Ust-Yansky | 3459 | 440 | 2938 | 0 | 81 |
| Eveno-Bytantaysky | 206062 | 16039 | 170402 | 16357 | 3264 |

Problems in the fuel supply in the Arctic zone are due to the same factors as for the entire decentralized zone: a large proportion of diesel fuel (more than 96% of total consumption in conventional terms); complex transportation scheme of delivery with several transshipments to different types of transport (sea, river, road); early delivery of fuel and material and technical resources associated with short periods of navigation and inaccessibility of small rivers; the need to create deposits of diesel fuel and material and technical resources, which leads to the freezing of working capital for up to one and a half years [12]. All of these problems lead to significant quantitative and qualitative losses during transportation of fuel, especially coal, and to the high cost of
electricity generated. However, these factors for the Arctic regions are aggravated by lower transport accessibility and more severe climatic conditions.

**Table 3.** The number of heat supply facilities in the north-eastern areas of the Sakha Republic (Yakutia) at the end of 2016.

| Districts            | Total of them with power, Gcal / hour | of them running on fuel | to 3 | from 3 to 20 | from 20 to 100 | solid | liquid |
|----------------------|---------------------------------------|-------------------------|------|--------------|---------------|-------|--------|
| Abyisky              | 14                                    |                         | 7    | 7            | -             | 11    | 3      |
| Anabarsky            | 8                                     |                         | 1    | 7            | -             | -     | 8      |
| Allaikhovsky         | 10                                    |                         | 3    | 7            | -             | -     | 10     |
| Bulunsky             | 11                                    |                         | 3    | 7            | 1             | -     | 11     |
| Verkhnekolymsky      | 12                                    |                         | 1    | 11           | -             | 12    | -      |
| Verkhoyansky         | 24                                    |                         | 12   | 12           | -             | 24    | -      |
| Zhigansky            | 8                                     |                         | 5    | 2            | 1             | 7     | 1      |
| Momsky               | 13                                    |                         | 5    | 8            | -             | 4     | 9      |
| Nizhnekolymsky       | 6                                     |                         | -    | 6            | -             | 4     | 2      |
| Oleneksy             | 17                                    |                         | 6    | 11           | -             | -     | 17     |
| Srednekolymsky       | 14                                    |                         | 3    | 11           | -             | 13    | 1      |
| Ust-Yansky           | 9                                     |                         | 2    | 6            | 1             | 5     | 4      |
| Eveno-Bytantaysky    | 9                                     |                         | 4    | 5            | -             | 3     | 6      |
| Total                | 155                                   |                         | 52   | 100          | 3             | 83    | 72     |

**Table 4.** Fuel demand on the data of JSC “Sakhaenergo” (status 2016).

| Division of JSC "Sakhaenergo" | Fuel demand, thous. |
|--------------------------------|---------------------|
| Anabarsky DEN                  | 4,0                 |
| Belogorsky DEN                 | 4,6                 |
| Bulunsky EN                    | 12,9                |
| oil from it                    | 1,1                 |
| Verkhnekolymsky EN             | 13,4                |
| Zhigansky DEN                  | 5,5                 |
| of them oil                    | 0,3                 |
| Zyryansky DEN                  | 7,9                 |
| Momsy DEN                      | 4,6                 |
| Nizhnekolymsky DEN             | 3,0                 |
| Oleneksy DEN                   | 4,2                 |
| Srednekolymsky DEN             | 7,4                 |
| Chokurdaksy DEN                | 3,7                 |
| Eveno-Bytantaysky DEN          | 2,0                 |
| Yansky EN                      | 12,1                |
| of them coal                   | 2,0                 |
| Total for the arctic zone      |                     |
| including:                     | 85,3                |
| diesel fuel                    | 81,9                |
| oil                            | 2,0                 |

The heat and power problem of the northern and arctic districts can be solved by developing local sources of hydrocarbon resources.
The prospecting and discovery of projected hydrocarbon deposits in the immediate vicinity of potential consumers will significantly optimize the fuel and energy balances of the Arctic and northern regions of the Republic of Sakha (Yakutia). Also, the development of local sources of hydrocarbon resources will contribute to improving the environmental conditions, raising the socio-economic standard of living in the Arctic and northern regions and ensuring the economic and energy security of the Sakha Republic (Yakutia) [13-16].

4. Conclusion
In the electric power industry of the Arctic zone, as well as throughout the Republic, “bottlenecks” are mainly related to the technical condition of generating equipment and power grid facilities - this is physical and moral aging, which causes not only an increase in fuel consumption, but also an increased risk of emergency situations. In addition, in the Arctic regions, due to their remoteness and inaccessibility, the problem of fuel transportation is most acute [17-19]. Since the Arctic concentrates huge reserves of strategic resources of Russia the one of the important tasks is to develop it. The most probable volumes of hydrocarbon initial resources of the north-eastern Arctic shelf of Russia are estimated in the following volumes: Laptev NGO (oil and gas region): oil (extract) - 2.3 billion tons, free gas - 4.2 trillion m3; East Arctic NGO: oil (extract) - 6.0 billion tons, gas free - 4.7 trillion m3; Novosibirsk-Chukotka NGO: oil (extract) - 0.7 billion tons, gas free - 1.1 trillion m3 (table 1) [20].

In the long term, the hydrocarbon feedstock will completely replace imported diesel fuel in the arctic regions of the Republic.

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