# Features of heat energy supply of the Republic of Sakha (Yakutia) northern regions

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**Abstract.** Heat supply to remote customers residing in the Far North regions is related to certain difficulties. At the same time, due to climate features, providing heat to such customers has a high social significance. In this paper, we analyze the population variations in the given territories, the state of housing, and the provision of customers with heat and hot-water supply. The logistics complexity when delivering fuel with possible long transfers affects the fuel cost and quality, and, eventually, the thermal energy cost. Developing and upgrading the heat supply systems in the Republic's northern uluses (districts) is feasible only at a complex development of these territories by involving major investment into the development of mineral deposits.

## 1 Characteristics of the Northern uluses

The Arctic and Northern territories encompass Republic's 13 uluses (districts), whose territory is within the Arctic Circle and through whose territory the latter passes: Abyysky, Allaikhovsky, Anabarsky, Bulunsky, Verkhnekolymsky, Verkhoyansky, Zhigansky, Momsky, Nizhnekolymsky, Olenyoksky, Srednekolymsky, Ust-Yansky, and Eveno-Bytantaysky. Fig. 1 shows the location of these uluses in the Sakha Republic.

Their area is more than 52.2% of the Republic's gross area. Among the other Northern uluses, Olenyoksky and Bulunsky uluses have the biggest areas, 318.1 and 223.6 $km^2$, respectively. However, only 7.1% of the Republic's population reside in the Northern territories. The highest population is now in Verkhoyansky and Bulunsky uluses, being 11,400 and 8,400 people, respectively. The population density in the addressed uluses does not exceed 0.04 people/$km^2$, where as it is 0.31/$km^2$ in Yakutia, on average [1–3].

The living space in the Northern regions was 1569.3 thousand square meters in 2016, which does not exceed 7.5% of the total living space in the Republic. The share of slum and emergency dwellings is, generally, about 16.0%. However, in half of the Northern uluses, the share of slum and emergency dwellings considerably exceeds the republican mean values. Thus, for example, in Allaikhovsky ulus, more than 72.0% of the dwellings are in the slum or emergency state, in Verkhnekolymsky and Abyysky – 43.5% and 35.3%, respectively. Such a state of housing considerably increases heat energy losses through exterior envelopes of buildings, which leads to an increase in the heat consumption and the waste of fuel for its production [1–3].

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**Fig. 1.** Arctic and Northern uluses of the Sakha Republic

In 2016, provision of the housing facilities with heating and hot-water supply in the Republic was, generally, 77.2 and 51.2%, respectively. Herewith, in three Northern uluses, provision of housing with heating is somewhat below the mean, and, for example, is only 3.2% in the Abyysky ulus. In six Northern uluses, the customers do not have hot water supply at all. At the same time, provision with heating and hot-water supply reaches 99.2% in Allaikhovsky ulus. The insufficient level of provision with heating and hot-water supply in the Northern uluses reduces the quality of life and attractiveness of these territories for residing.

Housing commissioning in the Republic was 620.4 thousand square meters in 2016. Herewith, in the same year, the housing commissioning in the Northern uluses was only 3.0% of the republican. The highest metrics in housing commissioning were noted in Olenyoksky and Zhigansky uluses, with 3.15 and 2.97 thousand square meters, respectively. In Nizhnekolymsky and Ust-Yansky uluses, there was no housing commissioning in 2016 [1–3].

The social aspect of life in the Northern uluses features a population outflow, a decrease in the birthrate, an increase in the share of the people above the able-bodied age, insufficient conveniences in some uluses, low rates of housing commissioning and replacement of slum and emergency dwellings. Complicated logistics, a brief navigable period, and difficulties in equipping and operating winter tracks considerably raise the costs and lower the feasibility of large-scale projects to rehabilitate and upgrade the infrastructure in these uluses.

## 2 Heat energy supply in the Northern uluses

Heat supply to the customers in the Northern uluses is implemented by thermal energy production at boiler and waste-heat boilers of diesel power plants Power supply in the considered areas is local (isolated) and is carried out at the expense of power generation at

diesel power plants. In this regard, the volume of heat recovery at the power plant directly depends on the volume of electricity generation [1–3].

### 2.1 Heat energy production in the Northern uluses

Heat energy production in the Northern ulus of the Republic in 2016 amounted to 1447.6 thousand Gcal. The heat of the Northern regions provide sources of thermal energy the three major companies: two affiliated companies of the Public joint stock company "Yakutskenergo" and the State unitary enterprise "Housing and communal services of the Republic of Sakha (Yakutia)". Herewith, more than 94.3% of the heat energy is produced by boiler houses of the State unitary enterprise "Housing and communal services of the Republic of Sakha (Yakutia)". Fig. 2 shows the volume of heat production in the Northern uluses of the Republic.

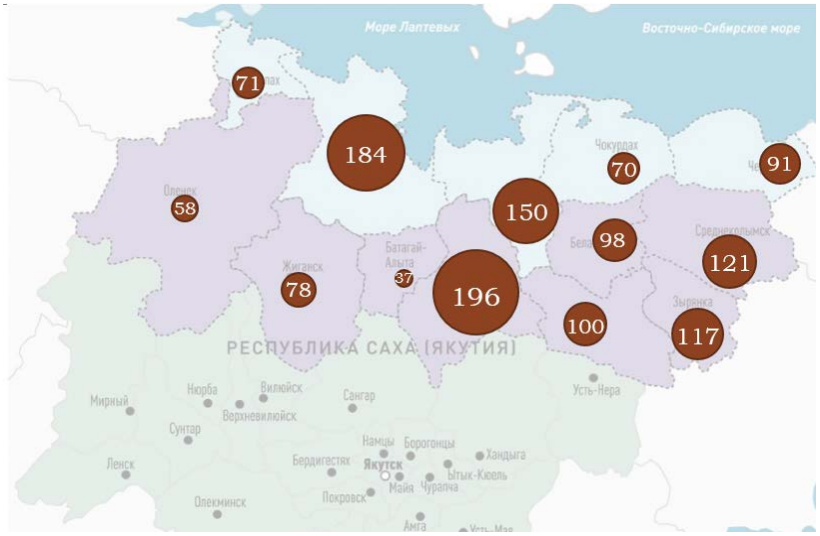


**Fig. 2.** Heat energy production in the Northern uluses, thousand Gcal

The most of the heat energy in 2016 was produced in Verkhoyansky and Bulunsky uluses, and totaled 195.9 and 184.3 thousand Gcal, respectively. On the contrary, in Eveno-Bytantaysky and Olenyoksky uluses, the heat energy production was 37.4 and 58.2 thousand Gcal, respectively.

### 2.2 Fuel supply of heat energy sources in the Northern uluses

For the heat energy production in 2016 in the Northern uluses of the Republic was consumed 264.9 thousand tons of equivalent fuel. Herewith, the coal share in the fuel balance of heat sources is more than 64.2%, the share of oil – 26.2%. The gas and firewood shares are condensated is 8.1% and 1.2% respectively [1–3]. Fig. 3 shows the consumption of different types of fuel at the sources of heat supply in the Northern uluses of the Republic.

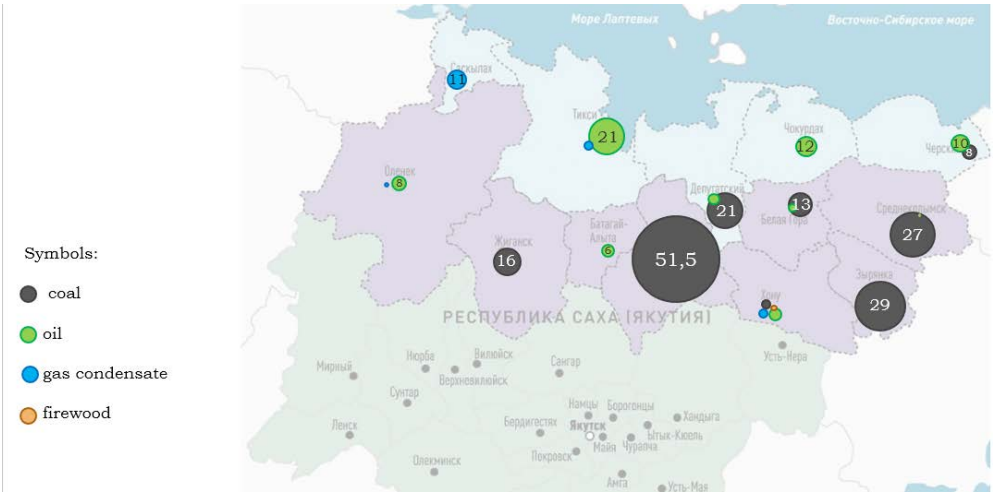


**Fig. 3.** Consumption of different types of fuel for heat energy production in the Northern uluses

According to the figure, liquid fuel (oil, gas condensate) dominated in the fuel balance of heat sources in the Arctic regions. The main volume of liquid fuel is delivered to the Northern uluses of the Republic by tankers along the Northern sea route. In the Northern uluses, through the territory of which the Northern polar circle passes, the main type of fuel on the sources of heat supply is coal. This circumstance is connected, mainly, with the location of coal deposits in close proximity (zyryanskoye coal deposits), and the presence of logistic schemes of fuel delivery (the coal from the Zyryansky, Dzhebariki-Hay fields, a small amount of coal from Arkagalinskoye field). The most significant consumption of coal for the production of thermal energy in 2016 was observed in the Verkhoyansk ulus (51.5 thousand tons). In the heat supply sources in this area is used Dzhebariki-Hay coal.

Fig. 4 shows the specific fuel consumption for the production of heat energy at the boiler in the Northern uluses. The highest specific fuel consumption takes place in the Verkhoyansky and Verkhnekolymsky uluses and is 274.9 and 259.8 kg of equivalent fuel/Gcal respectively. The boilers in these areas for the heat energy production use coal of Dzhebariki-Khai and Zyryansky fields. Such high rates of specific fuel consumption indicate a reduced calorific value of the fuel due to poor quality. There is a practice of burning fuel of lower quality at boilers located in close proximity to the field, and coal of higher quality is transported to remote areas. Zyryanskoye coal deposit is located in Verkhnekolymsky ulus. The lowest specific fuel consumption for boilers is observed in those areas where the main fuel for the production of heat energy is oil and gas condensate. Thus, Bulunsky, Anabarsky and Oleneksky uluses, where the liquid fuel is used for the heat energy production, have the lowest values of specific fuel consumption for boilers: 145.5, and 161.4 m 170,3 kg of equivalent fuel/Gcal, respectively.

### 2.3 Costs for the fuel purchase and delivery in the Northern uluses

The lack of railway communication, low water of rivers in the Northern uluses and limited period of navigation, the lack of an extensive network of roads with solid road surface for year – round use, the complexity of the construction and operation of "avtozimnikov" – all these features of the transport system of the Republic determine the complex schedule of delivery of goods, including fuel to the sources of electricity and heat, in the Northern uluses. Due to the remoteness and inaccessibility of the Northern uluses, the cost of fuel delivery increases significantly.

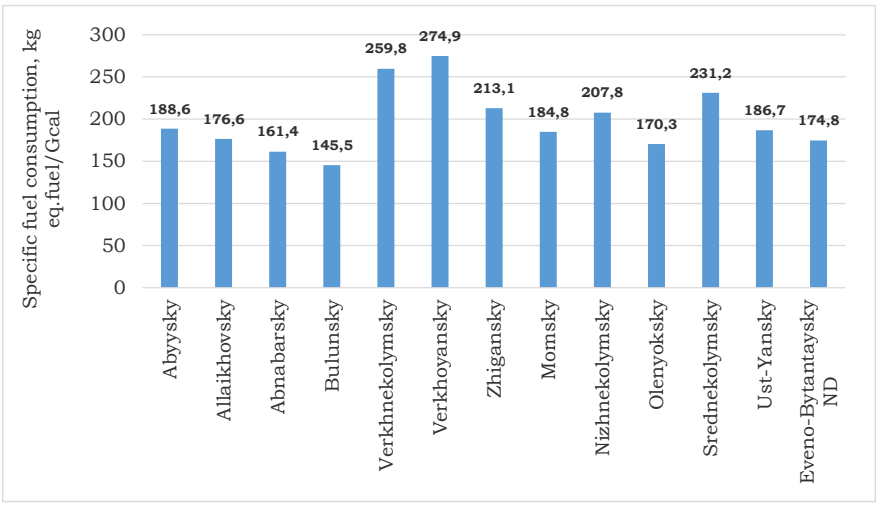


**Fig. 4.** Specific fuel consumption for heat energy production in the Northern uluses

In the heat energy final cost, the fuel component has a significant weight. Due to the fact that the main share in the development of heat energy in the Northern ulus is the State unitary enterprise "Housing and communal services of the Republic of Sakha (Yakutia)", we will analyze the company's costs for the purchase and delivery of fuel to heat sources in the ulus. The total cost of purchasing fuel of this company in 2016 amounted to 1444.1 million rubles, in addition, the cost of purchased electricity for the needs of heat sources amounted to 383.3 million rubles. The cost of delivering fuel to the boilers of the Northern uluses cost the heat supply company in 2016 is 2022.9 million rubles, while 67.0% of this amount is accounted for the delivery of coal [3–4]. Fig. 5 shows the unit costs for the purchase and delivery of 1 ton of coal for the boiler of the State unitary enterprise "Housing and communal services of the Republic of Sakha (Yakutia)" in Northern uluses of the Republic.

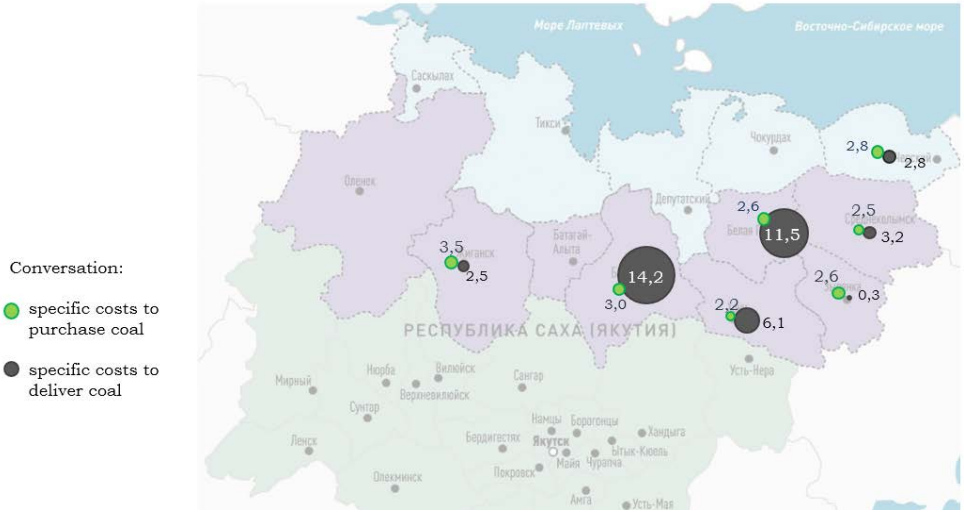


**Fig. 5.** Specific costs to purchase and delivery of coal in the Northern uluses

In accordance with figure the cost of delivery 1 ton of coal to Verkhoyansk and Abyysky uluses is in 4.73 and 4.42 times higher than the cost of the fuel itself. On the contrary, cost of delivery of coal to Verkhnekolymsky ulus is in 10 times less the cost of the coal, due to the close location of the coal field. In Zhigansky, Srednekolymsky and Nizhnekolymsky uluses, the cost of coal and coal delivery are approximately the same. Fig. 6 shows the specific costs to purchase and delivery of 1 ton of oil to the boilers of the State unitary enterprise "Housing and communal services of the Republic of Sakha (Yakutia)". in Northern uluses.

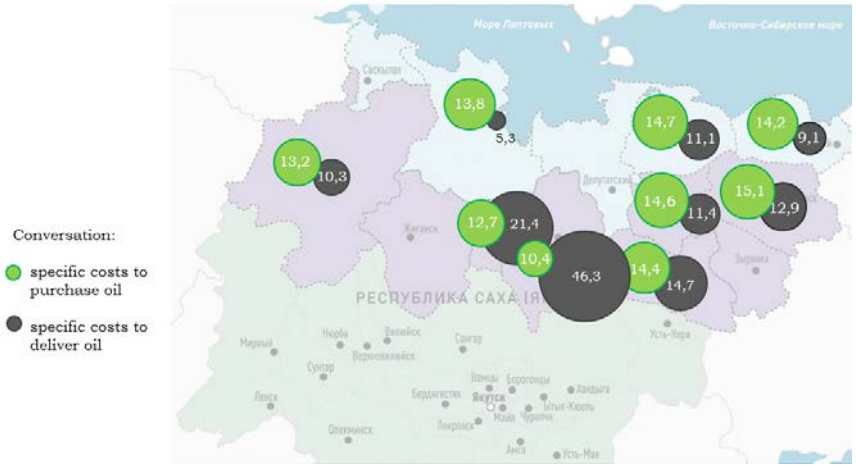


**Fig. 6.** Specific costs to purchase and delivery of oil in the Northern uluses

As can be seen from the figure, the cost of delivery of 1 ton of oil to the Arctic uluses is slightly lower compared to the delivery cost to the areas closer to the Republic's center. This is due to the fact that the delivery of oil is carried out on the Northern sea route. In Verkhoyansky ulus, the oil delivery is in 4.5 times higher than the cost of the fuel itself. Heat energy costs produced by the boilers the State unitary enterprise "Housing and communal services of the Republic of Sakha (Yakutia)" in 2016 are shown in fig. 7.

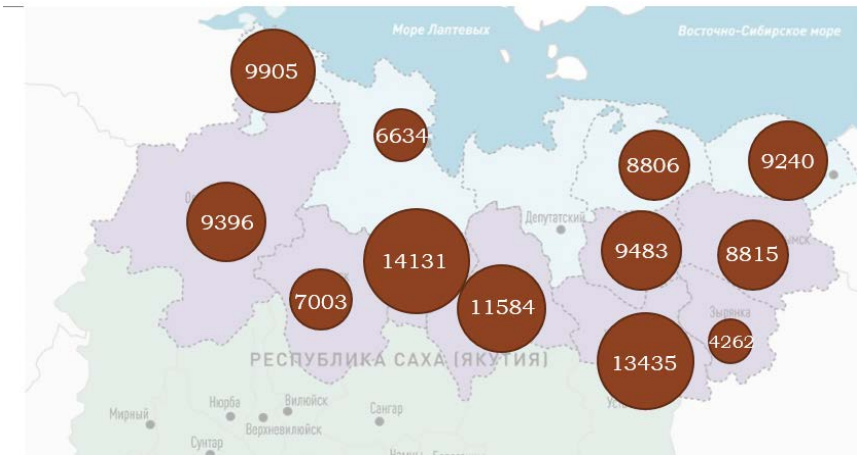


**Fig. 7.** Heat energy costs for the population from boilers of the State unitary enterprise "Housing and communal services of the Republic of Sakha (Yakutia)" in the Northern uluses

As can be seen from the figure, the heat energy costs of the heat supply company in the neighboring uluses may be differ by 2–3 times. Thus, in the Verkhnekolymsky ulus, the heat energy cost is in 2.1 times lower than the established heat energy cost in the Srednekolymsky ulus and 3.15 times lower than the established heat energy cost in the Momsky ulus. Such a significant difference in heat energy costs is primarily due to the fact that the fuel component in the heat energy cost plays a major role [3–4].

## 3 The main features of heat supply in the Northern uluses

The main features of heat supply in the Northern uluses of the Republic [3–8] are:

- higher infrastructure costs due to severe environmental conditions (permafrost, low air temperatures), which assumes using special expensive materials when building and maintaining the heat supply sources and heating networks;
- deterioration in the solid fuel quality and its loss (coal, in particular), because of transloads in expectation of the navigable period start or the winter track equipment;
- considerable increase in the cost of the cargo delivered due to notable distances, lack of railroads, poor road-net development, territorial disconnection of individual roads.

## 4 Conclusions

Climate conditions in the Arctic uluses of the Sakha (Yakutia) Republic require a higher reliability and operability of the infrastructure in settlements [3, 8].

Reducing the wear of the communal and of the power engineering basic assets, introducing new power and heat capacities to increase the energy efficiency and to decrease the losses in grids and heating networks will enable to raise the quality of services, provide funds savings for the budget and population minimize the probability of failures and emergencies.

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