Efficiency of Energy Supply in the North-Eastern Regions of the Republic of Sakha (Yakutia)

I D Elyakova¹, A L Elyakov², A A Pakhomov³

¹Institute of Finances and Economics, M.K. Ammosov North-Eastern Federal University, Yakutsk, Russian Federation
²Institute of Finances and Economics, M.K. Ammosov North-Eastern Federal University, Yakutsk, Russian Federation
³Department of Regional Economic and Social Research, Federal Research Centre “The Yakut Scientific Centre of the Siberian Branch of the Russian Academy of Sciences, Yakutsk, Russian Federation

E-mail: elyak@list.ru, elyakov96@mail.ru, a.a.pakhomov@prez.ysn.ru

Abstract. In this paper a comparative assessment of the efficiency of electrical and thermal energy production and consumption in a particular region of the Arctic areas of the Republic of Sakha (Yakutia) is presented. Based on the analysis, the existing threats of power supply are revealed and recommendations for effective power supply of the Ust-Maysky District in the Eastern economic zone (EEZ) of the Republic of Sakha (Yakutia) are given. The relevance of the study stems from the fact that the analysis of cost and not only natural indices of electrical and thermal energy production and consumption has been carried out for the first time and no relevant studies have been conducted in the Republic of Sakha in recent years, especially in the context of each locality and the main groups of consumers. The study allows us to propose recommendations for efficient electricity consumption in the context of the settlements of the Ust-Maysky District of the Eastern economic zone of the Republic of Sakha (Yakutia).

1. Introduction

In accordance with the Energy Strategy of the Republic of Sakha (Yakutia) for the period up to 2030, developed by the Government of the Russian Federation [9], the GRP of the Republic of Sakha (Yakutia) is expected to increase by almost 8.5 times by 2030 in comparison with 2005.

According to the scenario of industrial development of the Republic, the realization of large investment projects in natural resource industries and transportation infrastructure in the forecasted future will ensure the growth of GRP.

In order to define the strategy, it is necessary to form conditions for the development of the republic’s fuel and energy complex and balance with regard to the development of non-traditional energy (throughout the Eastern economic zone [EEZ]), which can have a significant impact on economic, social and cultural processes in the republic.

In our study we used the following analytical materials: The General Layout of Power Facilities Up to 2035. The Energy Strategy of the Republic of Sakha (Yakutia) for the Period Up to 2030 [9], the Scheme for Integrated Development of Productive Forces, Transport and Energy of the Republic of Sakha (Yakutia) up to 2020 [11], the General Layout of Power Facilities Up to 2035 [10], Fuel and
energy balance of the Republic of Sakha (Yakutia). Part. 1 [8], Scheme and program of development of electric power industry of the Republic of Sakha (Yakutia) for 2017-2021 [12], Annual Reports of PJSC Yakutskenergo for 2011-2016 [14], Annual Reports of Sakhaenergo PJSC for 2011-2016 [15], Official materials of the Ministry of Housing and Utilities of the Republic of Sakha (Yakutia) [16], Official materials of the Ministry of Industry and Geology of the Republic of Sakha (Yakutia) [17], Official materials of the State Committee for Price Policy of the Republic of Sakha (Yakutia) [18]. The Russian Statistical Yearbook Rosstat data etc. [13].

The research object is the natural resource potential, the mining and processing industry in the EEZ.

The objectives of the study are as follows:

- To present an analysis of the existing general and specific problems of electricity supply in the Ust-Maysky District of the EEZ;
- To give scientifically grounded proposals and recommendations on efficient electricity and thermal consumption and production in the EEZ areas.

Statistical collections of the Russian Federation (2000–2016), analytical and static reports of the municipal Districts of the Republic of Sakha (Yakutia) (2000–2016) and reports of PJSC Yakutskenergo, JSC Sakhaenergo were used as an information database for the development of the fuel and energy balance.

2. Research methods and methodology

The problems of energy production and demand in the northern regions are not temporary. E.g., the problem of the efficiency of electric heating and development of renewable energy sources was central for the previous surveys of Chamorro, Mondéjar, Ramos, Segovia, Martín, Villamañán, Elyakova, Koryagina, Pakhomov, A.A., Poiseyev [1,2,3,6]. This question is also presented in the researches of Elyakova, Nazarova, Y.A. et al - they assessed possible electricity rates in case of renewable energy sources technologies[4,5,7]. The objective of the study was the cost-effectiveness analysis of the considered energy supply options in comparison to the current electricity rates in some remote Arctic communities. The calculations indicated that the introduction of innovative power generation technologies will make it possible to reduce existing tariffs by 2–4 times (on the example of the Republic of Sakha (Yakutia)).

The study uses general scientific methods (systemic, historical, analysis and synthesis method); specific scientific methods (the cognitive method, the problem-chronological method), theoretical research methods with subsequent analysis and generalization of findings (statistical, observation and comparison, balance and empirical methods), expert assessment.

Statistical collections of the Russian Federation (2000–2016), analytical and static reports of municipal districts of the Republic of Sakha (Yakutia) (2000–2016), and the reports of PJSC Yakutskenergo and OAO Sakhaenergo were used as information for developing the fuel and energy balance.

3. Results and discussion

3.1. General Characteristics of Energy Supply to the EEZ

The most reliable and efficient power supply system is centralized power supply which is provided to consumers from centralized sources (SDPP, HPP, APP and CHP), if they provide electricity to a single network of the power system.

Ust-Maysky district belongs to the Central energy area of PJSC AK "Yakutskenergo". Centralized power supply in Ust-May area is provided by PJSC "Yakutskenergo" and decentralized power supply is provided by JSC Sakhaenergo and PJSC Yakutskenergo.

In this area centralized energy supply covers the largest part of consumers in the Eastern Economic zone (95.6 %) than in Oymyakon district (83.3 %) and Tomponsky district (82,9 %). The smallest share of consumers in these regions (4.4 %) is covered by decentralized power supply from local
diesel power plants, mainly from basic diesel power plants of JSC Sakhaenergo and local diesel power plants of PJSC Yakutskenergo.

In the area covered by the centralized energy supply the largest portion of consumers in the Eastern economic zone (95.6%) than in Oymyakon district (83.3%) and Tomponsky district (82.9 %).

The volumes of consumption of electric and thermal energy, boiler and furnace fuel and coal production in the regions of the Eastern economic zone are presented in table 1.

**Table 1.** Main indices of consumption and extraction (production ) of fuel and energy resources of EEZ (as of 2016).

| Index                                      | Oymyakonsky ulus | Tomponsky ulus | Ust-Maysky ulus | Total for EEZ |
|--------------------------------------------|------------------|----------------|-----------------|---------------|
| Extraction (production) of fuel and energy resources | 212              | 329            | 208             | 749           |
| Thermal energy, thousand Gcal              |                  |                |                 |               |
| Extraction (production) of fuel and energy resources |                  |                |                 |               |
| Consumption of fuel and energy resources   | 398              |                |                 |               |
| Electricity, thousand kWh                  | 123683           | 45469          | 46295           | 215447        |
| Thermal energy, thousand Gcal              | 155              | 249            | 142             | 546           |
| Boiler-furnace fuel, toe, total            | 45883            | 96295          | 41648           | 183826        |
| Including:.                                |                  |                |                 |               |
| Coal                                       | 45868            | 68884          | 41648           | 156400        |
| Oil fuel                                   | 3071             | 3071           |                 |               |
| Diesel fuel                                | 15               | 24340          |                 | 24355         |
| Boiler-furnace fuel, tons, including:.     |                  |                |                 |               |
| Coal of Dzhebariki-Khaya,                  | 10594            | 89294          | 53988           | 153877        |
| Coal of Arcagalinsky,                      | 54973            | 54973          |                 | 54973         |
| Oil fuel                                   | 2122             | 2122           |                 |               |
| Diesel fuel                                | 10               | 16795          |                 | 16805         |

Source: Compiled by the authors based on the Executive authorities of the Republic of Sakha (Yakutia)

3.2. **Electricity production**

The power supply in the Ust-Maysky district mainly (95,6%) are produced by the enterprises of PJSC “Yakutskenergo” from generating sources of Yakutsk SDPP in the Yakutsk city by the electric networks of Central electric networks of 110 kV Maiya –Sulgachi – Eldjikan - Solnechny (table 2).

**Table 2.** Electricity supply from Centralized generating power source Ust-Maysky district EEZ, thousand kWh.

| Ust-Maysky district | 2005  | 2012  | 2013  | 2014  | 2015  | 2016  | 2016/2012 | Share, % |
|---------------------|-------|-------|-------|-------|-------|-------|-----------|---------|
| Total amount        | 12987 | 40323 | 45578 | 45483 | 43496 | 46295 | 115       | 100, 0  |
| Centralized electric power supply of PJSC “Yakutskenergo” |       |       |       |       |       |       |           |         |
| Total               | 0     | 39022 | 43925 | 44146 | 42093 | 44239 | 113       | 95,6    |
| Ust-Maya            | 7645  | 7855  | 7695  | 7399  | 8222  | 108   | 17,8      |          |
Electricity supply from decentralized energy sources is provided from DPPs of JSC "Sakhaenergo" in Ust-Maya, Ezhansy, Belkachi, Ust-Mil, Troitsk.

The main production indices of decentralized power supply of DPPs JSC "Sakhaenergo" in the Ust-Maysky district are given in Table 3.

Table 3. Key indices of electricity production of DPPs JSC "Sakhaenergo" in the Ust-Maysky area.

| Name           | Ust-Maysky district | Belkachi | Troitsk | Ust-Mil | Ezhansy |
|----------------|---------------------|----------|---------|---------|---------|
| Petropavlovsk  | 1840 1645 1738 1922 | 2012 2013 | 2014 2015 | 2016 107 | 2016/2 012 |
| Ust-Maysky     | 2005 1645 1738 1922 | 2012 2013 | 2014 2015 | 2016 107 | 2016/2 012 |
| Eldjikan       | 2908 3731 3780 3724 | 3507 3507 | 3507 3507 | 3507 3507 | 3507 3507 |
| Kupsy          | 769 829 862 869 863 | 112 112 112 112 112 | 112 112 112 112 112 |
| Solnechny      | 25 860 29 865 30 071 28 179 29 684 | 115 115 115 115 115 | 115 115 115 115 115 |
| Noviy          | - 970 1273 1357 1105 | 855 855 855 855 855 | 855 855 855 855 855 |

Compiled by the authors based on data of PJSC "Yakutskenergo" for 2005-2016.
By assessing the main indices of power generation of DPS JSC "Sakhaenergo" in the Ust-Maysky district for the period under review it is revealed that low-power diesel power plants operate in settlements.

Specific consumption of natural fuel in DPS of settlements and losses in networks are within the normative indices, except DPS (Diesel power station) of Troitsk where specific consumption of natural fuel is equal to 694,4 g/kWh, 2 times higher than the standard level, which indicates the inefficiency of diesel generators because of underutilization of available capacities. The volume of delivery of diesel fuel is 1110 tons in the amount of 27.6 million rubles. (the cost of 1 ton of diesel fuel in the area is 24864 rubles.).

There is the wearing of the main electrical equipment and buildings of DPS in the settlements of the Ust-Maysky District (table 4).

Table 4 – The wearing of the main electrical equipment and DPS buildings in the settlements of the Ust-Maysky District for 2016

| Index                        | Belkachi | Troitsk | Ust-Mil | Ezhansy |
|------------------------------|----------|---------|---------|---------|
| Electric power of DPP (kW)   | 320      | 121     | 675     | 400     |
| Wearing of diesel generators (%) | 23       | 55      | 60      | 15      |
| Wearing of buildings (%)     | 0        | 30      | 93      | 55      |

The wear of the main equipment in the range of 55-60 % in the settlements Troitsk and Ust-Mil and DPP buildings (55-93 %) suggests that it is necessary to carry out their modernization and reconstruction.

The use of diesel fuel is the reason for the high cost of DPPs electricity generation (on average in 2016 59.4 rubles/kWh), exceeding the average Russian level more than 17 times (Troitsk – 197,4 RUB/kWh). The average for the district the cost of 1 ton of diesel fuel was 24865. The most expensive cost of diesel fuel in the settlement Belkachi (54668 RUB), Ust-Mil (53630 RUB), Ezhansy (47440 RUB), the cheapest - in the settlement Ust-Mayia– (31250 rubles) (table 5).

Table 5. Analysis of the cost of electricity produced by DPPs in the Ust Maysky District, million rubles.

| Settlement | Cost price, million rubles | Including: Fuel, million rubles | Payroll budget with unified social tax, million rubles | Industri service materials, million rubles | Other expenses, million rubles | Net supply, million kWh | Averag e tariff, rubles/kWh | Cost price of 1 kWh, rubles/kWh | Econom ically justified tariff, rubles/kWh | Averag e tariff, rubles/kWh |
|------------|---------------------------|---------------------------------|-------------------------------------------------------|------------------------------------------|---------------------------------|------------------------|-----------------------------|--------------------------------|--------------------------------|-----------------------------|
| Total      | 84,2                      | 27,6                            | 25,1                                                   | 7,1                                      | 24,3                            | 1,4                    | 59,4                        | 55,9                          | 4,80                           |
| Belkachi   | 16,6                      | 6,5                             | 5,4                                                    | 1,3                                      | 3,4                             | 0,3                    | 51,7                        | 205,6                         | 4,91                           |
| Troitsk    | 11,7                      | 1,2                             | 5,4                                                    | 0,9                                      | 4,2                             | 0,1                    | 197,4                       | 3,95                          | 4,87                           |
| Ust-Mil    | 32,7                      | 9,9                             | 8,1                                                    | 3,4                                      | 11,3                            | 0,6                    | 58,1                        | 53,5                          | 4,78                           |
| Ezhansy    | 23,3                      | 10,1                            | 6,3                                                    | 1,6                                      | 5,3                             | 0,5                    | 49,1                        |                               |                               |
Analysis of the cost of electricity produced by DPPs in the district shows that the largest share in the cost is the cost of using diesel fuel (32.8%) and labor (29.8%).

The dynamics analysis of the energy consumption structure from decentralized sources of JSC "Sakhaenergo" for certain groups of consumers and average electricity tariffs by consumer groups, over the last 5 years, shows that the indicators of electricity consumption are preserved.

3.3. Electricity consumption

In Ust-Maysky district the largest part of EEZ consumers – 95.6 %, which use centralized energy supply including the settlements Ust-Maya, Solnechny, Eldjikan, Petropavlovsk, Kyupsy and decentralized energy supply use only 4.4 % of consumers, where electricity is supplied from diesel power plants of JSC "Sakhaenergo". Currently, the largest consumers of electricity in Ust-Maysky district are the settlements Solnechny and Ust-Maiya.

Proceeding from a retrospective analysis of consumption and production of fuel and energy resources of the EEZ it is possible to distinguish two dynamic periods: till 2005 – low growth rates, 2012-2016 – high. The lowest volume of electricity consumption for this period was in 2016 – 45469 thousand kWh, this may be due to the economic situation in the Republic (table 6).

**Table 6.** Electricity Consumption by settlements in the Ust-Maysky District of the EEZ, thousand kWh.

| Ust-Maysky District     | 2005  | 2012  | 2013  | 2014  | 2015  | 2016  | 2016/2012 | weight, % |
|-------------------------|-------|-------|-------|-------|-------|-------|-----------|-----------|
| Total                   | 12987 | 40323 | 45578 | 45483 | 43496 | 46295 | 115       | 100,0     |
| Centralized power supply from PJSC “Yakutskenergo” |       |       |       |       |       |       |           |           |
| Total                   | 0     | 39022 | 43925 | 44146 | 42093 | 44239 | 113       | 95,6      |
| Ust-Maiya               | 7645  | 7855  | 7695  | 7399  | 8222  | 108   | 17,8      |           |
| Petropavlovsk           | 1840  | 1645  | 1738  | 1922  | 1963  | 107   | 4,2       |           |
| Eldjikan                | 2908  | 3731  | 3780  | 3724  | 3507  | 121   | 7,6       |           |
| Kyupsy                  | 769   | 829   | 862   | 869   | 863   | 112   | 1,9       |           |
| Solnechny               | 25860 | 29865 | 30471 | 28179 | 29684 | 115   | 64,1      |           |
| Ust-Maysky District     | 2005  | 2012  | 2013  | 2014  | 2015  | 2016  | 2016/2012 | Y.d.вес, %|
| Decentralized power supply from PJSC “Yakutskenergo” |       |       |       |       |       |       |           |           |
| Total                   | 0     | 1301  | 1653  | 1337  | 1403  | 655   | 50        | 1,4       |
| Belkachi                | 311   | 332   | 333   | 319   | 124   | 40    | 0,3       |           |
| Ust-Mil                 | 442   | 499   | 412   | 428   | 155   | 35    | 0,3       |           |
| Troitsk                 | 57    | 63    | 66    | 80    | 23    | 40    | 0,0       |           |
| Ezhansy                 | 491   | 759   | 526   | 576   | 353   | 72    | 0,8       |           |
| Decentralized power supply from DPP “Sakhaenergo” |       |       |       |       |       |       |           |           |
| Total                   | 12987 | 0     | 0     | 0     | 1401  | 3,0   |           |           |
| Belkachi                | 256   | 316   | 0     | 0     | 0     | 0,7   |           |           |
| Troitsk                 | 48    | 52    | 0     | 0     | 0     | 0,1   |           |           |
| Ust-Maiya               | 11598 | 0     | 0     | 0     | 0     | 0,0   |           |           |
| Ust-Mil                 | 547   | 472   | 0     | 0     | 0     | 1,0   |           |           |
| Ezhansy                 | 538   | 561   | 0     | 0     | 0     | 1,2   |           |           |
In the second quarter of 2016 there was a transfer of the basic diesel power plants of JSC "Yakutskenergo" to its subsidiary – JSC "Sakhaenergo", only the backup diesel power plants were in the balance sheet of JSC "Yakutskenergo".

The dynamics analysis of the electricity consumption from PJSC "Yakutskenergo" for certain groups of consumers and average electricity tariffs by consumer groups over the last 5 years shows that there is a tendency to growth of volumes of power consumption in the whole of Ust-Maysky district and for all consumer groups (table 7).

**Table 7. Electricity Consumption from centralized energy sources of JSC "Yakutskenergo" by groups of the main consumers in Ust-Maysky district.**

| Consumers                        | 2012 Volume Thousand kWh | 2016 Volume Thousand kWh | 2016/2012 Volum % | Revenue Thousand rubles | Revenue Thousand rubles | 2016/2012 Revenue % | Tariff Rubles kWh | Tariff Rubles kWh | 2016/2012 Tariff % |
|----------------------------------|---------------------------|--------------------------|-------------------|-------------------------|-------------------------|-----------------------|-------------------|-------------------|-------------------|
| Ust-Maysky district              |                           |                          |                   |                          |                          |                       |                   |                   |                   |
| Total amount                     | 39022                     | 157567                   | 4,04              | 44239                   | 286408                  | 6,47                  | 113               | 182               | 160               |
| Population, total                | 6580                      | 16253                    | 2,47              | 7225                    | 27132                   | 3,76                  | 110               | 167               | 152               |
| Budget, total                    | 1522                      | 6219                     | 4,09              | 1543                    | 11203                   | 7,26                  | 101               | 180               | 178               |
| Enterprises of housing and utilities infrastructure | 7928                      | 32273                    | 4,07              | 6053                    | 43651                   | 7,21                  | 76                | 135               | 177               |
| Others                           | 22992                     | 102822                   | 4,47              | 29419                   | 204422                  | 6,95                  | 128               | 199               | 155               |
| Ust-Maiya                        |                           |                          |                   |                          |                          |                       |                   |                   |                   |
| Total amount                     | 7645                      | 27188                    | 3,56              | 8222                    | 47925                   | 5,83                  | 108               | 176               | 164               |
| Population, total                | 2861                      | 7197                     | 2,52              | 3307                    | 12443                   | 3,76                  | 116               | 173               | 150               |
| Budget, total                    | 1233                      | 5032                     | 4,08              | 1203                    | 8692                    | 7,23                  | 98                | 173               | 177               |
| Enterprises of housing and utilities infrastructure | 2694                      | 10957                    | 4,07              | 2768                    | 19946                   | 7,21                  | 103               | 182               | 177               |
| Others                           | 857                       | 4002                     | 4,67              | 944                     | 6844                    | 7,25                  | 110               | 171               | 155               |
| Petropavlovsk                    |                           |                          |                   |                          |                          |                       |                   |                   |                   |
| Total amount                     | 1840                      | 6284                     | 3,42              | 1963                    | 11581                   | 5,90                  | 107               | 184               | 173               |
| Population, total                | 789                       | 1829                     | 2,32              | 858                     | 3545                    | 4,13                  | 109               | 194               | 178               |
| Budget, total                    | 97                        | 400                      | 4,14              | 136                     | 1008                    | 7,39                  | 141               | 252               | 178               |
| Enterprises                      | 566                       | 2259                     | 3,99              | 655                     | 4795                    | 7,32                  | 116               | 212               | 183               |
| Enterprise | Total amount | Population, total | Budget, total | Enterprises of housing and utilities infrastructure | Others |
|------------|--------------|------------------|--------------|--------------------------------------------------|--------|
| Eldjikan   | 2908 9647    | 1490 3748        | 53 219       | 1254 5161 4,12 1855 13400 7,22 148 260 176      |
| Kyupsy     | 769 2462     | 384 911          | 12 48         | 367 1474 4,02 390 2804 106 190 179               |
| Solnechny  | 25860 111986 | 1056 2568        | 127 520       | 3047 12422 4,08 384 2706 13 22 173              |
| Others     | 388 1796     | 1490 3748        | 53 219       | 1254 5161 4,12 1855 13400 7,22 148 260 176      |
|            |              |                  |              | 111 519 4,67 137 999 7,28 124 193 156               |
|            |              |                  |              | 769 2462 3,20 863 4345 5,03 112 176 157              |
|            |              |                  |              | 384 911 2,37 407 1058 2,60 106 116 110               |
|            |              |                  |              | 12 48 4,00 24 182 7,58 200 379 190                   |
|            |              |                  |              | 1490 3748 2,52 1441 5521 3,83 97 147 152              |
|            |              |                  |              | 53 219 4,13 74 544 7,37 139 248 178                   |

Generally there is an increase in the district in electricity consumption by 5217 thousand kWh. (by 13.3%), but at the same time, utilities have a decrease of 1875 thousand kWh (by 24%), , the indices have not been changed much for other consumers. In the structure of electricity consumption the other consumers, including industrial enterprises – 71.3%, utilities – 15.2%, the population – 9.4% have the
highest indices. During the study period, there was an increase in electricity sales among consumers, as well as an increase in average tariffs in the whole district by 60%, including the largest increase in average tariffs by 78% – for budget organizations and utilities, for the population – by 52%.

Consumption of electricity from decentralized energy sources of JSC "Yakutskenergo" in the main groups of consumers in table 8.

**Table 8.** Electricity consumption from decentralized energy sources of JSC "Sakhaenergo" in Ust-Maysky district.

| Groups of consumers | 2012 Volume Thousand kWh | Revenue Thousand rubles. | Tariff Rubles / kWt | 2016 Volume Thousand kWh | Revenue Thousand rubles. | Tariff Rubles / kWt | 2016/2012 % | 2016/2012 % | 2016/2012 % |
|---------------------|---------------------------|--------------------------|---------------------|---------------------------|--------------------------|---------------------|-------------|-------------|-------------|
| Total amount        | 1301                      | 4039                     | 3,10                | 655                       | 3506                     | 5,35                | 50          | 87          | 172         |
| Population, total   | 749                       | 1735                     | 2,32                | 258                       | 930                      | 3,60                | 35          | 54          | 155         |
| Budget, total       | 95                        | 390                      | 4,13                | 74                        | 474                      | 6,39                | 78          | 122         | 155         |
| Enterprises of housing and utilities infrastructure | 363                      | 1535                     | 4,23                | 272                       | 1763                     | 6,48                | 75          | 115         | 153         |
| Others Belkachi     | 95                        | 379                      | 3,99                | 51                        | 339                      | 6,70                | 53          | 89          | 168         |
| Total amount        | 311                       | 1027                     | 3,30                | 124                       | 664                      | 5,35                | 40          | 65          | 162         |
| Population, total   | 156                       | 362                      | 2,32                | 55                        | 198                      | 3,58                | 35          | 55          | 154         |
| Budget, total       | 20                        | 85                       | 4,25                | 8                         | 52                       | 6,55                | 40          | 61          | 154         |
| Enterprises of housing and utilities infrastructure | 86                        | 355                      | 4,13                | 51                        | 348                      | 6,82                | 59          | 98          | 165         |
| Others Ust-Mil      | 49                        | 225                      | 4,59                | 10                        | 66                       | 6,77                | 20          | 29          | 147         |
| Total amount        | 442                       | 1346                     | 3,05                | 155                       | 778                      | 5,02                | 35          | 58          | 165         |
| Population, total   | 265                       | 615                      | 2,32                | 86                        | 306                      | 3,56                | 32          | 50          | 153         |
| Budget, total       | 27                        | 111                      | 4,11                | 14                        | 94                       | 6,62                | 53          | 85          | 161         |
| Enterprises of housing and utilities infrastructure | 129                      | 520                      | 4,03                | 50                        | 340                      | 6,80                | 39          | 65          | 169         |
The analysis of electricity consumption by groups of major consumers from decentralized energy sources JSC "Yakutskenergo" in Ust-Maysky district shows a sharp reduction of electricity consumption (50%), including other entities – 46.3%, for utilities – by 25%, budgetary organizations – 22.1%, according to the population – by 65.6%.

In the structure of electricity consumption other consumers have the highest indices, including utilities (41.5%), the population (39.4%), industrial enterprises (7.8%). This is mainly due to the growth of consumption from a centralized source of electricity – Yakutsk SDPP and the construction of high-voltage power lines to the settlements Eldjikan and Solnechny.

In the future, in the decentralized zone of diesel power plants operation, the use of non-traditional and renewable energy sources in conjunction with existing diesel power plants is effective. One of the ways is the construction of DPPs with the installation of solar power plants.

The dynamics analysis of the energy consumption structure from decentralized sources of JSC "Sakhaenergo" for certain groups of consumers and average electricity tariffs by consumer groups, over the last 5 years, shows that the indices of electricity consumption are preserved. The decrease in electricity consumption from decentralized sources by other consumers was 33 %. There was an increase in average electricity tariffs by 55%, including 61 % for the population, 71% for utilities, 76% for budget organizations, and 81% for other consumers.

4. Conclusions
The problems of power supply and their expected consequences for the Eastern regions of the Republic are revealed on the basis of this research.
We believe that the main institutional, organizational and technical problems of reliable energy supply in the whole EEZ are:

- nonavailability of fuel and energy balance (FEB) for EEZ, including Districts, in the context of settlements;
- preparation of FEB as a whole in the Republic of Sakha (Yakutia) only in natural indices of the produced and used fuel and energy resources;
- the absence of a single coordinating and controlling body of Executive power in the Republic of Sakha (Yakutia) for the preparation of FEB, including the areas of the EEZ.

Technical risks of power supply and thermal supply were identified and analyzed:
- high level of electrical and thermal networks wearing;
- accident rate of power supply and thermal supply sources;
- irrational use of electricity and thermal energy;
- increase in heat networks losses;
- nonavailability of efficient energy-saving technologies;
- difficulties of Northern delivery of coal and diesel fuel for boiler houses to the settlements.

We have also identified specific economic threats in the Ust-Maisky district of EEZ:
- absence of financing sources for the construction of intra-district power lines;
- increase in the cost of electricity production;
- the growth in rates for diesel fuel and the rapid increase in diesel fuel prices compared to the tariffs for electricity;
- high fuel component share for electric power cost in Troitsk;
- high cost of electricity production, leading to high tariffs for electricity produced by DPPs.

5. Recommendations
In our opinion, the conditions of long-term efficient provision of energy resources to consumers in the Ust-Maysky District of the Eastern economic zone are:

1. It is advisable to develop the Energy strategy of the Republic of Sakha (Yakutia), promising fuel and energy balance, including balances of power and electricity, heat in natural and cost indices for a comprehensive assessment of their efficiency in the form of a software product.

2. To develop long-term programs for the development of electric and heat power enterprises, including investment projects, taking into account the main mechanisms of their implementation in the settlements of the EEZ, such as:
   - environmental policy in the field of production and use of fuel and energy resources among producers of FER and consumers including the population-to ensure the preservation of the natural environment for the population and ecosystems of the region in the production and consumption of fuel and energy resources.
   - technological and technical mechanisms for research and production support of energy saving, timely supply of efficient fuel-energy resources and preparation of a rational base and prospective balance of fuel and energy resources of specific areas in interrelation among themselves and with the economic zones and the neighboring areas of the Republic;
   - economic mechanisms - to provide fuel and energy resources through tax regulation, budget policy, tariff and price policy at the level of the Republican and municipal authorities.

3. Effectively use the potential of renewable energy sources in the Eastern regions of Yakutia to reduce the cost of importing expensive diesel fuel and increase the efficiency of production and use of energy resources.

6. References
[1] Elyakova I D, Pakhomov A A, Poiseyev I I, Yefremov E I, Darbasov V R, Noyeva E Y, Khristoforov A A, Elyakov A L 2016 Prospects for development of renewable energy sources to preserve the ecosystem of arctic zone of Russia Indian Journal of Science and Technology 9(46) 1-9
[2] Elyakova I D 2015 Organizational and Economic Mechanisms for Ensuring the Electric Power Safety of the Republic of Sakha (Yakutia) Yakutsk: publishing house of NEFU 318 p
[3] Elyakova I D 2017 Evaluation of the efficiency of centralized power supply in the Tomponsky District of the Eastern economic zone of the Republic of Sakha (Yakutia) Economy and entrepreneurship 10 part 2 pp 367-373
[4] Elyakova I D 2014 Safety of electric power industry of the North: on the example of the Republic of Sakha (Yakutia) North-Eastern Federal University named after M K Ammosov (Yakutsk: publishing house of NEFU) 280 p
[5] Elyakova I D 2017 Analysis and evaluation of the efficiency of electricity consumption in the Tomponsky District of the Eastern economic zone of the Republic of Sakha (Yakutia) Economy and entrepreneurship 10 part 2 pp 218-223
[6] Chamorro C R, Mondéjar M E, Ramos R, Segovia J J, Martín M C & Villamañán M A 2012 World geothermal power production status: Energy, environmental and economic study of high enthalpy technologies Energy 42(1) 10-18
[7] Christidis A, Koch C, Pottel L & Tsatsaronis G 2012 The contribution of heat storage to the profitable operation of combined heat and power plants in liberalized electricity markets Energy 41(1) 75-82
[8] Petrov N A 2005 The fuel and energy balance of the Republic of Sakha (Yakutia) Part I V P Larionov’s Institute of Physical-Technical Problems of the North SB RAS (Yakutsk: Sakhapoligrafizdat)
[9] Petrov O N, Saneyev B G, Alekseyev G F, Safronov A F 2010 The Energy Strategy of the Republic of Sakha (Yakutia) for the Period Up to 2030 Government of the Republic of Sakha (Yakutia) Yakutsk (Irktusk: Media Holding “Yakutia” and others) p 328
[10] The General Layout of Power Facilities Up to 2035 2017 Approved by the Order of the Government of the Russian Federation No 1209
[11] The Scheme for Integrated Development of Productive Forces 2016 Transport and Energy of the Republic of Sakha (Yakutia) up to 2020 (Moscow: Yakutsk)
[12] The Scheme and Program for the Development of the Energy Industry of the Republic of Sakha (Yakutia) for 2017-2021 (Approved by the Decree of the Head of the Republic of Sakha (Yakutia) No. 1908 of May 9, 2017
[13] The Russian Statistical Yearbook Rosstat 2016 (Moscow) p 725 Available from: http://www.gks.ru/bgd/regl/b16_13
[14] Annual reports of PJSC "Yakutskenergo" for 2011 -2016
[15] Annual reports of PJSC "Sakhaenergo" for 2011-2016
[16] Official materials of the Ministry of Housing and Utilities of the Republic of Sakha (Yakutia)
[17] Official materials of the Ministry of Industry and Geology of the Republic of Sakha (Yakutia)
[18] Official materials of the State Committee for Price Policy of the Republic of Sakha (Yakutia)