Analysis of the Production and Consumption of Thermal Energy in the Arctic Regions of the Republic of Sakha (Yakutia)

I D Elyakova, A L Elyakov, A A Pakhomov

1 Institute of Finances and Economics, M.K. Ammosov North-Eastern Federal University, Yakutsk, Russian Federation
2 Institute of Finances and Economics, M.K. Ammosov North-Eastern Federal University, Yakutsk, Russian Federation
3 Department 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. A comparative assessment of thermal energy production and consumption efficiency to the Arctic region in the Republic of Sakha (Yakutia) is presented in this article. Existing problems and risks in the heat supply have been identified based on the analysis and the recommendations on the effective heating of the Tomponsky district in the Eastern Economic Zone (EEZ) of the Republic of Sakha (Yakutia) are given. The results of the study allow us to develop sound recommendations for the efficient production and consumption of thermal energy in the context of the settlements in the Tomponsky district of the Eastern Economic Zone of the Republic of Sakha (Yakutia).

1. Introduction

In order to define the strategy it is necessary to create conditions for the development of the complex and development of the fuel and energy balance of the Republic of Sakha (Yakutia) taking into account the development of alternative energy (for EEZ), that can have a significant impact on the 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], Official materials of the Ministry of Housing and Utilities of the Republic of Sakha (Yakutia) [15], Official materials of the Ministry of Industry and Geology of the Republic of Sakha (Yakutia) [16], Official materials of the State Committee for Price Policy of the Republic of Sakha (Yakutia) [17]. The Russian Statistical Yearbook Rosstat data etc. [13].

The object of the study is utilities and consumers of thermal energy in the EEZ.
The aim of the study is: to make an analysis of the heat supply problems in the context of EEZ areas; to give scientific credence of heat supply effective directions in the Western regions of Yakutia.

2. Research methods and methodology

The problem of conditions for effective long-term heat supply is relevant for the study of processes and phenomena of thermal energy production in the world economy. The study used the following research methods: General scientific methods (systematic and historical method, method of analysis and synthesis); specific research methods (research method, problem-chronological method); theoretical methods with subsequent analysis and generalization of results (statistical, Supervisory and compare, balance and empirical methods).

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].

3. Results and discussion

3.1. Heat supply general characteristics in EEZ

There are three North-Eastern districts of the Republic: Tomponsky, Oymyakon and Ust-Maysky districts in the Eastern Economic Zone of the Republic of Sakha (Yakutia).

Heat supply to consumers in the Eastern Economic Zone is carried out by more than 60 boiler houses which are powered by coal, oil and diesel fuel. Boiler houses of SUE “HCS of RS (Y)” (State Unitary Enterprise “Housing and Communal Services of The Republic of Sakha (Yakutia)” has the main share in the structure of heat production in the amount of 24 PCs. Almost all boilers run on coal. There are also installed backup power supplies (DPPs). Diesel fuel is used as a backup fuel for coal boilers.

The boilers of SUE “HCS of RS (Y)”, SC "ALROSA" (PJSC), JSC "Teploenergoservis", LLC Stroyremonstervis”, “the Dzhebariki-Khaya mine” which is a branch of SJSC holding company “Yakutugol” and JSC "Sakhaneftegazsbyt” have the main share in the structure of heat production. 749 thousand Gcal of thermal energy were produced and 546 thousand Gcal of thermal energy were consumed in 2017.

3.2. Thermal energy production

Production of thermal energy in Tomponsky district was amounted to 310,9 thousand Gcal in 2017. The structure of thermal energy production in 2017 is presented in table 1.

| Source of thermal energy | Settlement     | Thermal energy production, thousand Gcal | Number of boilers | Type of fuel                      |
|--------------------------|----------------|------------------------------------------|-------------------|-----------------------------------|
| Tomponsky district, including: | Khandyga | 112,7 | 9 | Coal of Dzhebariki-Khaya, DPPs       |
|                          | Keskił      | 10,2 | 1 | Diesel fuel for emergency              |
|                          | Noviy      | 5,7 | 1 |                                      |
|                          | Saidy      | 0,0 | 1 |                                      |
|                          | Teypliy Klutch | 18,2 | 1 |                                      |
|                          | Razvilka   | 2,5 | 1 |                                      |
|                          | Aeroport   | 5,7 | 1 |                                      |
Table 2. The production and consumption balance of thermal energy, thousand Gcal.

| Index                                                                 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|------------------------------------------------------------------------|------|------|------|------|------|------|
| Thermal energy production, total                                       | 379  | 363  | 372  | 360  | 329  | 311  |
| Boilers, including:                                                    |      |      |      |      |      |      |
| SUE "HCS of RS (Y)"                                                    | 267  | 263  | 269  | 258  | 249  | 232  |
| LLC Stroyremontservis"                                                | 214  | 212  | 212  | 202  | 194  | 179  |
| "the Dzhebariki-Khaya mine", a branch of SJSC holding company "Yakutogol" |      |      |      |      |      |      |
| JSC "Sakhaneftegazsbyt"                                               |      |      |      |      |      |      |
| Municipal authority "Tomponsky district"                              |      |      |      |      |      |      |
| "In-house need of heat source"                                        | 14   | 14   | 14   | 14   | 13   | 12   |
| Network losses                                                         | 96   | 85   | 89   | 89   | 67   | 67   |
| Heat energy consumption, total                                         | 283  | 278  | 283  | 272  | 261  | 244  |

Compiled by the authors based on data of the State Committee for Price Policy of the Republic of Sakha (Yakutia)

The thermal energy production and consumption balance in the Tomponsky district is made according to the tariff decisions of the State Committee for Price Policy of the Republic of Sakha (Yakutia) (Table 2).

The total installed capacity of the boilers in the Tomponsky district is estimated at 196.9 Gcal/h, including: SUE “HCS of RS (Y)" – 173.1 Gcal/h, LLC "Teplod" - 7.6 Gcal/h, LLC "Stroyremontservis" – 0.6 Gcal/h, "the Dzhebariki-Khaya mine", a branch of SJSC holding company “Yakutogol" - 10.9 Gcal/h and JSC "Sakhaneftegazsbyt" - 4.8 Gcal/h (table 3).
Table 3. Installed heat capacity of the boilers in the Tomponsky district, 2017.

| Source of thermal energy | Settlement | Installed heat capacity, Gcal/h |
|--------------------------|------------|---------------------------------|
| Tomponsky district, including: | Khandyga | 81,4 |
|                          | Keskil    | 5,0    |
|                          | Noviy    | 4,7    |
|                          | Saidy    | 0,1    |
|                          | Teypil Klutch | 10,8 |
|                          | Razvilka | 4,4    |
| SUE “HCS of RS (Y)” | Aeroport | 6,3    |
|                          | Krest-Khaldjai | 10,8 |
|                          | Udarnik | 2,4    |
|                          | Ary-Tolon | 1,1    |
|                          | Megino-Aldan | 6,2    |
|                          | Topolinoe | 7,8    |
|                          | Dzhebariki-Khaya | 32,2 |
| LLC “Teplo+” | Khandyga | 7,6    |
| LLC “Stroyremontservis” | Khandyga | 0,6    |
| “the Dzhebariki-Khaya mine”, a branch of SJSC holding company “Yakutugol” | Dzhebariki-Khaya | 10,9 |
| JSC ”Sakhaneftegazsbyt” | Khandyga | 4,8    |

Compiled by the authors based on data of the State Committee for Price Policy of the Republic of Sakha (Yakutia)

The analysis of fuel consumption by suppliers of thermal energy in the settlements of the Tomponsky district for 2012-2017 is presented in table 4.

Table 4. Analysis of fuel consumption for thermal energy production.

| Tomponsky district | Type of fuel | Unit | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2017/2016 |
|--------------------|--------------|------|------|------|------|------|------|------|------------|
| SUE “HCS of RS (Y)” | Coal of Dzhebariki-Khaya, Diesel fuel fortons emergency DPPs | 67 947 | 67 359 | 77 736 | 37 451 | 37 451 | 33 586 | 90 |
| Khandyga | Diesel fuel fortons emergency DPPs | 37,9 | 6,4 | 19,7 | 7,9 | 7,9 | 7,5 | 95 |
| Khandyga | Coal of Dzhebariki-tions Khaya | 3 858 | 3 858 | 3 028 | 78 |
| Keskil | Diesel fuel fortons emergency DPPs | 0,8 | 0,8 | 0,8 | 98 |
| Keskil | Coal of Dzhebariki-tions Khaya | 2 003 | 2 003 | 1 708 | 85 |
| Noviy | Diesel fuel fortons emergency DPPs | 0,4 | 0,4 | 0,4 | 98 |
| Noviy | Coal of Dzhebariki-tions Khaya | 85 | 85 | 0 |
| Saidy | Diesel fuel fortons emergency DPPs | 0,02 | 0,02 | 0 |
| Teypil | Coal of Dzhebariki-tions | 5 142 | 5 142 | 5 379 | 105 |
| Location          | Source of Coal        | Quantity (tons) | Diesel fuel for emergency DPPs (tons) |
|-------------------|-----------------------|-----------------|---------------------------------------|
| Klutch            | Dzhebariki-Khaya      | 815             | 1.2, 1.2, 1.1, 95                     |
| Razvilkha         | Dzhebariki-Khaya      | 1650            | 0.2, 0.2, 0.2, 97                     |
| Aeroport          | Dzhebariki-Khaya      | 5854            | 1.650, 1.650, 1.699, 103              |
| Krest-Khaldjai    | Dzhebariki-Khaya      | 937             | 0.4, 0.4, 0.4, 99                     |
| Udarnik           | Dzhebariki-Khaya      | 546             | 1.4, 1.3, 1.4, 107                    |
| Ary-Tolon         | Dzhebariki-Khaya      | 937             | 0.2, 0.2, 0.2, 104                    |
| Megino-Aldan      | Dzhebariki-Khaya      | 815             | 0.1, 0.1, 0.1, 104                    |
| Topolinoe         | Oil of Talakan        | 2609            | 0.9, 0.9, 0.9, 99                     |
| Dzhebariki-Khaya | Oil of Talakan (Irelyakh, 2014-2015) | 14 985 | 0.9, 0.9, 0.9, 98                     |
| LLC "Teplo+" (former LLC "Teploservis") | Coal of Dzhebariki-Khaya | 6 532 | 14 955, 14 955, 10 930, 76 |
| Khandyga          | Dzhebariki-Khaya      | 6 532           | 13.3, 13.3, 2.6, 58                   |
| LLC "Stroyremontservis" | Coal of Dzhebariki-Khaya | 6 532 | 13.3, 13.3, 2.6, 58                   |
| Khandyga          | Diesel fuel for emergency DPPs | 616 | 0.9, 0.9, 0.9, 99                     |
| "the Dzhebariki-Khaya mine", a branch of SJSC holding company “Yakutugol” | Coal of Dzhebariki-Khaya | 616 | 10 069, 10 069, 9 069, 77 |
| JSC "Sakhaneftegazsbyt" | Oil of Talakan         | 374             | 10 069, 10 069, 9 069, 100             |
Municipal authority "Tomponsky district"

| Coal of Dzhebariki-Khaya | Total | Khandyga | Keskil | Noviy | Sadiy | Teptyi | Kluch | Razvika | Aeroport | Krest-Khaljai | Udarnik | Ary-Tolon | Megino-Aldan | Topolinov | Dzhebariki-Khaya |
|--------------------------|-------|-----------|---------|-------|-------|--------|-------|---------|----------|---------------|---------|----------|---------------|------------|------------------|
|                          | 368   | 368       |         |       |       |        |       |         |          |               |         |          |               | 368        |                  |

Compiled by the authors based on data of the State Committee for Price Policy of the Republic of Sakha (Yakutia) for 2012-2017.

Fuel use assessment for 2016 was carried out based on the above data (table 5). The highest average tariff for heat energy (28 thousand RUB.) is in the boiler of Saidyy settlement, which was closed in 2017. The share of fuel costs at the average tariff for the district is about 27%, for each settlement - from 10% to 68%. One third of the cost of fuel is the cost of its delivery (transportation) and storage.

**Table 5.** Comparative assessment of fuel use in settlements in the Tomponsky district for 2016.

| Tomponsky district | Dzh. Kh. coal consumption | Unit | TOTAL | Khandyga | Keskil | Noviy | Sadiy | Teptyi | Kluch | Razvika | Aeroport | Krest-Khaljai | Udarnik | Ary-Tolon | Megino-Aldan | Topolinov | Dzhebariki-Khaya |
|--------------------|--------------------------|------|-------|---------|--------|-------|-------|--------|-------|---------|----------|---------------|---------|----------|---------------|------------|------------------|
|                    |                          | Thous. and tons | 89,3 | 43,1 | 3,1 | 1,8 | 0,1 | 5,7 | 0,8 | 1,7 | 6,5 | 0,8 | 0,5 | 4,1 | 21,1 |
| Cost of coal, including: procurement | Thous. Rubles./ton | 6 | 6 | 5 | 5 | 5 | 6 | 8 | 6 | 6 | 6 | 5 | 3 |
| Delivery (transportation) |       | 1,7 | 1,0 | 1,5 | 1,1 | 1,2 | 1,2 | 2,4 | 4,2 | 1,7 | 2,0 | 1,8 | 1,5 | 0,3 |
| Cost of coal: procurement | Million Rub. | 232 | 232 | 17 | 9 | 0 | 30 | 5 | 14 | 37 | 5 | 3 | 23 | 72 |
| Delivery (transportation) |       | 55 | 55 | 5 | 2 | 0 | 7 | 2 | 7 | 11 | 2 | 1 | 6 | 4 |
| Talakan oil consumption | Thous. and tons | 2,1 | 0,4 | 1,7 |
| Cost of oil, including: procurement | Thous. Rubles./ton | 21,2 | 15,8 | 26,6 |
| Delivery (transportation) |       | 13,5 | 13,1 | 13,9 |
| Oil expenses: | Million Rub. | 7,7 | 2,7 | 12,7 |
|                   |                          | 51,8 | 7 | 45 |
|                   |                          | 29,1 | 6 | 24 |
Delivery (transportation)
Consumption of diesel fuel for emergency DPPs

|          | 2016 | 2017 |
|----------|------|------|
|          | 22,7 | 1    |
|          | 16,8 |     |
|          | 8    | 1    |
|          | 0,8  | 22   |
|          | 0,4  | 0,8  |
|          | 0,0  | 1,2  |
|          | 1,2  | 0,2  |
|          | 0,4  | 0,4  |
|          | 1,3  | 0,2  |
|          | 0,2  | 0,1  |
|          | 0,1  | 0,9  |
|          | 0,9  | 3    |

Consumption of diesel fuel for emergency DPPs

|          | Thous. Rubles | Million Rubles | Thous. Rubles | Million Rubles |
|----------|--------------|---------------|--------------|---------------|
|          | 32           | 0,5           | 37           | 0,3           |
|          | 32           | 0,02          | 32           | 0,01          |
|          | 32           | 0,01          | 32           | 0,001         |
|          | 32           | 0,03          | 32           | 0,005         |
|          | 32           | 0,01          | 32           | 0,04          |
|          | 32           | 0,006         | 32           | 0,003         |
|          | 32           | 0,03          | 32           | 0,03          |
|          | 32           | 0,08          | 32           | 0,03          |

Cost of diesel fuel

|          | Million Gcal | Thous. Gcal | 2016 | 2017 |
|----------|--------------|-------------|------|------|
|          | 4,4          | 4           | 5    | 6    |
|          | 6            | 5           | 8    | 7    |
|          | 28           | 5           | 8    | 4    |
|          | 25           | 4           | 8    | 8    |
|          | 14           | 6           | 5    | 6    |
|          | 9            | 3           | 3    | 3    |
|          | 4            | 4           | 4    | 4    |
|          | 5            | 3           | 5    | 6    |
|          | 8            | 2           | 8    | 3    |
|          | 102          | 11          | 62   | 68   |
|          | 95           | 10          | 96   | 38   |

Compiled by the authors based on data of the State Committee for Price Policy of the Republic of Sakha (Yakutia) for 2012-2017.

In the field of pricing policy since July 1, 2016, State Committee for Price Policy of the Republic of Sakha (Yakutia) approves the tariffs for thermal energy separately for each settlement. But for such large suppliers of thermal energy as the SUE “HCS of RS (Y)” and JSC “Teploenerservis”, economically reasonable rates are approved in the weighted average amount as a whole for the municipal area (table 6).

Table 6. Comparison of the thermal energy tariffs for the settlements in the Tomponsky district for 2016-2017.

| Settlement       | 2016 Volume thousand Gcal | 2016 Revenue thousand Rubles | 2016 Tariff Rubles / Gcal | 2017 Volume thousand Gcal | 2017 Revenue thousand Rubles | 2017 Tariff Rubles / Gcal | 2017/2012 rate of growth |
|------------------|---------------------------|-------------------------------|---------------------------|---------------------------|-------------------------------|---------------------------|--------------------------|
| Total in the     | 249                       | 1048                          | 4213                      | 232                       | 1004                          | 4332                      | 93                       |
| Tomponsky district|                           |                               |                           |                           |                               |                           | 96                       |
| Khandyga         | 96                        | 403                           | 4176                      | 86                        | 377                           | 4391                      | 94                       |
| Keski            | 6                         | 36                            | 5571                      | 6                         | 35                            | 5739                      | 100                      |
| Noviy            | 5                         | 24                            | 5025                      | 5                         | 24                            | 5145                      | 98                       |
| Saidy            | 0                         | 4                             | 27696                     | 0                         | 0                             | 0                         | 0                        |
| Teypliy Klutch   | 14                        | 72                            | 5077                      | 13                        | 67                            | 5194                      | 92                       |
| Razvilka         | 1                         | 11                            | 8156                      | 1                         | 11                            | 8874                      | 93                       |

7
Compiled by the authors based on data of the State Committee for Price Policy of the Republic of Sakha (Yakutia) for 2012-2017.

The growth of tariffs rates is due to the fact that heat consumption is reduced, and the prices affecting the volume of revenue are growing every year.

3.3. Thermal energy consumption

Thermal energy consumption in 2017 in the Thompson district amounted to 232 thousand Gcal, which is 7.1% lower than the previous year. In General, since 2012 there has been a tendency to reduce the consumption of thermal energy (table 7).

Table 7. Dynamics of thermal energy consumption in the Thompson district.

| Index | Unit | years 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|-------|------|------------|------|------|------|------|------|
| Thermal energy consumption | thousand Gcal | 269 | 264 | 269 | 258 | 249 | 232 |
| Absolute increase in heat consumption | thousand Gcal | -4 | 5 | -11 | -9 | -16 |
| Average growth rates | % | -1.6% | 1.7% | -4.3% | -3.7% | -7.1% |

Compiled by the authors based on data of the State Committee for Price Policy of the Republic of Sakha (Yakutia) for 2012-2017.

The analysis of dynamics of heat consumption on suppliers of thermal energy for the last 5 years shows that indices of heat consumption in general on the district decrease. (Table 3.11.14). According to the data of the SUE “HCS of RS (Y)” there is a slight increase of parameters only in three settlements: Krest-Khaldjai, Udarnik, Ary-Tolon. In other settlements, heat consumption decreased, in general, the company has a decrease of 16%. The SUE “HCS of RS (Y)” has the largest number of consumers - 77%, and it significantly affects the dynamics of heat consumption in the whole area, which has decreased since 2012 by 14%.

Table 8. Dynamics of heat consumption in the settlements of the Tomponsky district, thousand Gcal.

| Total in the Tomponsky district | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2017/2012 | 2017/2016 | Share 2017, % |
|--------------------------------|------|------|------|------|------|------|------------|------------|--------------|
| SUE “HCS of RS (Y)” | 269 | 264 | 269 | 258 | 249 | 232 | 86 | 93 | 100 |
| Total | 214 | 212 | 212 | 202 | 194 | 179 | 84 | 92 | 77 |
Compiled by the authors based on data of the State Committee for Price Policy of the Republic of Sakha (Yakutia) for 2012-2017.

There is a reduction in the consumption of thermal energy in almost every settlement. This is mainly due to changes in the number of consumers and actual shutdowns of heat supply facilities. Annual planned reduction of heat consumption due to the installation of metering devices also plays a role.

The dynamics of heat consumption for the main groups of consumers for the period 2012-2017 is presented in table 9. The greatest decrease in heat consumption is observed in the local budget, almost 2 times, and the smallest decrease - in the population. On the contrary, the Republican budget and internal consumption are growing.

Table 9. Dynamics of heat consumption by main groups of consumers, thousand Gcal.

| Index                              | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2017/2012 | Average growth rate % | Share, % |
|------------------------------------|------|------|------|------|------|------|-----------|-----------------------|----------|
| Total net supply                   | 269  | 264  | 269  | 258  | 249  | 232  | -36       | -16                   | 100      |
| Population                         | 154  | 155  | 159  | 158  | 150  | 144  | -11       | -8                    | 62       |
Financing from the budget, including:

|                          | 2012 | 2017 |
|--------------------------|------|------|
| Local budget institutions| 48   | 54   |
| Republican budget institutions| 48   | 50   |
| Federal budget institutions| 42   | 48   |
| Other consumers          | 42   | 42   |
| Internal consumption of organization | 23 | 23   |

Compiled by the authors based on data of the State Committee for Price Policy of the Republic of Sakha (Yakutia) for 2012-2017.

Figure 1. Structure of heat consumption in the Thompson district in 2012 and 2017.

As it can be seen from the figure 1, the largest share in the structure of heat consumption of the Tomponsky district is occupied by the population, it was 62% in 2017, the share of local budget institutions – 9%, the Republican and Federal budgets – 4% and 3%, respectively, the share of other types of consumers – 18%. In 2012, the share of the population was 57%, institutions of the local budget-16%, Republican and Federal budgets-1% and 3%, respectively, other types of consumers – 20%. The share of the internal consumption of the enterprise increased from 3% in 2012 to 4% in 2017.

4. Conclusions
The problems of heat supply are revealed and a rational direction of heat supply in the Arctic districts of Yakutia is suggested on the basis of this research.
The main systemic problems and risks of reliable heat supply in the Tomponsky district of the EEZ are:

- the main specific threat is the absence of a reliable year-round transport network and the possibility of marketing of the mine "Dzhebariki-Khaya" products;
- technical risks of heat supply: high thermal networks wearing; emergency of heat supply sources; irrational use of thermal energy; the growing losses in heat networks; delay decision in modernization and renewal of legal organizational forms; non-availability the of energy saving technologies; the difficulties and problems of transportation and supply of coal and diesel fuel for boiler houses in the settlements to northern Russia (Severny Zavoz) because of the complicated transport infrastructure.
- economic problems of heat supply: the high cost of tariffs for thermal energy production in boiler houses; rising prices for coal and diesel fuel; the high cost and difficulties of transportation and delivery of coal from the mine Dzhebariki-Khaya for boilers to hard-to-reach areas because of the complicated transport infrastructure; low level of financing and under-financing of investment projects for development of energy-saving technologies, funded from the budget; the absence of co-financing mechanisms for implementation energy efficiency projects for the development of thermal management, including at the expense of own and attracted resources of power companies, also at the expense of consumers.
- environmental threats: gross emissions of pollutants into the air; direct and indirect emissions of greenhouse gases (CO2, N2O in CO2 EQ., CH4 in CO2-EQ.; discharge of pollutants from waste water of thermal power plants.

Implementation of these risks can lead to the following consequences: increase in tariffs for thermal energy; restriction and / or termination of heat supply to consumers; decrease in safety of heat supply to consumers; increase in the number of insolvent consumers; increase in the cost of gold production.

As a result of the research, sustainable development of heating in the Arctic regions of Yakutia is proposed:

- to develop a long-term development Strategy of fuel and energy complex of the Sakha Republic (Yakutia) taking into account the optimal territorial distribution of productive forces of the sector and perspective fuel and energy balances for each municipal area taking into account the rational production and delivery (transportation) of fuel and energy resources;
- to choose priorities in the advanced development of the fuel and utility industry as basic industries in the comprehensive program of socio-economic development of municipalities in the Arctic regions and in the strategic planning of the development of the Republic as a whole;
- to form an effective mechanism of state regulation, as well as to develop a system of economic measures that contribute to the active implementation of investments;
- to ensure the energy security of centralized and decentralized heat energy markets in each local area of the Arctic region.

5. 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 1 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 (Irkutsk: 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] 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)