Differentiation of power supply systems for consumers in the Arctic zone

M M Gubanov, D E Morkovkin, Eraj Begmurodzoda, F F Sharipov and Ju A Romanova

1 Financial University under the Government of the Russian Federation, 49, Leningradsky avenue, Moscow, 125993, Russian Federation
2 Tajik National University, 2, Lohuti street, Dushanbe city, 734025, Republic of Tajikistan
3 State University of Management, 99, Ryazan Avenue, Moscow, 109542, Russian Federation
4 Moscow State University of technology and management K.G.Razumovsky (PKU), 73, Zemlyanoy Val street, Moscow, 109004, Russian Federation

E-mail: morkovkinde@mail.ru

Abstract. The article discusses the problems of providing energy supply to consumers in remote regions of Russia, including in the Arctic zone. The necessity of introducing and developing the best available technologies for autonomous energy supply to consumers in the decentralized electricity supply zone, which should be based on the combined use of technologies and reducing cross-subsidization for the long term in the framework of the implementation of a unified state energy policy, is proved. Differentiation of power supply systems of consumers was carried out, according to the results of which it is advisable to pay special attention to the location of the source of electric energy generation. The paper suggests that in the conditions of the Arctic zone it should be as close as possible to the center of energy consumption and the possibility of combined generation of electric and thermal energy.

1. Introduction

In order to solve the problems of ensuring energy supply to all consumers in the Arctic, it initially seems expedient to single out two main areas: the development of centralized power supply systems for consumers and the development of decentralized power supply systems for consumers. It is an obvious fact that ensuring reliable energy supply of the underdeveloped extended territories of the Arctic zone remote from the existing energy infrastructure in severe climatic conditions only through the creation of large power plants and the development of electric networks is technically and economically impractical, while the availability of energy sources for autonomous small consumers is the basis for the livelihoods of the population and to prevent depopulation of the country's territories [1-4].

The main priorities in ensuring energy supply to consumers in the Arctic zone are enshrined in the strategy and include [5-8]:

- Construction of nuclear thermal power plants;
• Optimization of the "northern delivery" of fuel through the use of renewable and alternative energy sources, as well as the modernization and reconstruction of energy plants with a developed resource and the introduction of energy-saving technologies and materials;
• Increasing energy efficiency and expanding the use of renewable energy sources (hereinafter - RES);
• Modernization and updating of housing and communal services using modern energy-saving technologies;
• Creation and implementation of economic mechanisms for the rational use of raw and biological resources, resource conservation and utilization of associated petroleum gas in areas of oil production.

2. Materials and methods
The purpose of this study is to differentiate consumer power supply systems by the criterion of the location of the source of electricity generation in the Arctic zone. To achieve this goal, the following tasks:

• A comprehensive analysis of the problems of providing energy supply to consumers of electric energy in remote regions of Russia;
• Verification of the hypothesis of the introduction and development of the best available technologies for autonomous energy supply to consumers of electric energy in the zone of decentralized electricity supply.

In the process of work, general scientific and specific methods of system analysis of the object, the method of analogy and comparison, the method of expert evaluations, which allowed the authors to solve the tasks, were used.

3. Results
In accordance with the above priorities, it is advisable to identify the following ways of developing centralized power supply systems: renovation of the electric power complex with the replacement of obsolete and physically obsolete equipment, increasing the capacity of intersystem sections to ensure the delivery of locked capacities, ensuring the technological connection of new consumers to existing ones and the creation of new power centers, increasing reliability of the power grid complex, rational integration in the energy system in new generation capacity through the use of nuclear power and renewable energy sources in order to minimize the fuel component in the final price for electricity, increasing electric power system management efficiency, reduction of losses in electric networks [9].

At the same time, the accession of new consumers to the Unified Energy System of Russia or a technologically isolated territorial electric energy system should be technically and economically justified during the development of a feasibility study with mandatory consideration of decentralized electricity supply options. The main criterion for making a decision should be its technical rationality and economic feasibility in accordance with long-term state goals, as well as the possible attraction of private capital. If the option of decentralized power supply is preferable, it is necessary to provide support for its implementation by presenting the best available technologies for autonomous power supply and state support for their implementation.

The integration of generating sources of electricity into the centralized power supply system and the point of their connection should also be justified as part of the development of a feasibility study, while in order to exclude additional costs for the power distribution scheme, the main priority should be the equivalence of replacement of inefficient or outdated generating capacities and minimal impact on prevailing power system structure. In the framework of this work, not only the full installed capacity of the power plant, but also the power of individual power units should be justified. If the emergence of a new generating source requires a change in the structure of the power system or the
appearance of additional costs for providing a reserve of electric power and energy, they need to be taken into account in the integrated financial and economic model of the project [10-11].

It is unacceptable to take government decisions to provide external energy infrastructure to prospective consumers or to build new generating capacities in the Arctic zone with accession to existing energy systems without a deep study of this issue at the pre-project stage. The obtained results also need to be further worked out and taken into account in the framework of developing program documents that are controlled by the Ministry of Energy of Russia, authorities of entities, network and generation companies and the system operator, and only after that make rational decisions on the implementation of large investment projects.

In order to ensure the implementation of the action plan, it is advisable to differentiate the development of modern centralized power supply schemes for the Arctic zone and the adoption of relevant government decisions, as follows [12-14]:

- The power supply to energy-intensive consumers, the connected capacity of which exceeds 50 MW and the related development of the electric grid infrastructure with a voltage class of 330 kV;
- The associated development of electric grid infrastructure with a voltage class of 220 kV and higher;
- Power supply to other consumers and construction of power plants with a capacity of less than 25 MW.

The development of these program documents should be based on the principles of ensuring reliable and high-quality centralized power supply to consumers, as well as the priorities of state policy for the development of the Arctic zone.

Taking into account the priorities of the state energy policy development necessary small generating sources of electric and thermal energy commensurate with consumers located in close proximity to consumers and the possibility of issuing electric power in a low-voltage network of centralized electricity and heat supply circuit. Such an approach will reduce the load on centralized electric and local heating networks and, due to the distribution of consumers and, accordingly, renewable energy sources across the territory of the subject, will reduce the uneven generation of electric energy and power throughout the energy system as a whole. Thus, the ratio of large and small consumers and energy sources will be maintained in the energy system, which will guarantee the energy security of the regions [15].

Changing the existing structure of the electric power complex of the Arctic zone towards creating the above-described distributed generation system based on renewable energy will require the government to solve a significant number of scientific, technical, legal and economic of resources.

For decentralized energy supply systems in accordance with the above state policy priorities, it is advisable to identify the following development paths: improving the energy efficiency of buildings and structures through the development of rational architectural and structural solutions, the use of modern building and insulation materials, compliance with advanced energy-saving construction technologies to eliminate heat energy losses and maximizing the use of natural light (realizing the concept of a “passive house”; providing constructed and reconstructed buildings with modern engineering systems, including ventilation with heat recovery, energy-saving artificial lighting, integrated automation and multi-tariff commercial metering to ensure the efficient use of electric and thermal energy (implementation of the “smart house” concept); optimization of the use of imported fuels with an increase in the efficiency of the use of energy; optimization of fuel delivery routes to reduce the transport component in the cost of its delivery; the search for modern science-based solutions to ensure the production of electric and thermal energy in the Arctic zone with the goal of maximum replacement of imported fuel [16-17].
4. Discussion
In these conditions, the most rational solution is the development of comprehensive government support measures for the introduction and development of the best affordable technologies for autonomous energy supply to consumers in the decentralized electricity supply zone, which should be based on the combined socio-economic effect of using these technologies and reducing cross-subsidization for the long term in the implementation framework unified state energy policy.

In order to further consider various categories of consumers and the corresponding energy supply technologies, we will differentiate and conditionally distinguish the following three main groups of consumers in the decentralized power supply zone:

- Enterprises for the production of hydrocarbons;
- Mining enterprises;
- Large seaports of the Northern Sea Route;
- Offshore oil and gas fields;
- Small settlements (towns, villages, villages and others);
- Military facilities.

Consistent with consumer groups, the existing and most promising types of energy supply sources, which can be considered to solve energy problems and meet the needs of the development of the economy of the Arctic zone, were also conditionally divided into three main groups:

- Power plants using fossil fuels (gas, oil, coal);
- Nuclear power plants of low power (AFMM), including floating ones;
- Hybrid complexes based on a combination of fossil fuels and renewable energy sources (solar, wind energy and small hydro), renewable energy sources in combination with high-capacity drives, fuel cells and other small generating sources.

5. Conclusion
Sources and power supply schemes of these consumers must be selected in accordance with the schedule of electric and heat load of consumers, the magnitude of electric and heat consumption, and the reliability categories of electric and heat supply, the possibility of rational management of demand for electric and thermal energy, as well as long-term goals of economic activity of consumers. Particular attention should be paid to the location of the source of electric energy generation, which in the Arctic zone should be as close as possible to the center of energy consumption and the possibility of combined generation of electric and thermal energy.

References
[1] Alpidovskaya M L, Gryaznova A G and Sokolov D P 2018 Regress Economy Vs Progress Economy: “Alternatives Of Senses” Advances in Intelligent Systems and Computing 622 638-46
[2] Repnikova V M, Bykova O N, Skryabin O O, Morkovkin D E and Novak L V 2019 Strategic aspects of innovative development of entrepreneurial entities in modern conditions International Journal of Engineering and Advanced Technology 8(4) 32-5
[3] Sorokin D E 2015 Economic theory, economic reality and economic policy Economy of region 1(1) 17-29
[4] Russian statistical yearbook 2018 (Moscow: Rosstat) 694
[5] Shumaev V A, Morkovkin D E, Nikonorova A V, Nezamaikin, V N and Yurzinova I L 2018 Innovative aspects of agrotourism project management SERVE 2017, Financial and Economic Tools Used in the World Hospitality Industry - Proceedings of the 5th International Conference on Management and Technology in Knowledge, Service, Tourism and Hospitality 241-8
[6] Ministry of Energy of the Russian Federation Retrieved from: https://minenergo.gov.ru
[7] Ivanova I A et al 2019 J. Phys.: Conf. Ser. 1399 033038
[8] Lopatkin D S et al 2019 J. Phys.: Conf. Ser. 1399 033061
[9] Energy Strategy of Russia until 2035 Retrieved from: https://minenergo.gov.ru/node/1920
[10] Tolkachev S A et al 2020 IOP Conf. Ser.: Earth Environ. Sci. 421 032041
[11] Dudin M N, Zasko V N, DONTSOVA O I and Osokina I V 2020 The energy politics of the European union and the possibility to implement it in post-soviet states International Journal of Energy Economics and Policy 10(2) 409-16
[12] Rudaya I L 2019 Issues of strategic management of Russian innovative organizations’ intellectual property Upravlenie 7 1 50-9
[13] Sadriddinov M I, Mezina T V, Morkovkin D E, Romanova Ju A and Gibadullin A A 2020 Assessment of technological development and economic sustainability of domestic industry in modern conditions IOP Conference Series: Materials Science and Engineering 734 012051
[14] Ustyuzhanina E V, Evsukov S G, Ustyuzhanin V L and Novikova E S 2019 The distribution of economic rent within global value chains in resource management International Journal of Supply Chain Management 8(6) 1018-26
[15] Yuryeva A A et al 2019 J. Phys.: Conf. Ser. 1399 033099
[16] Morkovkin D, Lopatkin D, Sadriddinov M, Shushunova T, Gibadullin A and Golikova O 2020 Assessment of innovation activity in the countries of the world E3S Web of Conferences 157 04015
[17] Pulyaeva V N et al 2019 IOP Conf. Ser.: Mater. Sci. Eng. 537 042033