THE EXPERIENCE AND PROSPECTIVE USE OF ALTERNATIVE ENERGY SOURCES FOR THE DEVELOPMENT OF THE REMOTE HUMAN SETTLEMENTS OF THE MURMANSK REGION

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Abstract. The experience and prospects for the use of alternative energy sources for the development of remote settlements in the Murmansk region have been considered in the paper. The Murmansk region which is located in the Far North of the Russian Federation has a sufficient number of traditional power generators. The region is energy-rich and exports energy to other regions of Russia and abroad. At the same time, the authors draw attention to the fact that traditional power sources are often not able to ensure widespread and inexpensive availability of electricity, especially in some remote rural settlements. Therefore, projects of supplying these territories from traditional power sources of generation and distribution of energy are inexpedient. The only way out in this case is alternative power engineering. Main advantages of alternative power generators are as follows. Firstly, the generators are located locally and do not require some developed system of power distribution. Secondly, there is low risk of the environment caused harm. In the present article, the authors consider the experience of using alternative energy sources in the Murmansk region: wind energy, solar energy, kinetic energy of water, tidal energy. The prospects for using alternative energy sources in the Murmansk region for providing energy to rural areas have been assessed. The opportunities for using alternative energy sources in the Murmansk region have been considered as well. The authors have concluded that the possibilities and prospects for the development of alternative power engineering exist. It has been proven that the best result for the development of remote and sparsely populated settlements can be provided by power generation using such alternative power sources as wind and solar generators.

Keywords: remote settlements, Murmansk region, alternative power engineering, wind generators, solar batteries.

Introduction

Social justice requires an equivalent supplying with energy to all the inhabitants of a country, regardless of regional possibilities for power production and delivery. The problem of ensuring regular and relatively inexpensive access to energy is primarily faced by remote and sparsely populated settlements, including ones located in the Far North. In this regard, the presented research is particularly relevant.

Traditional power sources even in energy-rich regions are often unable to ensure the availability of energy for any human settlement. This is due to two groups of reasons. Objective reasons are caused by remoteness and difficulty of access of some settlements, as well as a small number of human settlements in the Far North. Therefore, projects of supplying these territories from traditional power sources of generation and distribution of energy are inexpedient. Subjective ones are related to the lack of management of northern territories. Regardless of the reasons, the population of some remote settlements cannot receive energy from traditional power sources. This prevents the development of remote settlements. In this regard, the role of alternative power engineering is growing.

Alternative power engineering is a set of promising ways of obtaining power from renewable power sources. Alternative power generators are not as widely distributed as traditional ones, but they are of particular interest [1]. Directions of sources of alternative energy are presented at Figure 1.

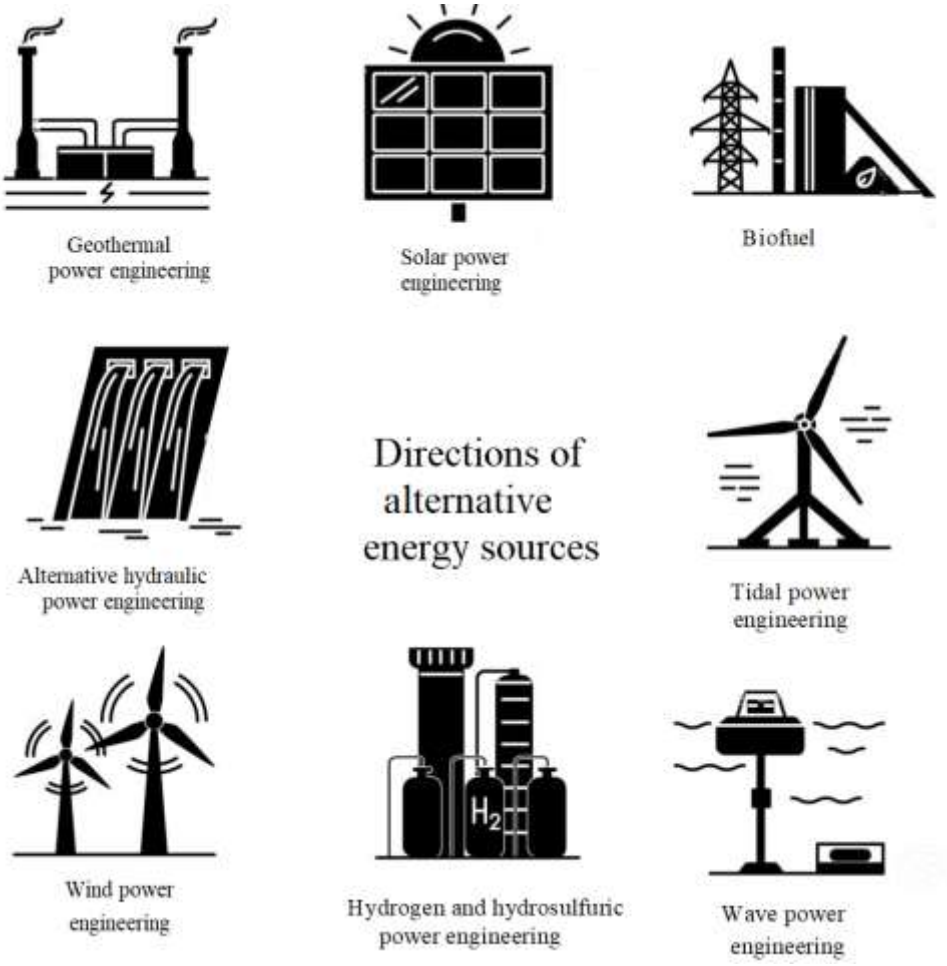

Figure 1: Directions of sources of alternative energy

The main advantages of alternative energy generators are as follows. Firstly, they are located locally and do not require a developed system of power distribution. Secondly, there is low risk of the environment caused harm.

The purpose of this research is to study an experience and assess prospects for the use of alternative power sources for the development of remote human settlements in the Murmansk region.

In order to achieve this aim, it is planned to solve several interrelated problems:

1. To assess possibilities and present the experience of using alternative power sources in the Murmansk region.
2. To develop prospects for the use of alternative energy for the development of remote human settlements in the Murmansk region.

In our research we proceeded from the following hypothesis: there are opportunities and prospects for alternative power use for the development of remote human settlements in the energy-rich Murmansk region.

Materials and methods

The analysis of the literature has shown that the use of various types of alternative energy largely depends on such factors as:

- climatic conditions of the region [2],
- industrial and public energy needs [3; 4],
- technical capabilities [5-7],
- government support [8-10].

In our earlier research, we compared the energy efficiency of economies of different countries in the world. The results of the research have shown that Russian economy has low energy efficiency. [10]. At the same time, the share of energy obtained from alternative power sources is extremely

small. There are enthusiasts among researchers who insist on the fact that alternative power sources can produce a big effect in the modern economy and they need to be implemented as widely as possible [12; 13]. And there are also a number of pessimists, who work in the field of energy and fuel complex and argue that alternative power sources are not very promising for Russia. Doubts concerning economic efficiency of introducing alternative energy sources are mainly as follows: Russia has a powerful energy potential, which is constantly replenished with traditional energy sources. First of all, these are nuclear power plants and powerful hydroelectric power plants. As a result, alternative power engineering is used not enough [14; 15]. It is even more interesting to study the experience of some regions successfully realizing alternative power projects.

The research has been carried out on the Murmansk region material. The region is located in the Far North Zone beyond the bounds of the Polar circle in the northwest of Russia. In the West Murmansk region has a lengthy boundary with Finland and Norway. The population of the region as of 2017 is about 0,75 million people. The population density is 5.23 people / km². Due to the climatic conditions, agriculture is underdeveloped [16; 17]. It is represented by fishing, small poultry, livestock, including reindeer herding. The region has rural areas with small population [18; 19]. The significant part of the population of separated rural settlements are indigenous peoples of the North, leading their traditional nomadic lifestyle [20; 21]. The centralized supply of electric power to separated rural areas is difficult due to a number of objective (remoteness and inaccessibility of settlements, harsh climate, swampy soil) reasons and subjective (local authorities are lack of financial resources and managerial skills) ones. Murmansk region has a very powerful energy system of traditional energy sources. It is based on the Kola nuclear power plant and 17 hydroelectric power plants.

Power generation in the energy system of the Murmansk region for 2016 amounted to 17.0 billion kWh and electricity consumption amounted to 12.3 billion kWh. Thus, Murmansk region had the opportunity to export 4.7 billion kWh of electricity. This suggests that the region has energy in excess. The high-voltage network ties together all power plants for working under a single centralized control. The power system of the Murmansk region is connected by the high-voltage network with interregional united power system of the North-West of Russia. The energy system of the Murmansk region has access to the power systems of Norway and Finland as well. The electric power is exported to these countries. The problem of electrical power engineering in the Murmansk region is the underdevelopment and carrying capacity of electrical energy distribution network.

Thus, at present the following conditions exist in the Murmansk region:

- surplus power generation for the region;
- reduction of domestic electric power demand;
- availability of remote human settlements, the centralized electric power supply in which is difficult because of a number of subjective and objective reasons.

The prevailing conditions dictate the need for the development of traditional power sources and the electric power distribution network. At the same time it is possible to use alternative power sources in areas where the expansion of the centralized energy supply zone is difficult because of extreme remoteness and insignificant energy load of human settlements.

Results and discussion

Now we will evaluate the possibilities of alternative power sources use in the Murmansk region.

1. Solar energy use. In the conditions of the Far North, use of solar batteries is hampered by the fact that in winter when power demand is largest, solar energy supply is minimal. Northern natural conditions are such that there are few sunny days even in summer. So, nowadays, practically only small objects (lighthouses, buoys, etc.) use solar energy because traditional power supply schemes are very expensive.

2. Wind energy using. Wind generators are used for converting kinetic wind energy into electrical one. The technical wind resources in the area under investigation can give about 360 billion kWh. Natural conditions on the northern coast of the Kola Peninsula are characterized by consistently strong wind, which average annual speed is about 8 meters per second [22].

The region has a positive experience in the use of alternative generators of electricity to supply remote settlements. In some settlements of the Terek district, integrated wind-solar-diesel power stations are used. The structure of such a complex power plant includes two traditional diesel generators. But at the same time, the station was supplemented with four wind generators and sixty solar panels. Thus, northern weather conditions are used in a comprehensive manner: constant strong winds and a summer polar day. Remote rural settlements of the Murmansk region did not have any centralized around-the-clock power supply until integrated wind-solar-diesel power stations were installed. The power was generated by diesel generator sets and fuel for them was provided from the regional budget. The use of alternative power sources has already significantly saved financial resources: before the project was realized, more than 300 tons of diesel fuel were supplied every year to remote communities for power supply, and at present only 140 tons are imported.

3. The use of energy of small rivers in the Murmansk region has potential for development as well. The experience in using hydropower of small rivers in the Murmansk region is available. In the 1940-50-s, several rural small hydropower plants with a capacity of 10 to 100 kW were built in the area. Later, they were driven out by cheaper diesel plants. Currently, due to a significant increase in the price of fossil fuels, interest in power of small rivers using has increased significantly. According to experts' opinions, water power resources of small rivers amount to 4.4 billion kWh with 516 MW of average annual capacity. At present, projects for the construction of small hydropower plants with a capacity from 500 kW to 6 MW are studied.

4. The use of tidal energy, and in fact the kinetic energy of the Earth rotation. The first and the only tidal power plant in Russia is located in the Murmansk region. The station is installed in the narrow part of the Kislaya Bay of the Barents Sea, the height of tides in which reaches 5 meters. The power station is 1.7 MW. At present the station is used as an experiment.

In the energy-abundant Murmansk region alternative power sources will not occupy a leading place in the predictable future. However, alternative energy sources may be required in separated settlements where there is no central power supply. Currently, there are more than one hundred such settlements in the region [22]. In addition, with the help of alternative power sources it is possible to supply energy to remotely standing objects (buoys, signal towers, etc.).

The using of wind and solar electric power is especially important for remote settlements in Russia's regions [23]. Wind or solar farms are almost maintenance-free. They do not need constant repairs and adjustment. The replacement of damaged or overage parts, such as panels of photoelectric converters, occurs in the current operating regime.

Heretofore, diesel generators are used in separated human settlements that do not have central energy supply. They need constant delivery of expensive diesel fuel and frequent parts replacement. In addition, waste products, such as barrels from diesel fuel, pollute the environment and need to be removed and recovered. Alternative energy generators do not need any raw materials and do not pollute the environment [2; 3; 24]. It is not necessary to manage alternative energy generators because they are easy operating and can be used for a long time.

This is an indisputable advantage of alternative power engineering over traditional one for rural areas of the Murmansk region.

Conclusions

The hypothesis that in the energy-surplus Murmansk region there are opportunities and prospects for the use of alternative energy for remote human settlements has been confirmed. The research has drawn the following conclusions:

1. Despite the fact that in the predictable future, alternative power sources will not occupy a leading place their use is very promising in the process of power supply of remote human settlements.
2. For the Murmansk area the wind is the most important alternative power source. A complex combination of traditional and alternative energy sources is most promising, allowing the most efficient use of northern weather conditions such as constant strong winds and summer polar days.
3. The advantages of alternative energy generators are the following: they do not need any raw materials and do not pollute the environment. They are easy operating and can be used for a long time.

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References

[1] Samarina V., Skufina T., Samarin A., Ushakov D. Alternative Energy Sources: Opportunities, Experience and Prospects of the Russian Regions in the Context of Global Trends. International Journal of Energy Economics and Policy, vol. 8(2), 2018, pp. 140-147.
[2] Foley J.A., Ramankutty N., Brauman K.A., Cassidy E.S., Gerber J.S. Solutions for a cultivated planet. Nature, vol. 478 (7369), 2011, pp. 337-342.
[3] Epstein A. The Moral Case for Fossil Fuels. New York, Portfolio/Penguin, 2012. 256 p.
[4] Zholobova, Yu.S., Kushchiy, N.A., Savon, D.Yu., Safronov, A.E. Minimization of ecological impact by application of new technologies of coal preparation and mining waste disposal. Gornyi Zhurnal. 2016. № 5. P. 109-112.
[5] Fargione J., Hill J., Tilman D., Polasky S., Hawthorne P. Land clearing and the biofuel carbon debt. Science, vol. 319 (5867), 2008, pp. 1235-1238.
[6] Amer A., Nasim F.ul-H., Batool K., Bibi A. Microbial β-Glucosidase: Sources, Production and Applications. Journal of Applied & Environmental Microbiology, vol. 5(1), 2017, pp. 31-46.
[7] Pittman J.K., Dean A.P., Osundeko O. The potential of sustainable algal biofuel production using wastewater resources. Bioresource Technology, vol. 102, 2011, pp. 17-25.
[8] Reay D.S. Not so sweet after all? Nature Climate Change, vol. 1, 2011, pp. 174-179.
[9] Chevassus-au-Louis, B., Salles, J.-M., Bielsa, S., Richard, D., Martin, G., Pujol, J.-L. Approche économique de la biodiversité et des services liés aux ecosystems: contribution à la décision publique. Rapport du CAS, Paris, 2009. 214 p.
[10] Samarina V.P., Skufina T.P., Baranov S.V. Comparative estimation of power efficiency of countries and world regions. Actual Problems of Economics, vol. 11 (173), 2015. pp. 127-136.
[11] Peshkova, M.K., Savon, D.Y. Mechanism of the government and private business partnership in ecological-and-economic appraisal of mining waste. Gornyi Zhurnal. 2016. № 10. P. 37-41
[12] Sims R. Renewable energy: A response to climate change. Solar Energy, vol. 76, 2004, pp. 9-17.
[13] Northrop R.B., Connor A.N. Ecological Sustainability: Understanding Complex Issues. London: CRC Press, 2016. 548 p.
[14] Hill J., Nelson E., Tilman D., Polasky S., Tiffany D. Environmental, economic, and energetic costs and benefits of biodiesel and ethanol biofuels. Proceedings of the National Academy of Sciences, vol. 103(30), 2006, pp. 11206-11210.
[15] Johnson J.A., Runge C.F., Senauer B., Foley J., Polasky S. Global agriculture and carbon trade-offs. Proceedings of the National Academy of Sciences, vol. 111 (34), 2014, pp. 12342-12347.
[16] Skufina T., Baranov S., Samarina V. Differentiation of Socio-Economical Environment as Factors of Regional Development (The Case Study of Murmansk Region, Russia). Advanced Science Letters, vol. 24, Number 9, September 2018, pp. 6329-6331.
[17] Baranov S., Skufina T., Samarina V. Regional Environment for Gross Domestic Product Formation (The Case of Russia Northern Regions). Advanced Science Letters, Volume 24, Number 9, September 2018, pp. 6335-6338.
[18] Samarina, V. P., Skufina, T. P., Samarin, A. V. Russia's North Regions as Frontier Territories: Demographic Indicators and Management Features. European Research Studies Journal, vol. XXI (3), 2018, pp. 705-716.
[19] Koptseva N. P. The results of theoretical and experimental research of the modern problems of the indigenous small-numbered peoples of the North, Siberia and the Far East in Siberian Federal University, Journal of Siberian Federal University, vol. 6, no. 5, 2013, pp 762-772.
[20] Shephard R. J., Rode A. The health consequences of «modernization»: Evidence from circumpolar peoples. Cambridge, Cambridge University Press, 1996. 306 p.
[21] Zamaraeva Ju. S. What are global transformations experienced by the indigenous peoples of the North? Journal of Siberian Federal University, vol. 10, no. 7, 2014, pp 1705-1718.

[22] Sergeev U. Prospects for the mastery of the nontraditional and renewed energy sources in the Kola peninsula (In Russian) [online] [21.07.2019]. Available at: http://www.osatom.ru/mediafiles/u/files/II_reg_forum_2009/Sergeev.pdf.
[23] Russia – International energy data and analysis, 2015. EIA. [online] [21.07.2019]. Available at: https://www.eia.gov/beta/international/analysis.cfm?iso=RUS
[24] Shibu J., Thallada B. Biomass and Biofuels: Advanced Biorefineries for Sustainable Production and Distribution. London: CRC Press, 2015. 392 p.