

The use of digital technologies for the Russian Arctic energy infrastructure assessment

Aleksandr Biev

*The Federal Research Centre «Kola Science Centre of the
Russian Academy of Sciences»
Apatity, Russian Federation*

<https://orcid.org/0000-0002-0076-5906>

Abstract— Despite the predominance in the economic specialization of the Russian Arctic regions of industries, one way or another related to energy, the problem of their fuel and energy supply, as a special category of consumers of the domestic energy market, still retains its high relevance. The aim of the study was to identify current trends in transport, logistics and energy subsystems on the basis of data obtained with the help of digital technologies. To achieve this goal, information tools for spatial data placement, in particular, geographic information systems (GIS) are used. The research methodology is based on the territorial-sectoral approach. Investment digital maps and regional registers of investment projects made on the basis of "Investor" GIS class are used as an information base of the study. The main directions of further formation of transport and energy subsystems in the Arctic as part of the national transport and energy complexes are determined. It is established that the modernization of the Arctic gas transportation complex and territorial gasification have become one of the basic directions of improving regional energy. The practical experience of implementation of transport and energy projects in the Russian Arctic is considered. It is determined that in the processes of formation of the territorial infrastructure of the Arctic regions, a pronounced imbalance of investment support between the programs of development of industrial and municipal energy has been established.

Keywords— *Russian Arctic, fuel supplies, infrastructure, geographic information system, investment, imbalance.*

I. INTRODUCTION

Issues of formation of innovative energy complex have become one of the most relevant areas of technological and socio-economic development in the Arctic zone of Russia (AZ RF) [1]. Particular attention is paid to the potential use of modern digital technologies to promote investment projects and technological competition in the world Arctic [2]. The goal-setting of the complex is based on the state tasks of ensuring raw materials exports, rationalization of domestic transportation of fuel and energy resources, ensuring national transport and energy security. The strategy of its development is outlined by the framework of the concept of a unified Arctic transport system developed since Soviet times. It defines the dominant role of the Northern sea route (NSR) and its transport approaches in the construction of schemes of interregional and transcontinental transport routes [3]. Ensuring the implementation of the concept in its updated version is impossible without further strengthening measures to increase the investment potential of the Arctic regions, and to ensure the formation of the necessary mechanisms for information support of investment activities [4, 5]. The modern agenda includes the development and application of appropriate digital

technologies that can improve the information infrastructure of the energy market. Finally, they will affect the formation of a favorable investment climate, reducing territorial energy threats and improving the quality of life of the local population [6]. The formation of territorial systems for ensuring the Arctic supply of fuel and energy resources corresponds to the framework of the well-known concept of cyclical development of economic, technological and other systems, set out in the works of foreign [7] and Russian scientists [8]. Trends in their changes primarily defined of the number of people living in the region, the level of production in the real sector. At the same time, supply processes in the conditions of the Russian and world Arctic have a number of characteristic features peculiar to sparsely populated areas with insufficient diversification of the economy, transport and infrastructure development [9, 10]. Special recognition at the world level has received the status of the Arctic as a region with the most vulnerable environment affected by human impact [11]. The intensive climatic changes taking place in it, in particular, the growth of average annual temperatures, melting of Arctic ice, the shift to the North of permafrost zones, are becoming a key factor in the expansion of Arctic Maritime navigation zones and the growth of transportation [12].

A special regime of state economic policy has been established for the Arctic regions [13]. The lack of a developed network of communications, engineering, information and digital infrastructure has necessitated the state regulation of socio-economic processes in the Arctic zone of Russia. State participation in the organization of supplies of fuel and energy resources in the Arctic is carried out on the principles of co-financing, involving branches of large Federal energy companies in regional competitive procedures for the selection of suppliers. At the regional level, support is provided for the development and implementation of special digital tools for investment projects that can optimize transport and energy processes in the Russian Arctic.

In Table 1 data have shown on the different types of transport used for the import and distribution of fuel resources in the AZ RF. It is important to note the extremely uneven nature of the development of the Russian Arctic transport complex. Nevertheless, almost all modes of transport are engaged in operations of Arctic fuel supplies. At different stages of deliveries organized on a regular basis, transportation of fuel resources is carried out by railways and by water (sea and inland river transport) routs. For material and technical supply of the temporary camps and settlements located in the isolated industrial areas, and also in special cases at the emergency situations connected with violation of

territorial life support systems functioning, aviation is involved. Road transport is mainly used in the initial and final logistics operations of fuel distribution from oil depots, temporary or seasonal storage points.

TABLE I. THE MAIN METHODS OF DELIVERY AND TYPES OF FUEL RESOURCES DELIVERED TO THE TERRITORY OF THE ARCTIC REGIONS OF RUSSIA (COMPLIED BY THE AUTHOR)

Arctic regions Mode of transport	The Arctic zone of Russia			
	Murmansk Oblast	Nenets AO ^a	Yamalo-Nenets AO ^a	Chukotka AO ^a
Pipe lines	-	Natural gas ^b	Natural gas	Natural gas ^b
Railway transport	Petroleum products, coal, liquefied petroleum gas	-	Petroleum products, coal	-
Ship transport	-	Petroleum products, coal	Petroleum products, coal, liquefied natural gas	Petroleum products, coal
Road transport ^c	-	Petroleum products, coal	Petroleum products, coal	-
Aviation	-	-	-	-

^a. Autonomous Okrug.

^b. The region has an isolated local gas pipeline system.

^c. Road delivery on winter roads and temporary technological roads.

The use of trunk delivery schemes is directly dependent on the degree of transport development of the territories, the availability of local fuel base, local energy production facilities [14]. Supply chains of fuel and energy resources-oil products and coal – dominating in the Arctic provide for the system-forming role of sea and rail transport [15]. The territorial railway infrastructure of the regions of the Central part of Russia, the Far East and the North-West Federal districts ensures the processes of intermediate transit, accumulation and transshipment of the most mass cargoes of the "Northern delivery" - fuel, food, industrial equipment and construction materials. Together with water routs delivery, the railway transport mode in the system of material and technical supply of the Russian Arctic territories is characterized by the greatest length of transport distances [16]. The further development of the transport and economic potential of the Arctic territories, directly related to the implementation of large, investment-intensive infrastructure projects, primarily, such as the Murmansk transport hub, the Northern latitudinal passage and Belkomur, will strengthen the role of the railway communications network in ensuring the transportation of traditional fuel and energy resources in the Russian Arctic.

The main volumes of gas fuel supplies to local consumers from the fields in the Nenets AO, Yamal-Nenets AO and Chukotka AO are carried out by local gas transportation systems. The connection of the Arctic gas transportation complex with the Unified gas supply system of the Russian Federation is carried out through the system of main gas pipelines laid on the territory of the Yamal-Nenets AO. In the Murmansk Oblast gas pipelines infrastructure is completely absent. Nevertheless,

considerable attention is paid to the plans of territorial gasification in all Russian Arctic regions. Over the past two years, a project for the development of a local gas pipeline system in the Chukotka AO has entered the stage of practical implementation. Pilot projects for the construction of modular gas boilers in Murmansk, Arkhangelsk Oblast and the Republic of Karelia have been developed. Preparatory work for the construction of gas pipelines-outlets, a network of inter-settlement gas pipelines in the Arctic regions of the Republic of Sakha (Yakutia) and Republic of Komi is underway. Gasification of the Arctic territories has its priority goal to have a positive impact on the solution of one of the most acute problems of social and economic development – to curb the growth of tariffs in the field of municipal heating and renovation of fixed assets of heat-and-power enterprises.

II. MATERIALS AND METHODS

To achieve the objectives of the study, expert methods of cognition were used. Also the methodology of system analysis, territorial and sectoral approach was applied. The publications of Russian and foreign specialists, geoinformatics data, digital regional investment maps and registers of investment projects of four subjects of the Russian Federation are used as the information base of the research. The following General methods of scientific research are used: induction, deduction, analysis and synthesis. Through the use of these methods, the scientific nature of the work performed is ensured.

III. RESULTS

The use of modern digital technologies, electronic databases to support investment projects, helps to assess the current and future processes of formation of the most important elements of the territorial energy infrastructure. In Table 2 the result of this assessment is presented. Project information is posted on the Internet on the official Websites of regional authorities of the Russian Arctic regions and then captured by GIS applications. Based on the analysis of the "Investor" GIS class data, it is shown that the modernization of the gas transportation complex has become one of the basic directions of improvement of regional energy systems.

TABLE II. THE MAIN DIRECTIONS OF INVESTMENT PROJECTS FOR THE DEVELOPMENT OF ENERGY INFRASTRUCTURE IN THE ARCTIC ZONE OF RUSSIA FOR THE PERIOD UP TO 2025 (COMPILED AND CALCULATED BY THE AUTHOR)

No.	Energy infrastructure development investment projects in the Arctic zone of Russia	
	Content of direction	Share in total funding, %
1	Construction of industrial facilities for oil and gas processing	45.1
2	Development of new oil and gas fields and maintenance of production levels	42.6
3	Construction and reconstruction of objects of gas transportation systems, territorial gasification of housing stock and industrial enterprises	10.2
4	Construction of new power supply, production and transmission facilities	1.1
5	Construction of boilers using biofuel, organization of its production	0.9
6	Reconstruction of the territorial complex of utilities and heating systems	0.1
	<i>For reference, the total amount of financial support for energy investment projects in the Arctic zone of Russia, billion rubles.</i>	3 602.5

The main flow of investments is aimed at ensuring the development of the Arctic oil and gas production and processing industry. Economic growth revealed in the oil and gas extracting and transportation industry, of course, affects the development of plans for the modernization of local energy. In the Arctic and sub-Arctic regions the possibilities of gasification of the territories of municipalities adjacent to the main routes of sea and pipeline gas transportation are being worked out. In the Yamal-Nenets AO, Nenets AO, and Chukotka AO there are state and regional targeted programs for territorial gasification. The indicators of their financing on the scale of all investments attracted to the development of the national gas transportation complex in the Russian Arctic remain insignificant. According to the results of the assessment carried out by the author, the total portfolio of targeted investment projects aimed at the development of Arctic gas transportation systems is more than 367 billion rubles. The share of its financial support is about 10.2% (see line 3 in table 2) of the total volume of all investment projects of energy specialization in the AZ RF. The share of the funds included in these expenses provided for the implementation of programs for the territorial gasification of the Arctic municipalities is estimated at about 0.9% (about 3.14 billion rubles). Such a low share of socially significant investments against the background of huge costs, poured into the deployment of industrial energy systems, gives reason to say that the emergence of large companies engaged in economic activity in the centers of Arctic mining and processing of raw materials, gave insignificant contributes to the creation of positive trends in the modernization of socially important energy subsystems. In the processes of formation of the territorial infrastructure of the Arctic regions, a pronounced imbalance of investment support between the programs for the development of industrial and local municipal energy has been established. In the analytics devoted to the problems of transport and energy infrastructure development in the Arctic, there are expert positions that defend the thesis that the goals of the Arctic "megaprojects" were not initially focused on solving local issues of energy supply [17, 18]. That is why there is no

sufficient reason to expect these to be achieved in the near future. In the end, the most popular projects in socio-economic terms (for example, the project of development of the Shtokman gas condensate field) and, at the same time, the most investment-intensive were not given their further initiation. In order to ensure production activities in new industrial areas, isolated from the centralized supply networks, the fuel and energy base of individual groups of industrial consumers has been established. First of all, they are represented by objects of extractive industries [19]. Thus, there will be no significant changes in the composition of key facilities of the Russian Arctic municipal energy infrastructure, the main schemes of delivery, fuel distribution, sources of supply in the short term. The consistent transformation of the territorial energy sector aimed at achieving industrial development objectives has had a weak impact on the processes of modernization of municipal energy systems. As a result the field of problems associated with fuel and energy provision of socially important consumer groups of the Arctic regions became much bigger.

IV. DISCUSSION

There are some signs that there will be obvious positive changes in the further methodology of energy supply chains development in the Arctic zone of Russia. In the study of practical ways to overcome these problems, it should be noted the unique experience of creating floating nuclear power plants. This is a promising way of innovative development of the regional energy complex, which can significantly change the existing transport schemes of delivery of traditional fuel resources in Arctic. Now it is being implemented.

When referring to traditional energy, it should be noted the importance of increasing the role of large corporations in ensuring regional energy security in the Arctic. To ensure reliable delivery of fuel and energy resources to the local markets of the Arctic regions is becoming a socially important task of the development of local business communities. There are some companies that are involved in these tasks. A markable event for the Murmansk Oblast is the decision of one of the largest Russian companies – NOVATEK – to switch to the scheme of intermediate transshipment of liquefied natural gas (LNG) through the sea terminal near Kildin Island. Gas deliveries along the Northern Sea Route are a part of the implementation of the Company's Yamal LNG Arctic project. The construction of a large gas transmission site a few kilometers to the East of the outlet of the Kola Bay re-opens the discussion of possibility to find the ways of Murmansk Oblast territorial gasification. The implementation of NOVATEK's proposed transport scheme makes prerequisites for the development of programs for the creation of a regional gas chemical complex. The formation of a base for the accumulation of mass, environmentally friendly and cost-effective fuel resources in close proximity to the regional centers of energy consumption is a necessary, but not sufficient condition for the transition of gasification projects in the Arctic region to the practical plane. Nevertheless, the presence of the potential to reduce the production and logistics costs of regional heat supply organizations makes the direction of their gasification quite promising. The implementation of territorial gasification projects can have a positive impact on

the solution of energy problems of socio-economic development in the Arctic zone of Russia.

V. CONCLUSIONS

The modern historical stage of formation of energy systems in the Russian Arctic is characterized by the development of a critical imbalance in the processes of investment support of industry and municipal transport and energy infrastructure. The organizational, economic and technological problems of regional transport complex lead to a steady rise in the cost of fuel resources, the complexity of transport schemes of their delivery, adversely affects the reliability of fuel and energy supply systems in the Russian Arctic zone. The low level of socially significant investments in the territorial energy infrastructure affects the state of related sectors of the regional economy, and also it is one of the reasons for the strengthening of the degradation processes of the General territorial infrastructure. Signs of their manifestation are noted in reduction of a number of key indicators in heating, first of all – municipal. A natural result of these changes was the establishment in the Arctic zone of Russia of the highest national level of energy supply tariffs, the cost of a basic set of consumer services, a high proportion of household expenditures directed to pay utility bills. Further continuation of these processes leads to an increase in energy threats to Russia's economic presence in the strategically important Arctic macro region, an aggravation of social tension and a deterioration in the quality of life of the people living here, a reduction in the population of the Arctic territories, a decrease in territorial production and energy potential.

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