

Article

Analysis of the Interconnected Development Potential of the Oil, Gas and Transport Industries in the Russian Arctic

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Abstract: This article describes the hydrocarbon reserves in the oil and gas provinces of Russia's Arctic territory, as well as specific features of the region's raw hydrocarbon potential. It has been noted that the implementation of Arctic hydrocarbon-associated projects requires that a unified transport and logistics system be created, with the Northern Sea Route being the basis. The factors affecting the volume of cargo transportation along the Arctic routes are presented. It has been established that the hydrocarbon extraction and liquefied natural gas production in the Russian Arctic zone is the most important factor in the formation of cargo flows along the Northern Sea Route. The most significant oil and gas projects that comprise the bulk of freight traffic flow along the Arctic transportation corridors have been reviewed. The ports, as the main element of the Arctic transport system, are described in terms of their state and infrastructure. It has been indicated that the construction, modernization, and operation of the Arctic ports are closely related to the creation of long-distance railway corridors, and the construction of new railway lines leading to the Arctic Basin ports can serve as a reliable basis for the growth of the Northern Sea Route's cargo potential. A conclusion has been drawn about the special significance of the Murmansk region for the formation of the Arctic transport system.

Keywords: Arctic; oil and gas industry; shelf; transport and logistics system; Northern Sea Route

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1. Introduction

Russia's raw hydrocarbon potential is described by specific features such as regional uneven development, underdevelopment of infrastructure in promising production areas, and the accumulation of significant oil and gas volumes in the offshore areas.

The recoverable oil and gas reserves in the Arctic exceed 245 billion tons of standard fuel [1,2]. Currently, we know 25 deposits on the Arctic shelf of Russia, located in the Barents and Kara Seas. Recoverable commercial reserves in these fields are estimated at 430 million tons of oil and 8.5 trillion cubic meters of natural gas. About 85% of these reserves are concentrated in the West Siberian, Timan-Pechora, and Barents-Kara oil and gas provinces, while the main share of the reserves (161.7 billion tons of standard fuel) falls on the West Siberian province [3].

In the context of the depletion of hydrocarbon reserves in traditional onshore production regions and taking into account the strategic importance of these natural resources for Russia, it becomes necessary to develop deposits in new regions with a complex geological structure, in particular, in the territories of Russia's Arctic territory [4]. It should be noted that at present, the development of fields in the Russian Arctic, including the continental shelf, is one of the most relevant areas for the development of the Russian oil and gas complex [5]. The Western Arctic shelf of Russia today can be considered a very promising area for the preparation of the resource base since more than 70% of the hydrocarbon potential of the Arctic shelf is concentrated within the Kara and Barents Seas, while the share of natural gas in total resources reaches 90% [2].

The development of large oil and gas fields in the Arctic zone of Russia and the waters of the Arctic Ocean can serve as a factor in a significant increase in the gross regional product of the Arctic regions of the country and an incentive for a multiplier effect in the Russian economy as a whole. According to the Federal State Statistics Service of Russia, the share of the gross regional product produced in the Arctic zone in the total gross regional product of the constituent entities of the Russian Federation increased from 5% in 2014 to 6.2% in 2021 [6].

The development of the Arctic fields can become a catalyst for the modernization of the oil and gas industry for Russia. After the introduction in 2014 of economic sanctions aimed at limiting the transfer of technologies for the development of oil and gas fields in the Arctic, large mining companies began to master qualitatively new technologies, closing the gap with other Arctic states.

To revitalize the activities of oil and gas companies in the Arctic zone, the issues of procurement, transportation, and processing of extracted raw hydrocarbons should be solved, and regional infrastructures should be created. Thus, stable economic ties of the newly created oil and gas industry with other sectors of the economy arise. The volume of cargo shipped to the Arctic regions by water transport increased from 16,531.6 thousand tons in 2000 to 25479.7 thousand tons in 2021. The most significant growth was shown by the volume of liquid cargo transported by sea—from 440.1 thousand tons in 2000 to 4466.2 thousand tons in 2021 [6]. Consequently, the transport sector performs an important function in the development of the Arctic regions, being a tool for the implementation of national and regional economic interests and allowing the delivery of products and raw materials to markets. A transport system in this region should be developed given that one transport highway can serve as a basis for more than one deposit [7]. In this context, the oil and gas industry in the Russian Arctic and the regional transport system can form the basis for a common transport and logistics infrastructure, which, in its turn, can become a source of strategic resources for the development of the Arctic zone.

Improving the efficiency of the industrial development of the Arctic regions, as well as the level of their socio-economic development, is the most important goal of the “Strategy for the Development of the Arctic Zone of the Russian Federation and Ensuring National Security for the period up to 2035” [8]. A unified transport and logistics system created in the Arctic zone, capable of becoming an effective tool for achieving the goal, should include the following:

- The Northern Sea Route (NSR) is a historically established transport communication of a national scale, which runs along the seas of the Arctic and Pacific Oceans.
- The set of vehicles, including railway, pipeline transport, aviation, sea, and river fleet facilities.
- The coastal infrastructure—ports and means of navigation and hydrographic and meteorological support.

The presence of an efficiently functioning transport infrastructure in the Russian Arctic makes it possible to solve the following strategic tasks:

1. Improving the efficiency of the Russian transport system. The development of Arctic hydrocarbon fields plays a very important role in ensuring the domestic consumption of energy resources in Russia and their export. The solution to this problem is possible only in the presence and continuous operation of transport networks throughout the region with access to the transport communications of Russia and the world. This requires the implementation of comprehensive infrastructure projects to modernize the existing transport infrastructure, which is part of the system of international transport corridors and the construction of new sea terminals.
2. Switching of export flows to Russian ports in order to reduce the risks associated with the introduction of economic sanctions. The solution to the problems of transportation of strategic energy carriers can be carried out through the development of

sea and rail transport, coordinated with the development of the pipeline infrastructure.

3. Implementation of the regional socio-economic potential of individual territories. For the Arctic zone, the presence of developed transport infrastructure makes it possible to ensure the influx of continuous flows of raw materials, materials, and finished products, which will contribute to the further development of extractive industries.
4. Formation of large competitive macro-regions. Solving the issues of developing the regions of the Arctic zone, which have significant reserves of minerals, in particular oil and gas, requires not only the construction of mining and processing enterprises but also the creation of an appropriate infrastructure to ensure their effective operation.
5. Creation of conditions favorable for human life. The presence of a developed transport infrastructure that provides communications with the territory of the entire country makes it possible to solve the problems of optimizing settlement in the territories being developed. Ensuring all-season transport accessibility contributes to the emergence of new settlements and industrial facilities and, in the future, to minimizing the use of the rotational method of mining.

Taking into account the peculiarities of the Arctic climate and the presence of vast undeveloped territories, it can be noted that a unified logistics system, built by combining the mainland and port infrastructure, should be based on key transport infrastructure projects in the region. A scientifically based, competent combination of such projects in space and time will be able to provide a new quality of logistics in the Arctic regions of Russia.

2. Literature Review

Over the past decade, the pace of study of the northern and Arctic territories has been growing rapidly. Theoretical and practical issues of the development of the Russian Arctic are most effectively worked out in the research of scientists at the St. Petersburg Mining University, the Kola Scientific Center of the Russian Academy of Sciences, and Moscow State University.

The problems of developing oil and gas fields on the Russian Arctic shelf are reflected in scientific publications of many researchers; however, special attention should be paid to the works of A.E. Cherepovitsyn, A.M. Fadeev, and V.A. Zuckerman [1,7,9,10], which are dedicated to the strategic management of the oil and gas complex in the Russian Arctic. The authors note that the formation and development of production and transport infrastructure in the Arctic-producing regions is a necessary condition for the effective development of shelf fields and is an important component of state policy aimed at developing the oil and gas complex as a driver for the economic development of a new producing region. In [7,10], the authors prove that the Kola Peninsula is the most promising base region for locating logistics enterprises for the operation of fields and transportation of oil and gas.

The factors of innovative development of the Arctic regions and the issues of import substitution in the development of offshore oil and gas fields are reflected in the works of Yu.P. Ampilov [11], S.A. Berezikov [12], T.V. Ponomarenko [13], V.S. Zharov [14,15]. In particular, Yu.P. Ampilov raises the problem of significant dependence on the processes of geological exploration and production of hydrocarbons in the Arctic zone on foreign technologies and equipment, which is significantly aggravated by conditions of sanctions. In addition, the author analyzes the situation that has developed in the markets for hydrocarbon products in connection with the current political situation and predicts a reorientation of oil and gas cargo flows from the European to Asian direction. It should be noted that Yu.P. Ampilov calls into question the large-scale implementation of offshore oil and gas projects in the Arctic in the near future [11]. V.S. Zharov [14,15] concludes that the innovative activity of companies developing Arctic deposits is extremely low. The

author emphasizes that without the necessary technological modernization, it is impossible to achieve the planned growth rates in production, which, in turn, will adversely affect the dynamics of cargo traffic along the Arctic transport corridors.

The main direction of the scientific activity of E.A. Korczak [16], T.P. Skufina, E.E. Emelyanova [17], and I.G. Gerasimova [18] is the solution to the problems of the socio-economic development of the Arctic territories.

T.P. Skufina and E.E. Emelyanova note that the share of transport services in the gross regional product of the Arctic zone of Russia since 2002 has remained consistently high—8%, with the average Russian level of 8.2% [17]. However, the authors emphasize that the extreme nature of natural and climatic conditions, vast territories, the direction and nature of historically established territorial and economic relations, and the peculiarities of settlement [17] seriously complicate and increase the cost of the formation of a unified Arctic transport system, increase the level of transport discrimination of the population, lead to the deterioration of the technical condition of the infrastructure and vehicles, and impose a number of restrictions on the use of certain modes of transport. For example, the activity of river transport is limited by a short navigation period (2–4 months), and the construction and operation of roads and railways are extremely difficult in permafrost and severe weather conditions in winter [17]. These problems are especially relevant for sparsely populated and hard-to-reach Arctic territories in the eastern sector of the Arctic. The lack of overland transport communication with the rest of the country in this area determines the multiple links and non-alternative nature of transport service schemes [17].

N.A. Serova N.A. and V.A. Serova [19,20] consider the main factors that determine the specifics of the development of transport in the Arctic: they note an insufficient provision of the Arctic zone with land transport communications compared to the average Russian level. The authors point out that with the onset of the global economic crisis, and subsequently the introduction of economic sanctions, funding for a number of Arctic infrastructure projects was reduced or suspended [19]. In particular, the share of investments in the transport industry of the Yamalo-Nenets Autonomous District (YNAD) decreased by 70%. One of the most serious threats to the exploitation of oil and gas fields is the problem of obsolescence of fixed assets of transport organizations—the average level of depreciation in transport is 47%, and depending on the mode of transport—90% [20].

Environmental problems of the implementation of oil and gas projects in the Arctic are considered in the works of N.V. Romasheva, D.M. Dmitrieva, G. Seite et al. [21–24].

The issues of the transport infrastructure formation in the Arctic zone of Russia, as well as the risks associated with extreme conditions for the transportation of hydrocarbon raw materials, are devoted to the works of A.A. Biev [25,26], N.I. Komkov, V.S. Selin [27].

N.I. Komkov, V.S. Selin, V.A. Zuckerman, and E.S. Goryachevskaya [27–29] consider possible scenario forecasts for the development of the NSR. The authors believe that the beginning of the shelf development, especially taking into account the probable climate warming, can lead to the implementation of an optimistic scenario, which provides for an increase in the volume of cargo transportation by 2020 to 25 million tons [27]. According to experts, the Northern Sea Route can become one of the main cargo routes on the globe and can reduce ice cover, which will favor the development of oil production and offshore gas [28]. However, the authors also warn of new risks. Influenced by factors such as rising sea levels, thawing permafrost and increased impact of waves as a result of the expansion of the open area water will further erode coastlines in the Arctic. All this can have dangerous impacts on the entire infrastructure, primarily the port [29], which must be taken into account when modernizing transport infrastructure. It should be noted that the high instability of the considered exogenous factors (the state of global commodity markets, geopolitical relations, and strategies of global corporations) [27,30] does not allow us to identify certain statistical correlations and forces authors to accept extreme expert scenarios, which reduces their reliability.

Zhao Z. et al. [31] note that in an unstable geopolitical situation, the presence of a single energy supply channel, as well as the limitation of energy supply through land transport corridors, can pose a potential threat to the energy security of a country or region. In this regard, the authors emphasize the exceptional importance of creating a maritime transport corridor. Taking the efficiency and reliability of pipeline transport into account, Zhang F. et al. [32] and Rios-Mercado R.Z et al. [33], however, also indicate that when gas is supplied over long distances (in particular, from Russia to Asian markets), it is more cost-effective to transport it in a liquefied state by sea.

Currently, the aggravation of the geopolitical situation, in particular, the tightening of economic sanctions, leads to changes in the structure of world energy transport flows. A number of authors [34,35] consider the influence of political factors on the natural gas market. Mozakka M. believes that for the Russian LNG, the East Asian market will become an alternative to the European market [34]. Richman et al. analyze the place of Russia in the world gas market depending on the state of its relations with the USA and Europe [35] and conclude the inevitability of the reorientation of Russian energy resource flows towards Asian directions.

When transporting cargo over long distances, it often becomes necessary to use a multimodal transportation scheme, i.e., the use of different modes of transport along the route of the cargo. In this regard, Song D. [36] points out the need to organize the coordinated work of the transport infrastructure, in particular, port and railway. The author proposes modeling and routing methods in a multimodal transport network. In addition, the author analyzes ways to model logistics processes in ports with limited capacity. The research of Cheraghchi F et al. [37] is also devoted to a similar topic, in which a mathematical model was developed for compiling optimal ship traffic schedules, taking into account the throughput of the port, the number of loading and unloading terminals, the number of ships, and the state of adjacent land transport communications.

The conducted literature review allows us to conclude that scientific research in the field of the spatial organization of production and transport facilities in the Arctic in the development of hydrocarbon resources is relevant and timely. However, many of the works are clearly focused on solving highly specialized issues.

Thus, many problems in the relationship between the oil and gas and transport industries in the Arctic zone remain unresolved.

3. Research Methods

The study was based mainly on the application of general scientific methods of analysis, synthesis, system analysis, and territorial-branch approach. The methodological basis of the study was the systematization and generalization of the data contained in the publications of specialists in the field of the development of Arctic hydrocarbon deposits and the socio-economic development of the northern territories of Russia. The analysis of a thematic sample of scientific publications registered in the scientometric databases Scopus and RSCI, as well as regulatory legal acts of the Russian Federation made it possible to formulate tasks that could be solved by an effectively functioning unified transport and logistics system of the Russian Arctic.

The information base of the study was as follows:

- Natural and cost indicators of the development of the Arctic zone of Russia, presented on the official websites of the Federal State Statistics Service of Russia [6], the Electronic Fund of Legal and Regulatory and Technical Documents [8];
- Data on the functioning of the NSR and the state of its main ports were obtained from the websites of the administration of the NSR, the state corporation Rosatom [38], and governmental authorities' [39,40] public company data.

Using the method of system analysis, the structure of the transport industry of the Arctic zone, the nature of multimodal transport links, and the role of the NSR in the development of the oil and gas industry of the Russian Arctic were studied.

The application of the branch method as an element of the method of economic and geographical research made it possible to study the features of the functioning of the transport and oil and gas industries, taking into account the geographical location of their objects. Features of the NSR track and the location of its most important ports are presented cartographically.

To assess the closeness of the relationship between the processes of implementing projects for the development of oil and gas resources in the Arctic and the intensity of the development of the Northern Sea Route, the following methods of statistical analysis were used:

1. An analysis of the time series, with the help of which the co-direction and coincidence of the nature of the dynamics of the total traffic flow along the NSR and the transportation of oil and gas cargo in the period of 2014–2022 are established. The nature of the dynamics was estimated based on the calculation of chain growth rates for the following indicators: the total traffic flow along the NSR, the total transportation volume of oil and gas cargoes, the transportation volume of oil and oil products, the transportation volume of LNG and gas condensate. Thus, 4 dynamic series were studied, of which each consisted of 9 levels. The chain growth rate for a specific level of the series (t_i) is calculated as follows:

$$t_i = \frac{x_i}{x_{i-1}} \quad (1)$$

where x_i and x_{i-1} are the value of the studied indicator in the current and previous year, respectively.

The results are presented graphically.

2. Correlation analysis made it possible to quantify the closeness of the relationship between the dynamics of the total cargo transportation volume along the NSR and the dynamics of the transportation volume of oil and oil products, LNG, and gas condensate. It has also been established that there is a connection between the dynamics of cargo transportation along the NSR and the dynamics of oil production and LNG production in the Russian Arctic zone. Based on the actual information of the Federal State Statistics Service of Russia, the NSR administration, and the State Atomic Corporation *Rosatom*, during the study, the pair correlation coefficients were calculated between the total traffic flow along the NSR from 2014 to 2022 and the following:
 - The transportation volume of oil and gas cargoes for the same period.
 - The oil production in the Russian Arctic zone from 2014 to 2022.
 - The gas production in the Russian Arctic zone from 2014 to 2022.
 - LNG production in the Russian Arctic zone from 2017 to 2022.

To obtain the result, the following formula for calculating the coefficient of the pair correlation between features X and Y was used:

$$r_{xy} = \frac{\sum_{i=1}^n (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^n (x_i - \bar{x})^2 \sum_{i=1}^n (y_i - \bar{y})^2}} \quad (2)$$

where x_i and y_i are variable values, and \bar{x} and \bar{y} are, accordingly, the arithmetic mean values of the indicators between which the relationship is established for the period under consideration.

The integrated use of these methods made it possible to ensure the reliability and validity of the conclusions.

4. Results and Discussion

In the Arctic zone of Russia, the transportation of goods is carried out using water, rail, air, and road transport. In modern geopolitical conditions, ensuring the interests of the country on sea routes is of particular importance for the sustainable development of

the Russian Arctic. At the same time, these water communications should be effectively interconnected with the routes of other modes of transport on the coast. Large Russian rivers flowing into the Arctic Ocean can become the main transport corridors both from the interior of Russia to the NSR and in the opposite direction, since the Ob, Yenisei, and Lena provide effective logistical opportunities for cargo transportation from the ports of the NSR to the interior regions of Russia, contributing to the further industrial development. To ensure domestic, import-export traffic and regular international transit navigation along the NSR, deep-water ports with modern logistics and services based on digitalization, as well as having multimodal transport links with transport (river, road, and rail) ways are needed countries (or construction of such a connection is planned) [41,42].

To ensure the growth of mining, as well as the creation of processing and service enterprises, it is necessary to solve the problem of their sustainable year-round transport accessibility in order to organize an uninterrupted supply of these companies. This is also important to ensure modern living conditions and the socio-economic development of the Arctic regions.

At the same time, the functioning of transport in the Arctic is subject to the influence of a number of objective factors that create significant restrictions on its development. These include the extreme climate nature, the natural environment's vulnerability, and the scale and remoteness of the Arctic territories [43]. The influence of these factors determines the seasonality of the use of certain transport modes, increases the cost of operating the transport infrastructure, and significantly increases transport costs, thereby complicating the task of providing the Arctic territories with vital products and reducing the competitiveness of local producers of goods and services.

The Northern Sea Route (NSR) is the basis of the transport and logistics system of the Arctic zone of Russia (Figure 1). It also comprises railway communications, the road system, and airports. Navigation, hydrographic and meteorological services, communication facilities, and port facilities shape the coastal infrastructure.

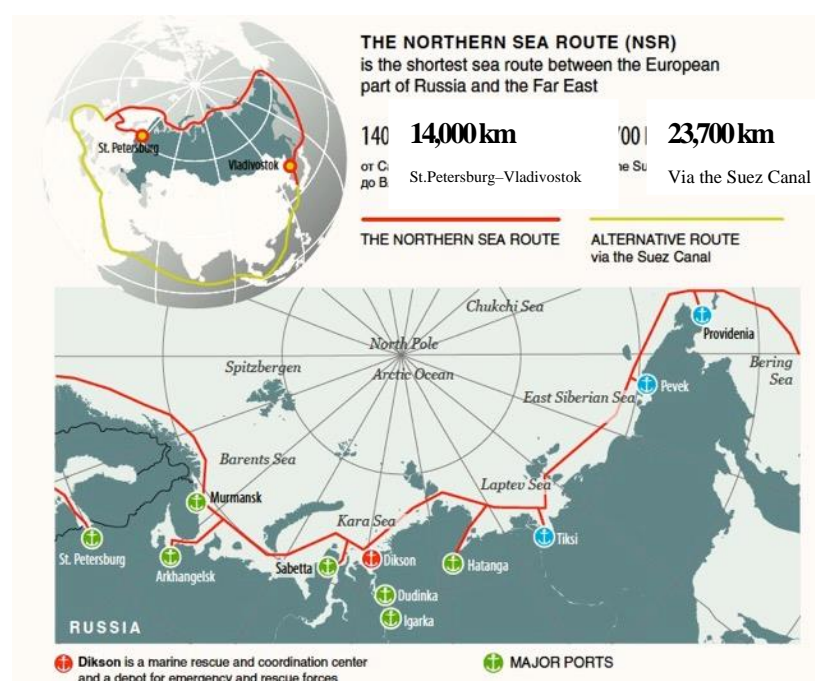


Figure 1. The line and main ports of the Northern Sea Route. Source: The NSR administration website [44].

The freight traffic flow along the NSR depends on many contradictory objective and subjective factors, such as the following: complex and changeable natural and climatic conditions; the state of the world hydrocarbons markets; the geopolitical situation; pricing

policy of the producing and shipping companies; the intensity and results of geological exploration in the Arctic waters; requirements for environmental safety; and the state of the icebreaker and tanker fleet as well as the port's infrastructure [27].

The ongoing climate change is very important for the development of transportation. Significant reduction in Arctic ice and degradation of permafrost is widely considered in a number of scientific papers [45–48]. The analysis shows that between 1980 and 2010, the area of sea ice decreased by 10–15% [49–51]. The works [42,52] have noted a sharp decrease in perennial ice. Thus, in 2008, the unprecedented melting of the Arctic ice reduced the area of the ice cover to 1 million km², for the first time temporarily clearing the ice and opening the Northern Sea Route for non-ice-breaking ships.

Studies show that by 2030, the NSR waterways will be ice-free for six months a year [51], and the ice cover area will decrease significantly (Figure 2). An increase in the navigation period along the NSR entails a lengthening of the period of navigation on river transport as well [42]. Thus, global warming makes the NSR a very promising commercial route.

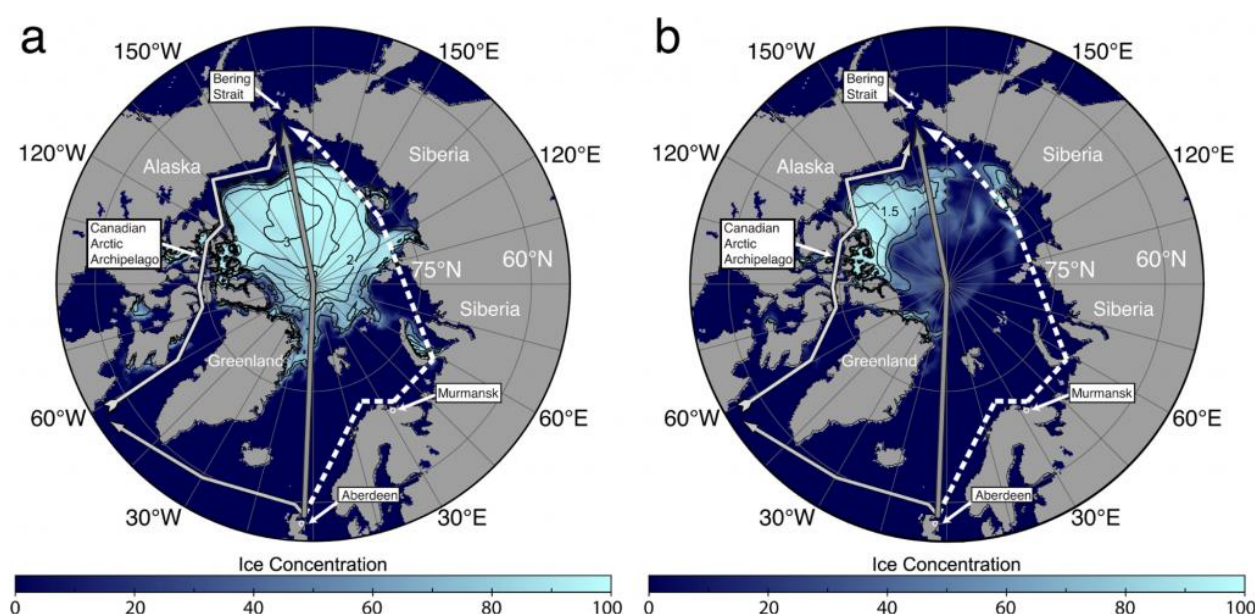


Figure 2. Model 2010–2019 (a) and 2030–2039 (b) sea ice concentration (%; shades of blue) and thickness (indicated contours) during the navigation period (June–October), according to the RCP 8.5 NEMO forecast. Source: [53]. Note that this figure shows the Arctic shipping routes: NSR (dashed arrow), Central Northern Passage (dark gray arrow), and Northwest Passage (light gray arrow).

As a result of the release of the ice cover of more and more of the Arctic Ocean, its water areas are becoming more accessible not only for navigation but also for exploration and the development of oil and gas fields. In particular, as a result of increasing the volume of geological exploration in the Norwegian section of the Barents Sea shelf (Figure 3), 3 large gas fields have been discovered over the past 30 years. According to the Norwegian Ministry of Oil and Energy, in 1984, the large Snøhvit field was discovered with gas reserves of 251.38 million m³ (in 2000—Goliat (31.36 million m³) and in 2011—Johan Castberg (88.9 million m³)) [54].

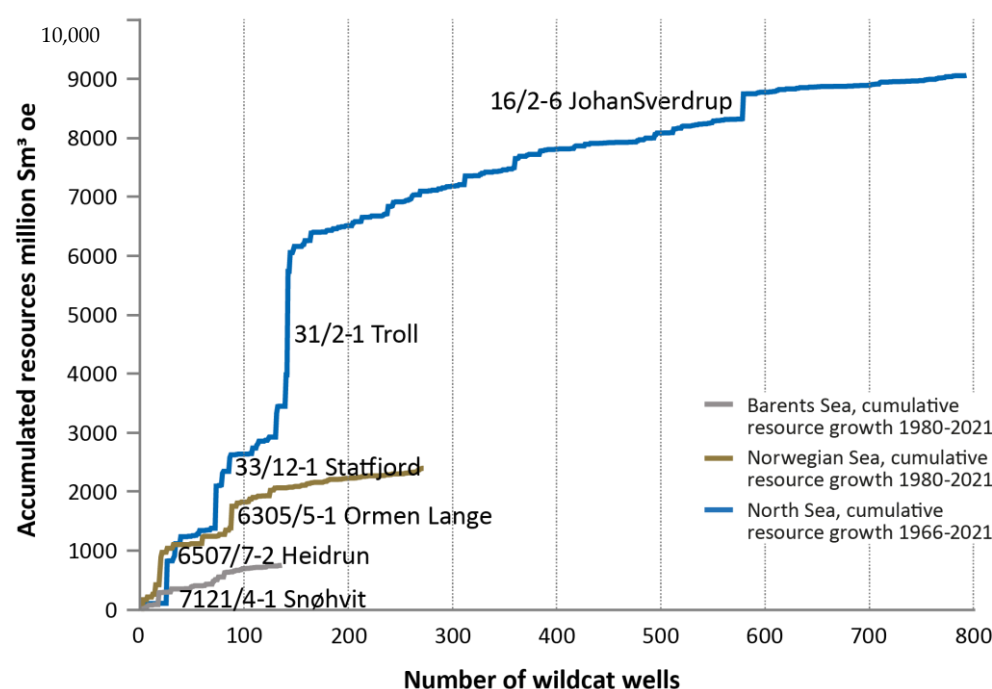


Figure 3. Volumes of explored gas reserves in offshore fields in Norway. Source: [54].

In the long term, climate warming may cause a global restructuring of trade flows. It should be noted that one of the significant advantages of the NSR is a significant reduction in transportation time. Thus, the maritime part of the cargo transportation chain between East Asia and Western Europe is reduced from 21,000 km to 12,800 km, which reduces the time of cargo transportation by an average of 10–15 days [55]. For example, according to experts, it takes 37 days to transport cargo from Kirkenes and Murmansk to Shanghai via the Suez Canal (12,050 miles) at a speed of 14 knots. The NSR reduces the distance to 6670 miles and travel time to 22 days at a speed of 12.9 knots, which gives a saving of 15 days (excluding the effect of ice conditions on the speed of ships) [51].

The scheme for transporting Russian LNG through the Suez Canal provides for the delivery of the product to the transshipment terminal in Murmansk by ice-class tankers, subsequently reloading the product into standard LNG tankers and shipping it to the Asian region. When LNG is transported eastward along the NSR, LNG will be reloaded from ice-class tankers to standard tankers in Kamchatka. The construction of terminals in Murmansk and Kamchatka is carried out by NOVATEK. Characteristics and locations of the terminals are presented in Table 1 and Figure 4.

Table 1. Parameters of the transshipment terminals.

| Parameters of the Terminals | Murmansk | Kamchatka Peninsula |
|---|---|---|
| Properties of offshore transshipment facility | 20 mln t | 20 mln t, 500 ship entries |
| Location | Ura Bay (40 km from Murmansk, 1000 nautical miles from Sabetta) | Bechevinskaya Bay (100 km from Petropavlovsk-Kamchatsky town, 4000 nautical miles from Sabetta) |
| Concept | 2 vessels—LNG storage, sale under FOB terms is possible | 2 vessels—LNG storage, sale under FOB terms is possible |

Source: OJSC NOVATEK [56].



Figure 4. LNG transshipment terminals. Source: OJSC NOVATEK [56].

Fifteen special tankers were built to supply LNG from the Yamal Peninsula to the Asia-Pacific region. The first such delivery was made in December 2017 using the unique LNG tanker *Christophe de Margerie*. This vessel can navigate all year round unescorted by icebreakers along the Northern Sea Route to the west and during the summer navigation to the east. In this regard, it becomes obvious that the start of LNG supplies via the Northern Sea Route by the Arc7 ice-class vessel is an incentive to intensify cargo transportation and further develop navigation in the NSR water area.

It should be noted that direct access to the Yamal Peninsula and to the NSR is provided through the Gulf of Ob and the Kara Sea. Consequently, by connecting the communications of the NSR and Western Siberia, the transport accessibility of Yamal and the Western Arctic is achieved. The transporting of regionally produced hydrocarbons to the processing and consumption zones would become effective, provided that the marine transport and infrastructure system is fully available. In turn, the development of maritime navigation will entail a further increase in the production and processing of hydrocarbon raw materials in the Arctic zone.

The data in Table 2 and Figure 5 reflect the acceleration in the growth of traffic volumes in the water area of the NSR. The implementation of oil and gas projects in the Arctic region and the rate of development of the Northern Sea Route are closely interrelated. Figure 5 confirms that traffic volumes in the NSR water area have significantly increased due to the intensification of the development of oil and gas fields in the Arctic zone. Due to the fact that from 2005 to 2014 the total volume of cargo transportation along the NSR was generally insignificant, this period is not considered in further analyses. The beginning of the zone of intensive growth in the transportation volume of oil and gas cargoes and, consequently, the total transportation volume in 2017 coincides with the commissioning of the first stage of the gas liquefaction plant as part of the Yamal-LNG project. After the commissioning of the third stage of the plant and reaching its design capacity in 2019, the traffic dynamics stabilize. At the same time, the calculation showed that the pair correlation coefficient between the considered indicators is 0.89; this indicates a close connection. The value of the correlation coefficient was obtained by Formula (2) based on the actual material presented in Table 2 and Figure 5. The result of applying the graphical method of analysis of relationships also indicates the presence of a direct close relationship between the indicators under consideration.

Table 2. The NSR traffic flow from 2005 to 2022.

| Year | The Traffic Flow, mln t | Chain Index | Year | The Traffic Flow, mln t | Chain Index |
|------|-------------------------|-------------|------|-------------------------|-------------|
| 2005 | 2.02 | 1.00 | 2014 | 3.98 | 1.02 |
| 2006 | 1.96 | 0.97 | 2015 | 5.43 | 1.36 |
| 2007 | 2.15 | 1.10 | 2016 | 7.48 | 1.38 |
| 2008 | 2.22 | 1.03 | 2017 | 10.76 | 1.44 |
| 2009 | 1.80 | 0.81 | 2018 | 20.18 | 1.88 |
| 2010 | 2.05 | 1.14 | 2019 | 31.53 | 1.56 |
| 2011 | 3.11 | 1.52 | 2020 | 32.97 | 1.046 |
| 2012 | 3.75 | 1.21 | 2021 | 34.85 | 1.057 |
| 2013 | 3.90 | 1.04 | 2022 | 34.03 | 0.976 |

Sources: [38,44,57,58], the author's calculations. Note: The base index in 2022 compared to 2005 is 16.85.

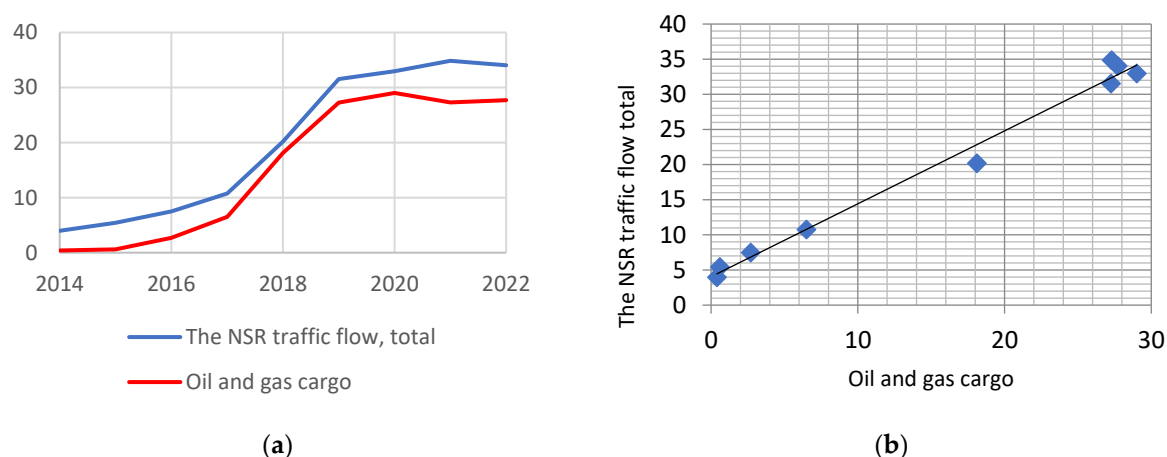


Figure 5. Volumes of oil and gas cargo transportation along the NSR in 2014–2022, mln t. (a) Factual data; (b) Correlation field. Source: compiled by the author according to the data of [6,38,44,57,58].

According to the State Atomic Energy Corporation *Rosatom*, in 2021, the increase in cargo traffic somewhat slowed down, and the volume of traffic amounted to 35 million tons, and the plan at the level of 41 million tons was not fulfilled. There is also an increase in the share of hydrocarbons in the total volume of transportation. So, if in 2017, the share of liquefied natural gas (LNG) in the structure of transportation along the NSR was less than 1%, oil—about 70%, then in 2018, the shares of the oil and LNG amounted to 40% and 42%, respectively; in 2019—27% and 60%, respectively; in 2020—24% and 59%, respectively; and in 2021—22% and 56%, respectively [38].

Figure 6 confirms that since 2017, the share of LNG and gas condensate in the total transportation volume has become predominant, while the share of oil and oil products has steadily remained low.

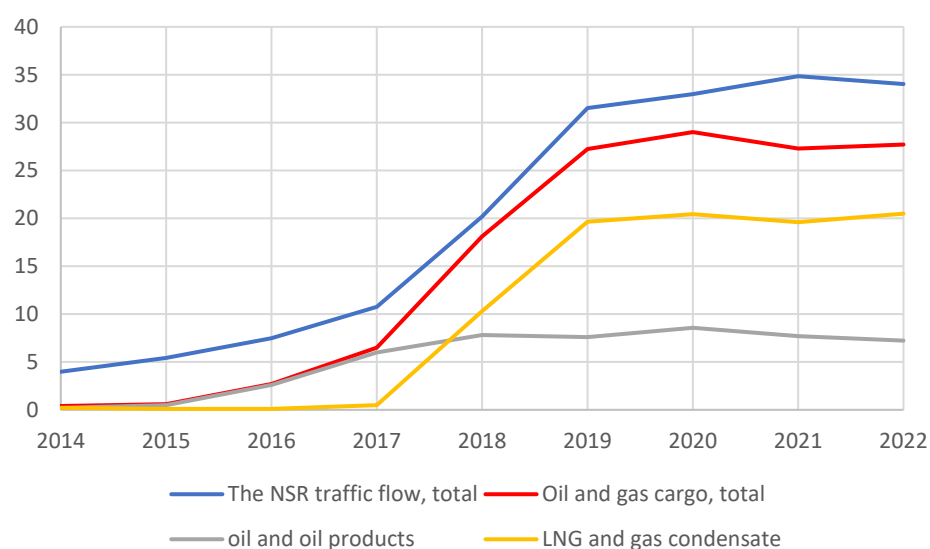


Figure 6. The NSR traffic flow in 2014–2022 by type of cargo, mln t. Source: compiled by the author according to the data of [6,38,44,57,58].

The calculation of chain indices for the time series of the total NSR traffic flow and the transportation volume of oil and gas cargo allows us to determine the nature of the dynamics of these indicators. The calculation results are shown in Figure 7. The dynamics of the total NSR traffic flow should be characterized as intensively growing in 2015–2019 (chain indices range from 1.36 to 1.88) and stable in 2020–2022. The dynamics of oil and gas cargo transportation are pulsating. In the period of 2016–2018, the chain indices of oil and gas cargo transportation are significantly ahead of the chain indices of the total traffic flow, which is associated with the intensification of the implementation of oil and gas projects in the Arctic. Since 2019, the chain indices of both indicators are the same since the share of oil and gas cargo reaches 90% of the total transportation volume.

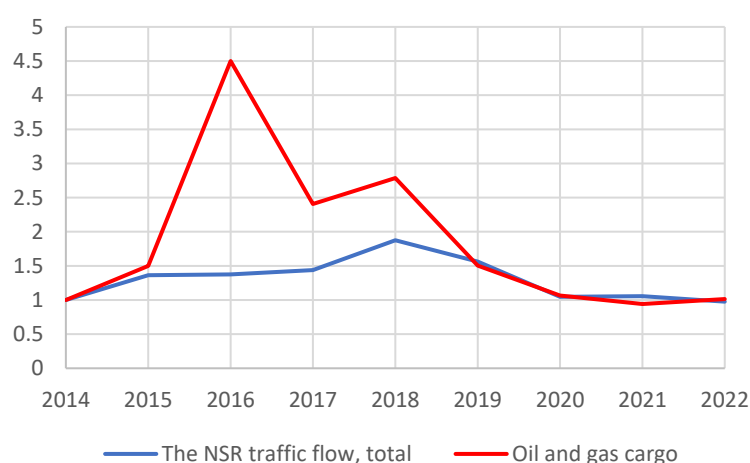


Figure 7. Chain indices of the total volume of the NSR traffic flow and oil and gas cargo transportation in 2014–2022 units. Source: compiled by the author according to the data of [6,38,44,57,58].

Figure 8 presents the results of calculating the chain indices of the total NSR traffic flow for various types of oil and gas cargo—oil and oil products, as well as LNG and gas condensate.

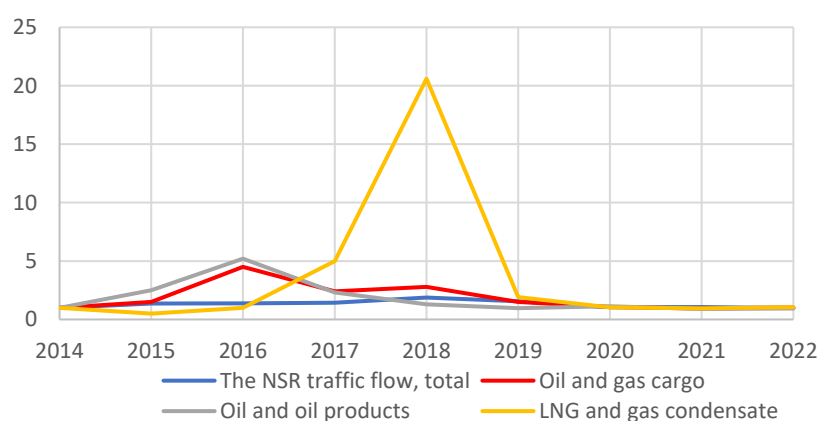


Figure 8. Chain indices of the NSR traffic flow in 2014–2022 by type of cargo units. Source: compiled by the author according to the data of [6,38,44,57,58].

The calculation results are shown in Figure 8, and they show an extremely intensive increase in the volume of LNG transportation, coinciding in time with the successful commissioning of the production lines of the Yamal-LNG project.

The obtained analysis results of the NSR traffic flow dynamics allow us to conclude that LNG production plays a decisive role in the formation of cargo flows along the Northern Sea Route.

Further, it is advisable to assess the tightness of the relationship between the NSR traffic flow and the volume of hydrocarbon production in the Arctic zone of the Russian Federation (AZRF). Table 3 shows the values of the pair correlation coefficients between a number of indicators.

Table 3. Pair correlation coefficients between the NSR traffic flow and the production of hydrocarbons in the Arctic zone of the Russian Federation.

| Functional Indicators | Factorial Indicators | Oil Production in the AZRF in 2014–2022, mln t | Natural Gas Production in the AZRF in 2014–2022, mln m ³ | LNG Production in the AZRF in 2017–2022, mln t |
|---|----------------------|--|--|---|
| Total NSR traffic flow in 2014–2022, mln t | | 0.66 | 0.93 | - |
| Total NSR traffic flow in 2017–2022, mln t | | - | - | 0.99 |

Source: author's calculations according to [6,38,44].

The table shows that the indicators of oil production in the Arctic zone are quite closely related to the total NSR traffic flow, but the value of the pair correlation coefficient between these features is minimal from those presented in the table. At the same time, it can be argued that there is a very close, practically functional relationship between the volumes of gas and LNG production with the total NSR traffic flow.

The calculations confirm that the cargo turnover along the Northern Sea Route is almost completely determined by the intensity of the implementation of the most important oil and gas projects in the Russian Arctic.

Further development of the transport and logistics system for servicing oil and gas projects in the Arctic territories requires not only the modernization of the existing port infrastructure but also the creation of new port complexes in the Arctic zone, as well as the optimization of the railway communications system [11,17,19].

Currently, the global oil and gas market provides quite favorable conditions for expanding the presence of the largest Russian producing companies, which gives an impetus to the economic development of the Arctic zone. However, the complicated geopolitical situation led to a reduction in the pipeline transportation of hydrocarbons from the northern regions of Russia to the markets of Europe and Asia. [11]. Under the current conditions, the oil and gas fields in the Arctic zone, which are located near the coasts suitable for the rapid construction or modernization of deep-water ports, gain special interest.

More intensive use of the Arctic transport corridors reduces the dependence on the terms and provisions of international treaties on the development of overland transport systems, as well as on communications in the waters of the Black and Baltic Seas. In addition, geopolitically unrestricted transportation along the Arctic routes makes it possible to comply with the terms of long-term contracts for the supply of hydrocarbons to foreign markets.

Currently, the bulk of freight traffic along the Arctic transport corridors is due to the following most significant oil and gas projects:

1. The large-scale integrated investment project Yamal-LNG, aimed at the production, liquefaction, and supply of natural gas from the Yuzhno-Tambeyskoye gas field to the customers. According to the PRMS standards, the volume of probable and proven gas reserves at the Yuzhno-Tambeyskoye gas field reaches 926 billion m³ [59]. The annual design production is 27 billion m³ of gas [60]. The annual production of LNG and gas condensate is envisaged at levels of 16.5 million tons and 1.2 million tons, respectively [60]. The plant's products are planned mainly to be supplied to the countries of Europe and the Asia-Pacific region. As part of the project, a multifunctional seaport Sabetta was built in the Ob Bay of the Kara Sea. The own fleet has been formed to export the products, including 16 ultra-large crude carriers of ice class Arc7 of the Yamalmax series, as well as 5 auxiliary vessels of the port fleet. To use 4–8 nuclear icebreakers is planned to ensure year-round pilotage of tankers in ice-congested water; logistic schemes have been developed for large-tonnage vessels along the Northern Sea Route, taking into account the environmental safety requirements. The unique geographic location of the Yamal Peninsula makes it possible to create a flexible and competitive logistics model that ensures year-round LNG supplies to the markets of the Asia-Pacific region and Europe. LNG will be supplied to the markets of Northeast Asia in summer via the NSR, and in winter via the western route with LNG transshipment at one of the European regasification terminals. In 2017, 2018, and 2019, the 1st, 2nd, and 3rd production lines were put into operation, respectively. In 2021 and 2022, 19.4 million tons and 21 million tons of LNG were produced, respectively [56], which indicates that the plant is operating in excess of production capacity.
2. Arctic LNG-2 project aimed at the development of oil and gas condensate fields in the Gydan Peninsula. The annual production volume is 19.8 million tons of LNG [3]. It is planned to supply products to the countries of Europe and Southeast Asia in 2023–2040. The project operator, PJSC NOVATEK, is intent on the creation of an Arctic cluster capable of providing up to 70 million tons of freight traffic along the NSR by 2040 [61].
3. Development of oil deposits on the western coast of the Ob Bay of the Kara Sea as part of the project New Port–Gates of the Arctic. Oil is to be supplied all year round through the unique sea terminal Gates of the Arctic in the amount of up to 8.5 million tons annually.
4. Development of the Payakhskaya group of oil fields (Taimyr Peninsula) and export of oil through the Tanalau cargo terminal at the mouth of the Yenisei in the amount of up to 5 million tons per year.
5. Development of the Prirazlomnoye offshore oil field with year-round transportation of the produced oil to the port of Murmansk by very large ice-class crude carriers. Until mid-2022, the logistics chain was as follows: oil produced on the offshore ice-

resistant fixed platform Prirazlomnaya was shifted to shuttle tankers, after which tankers delivered crude oil to the floating oil storage Umba. The same floating oil storage was used by Gazpromneft-Yamal LLC to store oil produced at the Novoportovskoye field. After delivery to the floating storage, an agreement was concluded with the buyer, who shipped oil to his own tanker and took it for further processing, or there was transportation, as a rule, to Rotterdam, after which oil was transferred to the buyer. In June 2022, the European Union introduced a package of sanctions prohibiting the supply of oil to Europe by sea, which jeopardized the activities of Gazprom Neft Shelf LLC and Gazpromneft-Yamal LLC. In this situation, the main direction of the supply of Russian oil becomes eastern: to China and India. Oil transportation from platform Prirazlomnaya is possible only by sea transport, and it is currently possible using the Northern Sea Route.

It should be noted that the Comprehensive Plan for the Modernization and Expansion of the Main Infrastructure (Decree of the Government of the Russian Federation dated 30 September 2018 No. 2101-r) provides for an increase in the volume of freight traffic along the NSR in 2022 to 51 million tons, in 2023 to 71 million tons, in 2024—up to 80 million tons. These indicators are expected to be achieved through the effective implementation of large oil and gas projects: the development of the Yuzhno-Tambeyskoye (Yamal-LNG project) and Novoportovskoye fields in the Yamal Peninsula.

However, at present, there is a threat of failure to meet the set targets for the following main reasons:

- According to PJSC *Rosneft*, the Vostok Oil project, aimed at developing the group of Payakha fields, was supposed to provide a cargo flow through the NSR in the amount of 25 million tons by 2024, but it will be able to reach the specified capacity only by 2025.
- PJSC *NOVATEK*, which is the main user of the NSR, previously planned to supply 46.7 million tons of cargo along this route by 2024 as part of the already operating Yamal-LNG liquefied natural gas plant and new projects—Arctic LNG-2 and Ob LNG. However, the plan was adjusted by the company to 35.5 million tons [57].
- In the conditions of economic sanctions, the volume of international companies' cargo transportation in NSR has significantly decreased.

In addition to the projects for the development of major hydrocarbon deposits of the Arctic shelf, the development, and maintenance of a complex coastal infrastructure is important in order to support the activities of producing companies and transporting products to the consumers [62]. At the same time, the development of the Northern Sea Route should become a valuable tool for creating a unified logistics complex.

It should be noted that the heart of the Arctic transport system, i.e., ports and port infrastructure, today is in disrepair and is characterized by severe physical depreciation and obsolescence. In particular, one of the main ports of the NSR is Tiksi. When it was put into operation, production facilities were designed for processing up to 600 thousand tons of cargo. However, at present, the port is processing only 10–15 thousand tons of cargo. According to the Ministry of Transport of the Republic of Sakha (Yakutia), this is due to the fact that the degree of mooring wall wear and overload portal cranes reaches 90% [39]. Since the Tiksi port is considered by the Government of the Republic of Sakha (Yakutia) as a basic infrastructure management point in the eastern part of the NSR, the issue of modernization of the port as part of a comprehensive project for the development of the NSR is very relevant. The mooring wall of the Pevek port is also completely worn out, which makes it possible to operate only one pier out of three [39]. Increasing the total throughput of the Arctic ports to 110 million tons in accordance with the Transport Strategy of Russia until 2030 [26] requires major repairs, reconstruction of port facilities, dredging works, etc., which needs significant investment.

Currently, as part of the implementation of the Development Strategy of the Arctic zone of the Russian Federation and to ensure national security for the period until 2035

[8], a number of investment projects are being carried out related to the development of transport and oil and gas sectors of the Russian Arctic (Table 4).

Table 4. The main investment projects implemented for the development of transport and oil and gas sectors of the Russian Arctic zone.

| Project Characteristics | Place of Implementation | Implementation Period | Investments, mln Rubles | Project Status |
|--|---------------------------------------|----------------------------|-------------------------|-------------------|
| Reconstruction of the Sea Port Bering: strengthening the berth walls, modernization of loading equipment, expansion of warehouse and repair facilities | NSR, The Chukotka Autonomous District | Until 2022 | 4167 | Implemented |
| Construction of non-freezing deep-water seaport Indiga | NSR, The Nenets Autonomous District | Until 2025 | 300,000 | Priority, planned |
| “Deep-water area”: the construction of the deep-water area of Arkhangelsk seaport will actively promote the development of offshore fields in the Arctic zone | NSR, Arkhangelsk | Until 2030 | 208,000 | Priority, planned |
| Construction of a support base for coastal support of offshore projects in the Russian Arctic zone: creation of berthing facilities and access to the federal road and rail network; creation of service areas for drilling platforms and vessels involved in geological exploration | Murmansk Region | Until 2025 | 18,000 | Current |
| Arctic LNG 2: construction of three LNG production lines | Murmansk Region | Until 2025 | 1,550,000 | Current |
| Development of the Zapadno-Ozernoye gas and Verkhne-Telekayskoye oil and gas condensate fields | The Chukotka Autonomous District | Determined by the investor | 5400 | Planned |
| Reconstruction of berth infrastructure facilities | Murmansk Region | Until 2022 | 2463 | Implemented |
| Northern Latitudinal Railway: connection of the Northern and Sverdlovsk railways and ensuring the shortest transit of hydrocarbon cargoes and cargoes necessary for the development of gas condensate and oil fields | Yamalo-Nenets Autonomous District | Until 2023 | 215,800 | Planned |
| Construction of the Sosnogorsk-Indiga railway to ensure more efficient transportation of hydrocarbons to the Northern Sea Route | Nenets Autonomous District | Until 2025 | 190,000 | Priority, planned |
| Construction of the Arkhangelsk seaport deep-water area | Arkhangelsk Region | Until 2030 | 36,569 | Current |
| Construction of the railway line Belkomur: formation of a new, | Arkhangelsk Region | Until 2030 | 225,000 | Priority, current |

“diagonal” direction in the system of international transport corridors of the European part of Russia; redistribution of cargo flows from the ports of the Baltic to the ports of Murmansk and Arkhangelsk

Creation and operation of the railway line Bovanenkovo–Sabetta: ensuring the delivery of goods and shift crews to the port of Sabetta, to the gas condensate fields of the Yamal Peninsula, and the export of liquid hydrocarbons

Yamalo-Nenets Autonomous District

Until 2036

114,142

Priority, current

Source: compiled by the author according to the data of [40].

As of the end of 2020, a number of ports in the Arctic zone are designed for the transshipment of oil, gas, and oil products (Table 5). In addition to the ports indicated in Table 5, the transshipment of oil and oil products in the Arctic zone involves the development of ports such as Vitino (oil, oil products, and condensate), Kharasavey (oil, gas condensate), Dickson (oil from the Payakha deposits).

Table 5. Major port of the Russian Arctic zone for transshipment of oil and gas products.

| Characteristics | Murmansk | Sabetta | Arkhangelsk | Varandey |
|---|--|--|--|---------------------------------|
| Location | Murmansk Region | Yamal Peninsula | Arkhangelsk Region | Nenets Autonomous District |
| Basin | Barents Sea | Kara Sea | White Sea | Barents Sea |
| Throughput capacity, thousand tons per year | 24,647.2 | 16,000 (LNG), 1350 (gas condensate) | 11,772.9 | 12,100.4 |
| Dimensions of the vessels (length/width/draft), m | With no restrictions | 350/50/12 | 114/14/3.6 | 120/15/3.5 |
| Number of terminals | 110 | 11 | 6 | 2 |
| Navigation | Year-round | Year-round | Year-round | Year-round |
| Special features | Base port for providing traffic under the MTA; the base of the nuclear icebreaker fleet; communication with the industrial centers of Russia and abroad by air, road, and rail | Largest center for the formation of port infrastructure to ensure the development of deposits in the Arctic waters | Providing direct access to the world ocean in the western and eastern directions | Connection to onshore oil tanks |

Source: compiled by the author according to the data of [14,15,25,28,29,63].

The intensification of geological exploration, production of hydrocarbons in the Arctic region, and acceleration of growth of freight traffic along the NSR are interdependent. Oil and gas fields in the Arctic zone of Russia are a long distance from the coast, as well as from the well-developed national industrial clusters. This necessitates solving the problems of both the procurement of projects for the development of offshore fields and the removal of extracted hydrocarbons from the fields. The development of transport schemes is determined by the increase in traffic of materials and resources for production management as well as the products of mining companies.

In this situation, it is obvious that the integration of the Arctic transport network into a single transport system in the country should be one of the most important tasks of

Russia's state policy in the Arctic. Therefore, it is natural that in the main strategic documents ("Comprehensive plan for the modernization and expansion of the main infrastructure", the state program "Socio-economic development of the Arctic zone of the Russian Federation", "Development of the Northern Sea Route and ensuring navigation in the Arctic"), considerable attention is paid to the development of the NSR and related sea-ports, airports, adjoining meridional river and road communications. These projects provide, in particular, for the construction of ice-class hydrographic and emergency rescue vessels, bases, and berths for the parking of these vessels in the port of Murmansk, and the implementation of measures for the navigation and hydrographic support of navigation along the NSR. The solution to these tasks will be ensured through the development of oil and gas fields as part of the implementation of the Yamal LNG and Novy Port projects.

Of particular importance in solving the problem of developing the port infrastructure of the Arctic is given to the project to improve the efficiency of the Murmansk transport hub. In accordance with the project, it is planned to create a deep-water marine hub based on the port of Murmansk, integrated into the international transport corridors "East-West" and "North-South". The implementation of the project will provide mining companies with access to new global sales markets. In addition, within the framework of the project, a section of the Kola federal highway has been reconstructed, and the construction of railway and energy infrastructure is underway.

The construction, modernization, and operation of the Arctic ports cannot be efficient without long railway lines. A striking example of this relationship is the beginning of the development of the investment project's Northern Latitudinal Railway in the Yamalo-Nenets Autonomous District. The project goal is to connect the Northern and Sverdlovsk railways. The project provides for the construction of a railway line with a length of over 700 km connecting the Obskaya, Salekhard, and Nadym stations. Successful implementation of the project would reduce transport communications from the oil and gas fields of Western Siberia to the seaports of the Baltic. This project plays an important role in the development of the mineral resource base of Western Siberia and the development of the transport infrastructure of both the Yamalo-Nenets Autonomous Territory and the entire Arctic zone. The implementation of the project will facilitate the creation of the Payakha oil and gas cluster, as well as contribute to the development of non-ferrous metal reserves in the Norilsk region.

The predicted volume of traffic along the Northern Latitudinal Railway is about 24 million tons of cargo per year, the bulk of the cargo traffic should be bulk oil cargo (crude oil, dark and light oil products) and gas condensate. The creation of such a transport artery is of great economic importance since it will allow connecting the West Siberian and Northwestern regions of the country by the shortest route. In the case of integrated development of the territories adjacent to the route, a significant increase in the industrial and export potential of Russia is possible. In addition, the proximity of the route to the NSR could increase the competitiveness of the sea route by increasing its throughput and expanding the possibilities for the timely redeployment of cargo flows between ports and modes of transport. At the next stage of the development of the transport infrastructure, the railway line will be extended from the Obskaya station to the port of Sabetta [62]. The project Northern Latitudinal Railway 2 will facilitate the solution to this problem, which will drive the development of industry in the central part of the Arctic zone of Russia [64]. The 170 km railway project was developed in 2019 and provides direct access to the Northern and Sverdlovsk railways to the Arctic port of Sabetta, which will contribute to the stable loading of the water corridor.

Obviously, the implementation of these projects is also of great geopolitical importance. However, it should be noted that the Northern Latitudinal Railway project, initiated in 2006, has not yet been implemented, and the construction start dates have been repeatedly postponed. For the construction of the highway, a public-private partnership agreement was concluded between the government of the Yamalo-Nenets Autonomous

Territory and *VIS TransStroy*, but in 2019, the agreement was terminated with a compensation payment to the concessionaire. The reasons for terminating the agreement are as follows:

- The absence of a comprehensive program for the socio-economic development of the territories adjacent to the route would ensure the full loading of the railway line and its payback.
- The instability of the ruble exchange rate hinders the implementation of industrial and infrastructure projects.
- The absence of a well-developed financial mechanism for project implementation.
- The continued and growing dependence of the Russian industry on imports of high-tech modern equipment in the face of economic sanctions.

In addition, the significance of the Belkomur project (White Sea–Komi–Ural) is worth mentioning, which will shorten the payback period of the Northern Latitudinal Railway. The project is to connect the stations of Karpogory and Vendinga by a railway line, which will connect the industrial centers of Syktyvkar, Kudymkar, and Solikamsk with the seaport of Arkhangelsk [65]. This logistic scheme will ensure the export of products and extracted feed from these regions to foreign markets.

It is important to note that the new railway lines leading to the ports of the Arctic Basin can serve as a reliable basis for the growth of the freight potential of the Northern Sea Route and contribute to providing direct access to the markets of Western Europe [12,66]. At the same time, a certain balance in the freight traffic volumes by sea and rail transport should be maintained, since a significant increase in the turnover of any one port can reduce the capabilities of other ports.

The main mode of transport for the transportation of hydrocarbons in the onshore part of the Arctic zone is pipelines. At present, the region is implementing a project for the construction of the Purpe-Samotlor oil pipeline to transport oil from the Vankor field (Krasnoyarsk Territory) with its delivery to the Eastern Siberia-Pacific Ocean pipeline system and further for export. On the Yamal Peninsula, *Gazprom* and *Transneft* are working to create new gas production centers and a gas transmission system. By 2030, it is planned to put into operation gas pipelines from the fields of the Ob and Taz bays “Bovanenkovo–Ukhta” and “Bovanenkovo–Ukhta-2” with a length of more than 2100 km [12].

Because the oil and gas fields of the Arctic shelf are a long distance from the coast, have extremely difficult natural and climatic conditions, and require the implementation of expensive projects such as the building of production complexes, laying of underwater pipelines, construction of facilities for liquefying and processing gas, it can be concluded that the industrial potential of the Murmansk Region is of special importance.

The Murmansk Region is characterized by the following features:

- Physical proximity to explore offshore oil and gas fields.
- Availability and vigorous activity of large geological exploration, shipbuilding, and research organizations [66,67].
- The possibility of a partial shift of large military industrial enterprises and the use of their unique fixed assets in the production of equipment for the oil and gas industry [68].
- Ease of use of the Kola Bay and adjacent bays for the basing of the icebreaker fleet.
- Developed industrial infrastructure, which allows us to locate enterprises in the region that carry out installation and repair of drilling and mining equipment [69] and maintenance of the fleet.

The listed features make it possible to consider Murmansk, which is the starting point of the NSR, as the most promising transport hub for the delivery of produced raw hydrocarbons to sales markets.

The discovery of unique oil and gas resources on the Arctic shelf can fundamentally change the prospects and directions for the development of the fuel and energy complex and related industries in the Murmansk region. The development of hydrocarbon

deposits and the creation of oil and gas infrastructure in the Murmansk region may provide additional opportunities for service companies in the area of attracting enterprises—suppliers of goods and services. The reconstruction of port terminals, the creation of bases for ice-breaking and rescue fleets, and the construction of oil transshipment complexes create prerequisites for the development of the Murmansk transport hub and its gradual transformation into one of the largest ports in Russia for the transshipment of oil, including oil produced in the fields of the Arctic shelf.

5. Conclusions

Based on the results of the studies carried out, the following conclusions can be drawn:

1. The implementation of ambitious projects for the development of Arctic oil and gas fields calls for special attention to the development of transport communications and infrastructure. The transport and logistics sector is becoming an important service sector.
2. Currently, the territory of the Russian Arctic is suitable for an effective transport and infrastructure system to ensure smooth and fast transportation of raw hydrocarbons produced, other cargo, and personnel to the areas of exploration and production. Harsh natural and climatic conditions and the remoteness of the fields from the coast-line will be taken into account.
3. Modernization of the existing transport and logistics schemes in the Arctic region, their integration into the system of world transport communications, and the creation of new high-tech port terminals and facilities will allow redirecting export flows to the Russian ports, thereby reducing the risks arising from the aggravation of the foreign policy situation. It follows from the analysis that the use of the Murmansk sea-port for the transportation of raw hydrocarbons has a number of competitive advantages:
 - The geographical and geopolitical position of the port allows for free access to the Atlantic Ocean, bypassing the closed straits.
 - The technical characteristics of the port allow the reception of large and ultra-large crude carriers without imposing requirements on their dimensions or freight-carrying capacity.
 - The almost total absence of ice cover in the port water area allows for year-round transportation to the Atlantic Ocean without an icebreaker escort.
 - A developed system of railways ensures regular transportation to the ports.
 - High industrial and human potential.
4. The Northern Sea Route, together with the adjoining railway lines, river communications, highways, aviation, and coastal infrastructure, can form the basis of the transport system of the Arctic zone and contribute to an increase in its transport and infrastructure potential. At the same time, the significance of the NSR is great as the shortest transport corridor linking Europe and the Pacific region.
5. The implementation of large-scale investment projects in the oil and gas industry of the Russian Arctic zone is of fundamental geopolitical importance, as it is a tool for strengthening Russia's regional presence in the Arctic, and also contributes to the development of regional development processes in the Arctic, namely, increasing the NSR cargo turnover; increasing the transport and infrastructure potential of the region; construction of infrastructure facilities in the oil and gas industry; and the development of domestic shipbuilding.
6. The industrial development of the Arctic zone involves an increase in the hydrocarbon resources production and cargo transshipment and therefore requires the formation of an efficient transport infrastructure. In particular, the implementation of the Yamal LNG project plays an important role in the region's development. The

creation of the northernmost LNG plant, as well as a full-fledged year-round seaport of Sabetta, can become incentives for the Northern Sea Route development.

7. The need to create a transport system based on the Northern Sea Route with a developed network of ports and infrastructure, including navigation, hydrometeorological, repair, and information services, is becoming very relevant.
8. In case of sustainable warming, the ice cover thickness in the Arctic may decrease, which will create more favorable conditions for navigation in the Arctic seas and further intensification of hydrocarbon production on the shelf. The Northern Sea Route in this situation can become one of the most important transport corridors in the world.
9. The production of liquefied natural gas is one of the most important factors in the development of shipping in the Arctic zone.

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