The Role of the Russian Arctic Gas Industry in the Northern Sea Route Development

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Abstract. The Russian region of the Arctic has been described in terms of unique hydrocarbon potential, as well as strong concentration of major natural gas fields. The article presents reserves of natural gas, oil and condensate in the main oil and gas provinces of the Russian Arctic. It is indicated that the development of Russia's economic activity in the Arctic depends largely on the increased transport and infrastructure capacity of the region. The activities of the largest Russian extractive industries such as PAO Gazprom, PAO Rosneft Oil Company, PAO NOVATEK for the production of natural gas in the Arctic zone have been described. The implementation of the integrated investment project “Yamal-LNG”, which provides for the production of natural gas at the Yuzhno-Tambeyskoye field, its liquefaction, and supply to consumers has been singled out as one of the most significant areas for developing the resource base of the Arctic zone. The article touches on the production capacities of a liquefied natural gas (LNG) plant, as well as the logistic structures for delivering LNG to consumers. It is also indicated that transportation of liquefied natural gas along the Northern Sea Route has a variety of significant advantages. Review of the activities carried out by Russian companies in the development of the Arctic gas fields has revealed the relationship between the processes of implementing gas projects in the region and the rate of development of the Northern Sea Route (NSR). The dynamics of cargo transportation by the NSR has been analyzed and also external and internal factors that determine the effectiveness of the functioning of the NSR transport system have been highlighted. Current state of the icebreaking fleet has been appraised as one of the most important drivers in cargo transportation along the NSR. Availability of liquefied natural gas as marine fuel has been discussed as one of the advantages of the NSR, which will allow observing stringent environmental standards of shipping in the Arctic and reducing freight costs. Conclusions have been drawn on the high importance of gas production projects to be implemented in the Russian region of the Arctic for the development of shipping along the Northern Sea Route.

1. Introduction
Currently, the basic line of the development of the economy of the Russian region of the Arctic is associated with hydrocarbon production, as well as with geological exploration meant to identify new areas of production. The territory of the Russian Arctic has unique hydrocarbon potential represented by natural gas, oil, condensate, and original bitumen. Produced hydrocarbon reserves in the Arctic zone are estimated at 245 billion tons of fuel equivalent. It should be noted that about 85% of these reserves are concentrated in the West Siberian, Timan-Pechora and Barents Kara petroleum provinces, with the majority of reserves (161.7 billion tons of fuel equivalent) being in the West Siberian petroleum province [11].
The West Siberian petroleum province is characterized by an extremely high concentration of unique natural gas fields. Today, this province includes a number of deposits such as Bovanenkovskoye, Urengoyskoye, Yamburgskoye, Russkoye, Kharasaveyskoye and many others. In this area, the total proven reserves of natural gas exceed 30 trillion m³; oil reserves are estimated at 2.5 billion tons, and condensate at 900 million tons [12]. It should be noted that the deposits are generally characterized by relatively simple geological conditions and a shallow depth of occurrence.

The West Arctic shelf of the Russian Federation can be treated as a very promising area for further exploration and preparation of the raw material source, since over 70% of the hydrocarbon potential of the Arctic shelf is concentrated within the Kara and Barents Seas, with natural gas contributing to the total resources 90% [10].

At the same time, it is worth noting that intensified gas exploration on the shelf of the Barents and Kara Seas is constrained by significant proven natural gas reserves on the Yamal Peninsula, as well as by the successful launch of the unique Yamal-LNG project.

Natural gas produced in the Arctic can be transported both through the pipeline system and by sea (if liquefied). An increase in transport and infrastructure potential may contribute to the development of Russia's economic activity in this region, in particular, within the Arctic sea space [12].

For the purpose of supply of produced hydrocarbons to the foreign market, to develop the infrastructure of the Northern Sea Route seems expedient. This includes not only ports, icebreaking fleet, search and rescue and environmental services, but also pipelines, roads and railways, airports, and administrative authorities. Consequently, the development of the Northern Sea Route may become one of the main drivers in the formation of the transport system of the Arctic zone and the strengthening of Russia's economic presence in the region.

2. Research
The world natural gas production is led by PAO Gazprom. Seventy-seven percent of the company's production facilities are concentrated in the Arctic zone of the Russian Federation (Nadyr-Pur-Tazovsky district of the Yamalo-Nenets Autonomous District). PAO Gazprom actively creates large gas production hubs in promising new areas, e.g. on the Yamal Peninsula and Sakhalin Island. It is also planned to develop deposits on the Arctic shelf and in the waters of the Gulf of Ob and Taz Bay. PAO Gazprom is developing large-scale LNG projects such as “Sakhalin-2”, “Vladivostok-LNG”, and “Baltic LNG”. Oil and gas fields on the Sakhalin have been developed since 1996. The Sakhalin-2 project is being implemented on the basis of the Piltun-Astokhskoye oil and Lunskoye gas fields in the Sea of Okhotsk near the north-eastern coast of the Sakhalin Island. The project operator is Sakhalin Energy; the total gas reserves exceed 600 billion m³ [9].

Rosneft Oil Company also possesses significant natural gas resources on the Arctic shelf, which amount to about 23 trillion m³ [9]. Offshore fields are difficult to access, and it seems economically inexpedient to integrate them into the Unified Gas Supply System. In that respect, the company regards the development of LNG production and its implementation on the foreign market as one of the strategic directions for activities.

NOVATEK is currently working on the implementation of the Arctic-LNG project for the production of liquefied natural gas. The construction of a gas liquefaction plant is planned on the territory of the Gyda Peninsula. The resource portfolio of the project includes the following:
- Salmanovskoye (Utrennee) field in the north of the Gyda Peninsula and partially in the water area of the Gulf of Ob, possessing natural gas reserves of 259.8 billion m³ [6];
- A geophysical oil and gas condensate field in the central part of the Gyda Peninsula and on the coast of the Gulf of Ob possessing natural gas reserves of 125.6 billion m³ [12].

The product gas is planned to be delivered to consumers in Europe and America by sea, using liquefied gas tankers, with the direction of delivery determined by market conditions.

Yamal-LNG is the most significant project in the Russian region of the Arctic, which involves the extraction of natural gas from the Yuzhno-Tambeyskoye field, its liquefaction and supply to consumers. The probable and proven gas reserves at the Yuzhno-Tambeyskoye field reach 926 billion
The annual estimated level of gas production is 27 billion m$^3$, the development period at least 20 years [14]. The project is implemented by a joint venture of NOVATEK (50.1%), the French concern Total (20%), the Chinese company CNPC (20%) and the Silk Road Fund (9.9%) [13].

As part of the Yamal-LNG project, the construction of a liquefied natural gas (LNG) plant has been proposed. The plant includes three processing lines with a capacity of 5.5 million tons of liquefied gas per year. Supplies of LNG under long-term contracts were launched in April 2018, while the third line was completed and launched in 2019. The annual production of LNG and gas condensate is estimated at 16.5 million tons and 1.2 million tons, respectively. The main consumers of the output of the plant will be the countries of the Asia-Pacific region and Europe [3].

To transport LNG to the countries of the Asia-Pacific region, using ice-class liquefied gas tankers that would deliver cargo immediately to the consumer was expected. However, subsequently, because of very high price of Arc7 class tankers and, consequently, heavy expenses for LNG delivery, the logistics solutions have been revised. Now, two logistic structures are proposed: along the Northern Sea Route in ice-class tankers to the east, and through the Suez Canal to the west. One of the compelling advantages of the Northern Sea Route is a materially reduced time of transportation. For example, cargo can be carried from Norway to Japan 7 to 22 days faster than through the Suez Canal [7].

The scheme of transportation through the Suez Canal provides for the delivery of LNG to the transshipment terminal in Murmansk with ice-class tankers, followed by transshipment to standard LNG tankers and shipment to the Asian region. When transporting LNG eastward along the Northern Sea Route, it is expected that LNG would be transshipped from ice-class tankers to standard ones in Kamchatka. The terminals in Murmansk and Kamchatka will be constructed by PAO NOVATEK; the commissioning is scheduled for 2022 – 2023 [4]. Specifications of the terminals are shown in Table 1.

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 not escorted by icebreakers along the Northern Sea Route to the west and during the summer navigation to the east.

| 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 storages, sale under FOB terms is possible | 2 vessels – LNG storages, sale under FOB terms is possible |

Source: PAO NOVATEK.

The LNG tanker Christophe de Margerie was built in 2016 at the shipyard of Daewoo Shipbuilding Marine Engineering (South Korea). The length of the vessel is 300 m, displacement 172 thousand m$^3$, the power plant capacity 45 MW. The tanker is capable of turning around its axis, as well as breaking ice up to 2.1 m thick. This vessel was designed to meet extremely stringent environmental requirements [3]. The tanker propulsion system can use both standard fuels and tank return LNG. The tanker Christophe de Margerie was the earliest one from the vessels of new Yamalmax type, and is
currently the largest icebreaking vessel in the world. Obviously, the start of LNG deliveries along the Northern Sea Route by an Arc7 ice-class vessel will boost cargo transportation and further development of shipping in the Arctic Ocean.

It should be noted that the Yamal Peninsula has direct access to the Northern Sea Route (NSR) through the Gulf of Ob and the Kara Sea. Consequently, connecting the communications of the NSR and Western Siberia will ensure transport accessibility of Yamal and the Western Arctic.

A review of the activities of Russian companies in developing gas fields in the Arctic reveals a clear relationship between the processes of implementation of gas projects in the region and the rate of development of the Northern Sea Route. Efficiency of the process of shipment of the gas produced in the region to the consumer depends largely on availability and successful operation of the marine transport system.

According to the NSR Administration, in contrast to 2007, when the total cargo traffic hardly exceeded 2.5 million tons, the intensive implementation of oil and gas projects in the Arctic increased this indicator to 19.689 million tons, including by type of cargo: general cargo – 2.34 million tons (–6.3% compared to 2017); coal – 290.8 million tons (–16%); ores – 43 thousand tons (+29.9%); oil and oil products – 7.81 million tons (+15.6%); gas condensate – 805.4 thousand tons (7.5 times greater); LNG – 8.399 million tons (37.7 times greater) [15]. The decrease in the volumes of shipment of general cargo and coal is due both to the completion of general construction at the port of Sabetta and at the Yamal-LNG facilities, and to the suspension of the production of Taimyr coal. Multiply increased amounts of hydrocarbons transported are mainly due to the commissioning of the Yamal-LNG project in 2017.

The length of the Northern Sea Route from its beginning at the Kara Gate to the end in Providence Bay is 5,600 km. In fact, the NSR is the internal transport artery of Russia. The Barents Sea is not included in the NSR water area, although it is through its ports that the main NSR cargo flows, in particular, the hydrocarbons from the Gulf of Ob, pass, and the nuclear icebreaker fleet is based on the Kola Peninsula.

The NSR transport system can be treated as the most sophisticated design and engineering, as well as organizational and economic entity [11], which depends on many objective and subjective considerations. Objective external factors should include mainly the world energy market conjuncture, since the tendency to export hydrocarbons through the NSR is currently obvious. An important objective factor, which determines the volume of cargo transportation through the NSR, is the possible change in the climatic conditions in the region. Thus, according to experts’ forecasts, global warming in the next 5 years may result in the possibility for Arc7 ice-class vessels to pass through the Kara Sea not escorted by icebreakers [4].

The most important internal factors determining the effectiveness of the NSR operation include the specifics of state policy in the field of mining and development of coastal regions, the state of the national merchant and icebreaking fleets, the state of maritime transport infrastructure (in particular, ports, security services, hydrometeorology, warning services and other).

According to experts, in the coming years, oil production in Russia will begin to decline, with oil transported by sea in the western sector of the NSR only, focusing on the European market [5]. This is mainly because the North American market is fully loaded with its own shale oil, as well as because a more attractive Asian market will be unavailable, since the eastern sector of the NSR is impassable without icebreaking support for 5-6 months a year.

The North American LNG market was the most preferable for Russia, but the construction of terminals for LNG imports was suspended in 2010 due to a sharp increase in shale gas production. Nevertheless, start of the Yamal-LNG investment project made it possible to increase volumes of transportation. The uniqueness in that as part of the project, based on public-private partnership, a multifunctional seaport of Sabetta was built on the coast of the Kara Sea, in full absence of infrastructure. It was constructed by order of the Federal State Unitary Enterprise “Rosmorport”. As by the agreement, some of the facilities are state-owned, and the others belong to the Yamal-LNG project. According to a source [2], ice barriers, operational waters, access channels, vessel traffic
management system and navigation support system, as well as marine services buildings are in federal ownership. Yamal-LNG facilities include process berths for transshipment of LNG and gas condensate, rolling cargo berths, construction cargo berths, storage facilities, an administration area, engineering networks and communications [3]. The port of Sabetta operates year-round to provide the passage of large-capacity gas tankers along the Northern Sea Route, subject to environmental safety requirements.

In addition, attention should be paid to the project for the construction of a new port in Indiga Bay. This port also plans to build a natural gas liquefaction plant, terminals for loading LNG into large-capacity tankers, oil loading terminals, a ship repair base, and an emergency rescue center. The new port can facilitate the connection of the Northern Sea Route with the East – West transport corridor, as well as the integration of the Nenets Autonomous Okrug with the transport network of Russia [5].

As already noted, one of the critical factors for cargo transportation along the NSR is the state of the icebreaking fleet. Currently, it consists of 6 nuclear-power and 5 diesel-electric icebreakers. However, by 2022, it would be possible to operate only one nuclear-powered submarine named “Fifty years of the Victory”. Currently, three universal nuclear-power icebreakers under the project 22220, namely “Arctic”, “Urals”, and “Siberia”, are being built at the production sites of AO Baltic Shipyards in Saint Petersburg. In August 2019, an agreement was signed on the construction of two more vessels of this type. The icebreakers will be dual-draught, so as to be operated not only in Arctic waters with ice up to 2.8 m thick, but also in the mouths of polar rivers. However, it is obvious that these are not sufficient for the year-round transportation of increased volumes of hydrocarbons in the Arctic zone.

The necessity of icebreaking escort for large-capacity gas tankers has promoted the development of an innovative solution that allows laying channels on the ice 50 m wide and even more. The Krylov State Scientific Center has developed the design of an icebreaker with two hulls held together by a single platform [5]. This design made it possible to lay channels of a width that enable large tankers to safely move in any ice, as well as significantly reduce ice resistance.

The Northern Sea Route features an additional advantage, which is the possibility of bunkering of vessels carrying natural gas from coastal or offshore fields practically along its entire length. An increase in the volume of transportation along the NSR has led inevitably to increased fuel consumption, which resulted in increased harmful emissions into the atmosphere and accidental oil spills. In the context of increasingly restrictive requirements for marine fuel and a possible ban by the International Maritime Organization on the use of fuel oil residue in the Arctic, the use of LNG as a marine fuel will make it possible to comply with current and expected environmental standards. Unlike standard heavy fuel oil, liquefied natural gas has significant power and environmental benefits. When LNG is used, emissions of particulates and SOx are significantly reduced, NOx emissions are reduced by 80% [7], and there is also a decrease in greenhouse gas emissions. In addition, LNG is highly competitive marine fuel in terms of price, since it is produced in the nearest Arctic fields, and there are no significant costs for its delivery.

3. Conclusion

With reference to the foregoing, we can draw the following conclusions:

1. The Northern Sea Route is a long-standing national transport communication of Russia [8] and can serve to optimize global transport flows, thus contributing to the economic development of not only the Russian region of the Arctic, but also the northern regions of Europe and the USA. Concurrently, the NSR is of great importance as the shortest transport corridor connecting Europe and the Asia-Pacific region.

2. Industrial development of the Arctic zone implies growing hydrocarbon production and cargo transshipment, and therefore requires efficient transport infrastructure [1]. In particular, the implementation of the Yamal-LNG project, which involves the annual commissioning of new facilities, is of paramount importance for the development of the region as a whole. Construction of the northernmost LNG plant and a full year-round seaport of Sabetta can encourage the development of the Northern Sea Route.
3. The need to create a transport system based on the Northern Sea Route, with a developed port network and infrastructure which includes navigation, hydrometeorological, repair, information services, is growing more urgent.

4. Transportation of gas produced in the Russian Arctic requires a modern icebreaking fleet that would meet all environmental safety requirements. Design, construction and commissioning of reinforced ice-class vessels, as well as the creation of transshipment terminals, will ensure year-round cargo traffic along the Northern Sea Route.

5. In the case of sustained warming, the Arctic ice cover may melt in thickness, which will create more favorable conditions for navigation in the Arctic seas and boost hydrocarbon production on the shelf. In this context, the Northern Sea Route may become one of the most critical transport corridors in the world.

6. The production of liquefied natural gas is one of the key growth drivers for shipping in the Arctic.

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