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Spatial Organisation of Gas Resources Development in the Yamal Oil and Gas Bearing Region *

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Abstract. The Yamal oil and gas province (OGP) is strategically important for the Russian gas industry. In the coming decade, gas production in Yamal is expected to grow to 180–200 billion cubic meters per year. The main goal of the article is to solve a scientific problem consisting in the study of the spatial organization of the development of gas resources, determination of the rational structure of reproduction of natural gas reserves in the Yamal oil-gas-bearing region in the context of the modernization of the Arctic gas industry complex. The article assessed the gas resources of Yamal, revealed trends in the economic development of natural gas fields, presented the characteristics of investment projects based on the fields being developed. An analysis was carried out that made it possible to differentiate the deposits by the degree of their prospects, and a strategy for expanding the hydrocarbon potential of Yamal was determined. It was revealed that the main areas of production in the Yamal oil-gas-bearing region are associated with the development of deposits with a high level of Cenomanian deposits. Such deposits are characterized by a higher increase in the capitalization and profitability of investment projects in real time compared to fields located in the northern and far eastern seas, including on the shelf of the Kara Sea. It was concluded that the strategy for the reproduction of hydrocarbon potential will be aimed at conducting prospecting and exploration in order to transfer forecast resources to industrial reserves of natural gas. The study applies a general scientific methodology providing for systemic and comprehensive approaches to justify the spatial organisation of gas resources development in the Yamal oil and gas bearing region. A significant body of factual material on the state of free gas and condensate reserves in Yamal has been analyzed. The results of the research were obtained with the use of comparative-analytical, statistical methods of economic analysis.
Keywords: *Arctic zone of Russia, Yamal oil-gas-bearing region, Arctic natural gas deposit, natural gas reserve, potential natural gas resource, reproduction of natural gas reserves, productivity of natural gas field.*

Introduction

Today Russia is one of the global leaders in natural gas production, second only to the United States, with more than 90% of production volume coming from the Russian Arctic sector. Scientific research in the field of spatial organization of regional economy in the Arctic during the economic development of energy resources is timely and relevant, since hydrocarbon resources development is one of the main drivers of economic development of the Arctic zone of Russia, as the prospects of discovering new deposits and hydrocarbon fields, including unique and large in reserves, are associated with the Arctic territories. Studies in the field of spatial organization of the economic development of hydrocarbon resources in the Western Arctic are used as a methodological approach in the works: [1, Kozmenko S., Saveliev A., Teslya A.], [2, Agarkov S.A., Saveliev A.N., Kozmenko S.Y., Ulchenko M.V., Shchegolkova A.A.], [3, Kozmenko S.Yu., Afanasiev R.A.].

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Technological processes for the development of hydrocarbon resources are the subject area of scientific research by N.P. Laverov, V.I. Bogoyavlensky [4], A.E. Kontorovich [5] and others.

Ensuring "sustainable reproduction of reserves and potential resources of Arctic natural gas, since it is this region that the main proven gas resources of Russia are localized in" [6, Shchegolkova A.A., Ulchenko M.V., p. 114], will allow maintaining the high competitive position of Russia in the global gas market [7, Kozmenko S.Yu., Saveliev A.N., Teslya A.B.]. Under these conditions, the main direction of economic development of the Arctic zone, in addition to the production of hydrocarbons itself, is geological exploration in order to ensure stable reproduction of reserves and potential hydrocarbon resources, including natural gas [6, Shchegolkova A.A., Ulchenko M.V.]. The most promising area for exploration and expansion of the raw hydrocarbon base is the northwestern part of the West Siberian oil and gas province (WSOGP) — the Yamal-Kara region, which includes the Yamal, Gydan and South Kara oil-and-gas bearing regions (OGR) [8, Kontorovich V.A., Kontorovich A.E.].

Spatial distribution of gas resources in the Arctic zone of Russia

According to various estimates, the volume of recoverable hydrocarbon reserves in the Arctic zone of Russia is about 245 billion tons of fuel equivalent. The Arctic zone includes the Naryan-Mar group of fields in the Timan-Pechora oil and gas province (OGP); deposits of the Barents-Kara OGP (Murmansk, Severo-Kildinskoe, Shtokman, Ledovoe, Ludlovskoe); WSOGP fields (two fields of the Ust-Yenisei OGR, Pur-Tazovsk OGR, Nadym-Pursk OGR, Yuzhno-Karskaya OGR, Gydan OGR, Yamal OGR). It should be noted that the major part of reserves (161.7 billion tons of fuel equivalent) belongs to the WSOGP, which is characterized by a high concentration of unique and large natural gas fields.

In recent years, substantial prospects for new hydrocarbon deposits and fields of WSOGP, including large ones, are associated with the Arctic territories, which include the Kara-Yamal region with the Yamal, Gydan and South Kara oil and gas regions (OGR). Commercial oil and gas deposits have already been identified there in a wide stratigraphic range — from the basement-sedimentary contact zone through the Cenomanian. However, as is well known, the main reserves of hydrocarbons (mainly gas and gas condensate) are discovered in the Aptian-Albian and Albian-Cenomanian productive complexes. This is explained primarily by their better knowledge of deep drilling [9, Skorobogatov V.A., Kabalin M.Yu.].

More than 70% of potential hydrocarbon resources are concentrated on the shelf of the Barents and Kara Seas, with the share of natural gas reaching 90%. However, the main problem of the economic development of the Arctic hydrocarbon resources is that most of the reserves are classified as hard-to-recover [1]. That is why the intensification of gas fields exploration directly on

[1] Global'nye tendentsii osvoeniya energeticheskikh resursov Rossiyskoy Arktiki. Chast' I. Tendentsii ekonomicheskogo razvitiya Rossiyskoy Arktiki [Global trends in the development of energy resources in the Russian Arctic. Part I. Trends

the shelf is constrained by the presence of significant volumes of not only explored, but also natural gas reserves under development on the Yamal Peninsula.

Gas potential assessment of the Yamal OGR

The Yamal oil and gas bearing region is unique in all parameters of gas and oil content, namely: the number of fields, discovered and explored reserves, the range of productivity, etc. To date, 31 fields with free gas reserves have been discovered on the Yamal Peninsula and adjacent waters, and 27 fields including 9 gas, 10 gas-condensate and 8 oil-and-gas fields onshore (without the Priyamalskiy shelf). The total reserves and resources of all the fields of the Yamal OGR, including the Priyamalskiy shelf, are the following: explored and preliminary estimated gas reserves (A + B + C1 + C2) — about 16 trillion m^3, prospective and forecast (C3 – D3) — about 22 trillion m^3; recoverable condensate reserves (A + B + C1) — "…over 226 million tons; oil reserves — 292 million tons" [10, Ananenkov A.G., p. 63].

Two powerful clusters of oil and gas accumulation have formed in Yamal — the Bovanenkovo and Tambey groups. The South Yamal group is represented by the Novoportovskoye and Rostovtsevskoye fields with predominant oil reserves (initial discovered oil reserves of about 1 billion tons, free gas — less than 1.3 trillion m^3). Natural gas reserves of the Tambeyskoye group, as well as the Kruzenshternovskoye and Kharasaveyskoye fields, have significantly increased. The Tambey-Malyginskiy group of deposits is less studied [9, Skorobogatov V.A., Kabalin M.Yu.]. The current value and structure of free gas and condensate reserves are presented in [9, Skorobogatov V.A., Kabalin M.Yu.] and are given in table 1.

Table 1

The state of free gas and condensate reserves in the Yamal OGR (onshore) as of 01.01.2017 (compiled according to the data [2], as well as [9, Skorobogatov V.A., Kabalin M.Yu.])

Field	Free gas, bcm			Condensate (recovered), mln tons			Degree of development	Subsoil user
	extraction /losses	$A+B_1+C_1$	B_2+C_2	extraction /losses	$A+B_1+C_1$	B_2+C_2		
Bovanenkovo group of fields								
OGC Bovanenkovskoye	211.3	4185.0	199.5	0.2	54.5	18.9	devel.	Department for Subsoil Use in the Urals Federal Okrug (Ural FO), OOO Gazprom dobycha Nadym
GC Kharasaveyskoye	1.3	1330.3	358.6	0.1	45.0	29.2	expl.	OOO Gazprom doby-

in the economic development of the Russian Arctic]. Ed. By Agarkov S.A., corr. member RAS Bogoyavlenskiy V.I., Dr. of Economics Kozmenko S.Yu., Dr. of Technical Sciences Masloboev V.A., Ph.D. Ulchenko M.V. Apatity, Kola Scientific Center of the Russian Academy of Sciences, 2019, 170 p.

[2] Katalog ob"ektov ucheta GBZ s dannymi svodnogo gosudarstvennogo reestra uchastkov nedr i litsenziy i GKM (vklyuchaya Sbornik svodnykh materialov o zapasakh obshcherasprostranennykh poleznykh iskopaemykh RF). Rossiyskiy Federal'nyy geologicheskiy fond [Catalog of GBZ accounting objects with data from the consolidated state register of subsoil plots and licenses and GCF (including the Collection of consolidated materials on the reserves of common minerals in the Russian Federation). Russian Federal Geological Fund]. URL: https://rfgf.ru/bal/a/index.php (accessed 21 January 2021).

								cha Nadym, PJSC Gazprom
GC Kruzenshternskoe	-	617.3	293.1	-	0.7	1.9	expl.	PJSC Gazprom
G Yuzhno-Kruzenshternskoe	-	6.5	12.1	-	-	-	expl.	PJSC Gazprom
G Severo-Bovanenkovskoe	-	4.5	10.0	-	-	-	expl.	D/SU in the Ural FO
Vostochno-Bovanenkovskoe	-	1.7	3.0	-	-	-	expl.	D/SU in the Ural FO
Total	**212.6**	**6145.3**	**876.3**	**0.3**	**100.2**	**50.0**		
Tambeyskaya group of fields								
GC Yuzhno-Tambeyskoye	3.0	953.9	332.9	0.2	28.4	19.9	expl.	OAO Yamal LNG, OOO NOVATEK-Yurkharovneftegaz
GC Severo-Tambeyskoye	-	862.4	261.9	-	32.2	18.2	expl.	PJSC Gazprom
GC Tasiyskoe	-	503.6	62.1	-	26.4	3.8	expl.	PJSC Gazprom
GC Malyginskoe	0.1	439.5	305.6	-	18.9	30.2	expl.	D/SU in the Ural FO, PJSC Gazprom
OGC Zapadno-Tambeyskoe	-	124.4	86.3	-	2.9	6.1	expl.	PJSC Gazprom
G Syadorskoe	0.1	24.6	-	-	-	-	expl.	OOO NOVATEK-Yurkharovneftegaz
Total	**3.2**	**2908.4**	**1048.8**	**0.2**	**108.8**	**78.2**		
South Yamal group of fields (Novoportovsk oil and gas accumulation unit)								
OGC Arctic	0.01	276.2	39.3	-	2.7	1.2	expl.	D/SU in the Ural FO
OGC Novoportovskoe	0.9	267.9	33.4	0.1	16.8	1.6	devel.	OOO Gazpromneft-Yamal
OGC Nurminskoe	0.1	178.4	45.0	-	4.7	1.5	expl.	D/SU in the Ural FO
GC Malo-Yamalskoe	0.03	114.7	114.0	0.01	7.1	12.3	expl.	D/SU in the Ural FO, OOO Gazpromneft-Yamal *
G Verkhnetiuteyskoe	-	110.7	-	-	-	-	expl.	OOO NOVATEK-Yurkharovneftegaz
GC West-Seyakhinskoe	-	95.7	103.5	-	2.5	4.1	expl.	OOO NOVATEK-Yurkharovneftegaz
OGC Rostovtsevskoe	-	61.8	21.9	-	2.8	1.3	expl.	D/SU in the Ural FO
OGC Neitinskoe	-	60.3	37.1	-	0.5	0.0	expl.	D/SU in the Ural FO
OGC Sredneyamalskoe	-	40.3	25.0	-	2.1	1.7	expl.	D/SU in the Ural FO
G Kamennomysskoe (onshore)	0.5	34.6	-	-	-	-	devel.	D/SU in the Ural FO, CJSC Yamaltek, OOO Gazpromneft-Yamal
GK Khambateyskoye	-	15.7	18.7	-	1.2	1.4	expl.	OOO Gazpromneft-Yamal
G Ust-Yuribey	-	11.9	1.9	-	-	-	expl.	OOO Ust-Yuribey
Blizhnenovoportovskoe	-	4	-	-	-	-	expl.	OOO Gazpromneft-Yamal
GC Baydaratskoe	-	2.1	2.3	-	0.1	0.2	expl.	D/SU in the Ural FO
G Nerstinskoe	-	1.7	-	-	-	-	expl.	D/SU in the Ural FO
Total	**1.54**	**1276.0**	**442.1**	**0.11**	**40.5**	**25.3**		
TOTAL	**217.34**	**10329.7**	**2367.2**	**0.61**	**249.5**	**153.5**		
*Subsoil user OOO NOVATEK-Yarsaleneftegaz exchanged assets with OOO Gazpromneft-Yamal for a stake in 2 fields of Arcticgas — Yevo-Yakhinskoye OGCF and Severo-Chaselskoye GCF								

In the reserves structure of the Yamal OGR, gas dominates, confined to the Cenomanian and Lower Cretaceous horizons. Gas reserves, concentrated in the deposits of the Cenomanian-Aptian complex, lie at depths of 700–1700 meters. This is "... dry (energy) natural gas, characterized as methane with a very low (about 0.1%) content of methane homologues, suitable for energy production and transportation without preliminary processing" [6, Shchegolkova A.A., Ulchenko M.V., p. 116]. Valanginian ("combination") gas deposits in the Neocomian-Jurassic sediments at depths of 1700–3200 meters are located under the unique Cenomanian deposits, most of which are under development. Valanginian gas, consisting of methane, ethane, propane, butane and heavier fractions (gas condensate), requires processing with the release of heavy fractions, which increases the cost of production [3].

Characteristics of natural gas fields' development in Yamal OGR

Currently, the oil and gas condensate field Bovanenkovskoye is being developed, as well as the fields included in the Novoportovsk oil and gas accumulation unit (OGCF Novoportovskoye, GF Kamennomysskoye (onshore)).

The Bovanenkovskoye OGCF is part of the Bovanenkovsk industrial zone (IZ); commissioned: GP-1 in 2012, GP-2 in 2014, GP-3 in 2018. The projected production level of 115 billion m^3 per year (during the development of the Cenomanian-Aptian deposits) was reached in 2019. In the long term, due to the connection of the Neocomian-Jurassic deposits, it is planned to increase the design level of gas production up to 140 billion m^3 per year. In order to transfer gas from the Bovanenkovskoye OGCF to the Unified Gas Supply System (UGSS) of Russia, a gas transmission corridor to Ukhta was put into operation in 2012 and 2017.

The Novoportovskoye OGCF (under development since 2012) is a strategic project of Gazprom Neft and is the center of a powerful cluster of hydrocarbon production, primarily oil (the oil grade was named Novy Port). A feature of the Novoportovskoye OGCF is its high gas-oil ratio. The complicated geology of the Novoportovskoye OGCF, remoteness from the network infrastructure in order to increase the efficiency of the field development required the creation of autonomous generation using its own raw materials — natural and associated petroleum gas — a gas turbine power plant (GTPP). The Novoportovskoye OGCF is also implementing a gas reinjection project to maintain reservoir pressure (RPM) and production levels. For this purpose, a compressor station (CS) with an integrated gas treatment unit (IGTU) was built in 2017. In addition to ongoing projects on the basis of the Novoportovskoye OGCF, work is underway to create a unique infrastructure project aimed at efficient monetization of all types of hydrocarbons (Table 2). It is supposed that

[3] Global'nye tendentsii osvoeniya energeticheskikh resursov Rossiyskoy Arktiki. Chast' I. Tendentsii ekonomicheskogo razvitiya Rossiyskoy Arktiki [Global trends in the development of energy resources in the Russian Arctic. Part I. Trends in the economic development of the Russian Arctic]. Ed. by Agarkov S.A., corr. member RAS Bogoyavlenskiy V.I., Dr. of Economics Kozmenko S.Yu., Dr. of Technical Sciences Masloboev V.A., Ph.D. Ulchenko M.V. Apatity, Kola Scientific Center of the Russian Academy of Sciences, 2019, 170 p.

with each ton of recoverable liquid HC at Novoportovskoye OGCF, up to five thousand m^3 will be extracted simultaneously.

Only Cenomanian deposits are productive at the Kamennomysskoye GF (onshore); design and survey work (R&D) is underway at the field. Table 2 provides information on the fields under development in the Yamal OGR.

Table 2

Developed fields in the Yamal oil and gas region (onshore)

Field/area of interest	Distribution of free gas by deposit type (as of 01.01.2016)	Production level 2019	Implementation of field-based projects
OGC Bovanenkovskoye part of the Megaproject Yamal Gazprom is included in the Bovanenkovskaya IZ	$(A+B_1+C_1)+(B_2+C_2)$: 4185.0+199.5 bcm ¯ NG; 54.5+18.9 bcm — GC Alb-cenomanian — 32% Aptian — 52.1 % Valanginian (neocom) — 8.3% Jurassic — 7.6%	free gas — 115 bcm	MGP Bovanenko-Ukhta-Torzhok-1 MGP Bovanenko-Ukhta-Torzhok-2 PC — 115 bcm ↓ MGP Yamal-Europe
OGC Novoportovskoye part of the Megaproject Yamal Gazprom is included in the southern IZ, the leading raw material is oil (since 2014)	$(A+B_1+C_1)+(B_2+C_2)$: 267.9+33.4 bcm ¯ NG; 16.8+1.6 bcm — GC Alb-cenomanian–5.4 % Valanginian (neocom) — 62.2 Jurassic — 32.4%	oil — 7.7 million tons on the basis of the gas processing plant associated petroleum gas is compressed in the amount of – 8.59 bcm Utilization of APG — 95%, of which: - injection of APG into the reservoir for reservoir pressure maintenance — 89-93% - fuel for gas turbine power plants — 2-3%	Project (commissioned in 2022): 1.construction of CTAF — PC: - according to APG — 11.03 bcm, - natural gas — 5.07 bcm 2.construction of the GTS: GTS Novoportovskoe-Yamburg (115 km) PC — 20.5 bcm ↓ GTS Yamburg-Tula-1 GTS Yamburg-Tula-2
G Kamennomysskoye (onshore) part of the Megaproject Yamal Gazprom is included in the southern IZ	$A+B_1+C_1$: 34.6 bcm ¯ NG Alb-cenomanian–100%	n/d	- the development of TCP for the implementation of design and survey work is underway, - preparation of a technical scheme for the development of the PC1 reservoir (Cenomanian stage)
NG — natural gas; GC — gas condensate; APG — associated petroleum gas; PC — projected capacity; CTAF — Complex of technological and auxiliary facilities; TCP — technical and commercial proposal; GTS — gas transmission system; MGP — main gas pipeline			

Fields differentiation of Yamal OGR by their prospects

The development of hydrocarbon deposits in the Yamal OGR was repeatedly postponed due to the inaccessibility of the regions of the Arctic zone, the ecological component, expressed, first of all, by the weak susceptibility of the natural environment to man-made loads and a long period of self-recovery, the complete absence of industrial and social infrastructure [11, Bogoyavlencky V.]. Difficult climatic conditions — the spread of permafrost, heaving and saline soils,

thermal erosion and thermokarst processes, a large number of lakes and rivers with a complex hydrological regime — aggravate the problem of the region development.

Development of new hydrocarbon fields demands solving a complex science-intensive technical problem and, accordingly, requires significant investments. Making a decision on the development of new fields in conditions of significant uncertainty is, in fact, the largest strategic task that involves consideration of all (technical, organisational and investment) components. The successful project implementation is primarily associated with the uniqueness of each hydrocarbon field. Only giant and unique fields with more than 90% of the initial natural gas reserves are considered most cost-effective.

Analysis of the distribution of deposits, taking into account their mining and geological characteristics [12, Lyugai D.V., Soin D.A., Skorobogatko A.N.], assessments of natural and climatic conditions, ecological component and the presence or absence of industrial and social infrastructure allows to differentiate the fields of Yamal OGR (distributed subsoil fund) by their prospects, to highlight the supposed stages of hydrocarbon resources development project (Tables 3–6).

Table 3

Distributed subsoil fund, explored fields (1st stage of project implementation)

Field/area of interest	Distribution of free gas by deposit type (as of 01.01.2016)	Planned terms of commissioning / field-based project
1st stage of gas production		
GC Kharasaveyskoye part of the Yamal Gaprom Megaproject is included in the Bovanenkovskaya Reservoir	$(A+B_1+C_1)+(B_2+C_2)$: 1330.3+358.6 bcm ¯ NG; 45.0+29.2 bcm — GC Alb-cenomanian — 16.1 % Aptian — 53.1 % Valanginian (neocom) — 29.8 Jurassic — 1%	**Project (commissioned in 2023):** 1.construction of CGTU; BCS; clusters of production gas wells, transport and energy infrastructure 2.construction of the GTS: GTS Kharasavey-Bovanenko (100 km) PC – 20.5 bcm MGP Bovanenko-Ukhta-Torzhok-1 (2012) MGP Bovanenko-Ukhta-Torzhok-2 (2017) MGP Bovanenko-Ukhta-Torzhok-3 (2023) total PC – 160 bcm MGP Yamal-Europe MGP Nord Stream 1, 2
BCS — booster compressor station; CGTU — complex gas treatment unit		

Table 4

Distributed subsoil fund, explored fields (2nd stage of project implementation)

Field/area of interest	Distribution of free gas by deposit type (as of 01.01.2016)	Planned commissioning dates
G Verkhnetiuteyskoe Is the resource base of NOVATEK for the Obskiy LNG project	$(A+B_1+C_1)+(B_2+C_2)$: 110.7 bcm — NG Alb-cenomanian — 100%	Obskiy LNG project In 2019, the study of the main technical solutions was completed, the design and selection of the main equipment began. 1st line — PC 2.5 million tons (2024) 2nd line — PC 2.5 million tons (2025)
GC Zapadno-Seyakhinskoye Is the resource base of NOVATEK for the Obskiy LNG project	$(A+B_1+C_1)+(B_2+C_2)$: 95.7+103.5 bcm — NG; 2.5+4.1 bcm — GC Alb-cenomanian — 31.3% Aptian — 30.6 % Valanginian (neocom) — 38.1%	
OGC Tambeyskoe (North-Tambeyskoe, West-Tambeyskoe, Tasiyskoe) part of the Yamal Gasprom Megaproject is included in the Tambey Reservoir	$(A+B_1+C_1)+(B_2+C_2)$: 1490.4+410.3 bcm ¯ NG; 61.5+28.1 bcm — GC Alb-cenomanian — 30.8% Aptian — 41.5 % Valanginian (neocom) — 17.5% Jurassic — 10.2	Commissioning of the oil and gas condensate field — 2026
GC Kruzenshternskoe **G** Yuzhno-Kruzenshternskoe part of the Yamal Gasprom Megaproject is included in the Bovanenkovo Reservoir	$(A+B_1+C_1)+(B_2+C_2)$: 623.8+305.2 bcm ¯ NG; 0.7+1.9 bcm — GC Alb-cenomanian — 78.8% Aptian — 21.2 %	Commissioning of the gas condensate field — 2028
G Blizhnenovoportovskoe part of the Yamal cluster of Gazprom Neft	$A+B_1+C_1+C_2$: 4 bcm ¯ NG Paleozoic carbonate deposits — 100%	It is a pilot site for the extraction of minerals from Paleozoic deposits in the Yamalo-Nenets Autonomous Okrug. Development commissioning is planned after 2022.
GC Khambateyskoye part of the Megaproekt Yamal Gazprom is included in the South IZ	$(A+B_1+C_1)+(B_2+C_2)$: 15.7+18.7 bcm ¯ NG; 1.2+1.4 bcm — GC Valanginian (neocom) — 100%	Commissioning of gas condensate fields into commercial development — 2023 Commissioning of wells – 2024
GC Malo-Yamalskoe part of the Yamal Gazprom Megaproekt enters the Yuzhny IZ	$(A+B_1+C_1)+(B_2+C_2)$: 114.7+114.0 bcm ¯ NG; 7.1+12.3 bcm — GC Alb-cenomanian — 21.2 % Jurassic — 78.8%	Design and survey work on the development of the Malo-Yamalskoye gas condensate field is being carried out (planned date of design and survey work is 2021)

Table 5

Distributed subsoil fund, explored fields (3rd stage of project implementation)

Field/area of interest	Distribution of free gas by deposit type (as of 01.01.2016)	Planned timing of the project
GC Malyginskoe part of the Yamal Gasprom Megaproject is included in the Tambey Reservoir	$(A+B_1+C_1)+(B_2+C_2)$: 439.5+305.6 bcm ¯ NG; 18.9+30.2 bcm — GC Alb-cenomanian — 16% Aptian — 42 % Valanginian (neocom) — 16% Jurassic — 26%	Design and survey work is underway. The term for putting the gas condensate field into operation has not been determined
G Syadorskoe resource base NOVATEK included in the Tambeyskaya IZ	$(A+B_1+C_1)+(B_2+C_2)$: 24.6 bcm –NG Alb-cenomanian — 100%	Design and survey work is underway. The term for putting the gas condensate field into operation has not been determined

Table 6

Distributed subsoil fund, explored deposits (unpromising)

Field/area of interest	Distribution of free gas by deposit type (as of 01.01.2016)	Planned timing of the project
G Ust-Yuribey resource base of OOO "Ust-Yuribey"	$(A+B_1+C_1)+(B_2+C_2)$: 11.9+1.9 bcm –NG Valanginian (neocom) — 100%	The term for the development is not defined

Table 7 summarises the distribution of free gas by types of deposits in the Yamal onshore oil and gas fields.

Table 7

Distribution of free gas by types of deposits in the Yamal oil-and-gas region (onshore) of the distributed fund (%)

Jurassic-Cretaceous deposits				Paleozoic deposits
Alb-cenomanian	Aptian	Valanginian (neocom)	Jurassic	Carbon
Developed deposits				
30.7	48.4	11.7	9.2	-
1st stage of project implementation				
16.1	53.1	29.8	1	-
2nd stage of project implementation				
45.2	30.7	13.0	11.0	0.1
3rd stage of project implementation				
18.6	40.7	15.5	25.2	-
unpromising				
-	-	100.0	-	-
Total for all deposits of the distributed fund				
32.13	42.83	15.4	9.6	0.04

Certain fields of the Yamal OGR are classified as unallocated subsoil fund (USF), with the most significant of them being of federal significance for the purposes of energy security and of strategic importance for the Russian Federation's gas supply. According to the assessment of these fields (Table 8), the main free gas reserves are concentrated in the Aptian-Albsenomanian oil and gas complex.

Table 8

Distribution of free gas by types of deposits by fields of strategic importance for gas supply to the Russian Federation, referred to objects of federal importance (%)

Field	Distribution of free gas by deposit type (as of 01.01.2016)		
	Alb-cenomanian	Aptian	Valanginian (neocom)
OGC Arcticheskoe	68.75	18.75	12.5
OGC Nurminskoe	17.6	32.4	50.0
OGC Rostovtsevskoe	10.7	10.7	78.6
OGC Neitinskoe	31.25	50.0	18.75

Thus, according to the nature of the revealed productivity, the main dominant complex of the Yamal OGR in terms of free gas resources is the Albian-Cenomanian and Aptian, where the main gas reserves are concentrated [11, Bogoyavlencky V.]. It should be noted that the basis of the hydrocarbon potential of this OGCF is formed by fields that are confined to large tectonic elements, namely to all positive closed structures of the 2nd and 3rd orders: Nurminskiy mezoval — Bovanenkovskoye OGCF, Verkhnetiuteyskoye GF, Zapadno-Seyakhinskoe GCF, Severo-Bovanenkovskoe GF (USF), Vostochno-Bovanenkovskoe GF (USF); to the Yuzhno-Yamalskiy val —

Novoportovskoye OGCF, Malo-Yamalskoye GCF; Kharasaveyskiy dome-shaped mezoval — Kharasaveyskoye GCF, Malyginskiy val — Malyginskoye GCF; to the Yuzhno-Tambeyskiy dome-shaped mezoval — Yuzhno-Tambeyskoye GCF; to the Severno-Tambeyskiy mezoval — Zapadno-Tambeyskoye OGCF, Severo-Tambeyskoye GCF, Tasiyskoye GCF; to the Bovanenkovsko-Arctic large val — Neitinskoe OGC (USF), Arcticheskoe OGC (USF).

Structural low zones of the Yamal OGR are characterized by small and medium-sized fields with hydrocarbon deposits in the Cenomanian and Neocomian [5, Kontorovich A.E.]. Thus, "… structures on the eastern plunge of the Nurminskiy mezoval (Seyakhinskoye structural terrace) are associated with the following deposits: Verkhnetiuteyskoye GF, Zapadno-Seyakhinskoe GCF, Severno-Bovanenkovskoe GF (USF), Vostochno-Bovanenkovskoe GF (USF); to the north and east of the South Yamal val — Rostovtsevskoe OGCF (USF), Nurminskoe OGCF (USF), Sredneyamalskoe OGCF (USF), Khambateyskoye GCF, Kamennomysskoe (onshore) GF, etc." [12, Lugay D.V., Soin D.A., Skorobogatko A.N., p. 31]. It can be assumed that "... the nature of the gas content of the section of individual promising areas primarily depends on their tectonic confinement" [12, Lyugay D.V., Soin D.A., Skorobogatko A.N., p. 31].

Conclusion

The assessment of the Yamal oil and gas potential allows us to conclude that the degree of exploration of natural gas reserves (the ratio of developed and explored reserves to the total volume), according to the State Balance Sheet as of 01.01.2017 (Table 1), is quite high and amounts to 81.4 % (free gas), 61.9% (condensate). The share of production / loss of developed and explored reserves is at the level of statistical error and amounts to 2.1% (free gas), 0.2% (condensate).

In future, the strategy for the expansion and development of the hydrocarbon potential of the Yamal OGR will focus on prospecting and exploration to convert inferred resources into commercial natural gas reserves, including by expanding gas production areas, with leadership from the Cenomanian to the Albian and especially Aptian, where, in contrast to the Cenomanian and Jurassic, it is particularly promising. At the same time, the geological risks of developing the hydrocarbon potential are minimal, compared to the waters of the Northern and Far Eastern seas, including the shelf of the Kara Sea, which require colossal financial and technological costs. Geological exploration, organization of natural gas production, processing, and transportation in the hard-to-reach Arctic regions of the Yamal OGR will require substantial investment resources and will, in fact, become a transnational task, since Yamal gas will remain the guarantee of Russia's energy security for the decades to come and form the basis for gas supplies to several countries in the Asia-Pacific Region.

The deployment of large-scale investment projects in the gas industry of the Arctic zone of Russia is of fundamental geopolitical importance, as it is a tool for the economic development of

the regional space and the strengthening of the regional presence of Russia in the Arctic [4], as well as providing stability and economic security of the Arctic regions, creating a cumulative effect, which will not only increase Russian natural gas production and exports, but will also contribute to regional development processes in the Arctic, namely:

- increasing the cargo turnover of the NSR;
- increasing the transport and infrastructure potential of the region;
- construction of infrastructure facilities for the gas industry, including new terminals for transshipment of LNG in Kamchatka and in the Murmansk Oblast;
- gasification of the Arctic territories;
- development of national shipbuilding industry;
- expanding the scientific and technical base; creation of about 90 thousand new high-tech jobs;
- increasing in tax revenues to the federal and regional budgets, etc.

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