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Yamal Fields Development.
Bovanenkovskoye Field as Beachhead for Yamal Development

Main author
Sergey Menshikov
Russia

ABSTRACT

The paper assesses the role of the Yamal Peninsula and the Bovanenkovskoye field, particularly in meeting the growing gas demand challenge.

Brief characteristics of the regional hydrocarbon resource base exploration data are provided, as well as prospects for the Yamal fields development.

Principal features of the Project for Cenomanian-Aptian Deposits Development in Bovanenkovskoye Oil, Gas and Condensate Field are presented, consideration is given to the issues associated with the project implementation and to the innovative solutions ensuring that the objectives set as part of the Yamal Megaproject are successfully met.

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Introduction

According to the outlook for the period until 2030, gas consumption in every sector of the gas market is going to rise.

The most dramatic demand growth is expected in regions with a poor gasification level, as well as in the Central and Northwestern Federal Districts. The overall gas demand volume in the aforementioned period (export supplies included) is estimated at over 964.9 billion cubic meters per annum.

In 2008, 664.9 billion cubic meters of gas were extracted in Russia, some 85.7 per cent of which were produced in the Nadym-Pur-Taz region of Western Siberia.

Bearing in mind that most of gas fields under development are mature production fields, it will be prudent to anticipate a natural decline in the output from operational fields.

New oil, gas and condensate fields are to be commissioned in the mature gas producing and new gas bearing regions in order to meet growing gas consumption in the domestic and foreign markets, as well as to offset a decline in the output from major gas fields.

Until 2012, the required gas production volumes are to be underpinned by the Nadym-Pur-Taz region resources. However, starting from 2012 it will be required to bring new fields onstream in promising gas production centers, such as the Yamal Peninsula, the Barents Sea, the Ob and Taz Bays, in order to meet gas production plans. Gazprom is confident that hydrocarbon resources of the Yamal Peninsula will play one of the most important roles in securing domestic and export gas supplies.

In the future, onshore and offshore gas production from the Yamal Peninsula may yield over 30 per cent of the nation’s total.

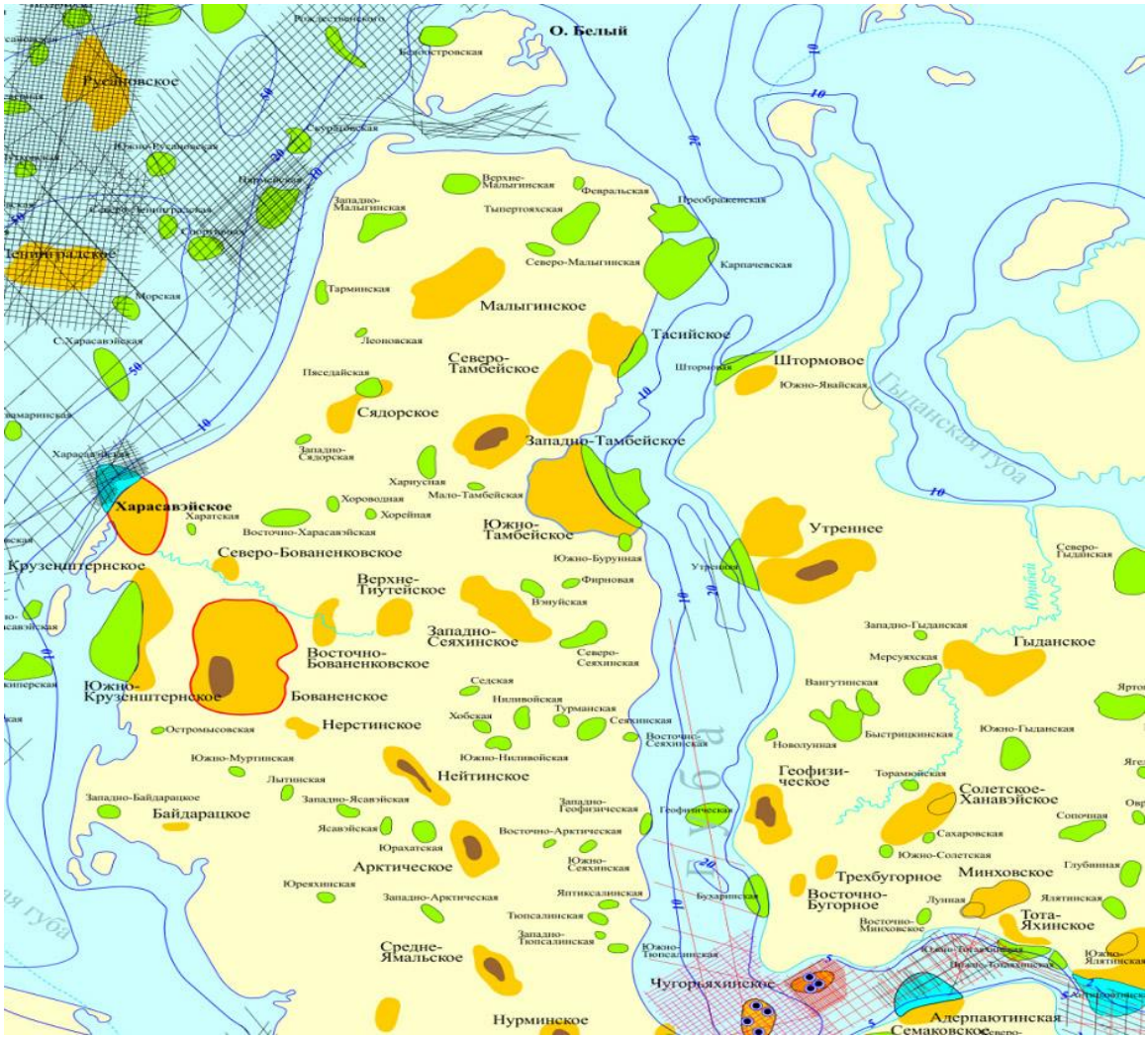

Figure 1. Yamal Peninsula oil, gas and condensate fields

1. Exploration Data Level of Yamal Peninsula Resource Base

The current level of exploration data on the Yamal subsurface resources may be assessed as considerably high for the Cretaceous formations and medium high for the upper Jurassic formations. Being at an earlier stage than onshore operations, offshore exploration and development of Yamal discovered unique and giant fields with the richest reserves.

Out of 26 hydrocarbon fields discovered in the Yamal Peninsula, only four fields' reserves were rubberstamped by the State Committee for Reserves so far. The Russian Federation has booked 10 trillion cubic meters of natural gas, 42 per cent of which are accrued on the Bovanenkovskoye oil, gas and condensate field.

Yuzhno-Tambeyskoye, Kharasaveyskoye and Kruzenshternskoye may also be considered as the largest fields of the Yamal Peninsula. Discovered resources of these fields exceed 3 trillion cubic meters of natural gas, though the fields are significantly underexplored as some 30 to 60 per cent of their acreage is located in the Kara Sea and the Ob Bay.

The Bovanenkovskoye, Kharasaveyskoye, Novoportovskoye, Kruzenshternskoye, Severo-Tambeyskoye, Zapadno-Tambeyskoye, Tasiyskoye and Malyginskoye fields development licenses are vested in Gazprom Group.

Nowadays, Gazprom is actively implementing the aggressive scenario of the program for comprehensive development of the Yamal Peninsula and adjacent offshore fields. The scenario stipulates construction of the Bovanenkovskoye field infrastructure facilities and the Bovanenkovo – Ukhta gas trunkline system.

Commissioning of the first startup complex of the comprehensive gas treatment unit at the Bovanenkovskoye oil, gas and condensate field with the capacity of 15 billion cubic meters per annum is slated for the third quarter of 2012.

2. Cenomanian-Aptian Deposits Development in Bovanenkovskoye Oil, Gas and Condensate Field

The Project for Cenomanian-Aptian Deposits Development in Bovanenkovskoye Oil, Gas and Condensate Field is unique.

To apprehend the scope of work to perform, suffice it to mention that the overall volume of the project design and estimate documentation exceeds 170 books.

Within this project, it is planned to put onstream three gas production fields, 12 booster compressor stations with the overall capacity of 1,460 MW, 775 gas and gas condensate wells in 56 well pads.

The lifespan of the Bovanenkovskoye oil, gas and condensate development project is 28 years. During this period, some 2.5 trillion cubic meters of gas and 1.6 million tons of gas condensate are planned to be extracted from deposits.

In accordance with the project objectives, the maximum production rate of the field will be reached in the fifth year of operation, that is in 2017. Meanwhile, the annual production rate during the plateau period will be equal to 115 billion cubic meters of gas and 97.7 thousand tons of condensate.

In the long run, after the Neocomian-Jurassic deposits of the Bovanenkovskoye oil, gas and condensate field are put into operation, the production rate is projected to rise to 140 billion cubic meters per annum.

The project stipulates construction of buildings and facilities of the main production line, as well as life support facilities (rotation shift camps, sports and fitness centers, a hospital, a captive power plant), fire prevention, sanitary, epidemiological and environmental safety facilities (solid waste landfills, a metal scrap processing base, a drilling mud neutralization shop), transport infrastructure (an airport, on-site and off-site motorways), which will support the operation of the whole field.

Figure 2. Rotation shift camp at production site No. 1

Figure 3. Rotation shift camp at production site No. 1

Figure 4. Fire station at production site No. 1

Figure 5. Captive power plant at production site No. 1

In addition, a railway line with the length of over 570 kilometers has been built to provide for year-round cargo delivery to the Bovanenkovskoye field and, subsequently, to other fields being developed in Yamal.

Figure 6. Obskaya railway station

Thus, within the Project for Cenomanian-Aptian Deposits Development in Bovanenkovskoye Oil, Gas and Condensate Field a highly potent social, life support and transport infrastructure is being set up allowing us to consider Bovanenkovskoye as a beachhead for further industrial development of the Yamal Peninsula.

3. Innovative Solutions for Bovanenkovskoye Oil, Gas and Condensate Field

To achieve most efficient, economically viable and complete extraction of hydrocarbon feedstock during the Bovanenkovskoye oil, gas and condensate field development, there had to be implemented an efficient instrument for preplanning of management decisions effects on the system which comprises: reservoirs, wells, a gathering system, booster compressor stations, comprehensive gas treatment units, a gas gathering system, a main compressor station. The situation development forecast plays a key role within the integrated field management system. Any intervention in the hydrocarbons production process must be efficient not only at the time of the action, but further on as well. Without a comprehensive forecast of management decision effects on different components and the whole system, every managerial action is a mere reaction on a current situation and can not bring to a final strategic goal.

Within the framework of the Bovanenkovskoye oil, gas and condensate field development project, an automated field management system (AFMS) is being developed for the first time along with the automated process control system (APCS). The former is based on the live integrated geological and process simulation model of the field.

The joint efforts taken by many experts to support the integrated simulation model functionality provides for identification of the way reservoirs, pipeline networks, equipment and gas treatment processes interact with each other. The experts will have an opportunity to find out the system bottlenecks and to arrive at decisions enabling to solve the problems. In such a way development and utilization of integrated gas field simulation models provide for understanding of a perfect image of available resources and boosting of the field management efficiency.

Utilization of the live integrated geological and process simulation model (LIGPSM) will provide for a continuous cycle of the Bovanenkovskoye field management, including upper and lower levels of control (Figure 7). The upper level of control is implemented on AFMS basis, which, in turn, is based on the LIGPSM. The AFMS provides for comprehensive analysis and forecast of the field development, computation and optimization of operation regimes of wells, gathering lines and other equipment. The optimal regimes of equipment operation are passed over to the lower level of control for implementation.

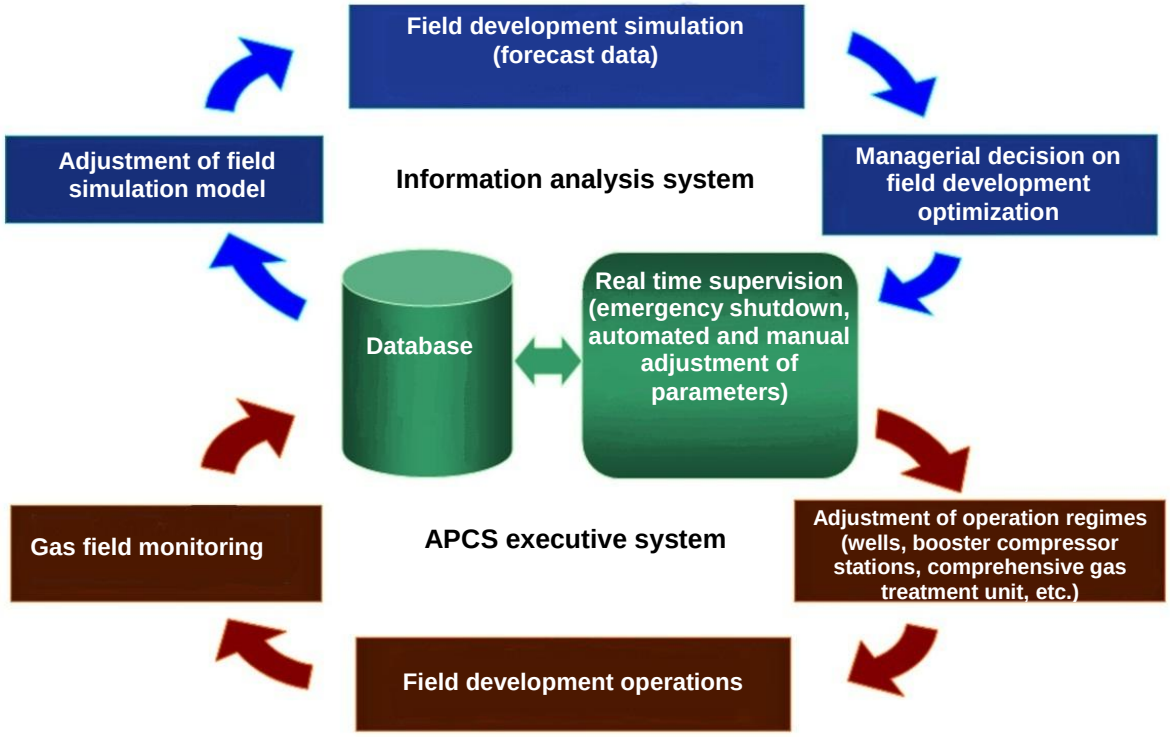

Figure 7. Continuous field management cycle

The lower level of control provides for real time control and adjustment of operation regimes of the wells, gathering lines and other equipment within the specified range, as well as emergency shutdown. This level of control is provided by the automated process control system.

Besides actions of direct control of the field development, the system of production control and hydrocarbons treatment also addresses the issues of the so-called fuzzy logic. These are environmental and geo-engineering issues where part of the interactions may be represented by quantitative models, and another one – exclusively by qualitative models (expert estimates method). To deal with these issues, the comprehensive field simulation model within the AFMS along with the live geological and process simulation model includes several non-formalized models:

- an environmental model which contains complete information on the environmental status and the process facilities having adverse environmental impacts. The model supports the development of a set of environmental protection measures to prevent adverse industrial impacts;
- a geo-engineering model which contains information on engineering, design and geological aspects of gas productions systems, supporting process safety, failsafe operation of wells, equipment, pipelines, buildings and structures based on the real time data of their actual operating status, comprehensive geo-engineering forecasts, analysis of changes in the facilities status, elimination and prevention of out-of-tolerance developments in the engineering status of the facilities, their components and assemblies.

Engineering and construction of the gas production complex and the transportation system are being carried out in the region of unequalled permafrost and geological complexity. The Yamal Peninsula is characterized by the widespread presence of permafrost soil having thickness of 120 to 250 meters, with high ice content and thick stratified and veined ice deposits (Figure 8). Dangerous exogenous processes are quite often here. All this in conjunction with climate change and locally induced industrial impacts have been taken into account in the process of engineering and construction solutions development to secure long lasting stability of groundwork and bases for engineering projects.

Figure 8. Bovanenkovskoye field. Subsurface ice melting accompanied by surface sagging

To identify the required safety margin of groundwork and bases reliability, a special forecast research of would-be developments in geo-cryological situation until 2050 has been executed in cooperation with the Geo-Cryology Institute under the Russian Academy of Sciences. The research demonstrated that during the lifespan of designed assets, geological and permafrost conditions in the region may undergo considerable changes: due to global warming, average annual temperatures of permafrost soils will rise, leading to the reduction of their bearing capacity. Several areas are forecasted to experience full-scale degradation of permafrost in the near-surface zone. A concept of geo-cryological parameters management for construction sites is being developed and implemented based on the results of the research. Infrastructure development facilities are placed at least complex sites in terms of geo-cryological conditions, in compliance with the results of specialized mapping. To achieve projected cryological conditions in soil bases of infrastructure facilities cooling systems (thermal stabilizers), heat shields and other engineering solutions of permafrost thermal conditioning are used (Figure 9).

Thermal stabilization solutions have been developed and are being implemented to secure wells and gas trunklines stability under conditions of frozen soil with high ice content. To reduce well heat load upon frozen soil, thermally insulated pipes are integrated in their design and vapor-liquid tubular cooling systems are employed at well heads (Figure 10). The production zone gas treatment technology provides for gas cooling, thus gas is injected into a trunkline at subzero temperatures. This

method secures gas trunkline stability in permafrost soils with high ice content. Every operation of permafrost soil thermal stabilization is designed on the basis of heat modeling results and giving due consideration to the predicted global warming trend.

Figure 9. Assembling tubular thermal stabilization system for permafrost soils in foundation of industrial facility

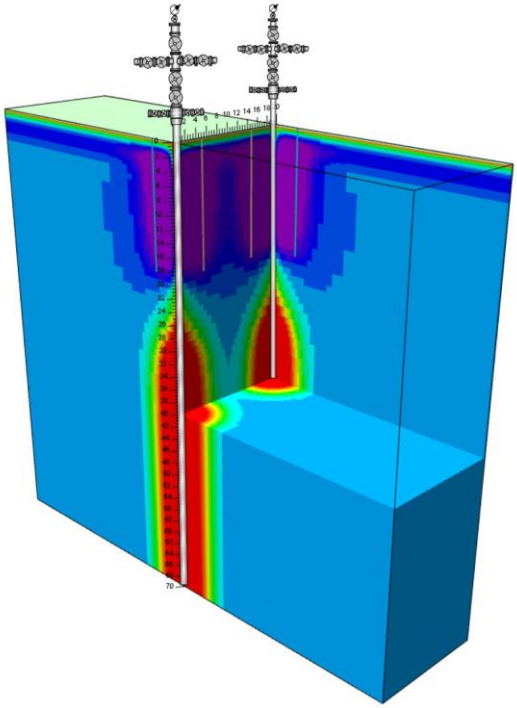

Figure 10. Simulation of gas wells heat exchange with permafrost soils (thermal stabilization design in wellhead zone)

A geo-engineering monitoring system has been designed and deployed, allowing to monitor developments in the frost condition of the area, at the foundations of gas production and transmission facilities, to identify in a timely manner formation of dangerous exogenous processes, to support buildings stability in extremely challenging frost conditions.

The region is ample with non-sustainable ecosystems with a low potential for self-regeneration. That is why special attention is focused on nature conservation.

Prior the commencement of the active stage of business operations, large scale ecological exploration of the area has been undertaken. Reference characteristics of the local ecosystem's key elements were identified and recorded, an environmental database has been established. During infrastructure facilities engineering, environmentally friendly construction and operation techniques, disturbed land reclamation methods, an industrial and household waste handling system, and an environmental monitoring system were developed. A system of environmental standards for gas production and transmission processes adapted to the regional environment has been designed and implemented.

A system of compensation measures for indigenous population has been devised and executed. Infrastructure facilities are engineered and constructed with regard to migration routes of the local population.

4. Summary

The hydrocarbon resource base of the Yamal Peninsula and adjacent offshore areas is so significant that its industrial development in the long run will support not only sustainable development of the Russian fuel and energy complex, but execution of commitments to foreign partners as well.

Transport infrastructure, power supply and life support assets which have been constructed within the pilot pre-development project for the Bovanenkovskoye oil, gas and condensate field development will remain in demand for development of other promising Yamal fields. And the experience in innovative solutions application will support engineering and pre-development of Yamal fields with maximum efficiency and minimum environmental risks.

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