Development of Yamal peninsular inland and offshore fields
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Once discovered and estimated, Yamal peninsular hydrocarbon resources have always been recognized as a background for the long-lasting sustainable development of the national gas industry, meeting the long-term gas demand both for domestic consumers and export.

It should be pointed out that the following factors make the efficient development of Yamal peninsular more complicated:

- Throughout distribution of permafrost rocks;
- Unfavourable ice conditions;
- Yamal ecological fragility to eventual industrial impact;
- Severe arctic climate (low temperature during winter period (below -40 °C), the average annual air temperature is minus 9 °C, the polar night lasts 80 days);
- Almost no infrastructure;
- The peninsular area is occupied by indigenous peoples of the Northern part of Russia with conventional use of natural resources.

Field development under very severe environment conditions of Yamal calls for new technologies to ensure reliability of gas production and gas transportation facilities, to preserve traditional historic lifestyle of indigenous people as well as to minimize the industrial impact on fragile and sensitive environment of the peninsula.

In 2006 “Gazporm” and Yamal-Nenets district authorities started to amend the Program for Development of Yamal peninsular inland and offshore fields in order to generate and implement the best solutions for the development of a new gas production region ensuring long-term gas supply to consumers.
The Program was amended based on the results of the long-term studies aimed at creating the scientific background for projecting, technical & technological and environmental solutions for field infrastructure development and construction of gas pipelines at Yamal peninsula.

The objective of the Program is to ensure the development of the new gas production area based on the comprehensive approach enabling to make managerial decisions on the following:

- To expand the national resources in natural gas and liquid hydrocarbons;
- To create long-term plans for gas, condensate and oil production at Yamal peninsula till 2030;
- To set up priority development guidelines for Yamal inland fields, the Kara sea shelf and Gulfs of Ob and Taz in terms of tactics and strategy for the development of the national gas industry;
- To set up industrial and social infrastructure for the new gas production district;
- Program governmental support measures.

The Program covers the entire process chain from raw material source to project infrastructure development and economic performance.

The main guidelines of the Program for Development of Yamal peninsular inland and offshore fields are the following.

**Raw material source**

The current geological and geophysical exploration degree of Yamal inland subsoil could be estimated as average.

Since the 1960-s 26 inland and 5 offshore fields have been discovered on and around Yamal peninsula based on the prospecting results.

The drilling exploration degree of Yamal shelf is estimated as very low but the exploration success ratio nearly reaches 1. 5 gas deposits were discovered at 5 prospective areas during deep drilling campaign.

The total potential hydrocarbon resources of Yamal and the Kara sea are estimated as follows:

- gas: 50.5 TCM;
- condensate: 3.2 bln. t;
- oil: 4.1 bln. t.

And prospective offshore resources are more than twice higher than onshore. 10 deposits out of those discovered on the peninsula and offshore belong to giant and unique in terms of gas resources.

For estimation of the main Program parameters **gas inland and offshore reserves** of Yamal are estimated at 10.7 TCM of reasonably assured, identified and estimated reserves and 4.6 TCM of inferred reserves.

Taking into account already discovered gas reserves, the main prospecting stage is to start after 2015. Implementation of prospecting program at Yamal will ensure replacement of recoverable reserves given the annual production level of 250 BCM during twelve years. In order to build new facilities for large-scale gas production, strategic reserves growth is possible on the Kara sea shelf, which reserves can increase up to 8.0 TCM.

**Field development**

The core gas and condensate production areas of Yamal region are rich Bovanenkovo and Tambey gas and gas condensate field clusters, whereas the core oil production areas include Novoportovskoe and Rostovtsevskoe oil & gas fields.

The priority development target is the richest in terms of reserves Bovanenkovo oil & gas condensate field located in the center of the peninsula. Currently, the field is at the infrastructure development stage.

In general, the predicted gas production level at Yamal peninsula together with offshore fields can account for from 310 to 363 BCM per year, including inland fields of 250 BCM per year.
The hydrocarbon condensate production evolution dynamics depends on gas recovery rate.

The maximum condensate and oil production can amount to 12 mln.t per year.

The following most important new technologies and technological solutions are expected to be applied in the development and facilities construction on Yamal peninsula fields:

- Combined system for the development of Senoman and Aptian multilayer stages;
- Application of heat-insulated pipes for well construction;
- Development of deep horizons applying horizontal and branched wells enabling to considerably reduce costs for facilities construction;
- Distance reduction between operating well heads from 40 to 20 meters. It will two times reduce cluster back filling volume;
- Construction of field modules for gas and condensate treatment with the capacity of 30 BCM per year and more.

By 2030 over 2000 wells, 14-16 GTU and booster compressor stations with capacity over 1100 MW should be commissioned to ensure the predicted gas, condensate and oil production level. From 4 to 8 submersible production units and 1-2 platforms are to be constructed on Yamal offshore fields.

**Gas transmission**

New multiline gas pipeline system Yamal-Ukhta, Ukhta-Torzhok, Ukhta-Cheboksary should be constructed and the existing GTS should be extended and upgraded in order to ensure gas transmission from Yamal peninsula fields to the unified gas supply system of Russia.

The length of the new gas transmission system to the center of Russia exceeds 2500 km.

The following technical solutions for Yamal gas transmission system are recommended based on the optimization feasibility study:

- **Yamal-Ukhta segment**: gas pipelines are to be built using pipes of dia. 1420 mm x 11.8 MPa with 9 compressor shops at each line;
- **Ukhta-Torzhok segment**: completing commissioning of compressor units of SRTO – Torzhok gas pipeline (*SRTO - Northern Tyumen regions*), construction of gas pipelines of dia. 1420 mm x 9.8 MPa;
- **Ukhta-Cheboksary segment**: construction of two-line gas pipeline with pipes of dia. 1420 mm x 11.8 MPa.
The distance of the linear part of the gas transmission system of dia. 1420 mm to be constructed during the period till 2030 is 11 – 13 thou. km; 13.7 – 16.4 mln.t of large diameter pipes are to be supplied accordingly.

The upgrading of the northern and central corridors of the current gas system is necessary within the above period in order to receive and transmit gas of Yamal peninsula fields.

The construction started and the first joint of Bovanenkovo-Ukhta trunk gas pipelines was welded in 2008.

The technical solutions for the construction of gas pipelines with the operating pressure of 11.8 MPa would enable to create trunk gas pipelines of a new generation based on recent achievements of the national and global science and industry in the pipeline construction.

Designing and construction of trunk gas pipelines from Yamal, which is unique in terms of technical and technological solutions, is carried out in line with new scientific base & methods and regulations.

Previously gas transmission efficiency was improved mainly by using larger gas pipeline diameter and gas compressor units with higher capacity.

In order to reduce the investment into the construction of the gas transmission system from Yamal peninsula, the pipeline rate should be improved by increasing the operating pressure and use of flow-coat as well as application of pipes made of high-strength K65 (X80) steel.
Under Yamal peninsula conditions, the technology and procedure of construction and installation works as well as field gas treatment including all-year-round gas cooling to -2 ºC at the inlet of the trunk line should satisfy particularly strict requirements.

Gas compressor equipment used for the construction of the gas transmission system from Yamal is based on high-tech solutions. New technical solutions on the compressor stations include the following:

- application of gas turbine energy saving equipment of the new generation (efficiency up to 39 %);
- NOx emission reduction based on “dry” burning methods (without injection of chemical agents into gas turbines);
- increase of gas compressor unit capacity up to 25-32 MW;
- module design of hangar gas compressor units.

Introduction of new technical solutions during the construction of compressor stations would allow to reduce CAPEX for the construction of compressor stations as well as maintenance costs and OPEX.

Transmission and processing of liquid hydrocarbons

Various options for transmission of liquid hydrocarbons from Yamal were considered within the Program.

The analysis of hydrocarbons production and consumption in Russia, and the workload metrics of existing production and transmission capacities showed that the transmission from Yamal by sea route via Kharasaway port would be the most efficient one.

350 km of condensate pipelines, 500 km of oil pipeline and 6 pumping stations with the total capacity 13.5 MW should be built to ensure liquid hydrocarbons transmission to Kharasaway.

5 small module gas condensate process installations for fuel (first of all, diesel and aviation kerosene) production should be created within the Program framework in order to provide construction and operating companies as well as other consumers of Yamalo-Nenets Autonomous District with oil products.
Environmental safety

Fields development in extremely severe climate conditions of Yamal requires new technology to secure gas production and gas transmission facilities as well as minimize the technological impact on fragile peninsula environment.

Ecosystems of the peninsula are very sensitive to technological impact on the environment related to:

- terrain disturbance;
- hydrology disturbance due to change in surface run-off formation;
- more active thermal erosion, thermal abrasion, thermokarst and other destructive processes.

The following problems should be settled during the fields’ development:

- changing conditions of permafrost soil and vegetation cover due to industrial impact;
- faster geocryologic and hydrologic process under industrial impact;
- securing wellbore stability during permafrost rock thawing;
- low-quality local construction materials for road and construction sites dumping.

The following actions are aimed at mitigating the negative impact on Yamal environment:

- exercise of engineering solutions aimed at minimization of consequences for environment:
- use of well cluster method;
- advanced motor road construction without disturbing the terrain;
- construction mainly during winter period;
- bases and foundations with minimal thermal and mechanical impact on frozen soil.
- use of low impact technologies and operating modes in difficult geocryologic conditions;
- land recreation;
- protection of wildlife habitat, archeological sites, ceremonial and cultural sites and monuments.
During the period 1990 – 2000 the comprehensive program of forward-looking studies “Development of scientific background for designing industrial, environmental and technical solutions for the facilities construction of Bovanenkovo oil and gas condensate field and “Yamal-Center” gas pipelines” was carried out for the purpose of identifying Yamal fields development methods minimizing the environmental impact.

The results of long-term studies provided information enough to settle practical goals to start facilities construction at the peninsula fields. Nevertheless, it is still important to proceed with scientific studies focused on Yamal peninsula environment.

**Social policy and infrastructure**

Yamal is a habitat of indigenous peoples of the Northern part of Russia with conventional lifestyles and economic activities (deer breeding, fishing, breeding and hunting for furry animals). Deer breeding is a leading activity. Totally, over 267 thousand head of reindeer graze at Yamal and the same grazing routes have been preserved for ages.
Active industrial intrusion into vital activity of indigenous people calls for comprehensive solutions for social & economical and medial & biological issues aimed at preserving and improving conventional activities of the peoples of the Northern part of Russia.

The scenario of agricultural and industrial development of Yamal district where industrial and conventional lifestyles are well balanced and combined during the development of Yamal fields is the core of the new social policy of the Program.

The scenario takes into consideration the experience of Canada and the USA and corresponds to the proposals of the YNAR Administrative authorities.

The Program assumes reimbursement payment for environment damage during the area development and capital expenditures into processing facilities for foodstuff production (made of deer and fish) for shift teams and construction staff.

**Power supply and infrastructure facilities**

There is no industrial or transport infrastructure (railway, motor roads and bridges, large power supply stations and lines) at Yamal peninsula.

It will be necessary to bring in a huge cargo volume (about up to 100 mln. t) for the industrial development of the area in order to construct certain facilities.

The suppliers of equipment and material (pipes, steel structure) are distributed almost all-over Russia: from Saint-Petersburg to Nakhodka. The annual volume of cargoes including gas transmission facilities amounts to about 2-2.5 mln.t.

The main unit of the transmission network is Obskaya-Bovanenkovo railway, which is to be built at Gazprom’s expense.
The following infrastructure facilities of both production and regional importance should be built during the development of Yamal fields:

- Obskaya-Bovanenkovo railway
- Motor roads
- Bovanenkovo airport
- Helicopter grounds at fields
- Port terminal at Kharasaway
- Pilot power supply stations
- Basic power supply stations at fields
- Power supply stations for internal needs
- Communication and TV facilities

**Technical and economic indicators**

The Program implementation will enable to ensure the development of the new gas production area of Russia with the annual production up to 363 BCM for natural gas and up to 12 MT for liquid hydrocarbons.

The total investments into the development of Yamal peninsula and construction of gas transmission system taking into account the predicted margin will amount to 165-199 bln. USD denominated in prices 2007.

The major part of the investments into the creation of the new gas production national region would be necessary to build fields facilities as currently there is no infrastructure as well as to build the gas transmission system into the center of Russia for over 2.5 thou. km.

Government support, stable tax regime and tax relieves would be necessary to efficiently implement the Program.
Government support measures

The Government support of large-scale projects aimed at development of local economies including oil and gas industry is a common practice in many countries of the world.

The government support measures for social and economical development of the region are necessary to develop the new gas production area.

The government support measures for social and economic development of YNAR consist of separate sub-programs supplementing the following existing target federal programs:

- “Economic and social development of indigenous small peoples of the Northern part, Siberia and the Far East till 2015”;
- “Reduction of risks and mitigation of emergency consequences of natural and industrial character in the Russian Federation till 2010”;
- “Upgrading of the national transmission system (2002-2010)”, “Development of the national transmission system (2010-2015)”;
- “Education development 2006-2010”.

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Summary and proposals

Yamal areal (onshore and offshore reserves of the Kara sea) has real potential for growth of natural gas commercial reserves in the amount of 11.7 TCM in the course of exploration works. This figure comprises 3.7 TCM of inland part and 8.0 TCM in the Kara sea shelf.

The unique natural potential of Yamal peninsula, its significance for economics and energy safety of Russia make the development of Yamal fields the most important strategic and economical objective of the national importance.

The Program for development of Yamal fields is comprehensive and consolidated efforts will be required from subsoil users, federal and local authorities to efficiently implement the Program aimed at creating a new gas production center and long-term reliable gas supply for Russian and foreign consumers.