Industrial Development of Gazprom's Unique Fields of East Siberia: Challenges and Ways to Address Them

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Gas production development in Russia today is connected, first of all, with addressing primary challenges, such as: reliable fulfillment of domestic energy demand, preservation and strengthening of Russia's positions in the global energy market. These issuess were used for laying the foundation of Gazprom's Eastern Gas Program.

Gas production dynamics in Russia is determined by the following factors:

- Growth of national economy and energy consumption;
- Decline in energy intensity of national economy;
- Growth of global economy and global energy consumption;
- Increased competition from alternative gas suppliers.

The stated factors show that today there is a need for not only boosting gas export, but also diversifying target markets. There are also certain threats to economic interests due to possible weakening of Russia' s position in the global gas market caused by increased competition from alternative suppliers. Additional gas resources for export can be provided by stepping up production and declining energy intensity of national economy.

Current long-term and mid-term forecasts of Russian gas production significantly exceed the Energy Strategy adopted in 2009.

According to the forecast of International Energy Agency, the average annual growth of global gas production to 2030 will amount to 1,9 %, in Russia – 1,7%.

It creates the need for further development of the mineral resource base of gas industry and field development in new regions.

At the current stage of gas industry development a special role belongs to R&D subsidiaries of producing companies. Gazprom is not an exception: it has a whole range of subsidiary R&D organizations. Gazprom VNIIGAZ is Gazprom's leading research centre in the area of gas production, transmission and processing.

The Institute has developed and implemented scientific and technical projects of development of major unique gas and gas condensate fields in Russia and the former USSR.

Gazprom VNIIGAZ has developed and implemented engineering projects of all underground gas storages operated in Russia, CIS countries and East Europe.

The Institute has performed the feasibility study and substantiated main principles of the Unified Gas Supply System development in the USSR.

Gazprom VNIIGAZ has designed projects of gas processing and gas chemical facilities in Astrakhan, Orenburg, Surgut (Russia), Mubarek (Uzbekistan).

Gazprom's decree in 2001 gave Gazprom VNIIGAZ the status of a leading R&D centre in the area of gas production, transmission and development.

Gazprom VNIIGAZ consists of 15 research centres, a pilot testing facility and branches in regions:

- R&D and engineering branch office (Severnipigaz, Ukhta);
- Department for R&D support of integrated development of Yamal fields and adjacent offshore areas (Salekhard);

- Laboratory of geological and field works in East Siberia (Lensk).

The current HR management policy created the best conditions for motivation and self-realization of research associates of the Institute and branch office, which employ over 2 000 specialists, including 50 doctors of science and 200 PhDs.

The current structure of explored gas reserves of Russia is as follows. The estimated commercial gas reserves ($B+C_1$ categories) amount to 47,8 TCM. Its main part belongs to Gazprom - 33,6 TCM, these are mainly West Siberian fields (the Nadym-Pur-Taz region). Gas reserves of other regions are of secondary importance. The volume of explored gas reserves of non-licensed stock has reduced by 2,5 times for the recent seven years.

Total gas in place of East Siberia and the Far East is estimated at 32,9 TCM. Main promising regions comprise the Irkutsk region, the Republic of Sakha (Yakutiya) and the Krasnoyarsk Territory where Chayadinskoye, Kovykhtinskoye and Yurubchenko-Tokhomskoye major fields were discovered. The significant share of total gas in place of Taymyr and Evenkiya is accounted for undiscovered resources (D_1 and D_2 categories).

The analysis of the structure of original gas in place of the Irkutsk region shows a low (15%) exploration degree of gas resources and probability of large fields discovery.

The prospects of setting up the Irkutsk gas production centre depend on their development. The basic field for setting up the Irkutsk gas production centre is the Kovykhtinskoye GCF, total gas reserves ≈ 2,0 BCM.

The exploration degree of gas in place is lower in Yakutiya compared to the Irkutsk region.

Total gas in place of Yakutiya amounts to ≈ 12,8 TCM, the main share belongs to undiscovered resources (C_3+D categories) – they account for nearly 80 %. Therefore, it is necessary to carry out prospecting and exploration works in the Republic of Sakha (Yakutiya). The Evenk Autonomous District is very poorly explored – the share of estimated undiscovered resources (C_3+D) amounts to nearly 90 % of gas in place. It is caused by the remoteness of the territory from existing transmission routes (Tran-Siberian road, Baykal-Amur road). The largest fields of the Krasnoyarsk Territory are located in the southern part of the Evenk Autonomous District: Yurubchenko-Tokhomskoye, Sobinsko-Payginskoye, Kuyumbinskoye and Omorinskoye. The prospects of establishing the Krasnoyarsk gas production centre depend on the development of these fields.

Thus, three major gas production centres that should become the foundation for the development of East Siberian fuel and energy industry are in progress in the east. Total estimated and explored reserves amount to 4,2 TCM, which reveals the high oil and gas potential of East Siberia.

The distinctive feature of basic fields of new gas production centres in eastern regions is high industrial concentration of helium in gas, which requires the development of appropriate gas processing facilities.

As far as new prospecting areas and HC field development in eastern regions are concerned, the following important aspects should be mentioned.

The prospecting areas comprise three main areas related to gas production centres support, energy supplies to gas transmission system and region gasification.

The industrial field development is characterized by scattered HC reserves located in several large and dozens of small fields; the dependency of industrial field development on

gas transmission construction in the eastern regions; difficult relations of subsurface users in terms of integrated use of HC feedstock.

Key issues of development of oil and gas condensate fields in East Siberia include:

- Severe natural and climatic conditions, complex mining and geological conditions, tectonic activity of the regions where new gas production centres are located;
- Poor geological exploration of pay deposits;
- Abnormally low reservoir pressure and temperature of pay deposits;
- Low productivity of reservoirs and wells at high probability of hydrate formation in bottomholes and wellbores;
- Multi-component compositions of HC feedstock, including associated helium, the need for helium extraction and storage;
- Achievement of high oil recovery factors without industrially tested technologies of thin oil fringe development;
- Lack of underground waters and significant remoteness of surface water sources required for well construction and production facilities, unstability caused by permafrost of seasonal water reservoirs;
- Poor development of industrial, power and transmission infrastructure in regions where new production centres are set up, deficit of production forces.

The efficient addressing of key issues of East Siberia field development is possible only in case of integrated field development.

Gazprom VNIIGAZ is the author of “The plan for development of the Chayadinskoye OGCF”. Therefore, the Institute is perfectly aware of the challenges of the development of basic fields of new gas production centres.

To illustrate the key issues of the development of East Siberia basic fields, we shall look at the Chayadinskoye OGCF.

The area of the Chayadinskiy license block amounts to 6 977 km^2 (field dimensions 120×22-30 km, height - 280 m).

Commercially productive Vendian terrigenous deposits occurring at 2 000 m depth are formed with talakhsky and khamakinsky horizon sandstones containing gas condensate deposits and biotubinsky horizon sandstones containing oil and gas condensate deposits.

Deposits are bedded, lythologically and tectonically screened.

Geological exploration degree of deposits varies from 16 % (talakhsky horizon) to 85 % (biotubinsky horizon).

The field has abnormally low initial pressure and temperature (reservoir pressure 12,0-13,3 MPa, formation temperature 9,0-13,6 ^{0}C).

Oil and gas condensate deposits of biotubinsky horizon have thin oil fringes with total oil in place of 200 mln.t (the area of the Northern block oil fringe amounts to 247 km^2). There is nearly no net oil pay zone (less than 17% of the total area), major part of reserves is located in large gas-oil and water-oil zones (over 83% of the total area).

When drawing up “The plan for development of the Chayadinskoye OGCF” Gazprom VNIIGAZ substantiated the concept of field development, which included the following key provisions:

- Stage-by-stage development of pay deposits of biotubinsky, khamakinsky and talakhsky horizons.
- Deposits of designed horizons (biotubinsky, khamakinsky and talakhsky) are assumed as independent development locations.
- Primary bringing to pilot operation the biotubunsky horizon oil fringe, testing of barrier technologies. In case of positive results, the gas condensate deposit and oil fringe will be brought into commercial development concurrently. Petroleum helium-containing gas will be completely disposed by reinjection into the gas cap of the biotubinsky horizon.
- Gas condensate deposits of the khamakinsky and talakhsky horizons will be first brought into development to ensure gas production, later the gas condensate part of the biotubinsky horizon deposit will be commissioned as well. It is planned to develop gas condensate deposits stage-by-stage – pilot operation first (for 5 years) and then – commercial development.
- Preliminary helium and nitrogen extraction at the field (GPP construction), reinjection of helium concentrate into the khamakinsky horizon (southern block II).
- Combined use of vertical and directional wells, as well as multi-bore multi-functional wells located in clusters with account of the boggy-rocky relief. Centralized reservoir-linear pattern of hydrocarbon collection. Gas treatment (low-temperature separation) is carried out in a single facility with GPP.

The need for achieving oil recovery factors approved by the State Committee for Reserves for the oil fringe of the biotubinsky deposit (0,259 – for the northern block given the separate (from gas cap) development of oil part using formation stimulation) conditions the primary commissioning of the oil fringe.

Taking into account the large area as well as other geological and process limitations of thin oil fringe development, it is recommended to develop the oil fringe using multi-functional wells with horizontal wellbores, barrier technologies for separation of oil fringe from gas cap.

The barrier technology with initiation of vertical oil displacement has the following stages:

- Development of a cushion nitrogen layer above the oil fringe;
- Development of a polymer barrier between the gas cap and oil fringe;
- Oil production at initiated vertical displacement by a working (displacement) agent.

In the initial period of field development 3 multi-functional wells for pilot testing of the barrier technology will be drilled. “The plan for development of the Chayadinskoye OGCF” suggests the centralized scheme of gas and oil collection.

Gazprom VNIIGAZ is the author of the “Concept of integrated development of license blocks of the Republic of Sakha (Yakutiya)”, which considered different scenarios of integrated development of 5 wells with the main role of the Chayadinskoye OGCF. For gas transmission from the Yakutsk centre, it is planned to build 2 748 km long trunk pipeline “Chayadinskoye OGCF – Khabarovsk” (gas will be supplied to consumers of the southern regions of Yakutiya, the Amur and Jewish Autonomous Districts).

The above mentioned Concept stipulates high pace of Yakutia fields development (commissioning of the Chayadinskoye OGCF in 2016, Tas-Yuryakhinskoye, Verkhnevilyuchanskoye OGCF and Srednetyungskoye, Sobolokh-Nedzhelinskoye – not later than 2020).

In future if the proposals of Gazprom VNIIGAZ for the sequence of commissioning the Yakitiya gas production centre fields are implemented, annual gas production in the constant production period can reach 30 ÷ 40 BCM.

Prolonging the time (not less than 30 years) of annual gas supplies in the amount of 30 ÷ 40 BCM will require full-scale prospecting and geological-exploration works in the region that should be started not later than in 2019.

The Yakutiya gas production centre development will ensure centralization of energy supply systems and it is planned to improve the transport infrastructure of the Republic of Sakha (Yakutiya):

- to 91,5 % of region population will have transport connection with the centre of the Republic and adjacent regions,
- Increase of all-year round motor roads by 47,5 %,
- Share of hard motor roads will amount to 57 %, length of railways will be enhanced by 10 times.

As it has been mentioned above, formation gases of East Siberia fields have high content of helium (from 0,24 to 0,6 %). It in its turn may help Russia to become a world leader in helium production since helium reserves significantly exceed both domestic and foreign consumer demand. Therefore, it is necessary to construct underground helium storages in eastern regions.

Long-term storage of large amounts of helium is possible in case of building underground helium storages in different geological structures: salt caverns, small depleted gas fields, reinjection of helium concentrate into one of blocks (locations, formations) of developed field.

Each storage method has its advantageas and disadvantages. To store small quantities of helium concentrate (to 1BCM) all three options of helium storages can be used. The storage of large volume of helium concentrate requires creating storages in developed and depleted fields.

If there are no favourable conditions for setting up helium storages in fields and salt caverns, its operational storage can be organized in artificial and natural underground spaces (underground mines, drifts, tunnels, natural caves), including coal and ore mines.

The technology of building UGS of the new type in mines using insulating sleeves of gas holders or special insulating coatings of mine walls has not yet been tested and its testing requires corresponding research studies.

It should be noted that today special geological exploration works aimed at prospecting promising locations for natural gas and helium concentrate storage are not carried out in East Siberia. These works should be launched in all 3 gas production areas.

To reduce capital investments for construction of connecting helium lines and helium losses during transmission, helium storages should be preferably located near gas chemical plants.

The helium concentrate produced in the Krasnoyarsk gas production centre can be stored in salt cavern alluviation near Bogychany township due to its limited volume. The alternative storage can be constructed in one of small fields of this region (Abakanskoye, Imbinskoye, Beryambinskoye).

The helium concentrate produced in the Irkutsk gas production centre can be also stored in salt cavern alluviation in the Balagansk region. The alternative storage can be constructed in the developed Atovskoye or one of formations of Chikanskoye fields.

The major volume of helium concentrate (≈ 7 BCM) is forecasted in the Chayadinsky gas production centre. Therefore, it is preferable to store it in separate blocks of the Chayadinskoye OGCF and Tar-Yuryakhinskoye OGCF and not in salt cavern alluviation.

Helium storages construction requires R&D works on the development of the technology of underground helium concentrate storage in fields with account of mining and geological conditions, requirements for the design of wells used for helium concentrate injection, additional development of potential locations with comparison of capital investments for different ways of storing helium concentrate. The disregard of these requirements may cause unjustified growth of project cost and substantial irreversible helium concentrate losses.

Taking into account the undertaken commitments on gas supplies to the Asian-Pacific region, it is possible to set up gas processing and gas chemical centres at East Siberia fields (in the Krasnoyarsk Territory – with capacity of raw gas processing to 10 BCM/year; in the Irkutsk region – to 5 BCM/year; in the Amur region, raw gas coming from Chayadinskoye and Kovychntinskoye fields, - to 45 BCM/year; in the Primorsky Territory, raw gas produced on the shelf of the Sakhalin Peninsula and Chayadinskoye field, - to 15 BCM/year).

The feedstock base of eastern regions of Russia is unique since formation gas contains valuable components for establishment and development of gas chemical industry – ethane, propane, butane.

Formation gases contain both a highly technological component – helium (its content varies from 0,24 to 0,6 %, which by many times exceeds the helium content in the Orenburg OGCF (0,05 %), and a ballast component – nitrogen (its content at separate fields reaches very high values - to 30% (Sobinskoye OGCF)).

Taking into account the potentials of target components of ethane and propane fractions ($C_{2+в}$ and $C_{3+в}$), it is possible to set up large gas chemical centres for production of a wide range of deeply processed products (liquefied natural gas, PVC, ethylene glycol, carbamide, methanol, acrylonitrile, ammonium nitrate, etc.).

With account of gas properties and requirements for gas calorific value of exported gas, the construction of an LNG plant in the Primosrky Territory will require to abandon the extraction of ethane fraction ($C_{2+в}$). Deep nitrogen extraction will be required at a gas processing plant in the Krasnoyarsk Territory.

Gazprom VNIIGAZ has experience and research base for development of modern energy saving gas processing technologies incorporating extraction of ethane fraction ($C_{2+в}$), helium and nitrogen as well as technologies of gas treatment for trunk pipeline transmission (including low-temperature separation with higher level of natural gas treatment and drying).

To conclude my presentation, I would like to summarize the following key points.

- Gas industry development in the eastern regions of Russia contributes to their economic development and provides the opportunity to enter the gas market of the Asian-Pacific region.
- The development of unique reserves of East Siberian fields requires a comprehensive approach: from geology, development, inter-field and trunk hydrocarbon

transmission, underground gas storage and valuable non-hydrocarbon components to feedstock processing.

- Total gas in place of the East Siberian region amounts to 32,9 TCM, including possible reserves (C_1 category) – 2,6 TCM, probable reserves (C_2) – 1,6 TCM, indicated and geological resources (C_3+D) – 28,7 TCM, exploration degree – 8 %. Gazprom VNIIGAZ forecasts the growth of discovered gas reserves in 2011-2035 at 5 ÷ 6 TCM.
- Current explored gas reserves of the East Siberian region and forecasted reserves growth can ensure the production capacities of 60 ÷ 70 BCM/year by 2020.
- Basic fields of the Irkutsk and Yakutiya gas production centres (Kovykhtinskoye GCF and Chayadinskoye OGCF respectively) by balance gas reserves belong to unique, by the geological structure – to very complex, by the exploration degree – to underexplored. The fields are characterized by very complex gas composition (high content of non-hydrocarbon components – nitrogen and helium); low reservoir pressures (lower than hydrostatic) and temperatures in pay deposits; low productivity of reservoirs and wells at high probability of hydrate formation in bottomhole areas and wellbores.
- Upon the results of geological exploration, pilot and testing operations it is necessary to update the geological structure of basic fields, gas, condensate and oil reserves and gas, condensate and oil recovery rates.
- There is a need for a set of experimental and laboratory studies, pilot and testing works on basic fields to improve the scientific and methodological foundations of their development and select the most efficient technologies for their integrated development.