Arctic LNG Industry Development: Overcoming Regional Challenges

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Introduction. Perspectives and tendencies of development of new oil and gas projects in the Arctic region make it necessary to conclude a fresh study of major factors which influence the development of large scale LNG production and transportation projects. The issue is highly topical because of the fact that large parts of Russian continental shelf which are situated in the Arctic region are proved to be the unique storeroom of oil and gas recourses.

Besides, about 80% of all those resources comprise of natural gas. Technologies of LNG production and transportation make it possible to find highly profitable markets for Russian Arctic offshore natural gas resources. But the realization of those projects in Arctic conditions implies a number of regional distinctive features which should be addressed with adequate means.

In the past several years a number of new oil and gas projects were successfully realized in the Arctic region. The experience of their strong and weak features requires additional analysis since it can help to find better and more efficient ways to develop Arctic resources in the future

The aim of the article is to discuss the challenges of LNG production developments in the Arctic region and to elaborate on the possible solutions which were demonstrated in 2009–2012.

Arctic region is well known for its harsh environment. Firstly it is necessary to consider natural and climatic environment of the region, which is characterized by:

- *Low temperatures and its seasonal variations*.
  The median temperatures of January varies greatly from –2–4°C in the southern part of Arctic to —25°C on the North of the Barents Sea, Baffin and Chukotka Sea the median temperature of January is –32—36°C, Minimal temperatures in these regions often go to –55—60°C. The break through of cyclones may rise the temperature to –2–10°C. The median temperatures of June are +2–3°C

- *Limited visibility because of fogs and precipitation*
  Often meteorological effects (mists, rains, heavy snowfalls) reduce visibility which limits the actions of air traffic, sea vessels traffic and performance of many engineering operations. The formation of particular Arctic cloud bends causes exceptional difficulties since those cloud bends couldn't be detected from the ground, they are formed at 30-100 meters above ground and could cause sudden problems for helicopters and jets. Since temperature of water is most of the time higher than the temperature of air it causes formation of fogs which imped most of operations.

- *Many days with stormy weather*

Storms aren't rare in the Arctic region due to temperature variations. Storms are accompanied by heavy winds (more than 20 meters/second) and high waves which both limit the possibility for operations and may seriously harm onshore and offshore installations. It is followed by considerable high and low tides, variations of sea currents speed, followed by substantial run-ups and roughness

- *Favorable conditions for ice formation on engineering installations especially in October- December*
  This weather phenomenon occurs when air temperatures fall below –4–7° C, water temperature is close to 0° C and the wind speed exceeds 6 meters per second. In these conditions ice formations are formed and lead to the misbalance of vessels and other sea installations. Distortion of ice formations causes lurch, additional windage and inability for the crew to operate properly. There were cases when undervaluation of ice formations in Arctic seas caused the destruction of sea vessels.

- *Low water temperatures, especially near the sea bottom*
  Arctic waters differ from other oceans because of low temperatures near the sea bottom. The studies show that while in most of oceans water temperatures near the sea bottom are usually in the same range of around 3°C , in the Arctic seas water temperatures fall below –1,7°–1,9°C. These temperatures are unfavorable for the operation of subsea pipelines and flow lines

- Arctic soils, permafrost and rocks
  Arctic earth is known for the frozen conditions of the ground and permafrost which require additional engineering solutions to be taken into account for all buld-up procedures. Some of the Arctic seashore is covered with rocks and cliffs which largergly limit the construction area.

- *Drifting ice cover and its considerable variations*
  Most of Arctic seas are covered with ice throughout the winter months[1], so it limits the possibility of construction and operation to the summer months of the year. Besides icebergs, ice-hummocks, ice fields require additional ice management means to be taken into account while planning operations in the region.

- *Polar nights, limited daylight through many months of the year.*
  Operations in the conditions of darkness bring additional risk and require supplementary measures in terms of providing additional artificial lighting

Moreover, the concept of offshore oil and gas developments must be accompanied by an adequate environmental policy aimed at preserving the natural environment, since the Arctic region is known for the very fragile balance of its ecosystems. The fragility of Arctic nature is dictated by its limited ability for self-recovery due to the low

[1] Detailed information available at http://www.aari.nw.ru/projects/ECIMO/ModuleLoad.php?mod=d0015&in=1

intensity of biocoenotic processes. At the same time most of parts of Arctic nature are one of the rarest evidences of untouched ecosystems which should remain intact.

As a result the development of Arctic oil and gas projects should avoid the following negative impacts:

– eradication, change and fragmentation of natural ecosystems
– cryogenic erosion as a result of eradication of natural plant formations
– invasion of alien plants and animals and displacement of endemic species
– damage of boicentric structure and disturbance of nutritive bas of plants and animals due to various types of pollution
– disturbance of migrations and wintering of animals

The listed above limitations of Arctic environment influence the development of oil and gas projects so that an adequate measure should be taken to eliminate the risks, reduce the costs and provide for the efficient implementation of the projects.

Primarily the technological scheme of natural gas production in the conditions of Arctic region should be taken into account. Unfortunately traditional ways of offshore natural gas production with the use of submerged and semi-submerged platforms are not always adequate due to the climatic environment and risks which entail their construction, installation and operation. In order to withstand storms and icebergs and ice formations such platforms should be designed in totally different way. For example the construction of an ice resistant GBS platform Hibernia required 160 000 cubic metres of concrete. The platform is 111 metres high, and it weighs 600,000 tonnes, with more than 400,000 tonnes of dry ballast added to the platform after it was installed, to help stabilize the structure. And even that scale of the platform was not enough to withstand ice. So a series of 16 sharp teeth around the Hibernia GBS ice wall were designed to distribute the force of an iceberg over the surface structure. Besided an ice management strategy is designed to avoid contact with icebergs.
But this platform was built in order to work for more than 20 years because the resource base of that particular region permitted engineers to sacrifice so many efforts to build it. But most of Arctic offshore fields are smaller in size and resource base and such huge megaton constructions may be commercially and technically unviable to develop those smaller oil and gas fields.

The usage of subsea production systems is regarded as one of the most optimal solutions for development of Arctic offshore natural gas fields. The subsea production systems have been under development and upgrade of technology since 70s'. After many years of successful operation those systems have demonstrated the reliability of technology and thus became applicable in all regions of offshore production both in the Arctic and South seas. The subsea production systems enabled to avoid major risks in the regions with harsh climatic conditions. For example in South-East Asia subsea production systems helped to minimize risks caused by typhoons. On Canadian shelf it helped to reduce risks of iceberg formations. So on Russian Arctic shelf where navigation is limited to 3-4 months a year there are few alternatives to subsea production systems.

As a rule several options are regarded when decision concerning the development of the field is being made. The integrative approach of selecting the options helps to

achieve the maximum technic-economic effect for the functioning of the overall project during all its lifetime. Often the best economic effect is reached by the use of floating of ground based platforms alongside with the subsea production systems.

However the benefits of subsea production units in the Arctic conditions include high reliability, the possibility of remote control and management, efficient repair ability due to their module based construction. Moreover they are able to provide unique capabilities for defense from ice formations and icebergs.

Other very important advantage is that subsea systems avoid the necessity for the long presence of operational personnel on the remote sea oil and gas production units where the environment of polar nights and low temperatures unfavorably influence on healthy lifestyle of personnel. Furthermore the lesser personnel is involved in working in the Arctic harsh conditions the lesser is the risk of accidents, traumatism and injuries. So a number of benefits follow in the fields of logistics, supply and organization of risk management.

The choice of liquefaction technology is another very important factor to be taken into account during the design and development of Arctic LNG projects. The rapid growth of LNG industry in the last decade was mostly dominated by the construction of LNG plants in warm climatic zones in such regions as Qatar, Trinidad and Tobago, Nigeria, Yemen, Equatorial Guinea and others. The construction of an LNG plant in cold climatic zones is followed by a number of limitations and difficulties but at the same time the adequate choice of liquefaction technology may lead to the production of LNG with significant economy of energy.

The design and construction of LNG plants which will operate in Arctic conditions should be in line with the following peculiarities:

- Low temperatures which may be used for the cooling of refrigerant after compression;
- The big difference in temperatures, the gap between summer and winter maximums and minimums may reach 40-60 ° C;
- Very limited experience of large scale LNG production in Arctic conditions. Among all world LNG plants there are only 3 which are working in the Arctic: one in the USA in the state of Alaska, one in Norway on Melkoya island and the one in Russia on Sakhalin island;
- The remoteness of transport networks and production infrastructure.

The choice of liquefaction process is the key issue. Today many companies mature liquefaction technologies in order to find the best solutions of operating in the Arctic climate. They try to reach optimal production and operational capabilities trying to use the advantages of cool climate and to limit its the risks and drawbacks. As a result they are aimed at achieving the best indicators of costs per ton of produced LNG.

The technologies of such companies as Shell, Air Products and Chemicals are known to be well proved, tested and reliable. Alongside the technology of liquefaction presented by Linde shows optimal solutions and, perhaps, the most compact in size, so it helps to minimize the size of LNG plant – taking into account that it is very important factor in the conditions of the rocky ground.

The usage of LNG tankers which are designed for operations in the Arctic region is another important factor for the development of Arctic LNG projects. A number of shipbuilding companies are designing new technologies to enhance capabilities of LNG tankers to withstand harsh Arctic conditions. Arctic LNG tankers are those which are able to operate in the Arctic seas covered with ice. These ships are rated with certain ice class depending on operation conditions. International Association of Classification Societies has developed requirements for all year tanker operations in the Arctic region. Russian Maritime Register of Shipping has also developed similar requirements for oil tankers which are also applicable for LNG tankers. So far there are only light ice class LNG tankers which are not designed to overcome heavy ice. Usually those LNG tankers require help of icebreakers. The development of new LNG projects in the Arctic Ocean requires the creation of new LNG tankers which will be capable to deliver LNG throughout the whole year from such remote locations like Yamal peninsular. This difficult technical task calls for the use of the most innovative technologies of modern shipbuilding.

Arctic LNG tankers require additional measures for winterization. It should be taken into account that the crew working in the Arctic conditions experience additional physical and physiological difficulties because of extreme temperatures, darkness, additional noise and vibrations while passing ice fields. So the facilities for the crew should be exceptionally well designed to meet those challenges.

Literature

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