SHIPPING LNG FROM A REMOTE ARCTIC PLANT

Frederic HANNON

TOTAL S.A – Gas, Renewables and Power – LNG Shipping Projects Manager

The Yamal LNG project is located at Sabetta on the West bank of the Ob River, in the Yamal Peninsula (Russia), to produce the huge Gas reserves of South Tambey fields. To export the 16.5 Mtpa LNG production from the 3 trains-liquefaction Plant, the shipping solution chosen to ensure the safe and reliable maritime transportation and operations year-round is to build a fleet of up to 15 Arctic LNG Carriers, with sufficient ice-class notation (Arc7) and ice-breaking capability to operate without the assistance of the Russian ice-breakers in the conditions of Barents and Kara Seas. But to accommodate these vessels in Sabetta, a new Port has to be designed in such a way that it is accessible and operable year round, the ice management being essential: the dredged north river and port access channels, the sheltering of the jetties of the port by ice protection barriers, the jetties and quays designed to sustain the ice loads, the brash ice management system, the winterization of equipment and the sizing of a support fleet in order to ease the operations in the ice. The first train of the Yamal LNG project has officially started its production of LNG on December 8th, 2017, and as of beginning of May 2018, already the 2nd Millions tons of LNG has been loaded from the Sabetta Port. Since the date of the abstract, a lot of events have occurred for the Yamal LNG Project: the three liquefaction trains have been put on stream and the project has reached the nameplate production one year ahead of the initial schedule: a very first for a LNG Project!
Background

The first official milestone of the project was the official decree of October 2010, which promoted the integrated development of the LNG industry in Siberia, granting some favorable conditions to produce and export LNG and condensate gas from remote regions. The second important milestone was the Final Investment Decision taken by the partners Novatek, Total, CNPC and Silk Road in December 2013 to launch the project. After four years of multiple challenges in terms of site preparation, maritime and aerial logistics, new winterized design for the liquefaction plant and the dedicated fleet of vessels, and construction in harsh environment, the first train has been officially started in December 2017. The second train was fully commissioned in May 2018 and as of December 2018, the plant has reached its nameplate production of 16.5 Mtpa one year ahead of schedule, achieving a tremendous performance while meeting the budget.

Marine-related challenges of the project are reminded in the following paper which will not address the other challenges.

Location of the Project in Yamal Peninsula (courtesy of Yamal SPG)

The Challenge of the Shipping Scheme and the Design of the Dedicated Vessels

Contemplating the unique location of Sabetta in the Yamal Peninsula, and using existing data regarding the ice conditions and general metocean along the Northern Sea Route, navigation simulations have been run with the Company's in-house developed software, in order to size the dedicated commercial fleet of LNG Carriers and condensate tankers. Fifteen LNG Carriers of about standard size of 170,000 m$^3$ of cargo capacity and two condensate tankers of about 53,000 m$^3$ will be required to export the 16.5 mtons per annum of LNG and 1.2 mtpa of condensate products, and the vessels need to be independent from the compulsory assistance of the Russian ice-breakers due to their hull width and large number.

At the time of the project, the highest ice class notation for a merchant vessel was Arc7 according to the rules of the Russian Maritime Register of Shipping, and only some vessels with Double Acting System (DAS) were able to sail during Arctic winter periods in Northern Seas, in the Gulf of Finland or in Barents and Kara Seas. It has been the starting point for the project shipping scheme: the project vessels will be able to sail independently year-round Westbound, and when ice conditions allows, Eastbound along the Northern Sea Route; a trans-shipment port in North Europe will help give more flexibility for the ice-breaking LNG carriers use, the cargo being transferred to conventional LNG carrier to reach the Gas Buyers in the far East Asia, when the Bering Strait is not practicable.

Starting from a generic design of a hull form encompassing all existing types of cargo containment systems (membrane, Moss, SPB types), with a reinforced bulbous bow, and a hybrid propulsion (a fixed central shaft and two lateral azimuthal thrusters for the DAS), the concept has evolved through numerous ice model tanks campaigns in european and canadian engineering facilities, to reach the final choice of a moderate ice-breaking bow and a triple set of azimuthal thrusters of new generation. The main innovations of these ships are the ice
reinforcement of the hull and the propulsion system – allowing the sailing ahead in open water and light ice conditions, and the sailing astern in various harsh ice conditions –, the winterization, and the green ship aspects.

![Ship with Double-Acting System principle](image)

After a laborious prequalification of the potential shipyards in year 2012, a slot reservation has been placed to a South Korean shipyard (Daewoo Shipbuilding & Mechanical Engineering), for a lot of fifteen LNG carriers of 172 km$^3$ capacity with 4 membrane type tanks. The ships had to be delivered in phase with the start-up of each train (5.5 mtpa each) of the liquefaction plant, so that a lot of 5 ships were anticipated for each train.

In parallel, the Project team was looking for the Shipowners of the vessels. The qualification criteria were encompassing the professionalism as LNG carrier operators and the experience in sailing in harsh environment and ice conditions. Few operators were attracted by the cumulated challenges at first, but the joining of additional Chinese partners to the project strongly contributed to the financing of the new shipbuildings. At the end, the total fleet of fifteen LNG Carriers has been distributed among a Joint Task Force of 4 Shipowners entities – Sovcomflot (1 unit), Teekay/CSLNG (6), Dynagas (5) and MOL/GLNG (3) – organized around the Charterer Yamal Trade, in order to follow-up the construction at the shipyard site and try to share and harmonize the future operations of the fleet.

The first Arc7 LNG Carrier named “SCF Christophe de Margerie” was delivered with a first acceptance in 2016 after her conventional sea and gas trials offshore the Korean shipyard, but was finally handed-over to Sovcomflot in March 2017 after her successful ice trials in Kara Sea. These were the first full ice-trials for a merchant vessel and the performances of the vessel were well above the anticipated design capabilities under the various ice conditions (2.5 knots ahead in 1.5 m level ice thickness, 7.2 knots versus 5 knots in astern conditions, crossing of ridges with 15 meter keel, moving in more than 2.1 m brash ice, etc…).

![The first Arc7 ice-breaking LNG Carrier during sea and gas trials and later ice trials](image)

**The Challenge of Maritime Logistics**

Due to the remote location and the absence of the suitable year-round overland transport infrastructure (e.g. roads, railways), most of the site preparation, construction materials and equipment required will need to be delivered by sea using the Northern Sea Route.

It all started with the site preparation, when the learnings of the exploratory trials of the ARCDEV program were used to deliver the first lots of equipment on the fast ice during winters, building some ice-roads to shore, and/or using an old existing jetty of the pioneer camp of Sabetta during open water season.
The first goal was to build a proper Marine Offloading Facilities (MOF), in order to ease the maritime access to the site, after dredging quite a lot of volumes of materials which would be used to fill some of the civil works. A fleet of about thirteen dredgers was seen at the scene during the peak of the dredging works to prepare the access to the future port of Sabetta.

The principle philosophy adopted to build the major portion of the onshore liquefaction plant was the modular concept. This would reduce the impact of the harsh environment on the construction process, enable the best use of available labor, and take into account the remoteness and limited access to the site. Hence most of the equipment is built and preassembled in shipyards in the Far East Asia and then delivered to Sabetta by Heavy Lift Vessels for final assembly and erection.

The MOF was initially consisting of four quays for bunkering, loading and discharging heavy loads, roll-on/roll-off, and berthing the future port fleet of tugboats and ice-breakers. The quays were designed to receive heavy loads and allow the maneuvering of the Self Propelled Modular Transporters (SPMTs) unloading the modules carriers by the side until the storage area. During the project, the necessity of unloading the module carriers mostly by the stern has led to the construction of an additional finger pier (quays 5 & 6) in the vicinity. At the peak of the logistics step, 25 winterized modular transporters were on the site, representing 1718 axles and 56,000 tons.
The Fleet of Module Carriers

This project has been the largest one in terms of use of heavy lift carriers:
- a total of 23 vessels have been hired, out of the current world wide fleet of about 50 vessels;
- a fleet of 10 core vessels have been utilized to deliver the 150 large modules to Sabetta (these modules have been assembled in 11 different shipyards in China, Indonesia and have required a quite large project team on the various sites to monitor the schedule and quality of the works);
- and two dedicated ice-reinforced module carriers (Arc7 Class) have been built in China at the beginning of the project, to allow a wider window of delivery at site during winters; the Heavy Lift Vessels (HFV) Audax and Pugnax were built in 20 months…

A Fleet Operations Center, located in Paris and Moscow, has been opened to monitor the metocean and ice conditions of the 76 voyages of the module carriers during the period from June 2015 to September 2017. This dedicated tool has allowed to check the best and safest routes for the various pieces of the puzzle, proposing the eastern route through the Bering Strait or imposing the route through the Suez Canal, when ice conditions were impenetrable along the Northern Sea Route. 38,000 mTons were safely delivered through 22 voyages using Bering Strait and 55 voyages through the Suez Canal and sometimes stored temporarily in the MISY (Module Intermediate Storage Yard) in Zeebrugge (Belgium) before being transferred to Sabetta.

The Challenges of the Port Design

The final choice for the design of the Port was focusing on the accessibility year-round for the multiple types of vessels during the construction and for the years of commercial services of the liquefaction plant, the sheltering of the vessels for their operations and the ice management during the 9 months of ice-infested waters.

The liquefaction Plant is located in the Arctic circle, on the west bank of the Ob River. The location of the Port has been decided in Sabetta, where in the 1980s, a pioneer camp had been set for geological exploration and meteorological surveys. The huge reserves of the Tambay gas fields are very close so the need of long pipeline is not a concern, but the access to this location for large vessels with 12 meter draft requires a dredged channel in the north of Ob Bay, about 50 kilometers; this will be an issue when assessing the dredge waste materials disposal and the design of the channel by itself:
Quite a good number of options for the design of the port have been contemplated and assessed at the conceptual stage of the project and the main criteria for the final choice were:

- the navigability of the access channels to the port and terminal;
- the ice management for the ships at berths and availability of infrastructures;
- the construction feasibility (quantities of works and materials, dredging, length of ice protection barriers or trestle);
- the possibility of Simultaneous Operations (SIMOPS) during the construction of the full Plant in three phases, with parallel construction and commercial operations;
- the possibility of extension of the Port (ex: a third jetty for export of LNG);
- the impact of the option on the schedule and the CAPEX.

Some Challenges due to the acceleration and earlier readiness of the project

The construction of the Liquefaction Plant has been accelerated particularly thanks to the experience gained on the modules delivery logistics and learning from the erection of the first train and its commissioning. The site slot reserved initially for the potential third LNG jetty has been used to build a finger pier to accommodate the module carriers to unload by the stern, and the dedicated Fleet support (4 ice-class Tugboats and port ice-breaker) of the Sabetta was ready on time so that the SIMOPS aspects have been optimized.

On the other hand, the original Trans-shipment point at Zeebrugge Terminal (including dedicated onshore storage tank construction and relevant equipment for Yamal LNG project) is following its own schedule and not fully ready at the time of the start-up of the third train in December 2018; only trans-shipment through jetties is available.

Out of the fifteen Arc7 LNG Carriers, only the ones dedicated to the trains 1 and 2 are ready for loading the nameplate production of the plant; the solution to cope with the optimized use of the available Arc7 LNG Carriers and provide more flexibility in shortening their voyages in ice, is the Ship-To-Ship transfer with conventional LNG carriers at a closer location, in Norwegian waters.
A few words of conclusion

From its very beginning the Yamal LNG project is a pilot project for Russia and for its promoters. Despite the hurdles of the harsh environment, the multiple challenges due to the remoteness and polar night, the need for innovations and customized solutions, and some external sanctions, the positive experience of the Yamal LNG project paves the way for further developments in the same far North such as Arctic LNG 2.

References


