Decades of developing Arctic LNG carriers

An artist's impression of an early Arctic LNG carrier design from the mid-1970s: Finnish shipbuilders' proposal for gas turbine powered ships capable of crossing the Northwest Passage. Aker Arctic's predecessors participated in many such LNG trade and ship studies related to the Canadian Arctic.

The use of liquefied natural gas (LNG) has been steadily growing. LNG, which consists mainly of methane, provides cleaner energy with less harmful emissions compared to oil fuel, and with current environmental concerns the need for clean options continues to grow. When vast gas resources in cold areas were found, it was essential to start developing systems to explore and transport these resources successfully, economically and safely to the market. Finnish engineers have been involved in developing transportation solutions for LNG for a long time.

The oversea transportation of LNG requires dedicated ships both in terms of size, as LNG is a light-weight cargo, and in terms of how the gas is stored on-board the vessel in its cryogenic liquid form. In fact, LNG 'exists' and is produced only for storing and transporting natural gas feasibly in its densified form: One cubic metre of LNG becomes 600 cubic metres of natural gas when vaporized back to its gaseous form.

Today there are almost 450 LNG carriers in service, the majority of which are large size ships. Some 110 such ships are currently on order. In the mid-1960s, the first commercial LNG carriers were developed and taken into use in Europe. In the early 1970s, LNG deliveries expanded to Japan. The two main LNG carrier types used today are derived from those ships. These are the so-called membrane- and Moss-type ships, which have both later developed sub-types and improved versions.

An LNG carrier at Sakhalin gas terminal (Photo courtesy: Sovcomflot)

LNG carriers for cold environments

Early Arctic pilot projects in the mid-1970s aimed at transporting LNG from the Canadian Arctic to elsewhere in North America and to Europe. Relatively large and high ice class ships were designed and proposed by Finnish companies. In the beginning of the 1980s, some US companies issued plans even for Arctic submarine LNG vessels. None of those plans came true and the development for arctic LNG vessels was halted for decades.

During the 1980s and 1990s, LNG shipping continued to grow steadily, but it took place in warm waters and concerned Middle East gas production. Slowly, however, LNG production began to expand north towards colder regions.

A breakthrough for LNG transportation in cold areas came when two production projects for LNG shipments began: the Snöhvit project in Norway (2007) and the Russian Sakhalin II LNG project on the island of Sakhalin (2009). Both were the first large-scale national LNG projects in areas with winter conditions. As a result, several ice class 1C Moss-type LNG carriers were built to serve the projects.

In the early 1970s, some of the first LNG carriers built in Norway also had the same ice class 1C, as did the first two PSB-type ships that were built in 1993 in Japan and sailed for a long period on the Alaska-Japan route.

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First Arctic LNG designs with the double acting icebreaking concept

For a long time, it has been known that there are vast natural resources of oil and gas in the Arctic regions.

Apart from the earlier Canadian LNG projects, a new era of interest in Arctic gas resources arose at the beginning of this century. The first concept ideas were drafted for Moss-type Arctic carriers in early 2000, but eventually the growing interest in LNG exports from the Arctic stimulated Aker Arctic to start developing a solution for LNG shipments. The first Arctic class DAS™ ship *Norilsk Nickel* was designed and built in Helsinki while large LNG Carriers were on the drawing board.

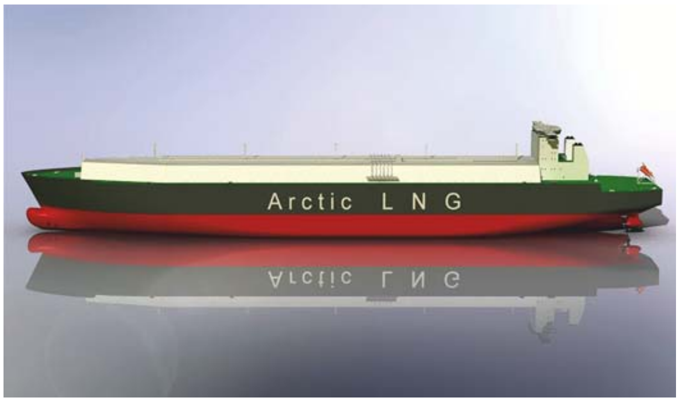
"In 2004, Aker Arctic kicked-off a large development programme which aimed to introduce a vessel design that would be able to bring LNG from the Arctic to the markets," says Mr Reko-Antti Suojanen, Managing Director, for Aker Arctic. The final outcome was a three-propeller double acting vessel concept, which also utilised the special new solution of the Integrated Hull Structure (IHS), which provided easy winterisation solutions as well as a stronger hull and savings in the steel weight.

"As the double acting concept was already a proven solution, we decided to use a bulbous bow form for these vessels and thus provide the maximum effectivity in open sea navigation, which in any case is used in many of these carriers," says Suojanen.

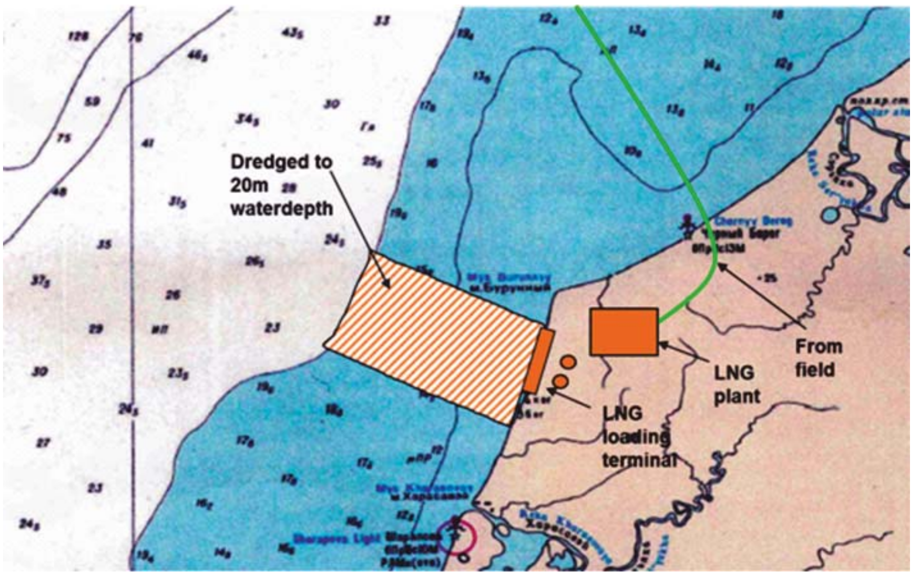
The design was called the Aker Arctic 206,000m³, and it was equipped with five tanks (see picture below). Cost estimates for the vessel and economic calculations showed that the transportation cost and the reliability of LNG shipments would be highly suitable for the markets. The average speed of the vessel would be sufficient even in the harshest mid-winter conditions from the Kara Sea to the European or North-American markets.

The Yamal peninsula was known for its vast gas reserves, and at that time Khrasevey was considered the best place for a port and LNG liquefaction facility.

Aker Arctic 206,000m³ IHS design for Arctic LNG transports from 2006.



Alternative design with the GTT No-96 tanks with a large capacity of 224,000m³. The same propulsion principle with three propellers was used.



Plan for the Kharasevey Arctic LNG terminal.
(Source: Aker Arctic presentation in Quebec 2008)

The complete transport solution

To solve the transportation problem, the carrier design is not the only issue. Successful operation also requires the appropriate route selection, the LNG loading solution in a cold environment, specific safety measures, overall port and terminal planning, supporting port ice breaker fleet and tug assistance, as well as various emergency precautions with the escort icebreakers. All these differ considerably from the traditional solutions used in LNG terminals in warm waters around the world.

The entire harbour area needs to be planned so that it can accommodate large cargo vessels. This includes the port icebreakers, support vessels and tugs, which all need to be designed specifically for the Arctic conditions. Loading and off-loading areas, including ice management procedures for removal of ice, are also essential.

"Safety requirements in all Arctic vessels are equally strict to those of other vessels, but are of a wider scope due to the cold environment," Suojanen adds. Apart from requirements related to safety as a gas carrier, safety plans have to be raised to a completely different level. Risk evaluation, risk management procedures, evacuation plans, the distance to habitation or to a safe haven and 'what to do in the case of an emergency' are all extremely important elements to consider to minimise risks.

Water depth in the Arctic varies from deep to very shallow and this poses additional challenges in designing large ships, including risks of grounding and bottom damage to vessels. Navigators need to be alert when sailing in such regions and should be aware of unsurveyed areas in Arctic waters with the risk of icebergs and multi-year ice.

Arctic LNG carrier "Christophe de Margerie" advancing in the Arctic ice.

Arctic LNG carriers for Yamal LNG

During the past years, the works related to Arctic LNG Carriers have focused on making plans become reality. From 2010, Aker Arctic has worked for the Yamal LNG company supporting its development project to design LNG-carriers and related port infrastructure and a port fleet for transporting natural gas from Sabetta to the markets elsewhere in the world.

"We have been extremely happy to see our long-term development, persistent work, new ideas and ships finally come true. It has been fantastic to work with our clients who have displayed an innovative attitude and the rock solid expertise, which will make LNG transports from the Arctic happen," says Suojanen.

Regarding ships for the Yamal LNG project, a series of 170,000 m³ sized Arctic LNG carriers that will carry gas to Europe and the Far East from the Yamal peninsula was proposed. The project stakeholders made the selection for the potential builder and the membrane tank concept.

The carriers need to be large so that they can transport a substantial amount of cargo – 16.5 million tons a year. The new, but today very common, size class of 170,000 m³ was also favoured, as it would allow transhipment operations to similarly sized ordinary open water LNG carriers that can transport gas cargoes further to overseas destinations more economically than the Arctic ships.

In addition to the Far East destinations, the ships will call on a regular basis at the Zeebrugge LNG terminal in Belgium where the transhipment of cargoes via onshore storage will also take place.

The first Arc7 Arctic LNG Carrier "Christophe de Margerie"

The first real Arctic LNG carrier, the *"Christophe de Margerie"*, is currently in service and will start regular LNG shipments later this year from Sabetta port in the Yamal peninsula. Her sister ships will join the fleet of 15 ships, one by one as they are completed and the LNG plant has reached its full capacity of 16.5 million tons of LNG a year. Read more about the *Christophe de Margerie* in its full-scale ice tests last winter on page 9.