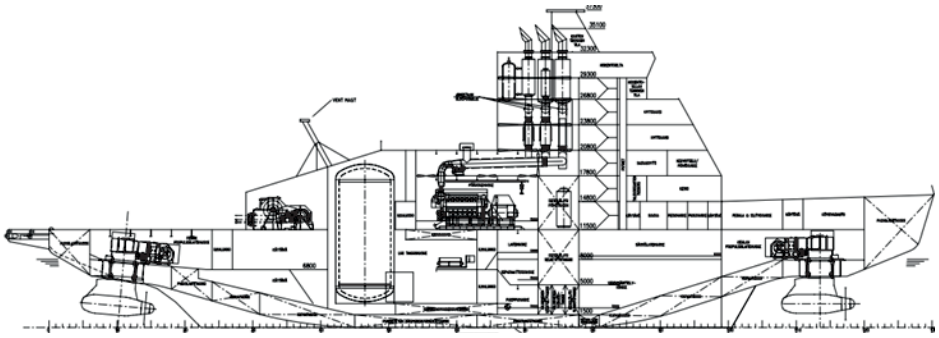
LNG fuelled machinery is a clean option

The use of LNG (liquefied natural gas) fuel is currently growing at a rate of 7-8% per year. Tightening environmental regulations is one reason but also proven LNG technology, lower fuel costs and vast gas resources are other driving forces behind new investment decisions.



LNG fuel can with today's technology also be used for ice-going vessels and icebreakers, which are exposed to fast power variations. Dual-fuelled Diesel-electric machinery of a Finnish icebreaker concept. (Picture: Aker Arctic)

Using gas as fuel in ships is nothing new. Since the early 1970´s LNG carriers have used the natural boil-off from LNG cargo as secondary fuel while transporting LNG to the market. Primary fuel is HFO or intentionally vaporised LNG. Still, the majority of conventional LNG carriers are fitted with steam turbine machinery, which can easily utilise the energy from the boil-off gas evaporating from the LNG while keeping the cargo cold.

Dual fuel engine technology

Since the beginning of 2000, diesel-electric machinery with dual fuel engines has taken over and is the most common choice in new ships. These ships are equipped to use both LNG and fuel oil as the primary fuel option.

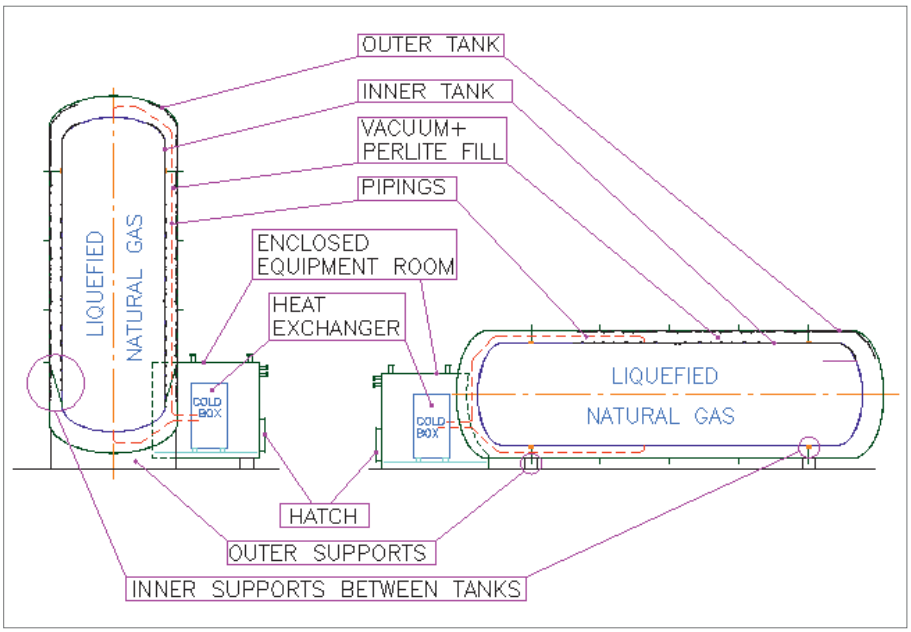
Gas engine technology has developed quickly, with Finnish company Wärtsilä Finland being a forerunner, and medium speed gas engines are now available in various sizes. Also, lean burn (gas only) type engines are on the market covering even the smallest engine range. Recently, large slow speed engines using either high pressure gas or lean gas have been introduced for marine use and have entered as rivals to medium speed gas engines.

"On the outside, dual-fuel engines look like ordinary oil-burning diesel engines. They are more expensive than ordinary diesel engines as they have two fuel systems. The change from one fuel to another can be done with the engine running and if a disturbance occurs in the gas fuel system or if the power rate gets too low for gas mode, the oil mode is switched on automatically. Dual-fuel engines develop about 10% less power than same sized oil-fired engines but their thermal efficiency in gas mode is slightly better," Mauri Lindholm, Principal Naval Architect at Aker Arctic Technology, explains.

Additional systems for gas-fuelled machinery are necessary. They include the LNG fuel tank with tank insulation, LNG vaporiser with heating system, gas fuel piping and ventilation of hazardous spaces. All these require space and add weight to the vessel. On the other hand, less equipment for fuel oil storage and use is needed.

"When liquefying natural gas, it shrinks to 1/600th of its original size. As a very light liquid, it still takes up more space than fuel oil with the same energy content. The storage tanks also need to have either an outer insulation, or a second enclosure with vacuum in-between the double structure for insulation and safety. A vaporiser unit is typically integrated in the LNG fuel tank.

Such a tank module is placed in a tank room – if the tank is placed inside a ship's hull. This means that storing LNG fuel may require more than three times the storage space compared to a fuel oil tank that can be constructed as a structural tank in a ship's hull. For ship designers this poses a challenge, as valuable space has to be used for fuel tanks. Also, when planning to modify existing vessels this is an important point to consider. One option is to position the storage tanks vertically to save space or, to place the gas fuel tanks on open deck – if the ship design allows," Mr Lindholm continues.



Vacuum insulated LNG fuel tank: Vertical and horizontal tank configuration (Aker Arctic).

Emission comparison

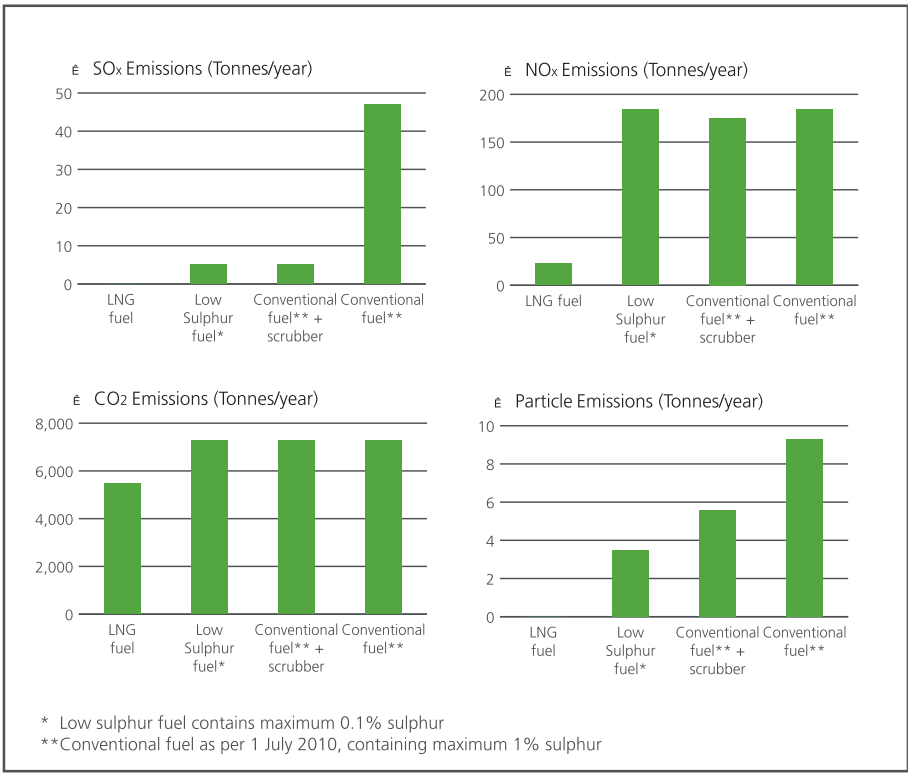
When burning LNG in combustion engines, a reduction of 80 to 90% of NOx emissions is achieved compared to fuel oils. LNG contains no sulphur and therefore a 100% reduction in SOx emissions as well as a 25 to 30% reduction in CO_2 is achieved. Particles like soot in exhaust gases are almost none and the smoke is invisible. There is less need for overhauling engines, lubrication oil purification or maintenance.

From 2015 onwards the Emission Control Areas (ECA) will have tighter emission regulations, and by using LNG fuel these are fulfilled and even surpassed. Older vessels can install scrubbers or use fuel with low sulphur content, but these actions may become expensive and do not reduce emissions to the same extent as LNG. Also, EEDI (Energy Efficiency Design Index) is expected to introduce more environmentally efficient ship designs.

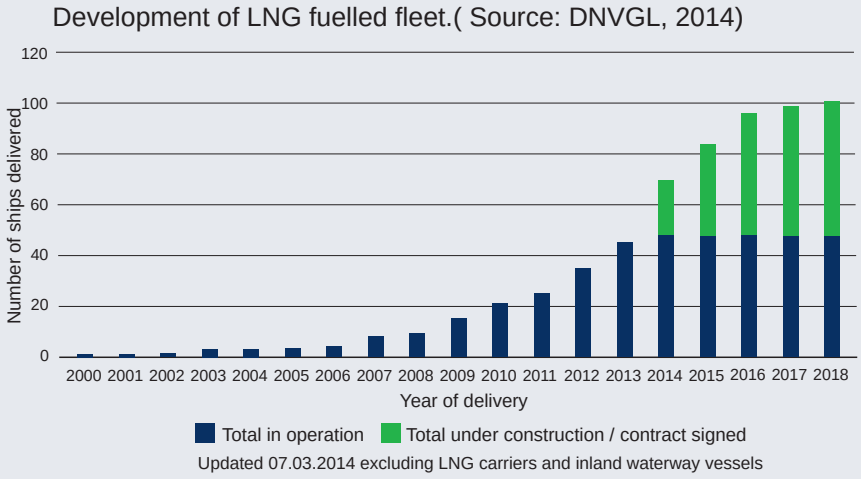
"Natural gas reserves are vast. Availability and distribution of LNG is improving all the time. LNG has become an everyday commodity with prices going down so that it can now be lower than that of HFO, therefore offering savings in fuel costs," Mr Lindholm adds.

Ships today and tomorrow

Today, there are proven gas engines of various sizes available. Apart from over 400 existing LNG tankers and 126 such ships on order, there are more than one hundred LNG fuelled ships around the world, many of them in Norway.
They comprise of offshore supply and service ships, patrol and coast guard ships, passenger and car ferries, smaller cargo ships, tankers, tugboats and river ships with more to come. According to future scenario reports, LNG will be the fuel of choice in 20 years' time. ►►



LNG is superb as cleaner fuel. A study of exhaust gas emissions of different fuel options (Source: DNV, Greener shipping in the Baltic Sea, 2010).



Development of LNG-fuelled fleet – excluding LNG carriers and inland waterway vessels (Source: DNV 2014)

The dual-fuelled offshore patrol vessel "Turva" for the Finnish Border Guard. The vessel was built by STX Finland in 2014. (Photo: Pentti Heikkilä)

"Viking Grace" receiving LNG fuel from a bunkering ship (Photo: Karl Gabor)

The new dual-fuelled icebreaker for the Finnish Transport Agency. The vessel is under construction at Arctech Helsinki shipyard and is due service at beginning of 2016. (Picture: Aker Arctic)

"The technology is available and a well-functioning solution can be designed for any ship type according to its needs. Ice-going vessels, especially icebreakers, that are exposed to fast power variations were initially a challenge, but this is not the case anymore as solutions to this operation have been developed," Mr Lindholm emphasises.

Finland will soon have three LNG fuelled vessels. The first one, introduced 2013, was the car passenger ferry *"Viking Grace"*, which became the first of her kind and today uses solely LNG fuel although she has dual-fuel machinery. The second is the patrol and coast guard vessel *"Turva"* for the Finnish Border Guard; Aker Arctic had a key role in its design developing the hull form, the machinery concept as well as performing the model tests. The third vessel is the new icebreaker for the Finnish Transport Agency now being built, which will be the first LNG-fuelled icebreaker in the world. Aker Arctic in cooperation with ILS and the Finnish Transport Agency have developed the vessel, made the conceptual design and related model testing of the ship.

Challenges with LNG

LNG is natural gas in liquefied form with a temperature of -160°C. It is a colourless, odourless, non-toxic, non-corrosive gas and its main component is methane, a greenhouse gas with lower CO_2 emissions compared to other fossil fuels. It is flammable, but its self-ignition temperature is high. The main risks are therefore fire, cold burns or leakage. With good design and operating principles adopted from gas carriers these risks can be minimised and an equivalent level of safety as with fuel oil is achieved by using the IMO Guidelines as a baseline standard. Adequate training is also essential.

The main challenge currently is the availability of LNG, but infrastructure for its supply and distribution is being planned in the Baltic Sea area and increasingly also elsewhere.
"The use of natural gas as a fuel is a promising and safe option that complies with upcoming air emission limitations and thereby preserves our environment for future generations. In many recent and on-going projects we are involved in, the LNG fuel option has been taken into consideration," Mr Lindholm concludes.

LNG fuel can with today's technology also be used for ice-going vessels and icebreakers, which are exposed to fast power variations.

Meet Mauri Lindholm

Mauri Lindholm has worked in shipbuilding and design for 34 years. He lives and works in Turku starting his career as Naval Architect at Turku Shipyard, which has changed owner and name several times since.

In 2005, he joined Aker Arctic Technology. Mauri usually works with conceptual ship designs and feasibility studies. He works closely, in addition to clients and colleagues at Aker Arctic, with cooperation partners of whom many are located in Turku. He is our LNG expert.

In his free time he enjoys sailing in the Turku archipelago, cooking and gardening with his wife and children.