Tightening environmental regulation is one of the drivers for expanding the use of LNG as a marine fuel. It is increasing pressure on shipowners to find cleaner fuel alternatives for their fleets, and LNG has a clear environmental benefit over other fossil fuels as it considerably reduces emissions and has a significant potential for increasing cost efficiency.

There are still a number of logistical obstacles on the way of LNG becoming the fuel of choice for shipping. However, the international maritime industry and regulatory bodies, as well as the shipowners that pioneer LNG-powered shipping, are showing the way to cleaner, safer maritime operations.

The International Energy Agency predicts that LNG trade will reach record heights, almost doubling between 2006 and 2015 to 393 billion cubic meters a year. Rapid expansion of the global LNG capacity is leading more shipowners in the direction of the LNG carrier sector, and the technology is quickly catching up, offering alternative propulsion solutions that provide increased energy efficiency.

Should the technology necessary for driving LNG use and transportation continue developing at the same pace, natural gas may soon become the marine fuel of the future, helping the humanity meet growing global energy demands and making the world a safer and cleaner place.

Fuelling the future

The alternative

Pressed by constantly increasing bunker oil prices and tightening environmental regulations that require a significant reduction in emissions, the global maritime industry is looking more towards utilizing cleaner energy sources.

From 2015, vessels operating in the Emission Control Areas (ECAs) of the North European waters will have to comply with stricter environmental standards, bringing down the sulfur content of their bunkers from the present 1.0 to 0.1 percent. Later in 2016, progressive reductions in nitrogen oxide (NO_x) emissions from marine engines will call for stricter controls on engines installed on ships constructed on or after Jan. 1, 2016 and operating in the ECAs.

By 2020, under the revised Annex VI of the International Convention for the Prevention of Pollution from Ships (MARPOL), environmental standards are to be strengthened further on a global scale, following a feasibility review to be completed no later than 2018.

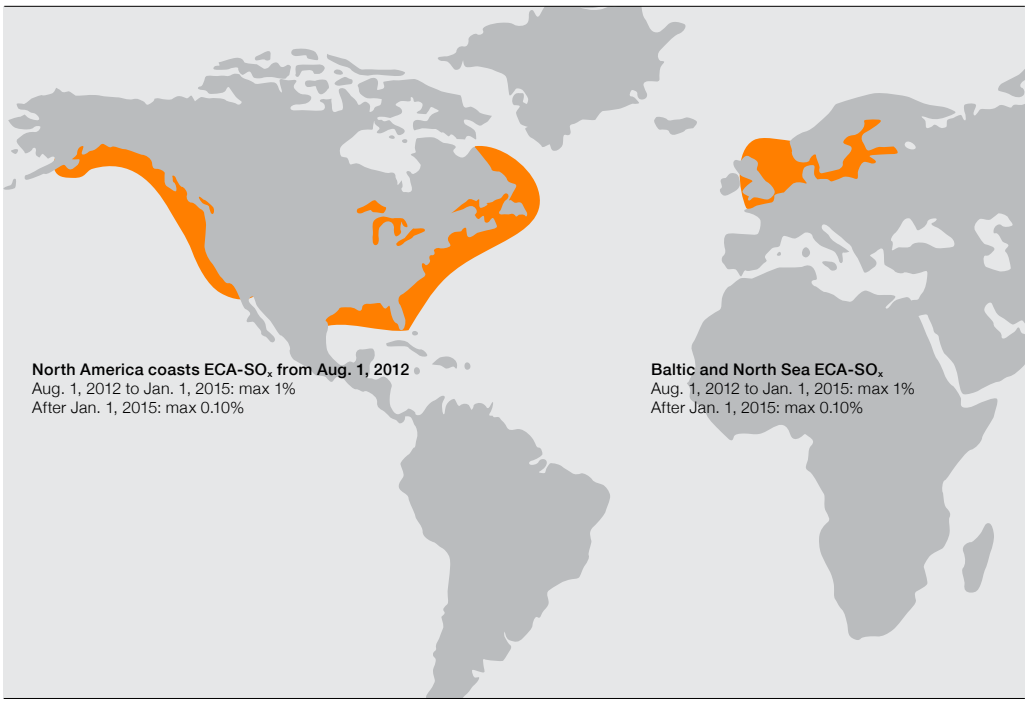
At the moment, shipowners have three main routes for meeting the ECA requirements from 2015 onwards. One is switching to low sulfur fuel, which only requires a number of slight modifications to the fuel system on board. However, the increasing demand for low sulfur fuel, combined with limited availability, is likely to drive prices up. Another alternative for shipowners is to introduce exhaust gas scrubbers that use seawater or chemicals to remove sulfur from the engine exhaust gas. Fitting a scrubber on board would require significant modifications and installing a fair amount of additional equipment. In addition, scrubbers require higher power consumption, which inevitably leads to increased CO_2 emissions.

The third solution is using liquefied natural gas (LNG) as an alternative to heavy fuel oil and marine diesel oil.

Environmental advantage

From an environmental standpoint, LNG has significant advantages over conventional marine fuels. According to Det Norske Veritas (DNV), utilizing LNG as fuel in lean-burn, four-stroke engines reduces the sulfur oxide (SO_x) and particulate emissions by up to 100 percent, NO_x emissions by approximately

Emission Control Areas (ECA)



90 percent and CO_2 emissions by approximately 20 percent. Cruise ships, smaller cargo ships and service vessels with auxiliary power are the ones utilizing four-stroke engines, which explains why most of the pioneering LNG-powered vessels belong to these categories.

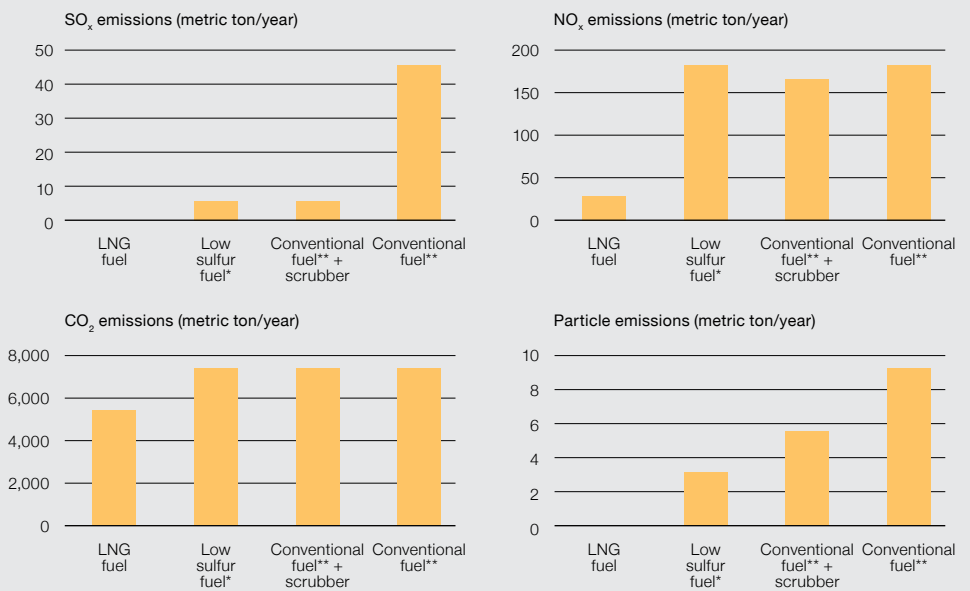
Cost efficiency

Even though newbuildings with LNG propulsion normally require an additional investment of up to 20 percent due to specially designed storage tanks and piping systems, LNG is still seen as a cost-efficient alternative to traditional marine fuels.

To demonstrate the economic advantage of LNG fuel, DNV has conducted a sample calculation on a cargo ship of approximately 2,700 gross metric tons, 3,300 kW main engine and 5,250 yearly sailing hours. Based on experience from ships built and currently under construction, DNV has calculated the additional investment cost for LNG propulsion to $3.6 million. It estimates that in a 20-year perspective, a conservative lifetime for a ship, the LNG solution would cost $4 million less than the scrubber option and $12 million less than the low sulfur fuel option.

By 2020, environmental standards are to be strengthened further on a global scale, following a feasibility review to be completed no later than 2018.

Environmental impact of LNG compared to other fuel options on a cargo ship of with 3,300 kW main engine and 5,250 yearly sailing hours



* Low sulfur fuel contains maximum 0.1% sulfur / ** Conventional fuel as per July 2010, containing maximum 1% sulfur Source: DNV

Understanding LNG

Liquefied natural gas (LNG) is natural gas that has been temporarily converted to liquid form for efficient storage and transport. Natural gas becomes liquid at –163°C, when it takes up only 1/600 of the space of the gas. This source of energy, consisting mainly of methane, originates from multiple gas fields worldwide, and global reserves are still rich.

Source: DNV

Safety

LNG operations worldwide have a safety record exceeding 40 years. According to a report issued by Sandia National Laboratories, operated for the United States Department of Energy, over the past 40 years only eight accidents involving LNG shipping occurred worldwide. None of these have led to a loss of life or a breach of the vessel's cargo containment system.

Despite these impressive statistics, concerns for LNG safety still remain a sensitive issue, as Fotis Karamitsos, European Commission's maritime transport director, points out. According to Karamitsos, one of the main reasons for people's skepticism is bad press focusing on dangers and suggesting that LNG-fuelled vessels or LNG tanks for bunkering could be linked to gas explosions, while there have been no such incidents.

Scott W. Tinker, professor at the University of Texas and state geologist for Texas, also addressed the safety issue in an interview with *ABB Review* (issue 2/2011). He said people are still a little worried about the safety of LNG facilities and that there is still misunderstanding about the safety of LNG tankers.

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"Although it hasn't been tested yet – and I hope it never will – simulations show that even if you put a torpedo through the dual hull, the LNG would basically 'flow' out, change its state and burn," Tinker said. "That would generate a lot of heat and wouldn't be good for the immediate vicinity but the tanker wouldn't really explode like a bomb. The event would basically be self-cleaning. In some sense it would be preferable to an oil spill, which is much more difficult to contain and clean."

LNG challenges and solutions

Despite the appeal of LNG as one of the best solutions for complying with tightening environmental regulations, it still has a long way to go before becoming widely used as a fuel alternative for worldwide shipping. At the moment there are only 27 LNG-powered ships in operation, with 29 confirmed newbuildings underway. The majority of these vessels are either passenger or platform supply vessels operating on short-sea routes in the Emission Control Areas (ECAs).

Det Norske Veritas (DNV) estimates that by 2020, there will be 1,000 LNG-fueled vessels in operation. This prognosis is based on an assessment of the age of the world fleet, fleet renewal rates, expected fleet growth, expected adoption of competing compliance measures, as well as expected future fuel prices.

According to Lars Petter Blikom, segment director for natural gas at DNV, for this prognosis to become reality, the LNG infrastructure needs to be fully developed within the Emission Control Areas at big shipping centers and then gradually expanded to other areas. “This is already well underway in key places, such as Rotterdam, Zeebrugge, and Hamburg,” Blikom says. “There is quite a lot happening already on distribution networks and bunkering.”

Bilkom also believes that soon there will be a wider adoption of LNG as fuel not only for the passenger and platform supply vessels, but for the rest of the world’s commercial fleet. “This is already materializing. Currently, general cargo, Ro-Ro, high speed and light craft vessels with LNG propulsion are under construction. We expect larger deep sea vessels to become a reality in the near future.”

However, to reach DNV’s prognosis, the international shipping industry has to address a number of challenges linked to LNG logistics and infrastructure.

Lack of guaranteed fuel supply is one of the main obstacles. According to Blikom, one of the first steps that needs to be taken to address this issue is establishing a distribution system for LNG where it is most needed.

"One aspect is regulatory, and this is being solved with extensive risk analysis and standardization work currently being undertaken. Another aspect is commercial. There needs to be a certain demand before the establishment of infrastructure is economically viable. Incentives to kick-start this development are currently being discussed in several locations," Blikom says.

Fotis Karamitsos, European Commission's maritime transport director, believes that environmental regulations, as well as increasing oil prices, are the factors that can move LNG shipping forward. "This certainly will be the driving force that will let people choose the alternatives to fuels currently in use, with LNG being the most promising one at present," Karamitsos says.

The second issue, according to Karamitsos, is that both governments and industry need to be ready to invest in the infrastructure. "From our perspective here in the EU, we are certainly going to support projects on the infrastructure side of things," he says. Karamitsos believes that new bunkering facilities will appear and this will help accommodate short-sea shipping in an efficient way. Long-distance shipping will follow, he believes.

Even though at the moment the LNG infrastructure is much more developed in the Northern Europe than the rest of the world, Karamitsos says that first project studies are already commencing in other parts of Europe, including the Mediterranean. He believes that the rapid expansion of the LNG infrastructure currently taking place in the United States and Asia will contribute to the worldwide development of LNG shipping, possibly first for transatlantic routes and then in the Pacific.

Knut Ørbeck-Nilsen, DNV's chief operating officer of the Norway, Russia and Finland division, believes that both the technology and concepts are in place and with the current number of LNG-fuelled vessels in operation, the next step for LNG shipping has to be taken by the shipowners.

"As long as [the shipowners] do that, the LNG terminals will become more active in trying to find user-friendly solutions at affordable prices, and everything will start moving in the right direction," Ørbeck-Nilssen says.

Pioneering LNG

Companies operating passenger ships are leading the way in introducing LNG as a fuel, and one of the major pioneers in this field is Viking Line. The Finnish company that runs a fleet of ferries and cruise ferries on routes between Finland, Sweden and the Baltic countries, is currently building a new addition to its collection of vessels, the largest LNG-powered passenger ship in existence, *M/S Viking Grace*.

M/S Viking Grace will serve the Turku – Åland Islands (Finland) – Stockholm (Sweden) route. Even though the vessel is still being constructed at the STX Finland shipyard with an estimated delivery date of January 2013, it has generated so much public interest and has attracted such attention from the press, that many people have already booked their voyages on this newbuilding.

The LNG-powered vessel, representing a new generation of ferries, signals a new era in environmentally friendly shipping for a ship of its caliber – 218 meters in length, 57,000 DWT in tonnage and with an ice class of 1 A Super.

Viking Line estimates that the newbuilding will have 25 percent lower CO_2 emissions than if it was powered by marine fuel oil. The NO_x output will be cut by 85 percent and SO_x by almost 100 percent. This will make *M/S Viking Grace* compliant with the environmental regulations that will come into force in 2016 – the vessel will be able to sail without restrictions in the Emission Control Areas (ECAs).

The LNG tanks on *M/S Viking Grace* are located outdoors on the rear deck. This way, if gas would to come into contact with air, it would simply rise and be ventilated away. In cooled form, the pressure in the tank and piping system is very low, and the pipes are double-mantled. This means that no gas will be emitted in case of a leakage. Should a leak occur, the vessel's comprehensive gas detection equipment would shut off the system, further improving safety.

To reduce the vessel's fuel consumption and greenhouse gas emissions, Viking Line's new vessel will be equipped with ABB's energy monitoring and management system (EMMA™). It compares and analyzes the historical and current operational data of the vessel, then calculates and advises on areas for improvement with easy-to-understand displays. ABB's scope of supply to Viking Line also includes an extended energy management tool that models energy consumption and calculates optimal operating conditions, so that ships can perform at the highest possible fuel and energy efficiency.

"ABB has an innovative approach to saving energy, and one of our top priorities is to lower the emissions and fuel consumption for our fleet," Kari Granberg, Viking Line's project manager for *M/S Viking Grace* told *Generations*. According to Granberg, having both EMMA and most of the electrical equipment supplied by ABB makes it convenient to get the needed information from different consumers into energy management system and use the fuel efficiently from the first day of *M/S Viking Grace*'s operation.

Talking about the potential for a wider adoption of LNG as a fuel not only for ferries and platform supply vessels, but also for the rest of the world's commercial fleet, Granberg says there are still a number of impediments standing in the way. Since LNG tanks take up to four times more space and some extra weight, compared with conventional fuel tanks, a vessel would lose cargo capacity or, alternatively, have to take less fuel on board, thus only being able to take up shortsea routes. Granberg believes there will soon be new solutions introduced to the market that will help solve this problem.

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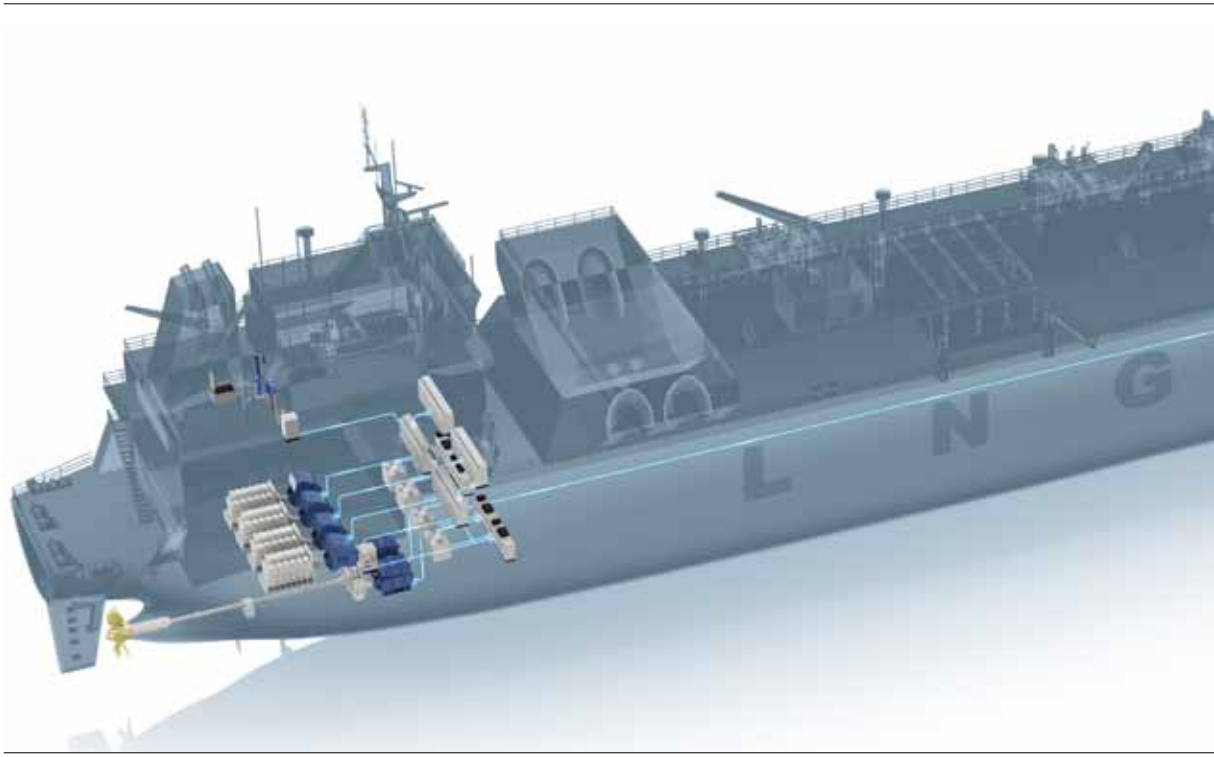


LNG transportation: sea of opportunities

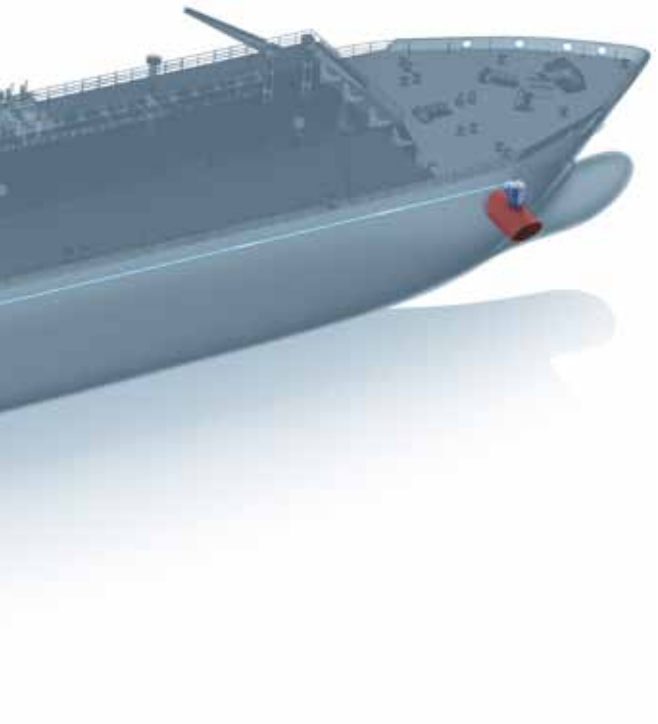
More and more shipowners are attracted to the liquefied natural gas (LNG) transportation market, as this segment offers appealing growth opportunities. The number of LNG newbuilding orders is set to grow to match the expected expansion of LNG availability, and rapid developments of LNG as one of the main shipping fuel alternatives, together with and an increasing long-term demand for natural gas worldwide, create a need for growth in the LNG transportation sector.

In its World Energy Outlook 2011, the International Energy Agency forecasts a golden age for natural gas, with 60 percent increase in demand globally between now and 2035. The world's commercial fleet is rapidly catching up with its LNG carrier newbuildings to meet this demand.

According to Golar, one of the world's largest independent owners and operators of LNG carriers, the worldwide LNG fleet currently stands at 365 vessels including floating storage and regasification units (FSRU), with a further 80 on order including FSRUs.

As predicted by Golar, substantial new supply of LNG is anticipated from Australia in the period 2014 to 2015, which will require significant additional shipping capacity. Additional LNG transportation capacity will also be needed to support the development of new liquefaction capacity, as well as the growing short term and spot LNG trading business, which Golar estimates to be between 18-22 percent of the overall LNG trade. Further development of the LNG export capacity in the United States will also contribute to the increased demand for tonnage.

Golar has recently placed an order for four additional carriers, which brings the total number of newbuild orders to 13 vessels. "It appears to be a good market out there," Hugo Skår, Golar's chief technology officer, told *Generations*, reflecting on the current outlook for LNG transportation companies. "We believe that there is a possible outlook both for demand and production, and have accordingly ordered more vessels. It needs to be controlled, of course, so that there is no oversupply of the shipping capacity."



Typical configuration of an LNG carrier

Dual-fuel electric propulsion has two main core technologies: dual-fuel four-stroke engines and the electric propulsion system. In close cooperation with engine manufacturers, ABB provides electric propulsion system arrangements to meet individual customer requirements and redundancy concepts for both single- and twin-screw LNG ship designs.

The LNG carriers fleet worldwide is moving from steam turbines to alternative propulsion solutions that provide more fuel flexibility and increased energy efficiency. According to the statistics released by *Marine Propulsion & Auxiliary Machinery*, up until 2006 all newbuilding LNG carriers of 18,000 cubic meters and above were provided with steam turbine propulsion units, with only 50 percent of the 184 new LNG carriers that have entered service since January 2006 being steam-driven.

Skår believes that the main incentive that motivates the shipowners to make this shift is the possibility of increasing fuel efficiency. “The other factor has been that the technology for using natural gas for powering engines was not properly developed until recently. As soon as the technology was in place, we saw a shift towards lean-burn diesel engines running on gas. I will not be surprised if the next step will be taken towards two-stroke engines running on gas, which will be more efficient than the high-speed engines that are in use now.” Skår says.

According to Skår, the best technology available today for increasing fuel efficiency in LNG carriers fleet is dual-fuel diesel engines used in combination with electric propulsion systems. Eleven out of the 13 newly ordered vessels are so far confirmed to be equipped with ABB’s power drives. “This will be the first time we introduce dual-fuel engines in our fleet,” Skår says. “Dual-fuel propulsion systems are the future for LNG transportation.”

The first large-size LNG carrier equipped with dual-fuel electric propulsion provided by ABB was launched back in 2006. Since then, numerous new LNG carriers have been delivered with dual-fuel electric propulsion. Some of the main advantages of electric propulsion include lower fuel consumption across the whole speed range, increased environmental sustainability, reduced installed power, enhanced maneuverability and crash stop, variable speed drives ensuring full flexibility in torque, revolutions per minute and power output at the propulsion motor and last but not least, reliability and availability through high propulsion redundancy and standardized, well-proven technology.

Text: Margarita Sjursen

Photos: Shutterstock, Viking Line