MARKIS

Swedish Maritime Technology Forum

Summary

Alternative fuels for shipping

LNG

Liquefied Natural Gas

SWEDISH MARITIME TECHNOLOGY FORUM
participated in a 3-year long project called MARKIS ending in May 2013.

One important area was to promote alternative fuels as a way to reduce harmful emissions from shipping in the Kattegat-Skagerrak region. During this period, LNG (liquefied natural gas) has been the main topic of discussion regarding alternative marine fuels.

This summary folder gives an introduction to what LNG for shipping is about and its current status, along with an overview of related project activities.

Illustration of LNG ship-to-ship bunkering. Picture by FKAB Marine Design.

WHAT

LNG is principally used for transporting natural gas over long distances to markets where it is regasified and distributed to users via pipeline. LNG as marine fuel for vessels, other than LNG carriers, started in Norway with the delivery of MF Glutra in 2000, a car/passenger ferry operating in Trondheim.

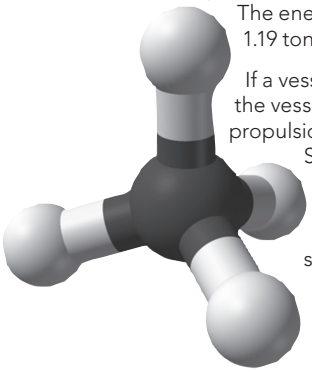
Today, there are about 40 vessels in operation worldwide, most in Norway, using LNG as main fuel.

Technology

Liquefied natural gas or LNG is natural gas that has been converted to liquid form for storage or transport. The main component of natural gas is methane (CH_4). The liquefaction process cools the gas down to the point that it condenses to a liquid, which occurs at a temperature of about -160° C at atmospheric pressure. By this procedure, the volume of the gas is reduced by a factor of approximately 600.

The energy content of one tonne LNG corresponds to 1.19 tonnes of diesel.

If a vessel is to be able to use LNG as its main fuel, the vessel has to be specially designed for LNG propulsion or retrofitted in the case of existing ships. Special tanks for holding the LNG has to be installed onboard the vessel as well as a gas engine system, pumps, hoses, etc. Very few conversions of existing ships have been made so far. Most are new built ships.



Molecule model of Methane (CH_4), the principal component of natural gas.

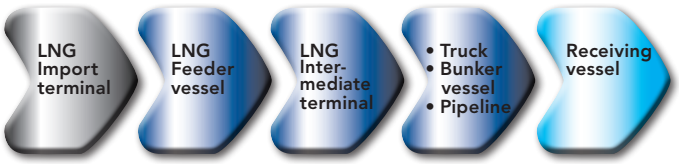
Supply Chain

The availability of LNG as marine fuel is depending on the establishment of a functioning supply chain infrastructure for transporting the gas from the source to the end user, the receiving vessel. From the LNG production plant, the gas is usually transported via large LNG tankers to large-scale import terminals. It will be necessary to set up several small-scale intermediate terminals for further distribution. These terminals will likely serve also other types of customers, such as energy and industrial users as well as for land transportation.

There are different options of supplying the LNG from the terminal to a gas-fuelled vessel. The three main alternatives are:

- ship-to-ship (STS)
- truck-to-ship (TTS)
- bunkering directly from terminal-to-ship via pipeline (TPS)

The normal way of bunkering conventional vessels is by ship-to-ship, so this method is probably to recommend. This has not been done for LNG until just recently when the first ever LNG bunker vessel was delivered for service in Stockholm.



Main supply chain for LNG as marine fuel.

WHY

Regulations

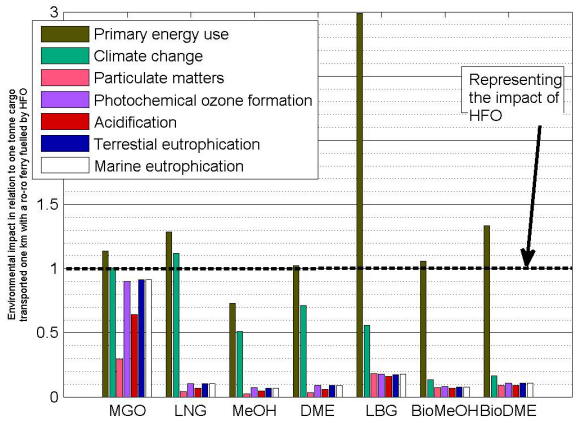
Most marine bunker fuel used today is heavy fuel oil (HFO) with high sulphur content. The International Maritime Organization (IMO), has decided on measures to reduce air pollution from ships through MARPOL Annex VI. Since 2012 there is a global limit of 3.5% on the sulphur content of marine fuel. In certain areas, Emission Control Areas (ECAs), the limit on sulphur is much more strict. Currently, the limit is 1% in the so-called SECA (Sulphur Emission Control Area) covering the Baltic Sea, North Sea and the English Channel. From 1 January 2015, the limit is reduced to 0.1% in this area.

Environment

In order to comply with the strict limits on sulphur and other expected regulated emissions (NOx, CO_2 and particulate matter), there are basically three main options:

- operating on low-sulphur fuel oil such as marine gas oil (MGO).
- operating on heavy fuel oil with an exhaust gas treatment system.
- operating on LNG or some other alternative fuel.

The figure to the left compares the environmental impact of different fuels to that of HFO (without cleaning technologies). Using LNG will reduce most emissions significantly. If liquefied biogas is available, the CO_2 impact would be lower as well.



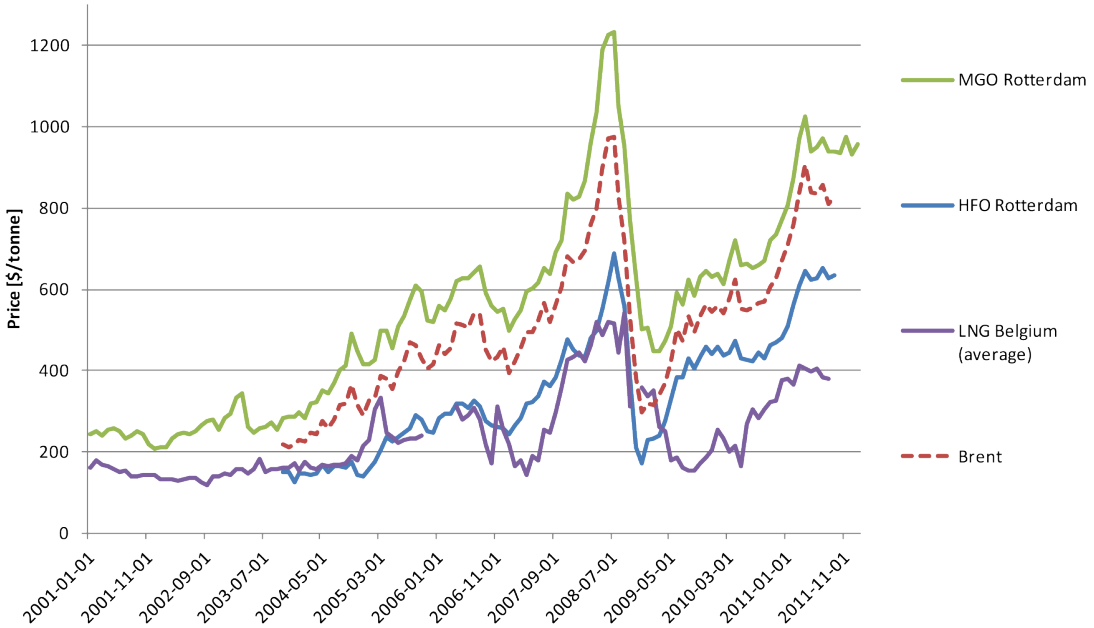
Summary of all investigated impact categories for marine gas oil (MGO), liquefied natural gas (LNG), methanol produced from natural gas (MeOH), dimethyl ether produced from natural gas (DME), liquefied biogas (LBG), methanol produced from biomass (BioMeOH) and dimethyl ether produced from biogas (BioDME) compared with heavy fuel oil (HFO) as shipping fuel (represented by the dashed line). Source: EffShip project WP2, 2013.

Price & Availability

LNG availability is shown on the next page. The current availability of LNG as marine fuel is very limited, but the infrastructure is developing. The price of LNG is believed to be competitive compared to the options of using MGO or even HFO as is indicated in the historical price chart below (current prices are roughly on the same level as in late 2011). Of course, the price of LNG as marine fuel will be affected by the cost of setting up new infrastructure for distributing the fuel to the receiving vessel. According to a recent estimation by White Smoke Consulting, the additional cost of delivery of LNG from hub to a vessel is 100-300 USD/tonne as compared to 10-75 USD/tonne for oil-based fuels.

There are, of course, serveral economic factors for a shipowner to take into account when deciding on which option to choose. Fuel price, the investment costs for new equipment, change of cargo space, time for bunkering, etc. MGO seems to be an interesting alternative, at least on a short-term basis, with low investment costs, but if all vessels were to convert to distillate fuel, the current production would not be able to meet the demand which will lead to even higher fuel prices. This must be compared to higher investment costs and possibly lower operational costs if using LNG instead.

Historical prices of HFO, MGO, LNG and Brent oil. Source: North European LNG Infrastructure Project (Full Report p. 63), 2012.



Map of main existing and planned LNG-terminals inside SECA (2012). Source: Gas Infrastructure Europe, CNSS project.

WHERE

Infrastructure

The map shows existing and planned LNG terminals inside the SECA of Northern Europe. These terminals are not specifically for marine purposes, but shows where LNG is or will become available.

Norway has a number of liquefaction plants producing LNG from gas distributed through pipelines from gas fields in the North Sea. Other than these, in Scandinavia, there are today only two small-scale import terminals of relevant size. One in Fredrikstad, Norway and one in Nynäshamn, Sweden with a storage capacity of 6,250 m³ and 30,000 m³, respectively. As a comparison, the large-scale import terminal in Rotterdam, the Netherlands has a current LNG storage capacity of 540,000 m³.

In the Kattegat and Skagerrak area, there are two terminals planned besides the existing one in Fredrikstad, Norway.

The terminal in Lysekil (30,000 m³) will mainly serve the Preemraff oil refinery. Start-up is scheduled for 2014. The proposed terminal in Gothenburg (12,000 m³) is designed for an annual capacity of about 400 million m³. Port of Gothenburg and the Port of Rotterdam, the largest port in Europe, have agreed to join forces to help speed up the implementation of LNG as marine fuel.

There are also discussions of other possible locations of LNG terminals, for example in Hirtshals, Denmark.

WHO

Ship types

Today, offshore vessels and ferries make up most of the LNG fuelled fleet and order-book. Most of the existing ships are operated in Norway. Typical vessels are platform supply vessels and car/passenger ferries. There are however projects to develop LNG-fuelled concepts for most ship types. Recently, the RoPax vessel Viking Grace was delivered with a dual-fuel engine system, the first large passenger ship in the world to use LNG. She is equipped with two LNG tanks on aft deck with a capacity of 200 m³ each.

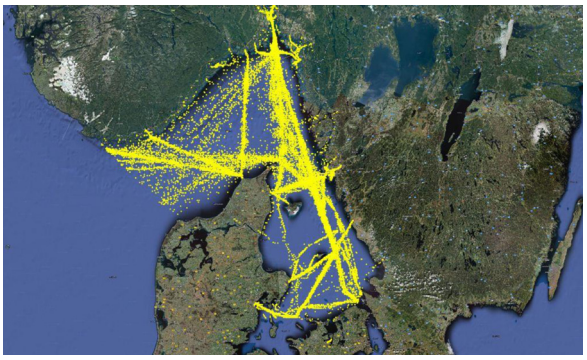
Demand for retrofitted ships using LNG is believed to be limited because of high investment costs. BitViking, a chemical tanker operating in Norway was converted in 2011 for gas propulsion with financial support from the Norwegian NOx-fund.

The chart below projects (for a medium LNG price level scenario) the LNG demand from different ship type categories in year 2020 spending full time inside SECA. In Kattegat-Skagerrak it is believed that most LNG demand will come from passenger vessels and container and RoRo ships. Hence, shipowners operating these types of ships, and ports called by them are most likely to be the first movers for using and offering LNG as marine fuel. The main routes for passenger vessels in this area today are clearly indicated in the movements plot map to the right.

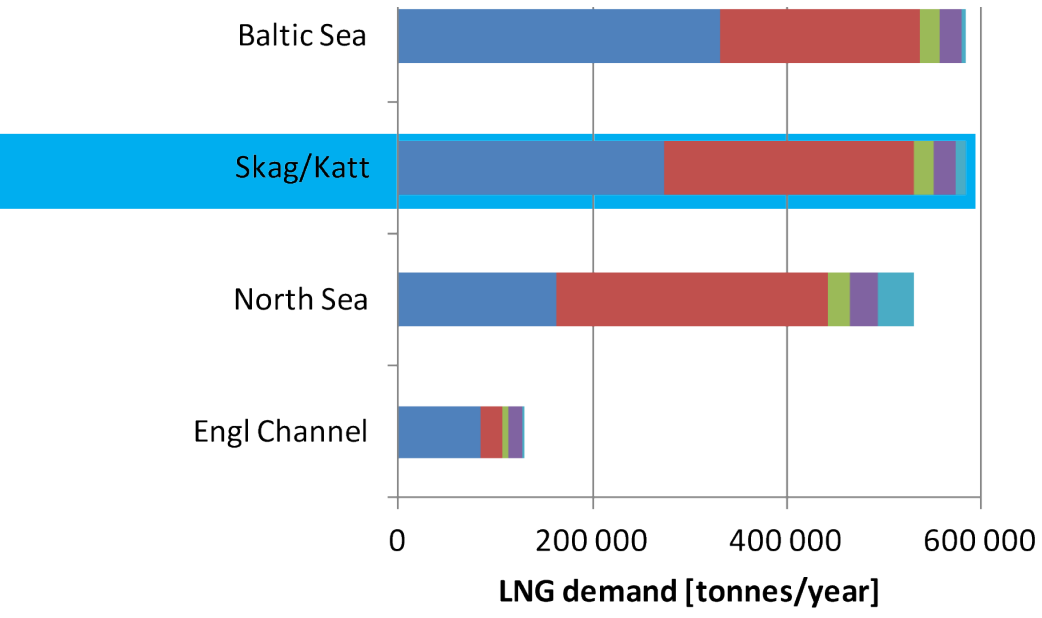
For example, Fjord Line will now put in operation two new RoPax cruise ferries between Norway and Denmark on the Bergen-Stavanger-Hirtshals line as well as on the Hirtshals-Langesund run. These vessels will have a single LNG engine system, first ever ships of this size and type to sail with an engine solely injected by LNG. Furthermore, between the ports of Sandefjord in Norway and Strömstad in Sweden, Color Line is planning to replace the existing vessel with a new RoPax vessel fuelled by LNG.

Picture by Skangass

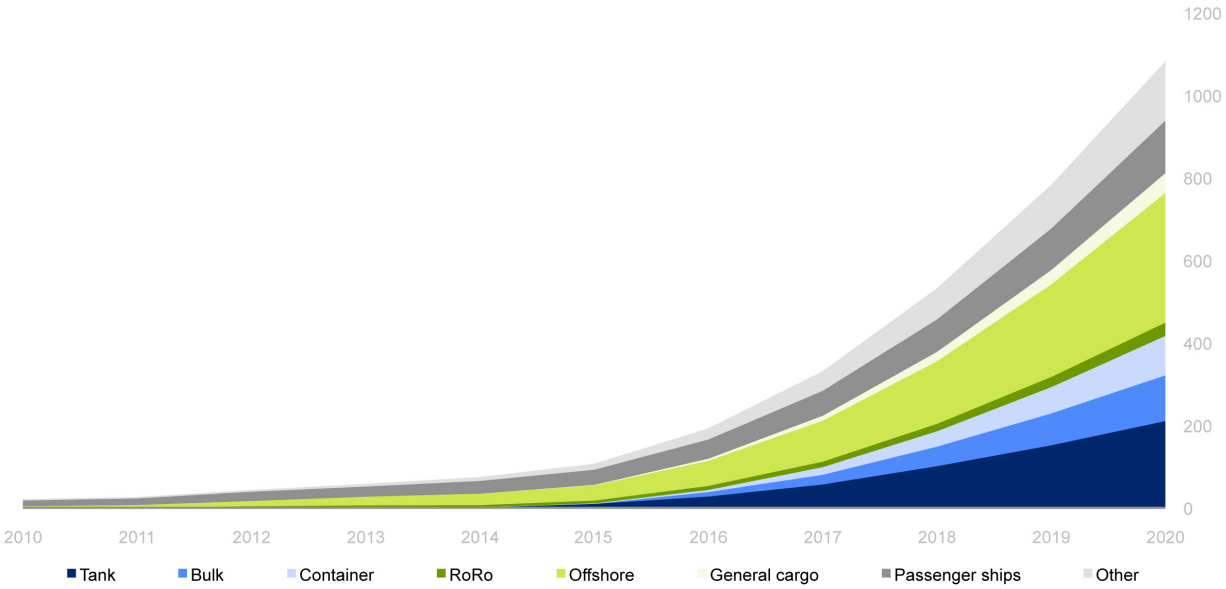

Picture by Fjord Line



Ship movements plot of passenger vessels sailing within or into/from the Skagerrak-Kattegat area during 6 months (May-Oct 2012). Source: Marine Benchmark.



Annual LNG demand 2020 in SECA. Source: North European LNG Infrastructure Project (Full Report p. 111), 2012.



Forecast of LNG fuelled vessels per ship segment worldwide. Source: DNV, 2012.

WHEN

Scenarios

About 30 LNG-fuelled ships are in the orderbook worldwide at present, excluding LNG carriers and inland waterway vessels. It is difficult to project the future use of marine LNG, as much depends on the general economic development. Under high economic development and high environmental awareness, the number of LNG-fuelled vessels will be around 1,000 in 2020, according to a projection by DNV in 2012.

Lloyd's Register made a study in 2012 about LNG-fuelled deep sea shipping. In their low demand case scenario of LNG-fuelled newbuild deliveries 2012-2025, less than 15 deep sea ships will be built of which half is cruise ships and the rest container ships. On the other hand, if market conditions are in favour of LNG, we could expect up to 2,000 deep sea ships to be delivered until 2025, of which 45% dry bulk carriers and almost 25% oil tankers, according to this study.

Challenges

The gas demand for transportation is small compared to land-based demand, mainly for power generation.
It is important that demand and supply of maritime LNG develop simultaneously to avoid a catch-22 chicken and egg problem.

Today, there are several uncertainties, for example, regarding the cost of LNG distribution and hence the fuel price; rules/standards on operational procedures; further emission requirements (new zones and other pollutants); certified/trained personnel; subsidy schemes; etc.

Some kind of governmental support seems necessary to aid early adopters both financially and through the promotion of an international and standardized regulatory framework.

Upcoming...

As shown, the LNG marine infrastructure is developing. More vessels are in order and a few more terminals are under construction or planned. Work is under way concerning the regulatory safety concepts for using gas as a ship fuel, e.g. standards on LNG bunkering procedures, but it may take some time before clear rules are present. Matters of education and training for on-shore and off-shore personnel have been addressed in the MARKIS project as an area where more efforts are needed, and partners of the project have initiated steps together with different stakeholders to create necessary LNG educations.

References*

Clean North Sea Shipping (CNSS) project

EffShip project

Eivind Dale, Det Norske Veritas (DNV), 2012

Energy Statistics Manual, International Energy Agency, 2005

Johan Algell, White Smoke Consulting, 2013

LNG-fuelled deep sea shipping, Lloyd's Register, 2012

LNG Map, Gas Infrastructure Europe, 2012

LNG ship to ship bunkering procedure, Swedish Maritime Technology Forum, 2010

North European LNG Infrastructure Project, Full Report, Danish Maritime Authority, 2012

Sjöfartstidningen, Nummer 2-2013

Stefan Borggren, Det Norske Veritas (DNV), 2012

Torbjörn Rydbergh, Marine Benchmark, 2013

LNG-related activities during the MARKIS project*

Seminars and workshops

Hamnutveckling i Skagerrak och Kattegatt, Borg Havn, Fredrikstad, 18 April 2013

Hamnutveckling och LNG-terminaler, Uddevalla, 6 December 2012

Scandinavian Maritime Conference 2012, Horten, 28-29 November 2012

LNG Seminar, European Maritime Day, Gothenburg, 22 May 2012

Utbildning och kompetensutveckling för framtidens bränsle – LNG, Göteborg, 7 March 2012

MARKIS Annual Conference 2011, Uddevalla, 30 November – 1 December 2011

EU-financed LNG-for-shipping related projects, Gothenburg, 11 October 2011

MARKIS Annual Conference 2010, Frederikshavn, 1 December 2010

Study trips

Study trip MAN Diesel & Turbo R&D Centre, Copenhagen, 5 May 2011

LNG Study trip DNV, Oslo, 16-17 November 2010

Film

LNG for shipping – or the chicken and egg story, 2012 (produced by CNSS project)

Education

Development of LNG education, Vestfold University College

Stakeholder collaboration for new LNG training courses, Högskolecentrum Bohuslän and Swedish Maritime Technology Forum

** Links to some of the reference material are accessible in the pdf-version of this document, also available at www.smtf.se.*

MARKIS

Maritime Competence and Innovation
Skagerrak & Kattegat

MARKIS is a maritime competence and innovation collaboration in the Skagerrak and Kattegat region supported by the EU INTERREG IVA Öresund-Kattegat-Skagerrak programme. Over a three-year period businesses, research and education institutions and public authorities will work together to make the Skagerrak and Kattegat region a global frontrunner in the conversion to sustainable shipping. MARKIS's vision is to establish a maritime region with no harmful emissions to air and water from shipping, and globally competitive maritime clusters.

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