LNG as a ship fuel: perspectives and challenges

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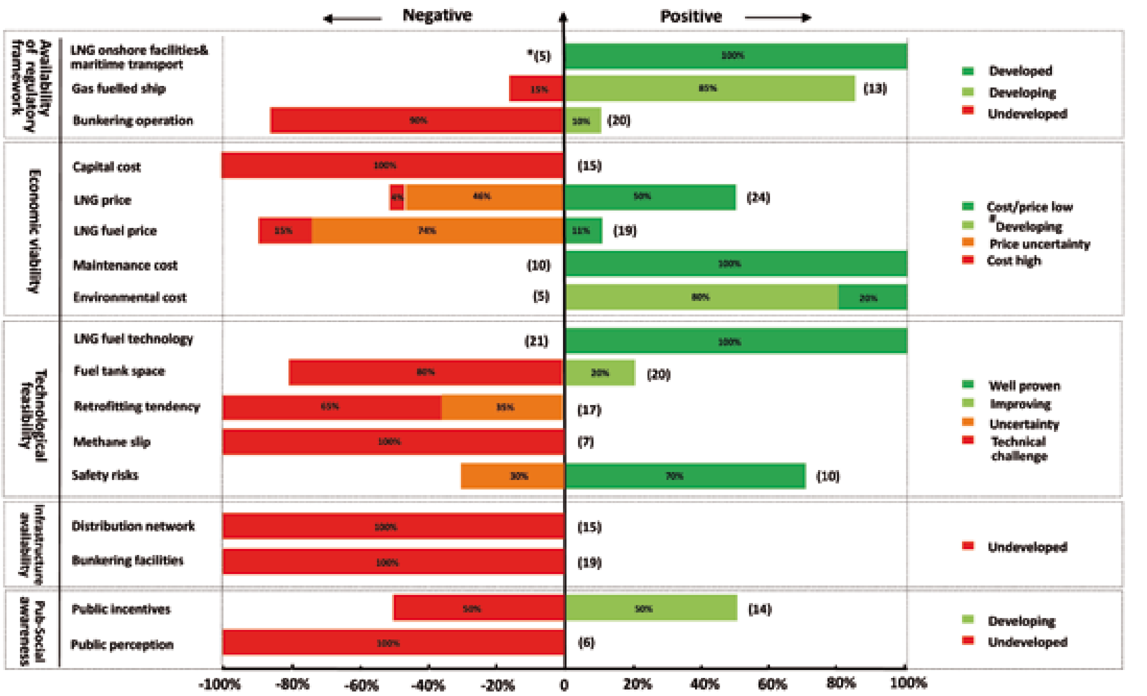
The upcoming stringent environmental regulations enacted by the International Maritime Organisation (IMO), particularly at the level of the emission control areas (ECA), serve as a catalyst for exploring the use of Liquefied Natural Gas (LNG) as a marine fuel. LNG promises a good environmental performance compared to conventional ship fuels. It emits nearly no sulphur oxide (SOx) or particle matter (PM) emissions, 90 percent less nitrogen oxide (NOx) and 20-25 percent less carbon dioxide (CO2). Research into LNG as a marine fuel saw a strong growth in recent years, but no study has analysed in a structured way, the level of convergence among the findings presented in the wide range of studies conducted by research centres, classification societies, ship engine manufacturers and consultancy firms. In order to fill this gap, we performed a systematic review to synthesise the findings of 33 published studies on the use of LNG as a ship fuel. The aim is to obtain a much broader understanding of the current perspectives and challenges for applying LNG as a bunker for ship propulsion.

Factors supporting or obstructing the adoption of LNG

Figure 1 provides an evaluation for 17 factors affecting the large-scale adoption possibilities for LNG. Not all of the 33 studies considered refer to all 17 factors. The figure shows the consistency and/or divergence in existing literature. Some divergence between earlier and later studies might be attributed to the ongoing technological innovation and economic and regulatory advances to support LNG as a ship fuel. Some of the most crucial challenges are discussed in the following sections.

Availability of a regulatory framework

There are some existing regulatory gaps regarding the application of LNG as a ship fuel. In recent years, the regulatory framework for onshore LNG installations and the maritime transport of LNG cargo have been established at international levels in line with the fast growth of the world LNG trade. These include the international



*Notes: * the number in parenthesis means the number of studies where the relevant issue is discussed*
 # Environmental cost is not yet established now except in Norway, but some studies expect that environmental cost will be developed in the future which can make LNG fuel more attractive

Figure 1: Positive and negative factors in the adoption of LNG as a ship fuel. The percentages refer to the share on a total of 33 studies.

code for the construction and equipment of ships carrying liquefied gases in bulk (IGC code); The Society of International Gas Tanker and Terminal operators (SIGTTO) and the Oil Companies International Marine Forum (OCIMF).

There is no international rule recognising that LNG can be used as a marine fuel, apart from the IGC code which allows LNG carriers to use boil-off gas as a part of the ship's propulsion. In order to fill this gap, the IMO has started to draft the international code of safety for ships using gases or other low flashpoint fuels (IGF code) which will cover safety and operational issues for gas-fuelled seagoing vessels. The code is expected to be finalised by 2014. In addition, the lack of a set of comprehensive LNG bunkering regulations is one of the key barriers to the new application. So far, no international standards have been established which incorporate minimum requirements for the bunkering procedures, training and equipment necessary to ensure safe LNG handling for gas-fuelled ships via both shore-based and ship-to-ship bunkering operations.

In 2011, ISO established a working group to develop such international guidelines for harmonising LNG bunkering standards. This working group delivered its first draft in June 2013. At the time of writing, the document was being subjected to an international hearing round before it should be published as an ISO document by 2014. Another regulatory barrier is related to the use of LNG on inland vessels in Europe. In line with the relevant European agreement concerning inland shipping e.g. the international carriage of dangerous goods by inland waterways (ADN) and the Rhine vessel inspection regulations (RVIR); the regimes prohibit the installation on inland ships of combustion engines that use a fuel with a flashpoint below 55C. This means LNG is restricted to be used as a fuel since its flashpoint is -180C. To close this regulatory gap, the competent EU authority has started to establish a specific permit process for LNG-powered inland vessels and later may develop appendices under the existing regulatory framework.

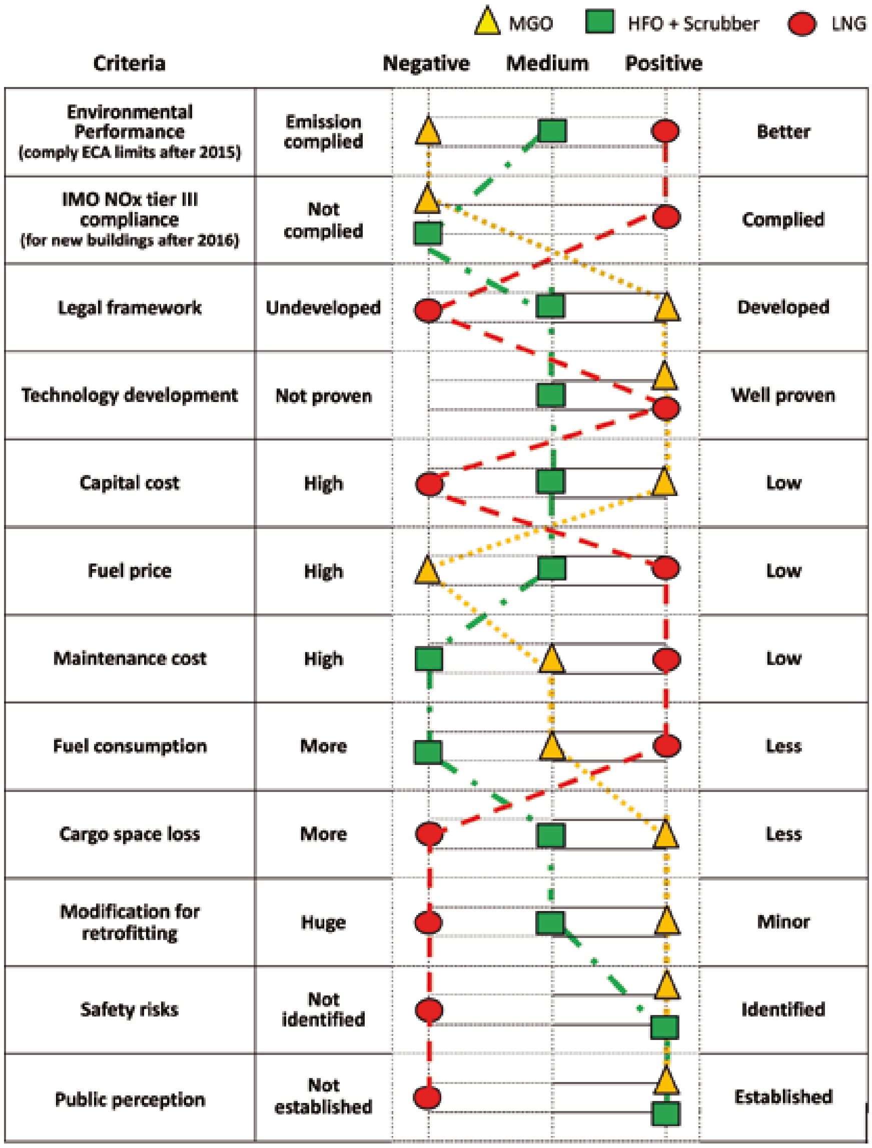


Figure 2: Comparison between three alternative solutions to meet IMO ECA regulations.

Economic viability

Sophisticated LNG engines and the cryogenic double-walled fuel tanks require significant capital investments, certainly when compared to oil fuelled ships. The observed cost range is partly linked to the ship design, the engine type (dual-fuel or single LNG engine), and the size of fuel tank (i.e. dependent on the frequency of refilling) etc. Overall, the estimated cost for an LNG fuelled ship is between 20 to 25 percent higher compared to an oil equivalent vessel. In addition, it is noted that the cost for a newly built LNG fuelled vessel is less than the cost to convert a similar existing vessel. LNG is therefore more feasible for new ships.

The LNG price lies at the core of the economic discussion on the use of LNG as a ship fuel. It is widely recognised that the current low natural gas price compared to the conventional oil fuel is a main economic driver for this new application. However, the various estimates of the future LNG price presented in the different studies make it hard to bring widely supported forecasts on the future energy prices. Moreover, the LNG bunker price to end users also includes the infrastructure cost of the LNG refuelling terminals, the distribution cost of LNG to the bunkering terminal and the cost of the bunkering operation. The current lack of LNG bunkering infrastructure and supply chain networks presents a far more uncertain picture for the LNG fuel price. This leads to uncertainty for ship operators on whether they could benefit from the offset between fuel cost savings and large capital investments.

Nevertheless, LNG engine developments highlight the lower maintenance cost in comparison to oil engines due to a more clean and efficient system and a long lifetime of the machinery. Furthermore, the possible environmental cost (e.g. taxation or emission trading scheme) charged to shipping by governments will make the LNG cost savings more attractive than other options. To date, there is only a NOx taxation system in Norway, but it is believed that the environmental cost regime for marine transport will develop in many countries in the coming years.

Technological feasibility

The use of LNG as a ship fuel is not new. The technology is well-established as

LNG carrier operators can look back on 40 years of experience in powering their ships using LNG. Moreover, the technology has also been tested on some 35 non-LNG carrier gas-fuelled vessels mostly sailing in Northern Europe. The space-consuming LNG fuel tanks affect ship productivity and freight earnings. LNG has a 1.8 times larger volume than diesel oil, and of one includes the whole system of LNG engine and cylindrical-shaped fuel tank onboard, the space needed is even three to four times larger than the conventional oil system. Another technical challenge is the unburned methane (CH_4) emitted from LNG or dual-fuel engines, which reduces the overall environmental performance of LNG-fuelled ships. Considering the safety risks associated with the bunkering operation of LNG-powered vessels, it is necessary to establish common safety risk assessment approaches and risk acceptance criteria for LNG fuelled ships and bunkering procedures.

Infrastructure availability

Almost all reviewed studies show a consensus that a critical challenge to the development of LNG as a ship fuel is the current lack of established bunkering infrastructure and distribution networks for delivering LNG to the ships. This significant barrier currently represents a ‘chicken-and-egg’ problem. Bunker suppliers are unwilling to invest in the infrastructure necessary until there is sufficient demand to supply commercial shipping with LNG fuel. On the other hand, ship owners are unwilling to invest in LNG-fuelled ships if supplies of LNG bunkers are difficult to obtain. Currently, there are four LNG bunkering methods. They are truck-to-ship, ship-to-ship, terminal (loading arm)-to-ship and LNG portable tank. A minimal bunkering infrastructure is needed to kick-start the market development. The European Commission proposed that LNG refuelling stations should be installed in all maritime and inland ports of the trans-European core network by 2020 (2025 for inland ports). This aim includes a total of 139 ports which account for about 10 percent of all EU ports in number.

Public-social awareness

Many of the reviewed studies agree that the ‘chicken-and-egg’ dilemma can best be mitigated through government involvement. The approach for such involvement can be subsidies, funding or reduced taxes etc. The EU has started to develop financial instruments to support the introduction of LNG bunkering infrastructure, such as the funding from the Trans-European Transport Network (TEN-T). In addition, some leading public port authorities in Europe, like Rotterdam and Antwerp, have already established port-specific emission regulations that give a discount in port dues to ship owners who use clean fuels for their vessels (i.e. the environmental ship index (ESI) programme). Another concern is the public acceptance of the use of LNG as a ship fuel. In order to increase public acceptance, better communication between the project developers, the authorities and the general public needs to be developed.

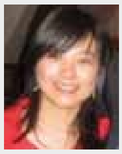
Options available to ship operators

In order to comply with the forthcoming ECA’s SOx limits in 2015 and NOx Tier III standard in 2016 (may have five-year delay to 2021); ship operators have three compliance strategies standing out as realistic options. Apart from switching to LNG, they can change to low sulphur fuel oil e.g. marine gas oil (MGO), or use scrubbers. Figure 2 shows the current advantages and challenges with each of the three alternatives.

Using low sulphur fuels (e.g. MGO) is the most immediate compliant solution, due to minor modifications to ships with limited up-front costs and the established supply chain and bunkering facilities. Nevertheless, the growing demand for distillate oils would cause the fuel price to rise. The use of scrubbers is considered a viable method for removing sulphur and particulate matter from exhaust gas emissions. However, at present, ship owners lack confidence about this solution due to high uncertainty over its technical performance, e.g. system reliability, the risk of non-compliance, etc. Also, in order to remove NOx to meet Tier III standards, the scrubber must be operated in conjunction with selective catalytic reduction (SCR), but the combination of these two technologies remains problematic.

LNG as a clear fuel can reach all environmental targets without any abatement technology. However, the current lack of bunkering infrastructure and operation standards imply that the use of LNG as a ship fuel is expected to first gain momentum in niche markets, like small ferry routes and regional liner traffic. In the longer run (perhaps from 2020) the adoption of LNG as a ship fuel on a global scale rests on three main factors: the price difference between LNG and low sulphur fuel oil; the global emission regulations e.g. the global SOx limits enforced in 2020 or 2025; the availability of LNG bunkering facilities in a global context.

About the authors



Siyuan Wang joined ITMMA (an institute of the University of Antwerp) as a PhD student under the CONNEC scholarship programme of the European Commission in 2010. She holds an MSc in Transport and Maritime Management from ITMMA and a masters in Maritime Law from Shanghai Maritime University. Her research activities at ITMMA focus particularly on the LNG market.

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About the organisation

PortEconomics is a web-based initiative aiming at generating and disseminating knowledge about seaports. It is developed and empowered by the members of the PortEconomics group, who are actively involved in academic and contract research in port economics, management, and policy. Since October 2012, Port Technology International and PortEconomics have been engaged in a partnership. www.porteconomics.eu.

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