Developments in Clean Shipping: Emergence of LNG as a Marine Fuel

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International shipping has seen two transitions in motive power. The first, during the industrial age, from wind power to coal (steam) and the second in the first half of the 20th century, from coal to oil. The third transition, from oil to natural gas, many argue, is currently underway. Liquefied Natural Gas (LNG) as a fuel for ships was first used in 2000, when the world's first LNG fuelled ferry, 'Glutara' commenced operations in Europe. Since then, ships have been powered by dual fuel engines which are designed to operate on liquid fuels as well as LNG. This includes LNG carriers, oil and chemical tankers, bulk carriers, coast guard ships, harbour tugs, Ro-Ro ships and high speed car-passenger ferries. At the end of 2014, there were over 50 LNG fuelled ships in operation and another 80 were under construction or on order books of shipyards, including a LNG powered icebreaker, LNG bunkers for ship to ship refuelling and container ships. It is estimated that by 2020 there would be over 1800 LNG fuelled ships in operation[i].

More recently the ship, *Kvitbjørn operated by* Nor Lines AS became the world's first vessel to operate between Asia and Europe solely on LNG. The ship sailed from Tsuji Heavy Industries shipyard in Jiangsu, China, to Bergen, Norway stopping for LNG fuelling in Singapore, India (Cochin) and Spain (Cartagena). This was the longest voyage undertaken by a vessel running only on LNG and was completed on 29 March 2015.

Drivers

There are two main drivers for the emergence of LNG as a marine fuel: stringent environmental regulations and the cost of implementing these regulations.

(a) Environmental regulations under MARPOL Annex VI[ii]: International shipping uses Heavy Fuel Oil (HFO), which is one of the dirtiest fuels in the world. Prior to 2005, merchant ships used bunker fuel with a sulphur content of over 4.5 per cent m/m. In order to control ship borne air emissions, regulations for the Prevention of Air Pollution from Ships were adopted by the IMO under MARPOL Annex VI[iii]. Regulation 14 covers emissions of Sulphur Oxides (SOx) and Particulate Matter (PM) from ships. It was decided to lower the sulphur content in fuels used by ships in a phased manner. Apart from this, a number of Emission Control Areas (ECAs) were promulgated in 2006, and the first ECA for limiting SO_x emissions was notified in the Baltic Sea. These ECAs adopted more stringent standards and fuels having upto 1.5 per cent m/m sulphur content only, were permitted to be used onboard ships operating in the ECAs. This limit was reduced to 1 per cent in 2010 and further to 0.1 per cent m/m[iv] on 01 Jan 2015. Figure 1 shows the regime for reduction in sulphur content for fuel used on-board ships inside and outside the ECAs. This environmental cleaning act has become a major driver for adoption of LNG as a fuel for ships operating in the ECAs.

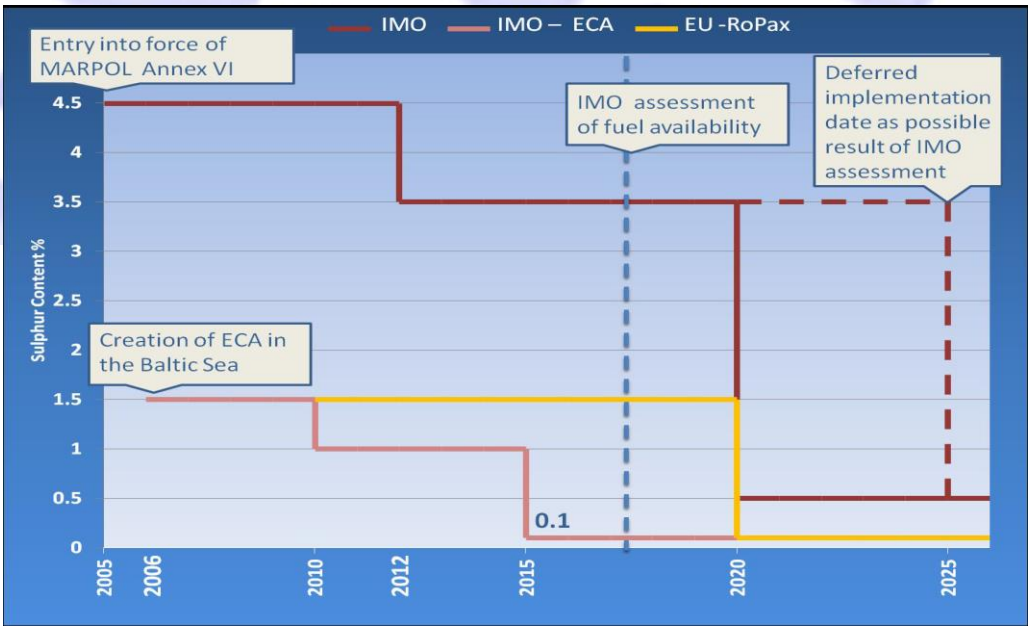

Fig 1. Allowable sulphur content in fuels used on board ships

(b) Cost of implementing environmental regulations: Consequent to the implementation of stringent environmental norms in ECAs, ship owners have to

consider various technical options to limit the SOx emissions from ships. Following choices are available to the ship owners:

(i) Use of low sulphur distillate fuels such as MDO[v] and MGO[vi].

(ii) Installation of scrubbers for emission control on-board ships while continuing to use high sulphur fuels.

(iii) Switching to the use of LNG as a primary fuel.

The choice between the above options is left to the ship owners and this is influenced by various factors such as capital cost of installation of systems, cost of fuel, availability of fuels and technological criteria. Switching to LNG as s primary fuel on-board ships has emerged as a cost effective option amongst competing technologies, and this has become the second driver for the emergence of LNG as a marine fuel.

Advantages

There are three main advantages of LNG as a marine fuel, which makes it one of the more attractive options for use on-board ships operating in the ECAs.

(a) **Cleaner Fuel**: LNG has only 0.004 per cent sulphur content which is much lesser than the upper limit of 0.1 per cent of sulphur authorised for use on-board ships operating in the ECAs. Use of LNG as a fuel on-board ships cuts down SOx emissions by 97-99 per cent, eliminates PM emissions, reduces NOx emissions by 60-80 per cent, and reduces CO_2 emissions by approximately 70 per cent. This makes it one of the most environmentally friendly fuels for ship propulsion.

(b) **Future Fuel**: Natural gas is touted as the fuel of the 21st century. It is estimated that global demand for natural gas is likely to grow by 2 per cent annually, compared with 1.2 per cent growth in total energy demand. Thus the share of natural gas in the total world consumption is forecasted to overtake that of coal before 2030 and natural gas is likely to meet 25 per cent[vii] of the global energy demand by 2035. Further, the reserve to production ratio for natural gas is around

250 years (at the current rate of consumption) and gas reserves are geographically dispersed across the globe, which eases concerns on security of supply of gas. These factors contribute to emergence of natural gas as the fuel of the future.

(c) **Lower price of LNG as compared to other alternatives**: LNG is currently priced lower than global HFO prices (USD 16/mmbtu). LNG approximately costs USD 14/mmbtu while MDO costs USD 25/mmbtu. Although LNG is priced much lower based on per unit energy content, there are additional costs which need to be added on account of additional port capex (capital expenditure) and opex (operational expenditure) and cost of new built LNG ships. Notwithstanding the above, the all-inclusive cost of LNG as a fuel for ship borne operations is currently the lowest amongst all three alternative technologies in the U.S. In Europe, the costs for HFO with scrubbers is the lowest, closely followed by LNG fuelled ships. However, for the Asia-Pacific region, the cost of ships using LNG is relatively higher than the costs for HFO with scrubbers and is closer to ships using MDO as a fuel.

Challenges

Notwithstanding the above advantages, there are various challenges which need to be overcome before LNG can emerge as a competitor to oil and can be used as a primary fuel by the shipping industry across the globe.

(a) **Technical Issues:** Natural gas has approximately half the energy to weight ratio as that of oil. Hence ships operating on LNG require twice the amount of space for fuel storage as that required for oil tanks. The larger space requirement for fuel therefore lowers the carrying capacity of the ship. LNG is stored at minus 162 degree C which requires additional on-board auxiliary systems for refrigeration. Natural gas is combustible and in its un-burnt form, is emitted as methane, a gas which has 25 times the global warming potential as that of CO_2. Hence extra precautions are required to prevent on-board leakage of gas by designing effective ventilation systems and by following good maintenance

practices. Further, safety regulations and operational procedures have to be evolved and internationally agreed for safe operations for use of LNG as fuel on-board ships.

(b) **High Capital Costs**: While the running cost of using LNG is low, the capital cost of installation of fuel handling and storage systems on-board ships is relatively high. This presents a challenge to the ship owners who are struggling with lower profits due to increased costs and overcapacity in shipping. While there are successful cases where LNG system have been retrofitted on-board existing ships for dual fuel usage, it is most economical to build LNG ready ships which have dual fuel use capability as new builds.

(c) **Availability of LNG Fuelling Stations**: Currently, there are limited fuelling stations for LNG and these are mostly concentrated in Europe and the U.S., primarily to supply LNG to ships operating in the ECA. The 'chicken and the egg dilemma' is hampering the growth of LNG fuelled ships, as ship owners expect that fuelling stations will be set up first, to cater for the growing demand of LNG, while port developers expect that there should be sufficient growth in LNG fuelled ships prior to developing LNG fuelling facilities at ports. Shore infrastructure for jetty based LNG fuelling involves laying pipelines for delivery of natural gas to the port area, liquefaction terminals, storage tanks and delivery infrastructure for transfer of LNG from jetty to the ship. The other option is for ship to ship transfer of LNG using LNG bunkers. Both these options are capital intensive and ports are therefore shying away from installing LNG fuelling infrastructure before there is sufficient demand for LNG from ships.

(d) **Availability of LNG**: The availability of LNG in the short term for shipping is also a concern for ship owners. It is estimated that if the entire shipping industry shifts to LNG as a fuel for shipping, the resulting demand for natural gas will be equal to 75% of the total world LNG trade as on date. Ship owners are therefore adopting a wait and watch strategy as they feel that it involves a considerable financial risk to shift to LNG as the primary fuel for use on-board ships.

(e) **Regulatory Uncertainty on a Global Scale**: The shipping industry is facing the impact of rising costs imposed due to stringent environmental regulations. According to the proposed implementation schedule, the current 3.5 per cent limit of sulphur content in the fuel, in areas beyond the ECA, would be reduced to 0.50 per cent after 01 January 2020. The implementation date is subject to a review, which would be completed by 2018 and depending on its outcome it could be deferred to 01 January 2025. The IMO is expected to review based on parameters such as the global supply and demand for low sulphur fuel oil, trends in low sulphur fuel prices and is likely to take into account technological constraints or any other relevant issues[viii]. This uncertainty on the possible delay in the date of the implementation, global trends in availability of low sulphur fuel and prices of distillate fuels is adding to the complexity of decision making for selection of competing technologies for lowering emissions from ships. Coupled with this is the delay in designation of additional areas as ECAs, notably around Japan and Australia. This global regulatory uncertainty is therefore hampering the growth of LNG fuelled ships.

Conclusion

It is evident that LNG is emerging as an alternate fuel for propulsion onboard ships. This is driven by increasing environmental concerns, stringent enforcement of regulatory mechanisms, and competitive cost of LNG as a fuel for ships. While there are many advantages of using LNG onboard ships, there are an equal number of challenges which have to be overcome progressively. When LNG would replace oil as the primary source of fuel onboard ships remains to be seen, but what cannot be debated are the giant steps for clean shipping which is transforming shipping into an environmentally friendly industry. It can be concluded that the transition from oil to LNG for ships is highly likely in the future and regulatory developments in shipping are aiding this clean transition.

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Notes

[i] DNV-GL, "Report shipping 2020", http://www.dnv.nl/binaries/shipping%202020%20-%20final%20report_tcm141-530559.pdf (accessed March 21, 2015)

[ii] MARPOL Annex VI, first adopted in 1997, limits the main air pollutants contained in ships exhaust gas, including Sulphur oxides (SO_x) and Nitrous oxides (NO_x), and prohibits deliberate emissions of ozone depleting substances (ODS).

[iii] Following entry into force of MARPOL Annex VI on 19 May 2005, the Marine Environment Protection Committee (MEPC), agreed to revise MARPOL Annex VI with the aim of significantly strengthening the emission limits in light of technological improvements and implementation experience. As a result of three years examination, MEPC 58 (October 2008) adopted the revised MARPOL Annex VI, which entered into force on 1 July 2010.

[iv] 0.10 per cent m/m equals 1000ppm (parts per million)

[v] Marine Diesel Oil

[vi] Marine Gas Oil

[vii] This is just short of the share of demand met by oil

[viii] ECG Association, The Association of European Vehicle Logistics, "Sulphur Content in Marine Fuels-Briefing Report", January 2013, http://www.ecgassociation.eu/Portals/0/Documentation/Publications/ECGBriefingReport_SulphurContent_Jan2013.pdf (accessed March 20, 2015)