

LNG as an Alternative Fuel to Reduce Pollution

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Abstract-Among the various challenges faced by the shipping industry from low freight rates to fuel prices, the major obstacle still being to comply with the regulation of MARPOL Annex-6 and decrease the air pollution from shipping industry. The preferred solution of using LNG, as an alternative fuel, is increasingly becoming popular as it eliminates the problem from its root cause i.e. air pollution.

This paper reviews several recent studies on the topic and discusses the suitability of LNG as an alternative fuel in international shipping for regulatory compliance as well as savings in fuel cost that has increased substantially in the last few years and expected to follow the same trend.

Keywords: *Marine Diesel Oil (MDO), LNG (Liquefied Natural Gas)*

1. Introduction:

Since 2008 the shipping industry has been facing various challenges after the economic meltdown, but dealing with the upcoming emission requirements of MARPOL Annex-VI, compulsion for the use of expensive low sulphur fuel (LSF), certainly comes on the top of the priority list. Now low freight rates due to overcapacity, likely to continue for longer than expected, is a real concern but high fuel price has already pushed many shipping giants globally towards their financial threshold limit and LNG (Liquefied Natural Gas) as an alternative fuel is a real promise today.

“There are compelling reasons for LNG to become the future fuel for shipping but there are also a good number of reasons why it may not become the future fuel for shipping for some time” Chairman, International Bunker Industry Association. Bunker spot LNG Asia conference, April-2012

With the aim being emission control as per the MARPOL Annex VI, there are various methods available which can be adopted by the shipping companies depending on their suitable requirement in order to achieve the goal of reducing the pollution cap to the level laid down as per MARPOL Annex-6

(NO_x and primary PM emissions are mainly linked to the performance of the vessel engine whereas the SO_x emission is related to the sulphur content in the fuel.)

There are different emission reduction possibilities:

Fuel type; use distillate fuel or low sulphur HFO or LNG
Emission control methods SO_x
Wet scrubbers (NaOH solution)
Dry scrubbers Ca(OH)₂, granulated limestone
Emission control methods NO_x
GR (Exhaust Gas Recirculation)
SCR (Selective Catalyst Reduction) using urea
The established abbreviation when cleaning the SO_x exhaust gas is EGC, Exhaust Gas Cleaning.

2. Main Work:

2.1 Different prime options currently available to meet the requirements set by MARPOL ANNEX 6:

Scrubbers:

Scrubbers are air pollution control devices that use liquid to remove particulate matter or gases from an industrial exhaust or flue gas stream. This atomized liquid (typically water) entrains particles and pollutant gases in order to effectively wash them out of the gas flow.

Advantages:

- Can handle flammable and explosive dust with little risk.
- Provides gas absorption and dust collection in a single unit.
- Provides cooling of hot gases.
- Compact, can often be retrofitted into existing collection system.

Disadvantages:

- High potential for corrosion problem
- Collected particles may not be recyclable
- Disposal of waste sludge is very expensive
- Requires makeup water to replace purged liquid.

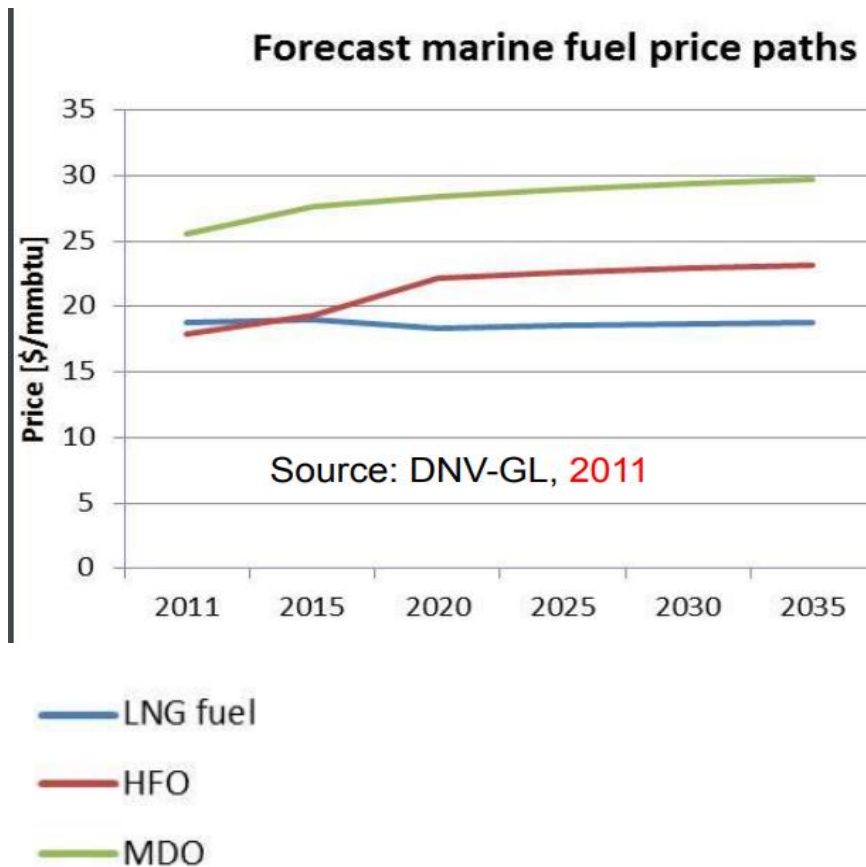
i. Using low Sulphur fuel:

As per the new regulation brought up by Marpol 73/78 all ships need to control Sox and NO_x. In order to do that the ships can shift to low Sulphur fuel as the Sulphur content. The prime disadvantage of using this fuel is the cost and subsequently the refineries are also not prepared to deliver this fuel at every location in needed quantity.

ii. Using LNG as marine fuel:

LNG is already a preferred option for SSS (Short Sea Shipping) in Europe and USA. There is no strict taxonomy of SSS but refers to the historical

term coastal trade which encompasses the movement of cargo and passengers mainly by sea, without directly crossing an ocean. LNG is not only a clean fuel but economical also. While the price of bunker fuel varies in close tandem with the global crude price, the cost of LNG is relatively independent. In the last two years bunker cost has become almost double but LNG price has gone down in many countries due to high production. Switching to distillate fuel or installation of exhaust gas scrubber are options suitable for existing ships depending upon their exposure in ECAs (Emission Control Areas) but for new building LNG definitely holds merit.



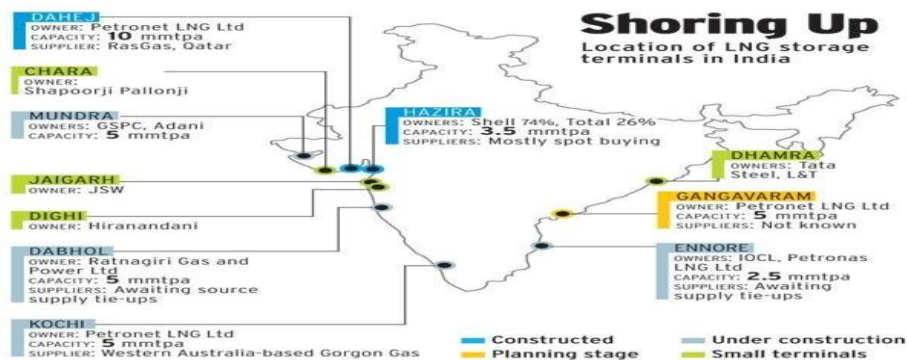
Despite all the challenges being faced in the path to achieve the goal of pollution control in Marine Industry, all the mega shipping giants are applying various ways to satisfy the requirements laid down by MARPOL-Annex 6 and initiate a new era of clean shipping. Most of the old ships as being equipped with the scrubbers while the question still remains what will be the shipping like in next decade?

To meet the green shipping aim, the prime focus is being laid on using the environment friendly fuel, and LNG is the prime candidate for this. Both the availability and cost of LNG are feasible for the shipping industry.

Today gas technology is well matured but a recent analysis of fuel choices by a reputed classification society shows that only 10 -15 % of the new buildings delivered up to 2020 will have the capacity for burning LNG. The largest obstacle to wide-spread take-up of LNG is the lack of bunkering network globally. In fact gas suppliers have business plans ready but what is missing is a real demand of the maritime market. Indeed, ship-owners are afraid not to be able to find LNG everywhere, so they do not command LNG fuelled ships for the international shipping. Now the dilemma is which come first LNG bunkering infrastructure or LNG fuelled vessels. Some of the current bunkering infrastructure, available around the world are shown in the figure below:-

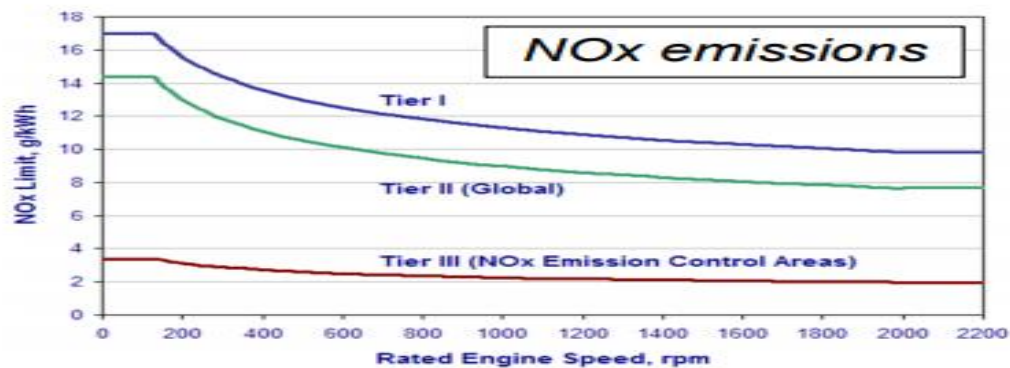
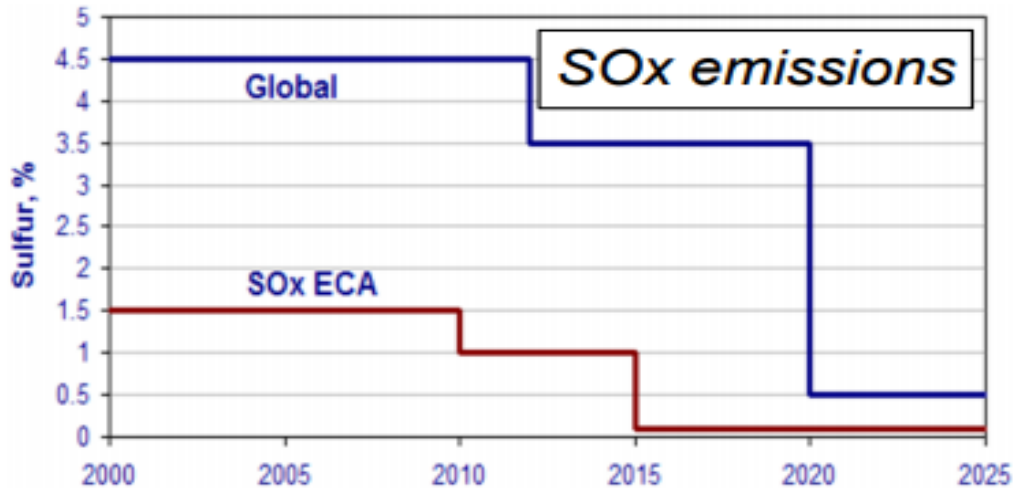


The vital LNG bunker locations in India are as follows:-



Factors Leading to Change in fuel

- I. Today the choice of LNG as an alternative fuel is surely a viable option to comply requirements of MARPOL Annex-VI, the control of NO_x (Regulation-13), SO_x (Regulation-14) and CO₂ (Chapter-4). The mandatory sulphur limit of fuel is 0.1% within ECA by 2015 and 0.5% globally.



- II. The carbon content ($CF = t\text{-CO}_2/t\text{-Fuel}$) of LNG is the least (2.75) compared to diesel oil (3.20) or heavy fuel oil (3.11) that improves the EEDI. LNG can reduce CO₂ by 20%, SO_x and NO_x about 95% and 80% respectively. So it is the most suitable fuel option for new ships and additional investment cost for LNG tank system can be recovered between 2 to 5 years depending upon its ECA exposure.
- III. During the combustion of fossil fuels, the Sulphur in the fuel is released in form of Sulphur oxides (SO_x), other pollutant are primary particle matter (PM) and nitrogen oxides (NO_x).
- IV. It is well known that air pollution seriously impact people's health and the environment. Sulfur dioxide and nitrogen oxides are the major precursors of

acid rain, which causes acidified soils, lakes and streams, accelerated corrosion of buildings and monuments, and reduced visibility.

- V. Sulfur dioxide is a major precursor of fine particulate soot; also NO_x forms related particles when reacting with ammonia, moisture, and other compounds. Small particles can penetrate deeply into sensitive lung tissue and damage it, causing premature death in extreme cases.
- VI. NO_x reacts with volatile organic compounds in the presence of sunlight to form Ozone. Ozone can cause adverse effects such as damage to lung tissue and reduction in lung function mostly in susceptible populations (children, elderly and asthmatics). When NO₂ is dissolved in water, a series of reactions occur which finally result in formation of nitrate. Too much addition of nitrate in the sea will cause unnatural algal bloom, especially near-shore areas are sensitive where the phosphorus from the agriculture together with nitrate may lead to enhanced biomass production.

Comparison of HFO, MDO and LNG

- a. The decision to use LNG as ship's fuel as opposed to using a scrubber system would depend on the price differential between LNG and HFO (Heavy Fuel Oil), the proportion of time spent operating within ECAs and the construction year for the new vessel. LNG will also meet the Tier-III NO_x requirement when SCR (Selective Catalytic Reduction), an emerging technology, is the only alternative.. The current annual demand for distillate fuels is around 30 million tonnes. This is expected to rise up to 45 million tonnes when the 0.1 percent limit comes into force in ECAs and may be around 200-250 million tonnes by 2020. At this juncture an "Incorrect investment decisions could be devastating for individual ship-owners and collectively they could impact negatively on the environment as well.
- b. So far LNG fueled cargo ships, have been delivered only for round trip and bunkering at a single port. Norway is the leading country to acquire such vessels but countries under EU and USA are going ahead for such vessels in SSS. European ports such as Netherlands, Sweden, Finland, Poland and Germany are making huge investment in LNG bunkering facilities and for three Belgian ports a feasibility study is underway. Now the oil major Shell is guaranteeing the availability of LNG in the US Gulf Coast region and the scope of service will be extended to other key North American shipping region in due course of time.MPA (Maritime and Port Authority) of Singapore, world's largest bunkering port, is also investigating the feasibility of LNG bunkering in Singapore in collaboration with DNV and 21 industry partners.

- c. The EU (European Union) has already introduced 0.1% Sulphur as a maximum level for ship's fuel when in ports and on inland waterways. Now a vast region of North America is under ECA from 1st Aug 2012 which means all ships within 200 nautical miles of US and Canada coast line must use expensive fuel, present price difference is about \$200/t, with maximum 1% Sulphur content, the present ECA limit till 1st January-2015. As per US Coast Guard non-compliance will attract fine up to **\$25,000** per day. Cheaper price of LNG in Europe and USA is making it more attractive for SSS.
- d. Today gas engines (Dual-Fuel) are well matured and all leading engine manufacturers are producing such engines with very low methane slip. This is the release of unburned natural gas through the engine exhaust. LNG is predominantly methane which is a substantially worse greenhouse gas than CO₂ although safe for marine use due to high ignition temperature and lighter than air. Now gas at a pressure of 300 bar is injected in the air compressed by the cylinder stroke that gives a more responsive solution than pre-mixed combustion method in which low-pressure gas is mixed with air and then compressed. Modern DF engines can burn gas and oil at any ratio depending upon the availability and cost. Although four-stroke gas engines are common in the market but Wartsila, MAN Diesel and Mitsubishi, all are now developing a range of slow-speed two-stroke engines to run on natural gas as well as oil. Burning gas within ECAs and liquid fuel elsewhere is an obvious solution today.
- e. LNG is gaining popularity globally. However findings of the Dutch research organization TNO suggests that due to methane slip there could be less of a reduction in overall greenhouse gases than many supporters of LNG claim.
- f. The last thirty years have seen a shift in the global energy fuel mix towards an increased role for natural gas. Since last 5 years global LNG production increased by 40% and the number of countries exporting and importing LNG are increasing every year. As per statistics oil continues to suffer a long run decline in global market share, while gas is gaining steadily and expected to be same as oil, 26% to 27% by 2030. The rise in freight rates of LNG carriers in the recent past, the only shipping sector which is not at a loss now, is a reflection of the increased demand for LNG shipment in many countries. When the freight of a capsized bulk carrier in the spot market is languishing at an average of a mere \$5,000 per day, the LNG spot and short-term rates are sky high at around \$150,000 per day. This trend is likely to continue in foreseeable future and ship owners should review options considering the pace LNG is gaining popularity globally. However findings of the Dutch research organization TNO

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- g. LNG is about to establish its presence as a major marine fuel? Probably the answer is yes, driven by the dual impacts of increasing legislation on exhaust gas emissions from ships and high oil prices. While the former is dictated by public opinion and expected to be more and more stringent in the era of high environmental awareness but the latter is guided by the law of supply and demand where contradictory views are emerging. An interesting report of the Harvard Kennedy School of USA published in June 2012 has challenged the long established notion that oil will run out soon is far from the truth. It suggests that so far mankind has extracted only 1trn tons of crude oil out of a total of over 8trn tons what is known as original oil in place. Also there is no SOLAS regulation for burning LNG as a fuel in international waters, with the exception of gas carriers. At present, the IMO Sub-Committee on BLG (Bulk and Liquid Gases) is working on the IGF Code (International Code of Safety for Gas-Fueled Ships) which is likely to miss the adoption deadline of 2013. This may be the immediate hurdle for the wider use of LNG to fuel ships.

3. Conclusion

In conclusion it can only be inferred that if economy and environment are not conflicting, LNG will create a wonder for the shipping industry. Price difference between LNG and HFO is a key factor for LNG to appear soon as an alternative fuel in international shipping.

“It takes 100 years to create a revolution in shipping. Steam power came 200 years ago then diesel power 100 years ago and gas power is tomorrow.”

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