LNG AS MARINE FUEL

Frederick Adamchak
Amokeye Adeede
Poten & Partners

ABSTRACT
The global shipping industry faces a challenge as new legislation will significantly limit sulfur emissions from ships, firstly in North America and northern Europe in 2015. LNG is a potential solution for meeting these requirements - it has virtually no sulfur content, and its combustion produces low NOx compared to fuel oil and marine diesel oil. LNG is not only cleaner-burning, but may have economic advantages - on a calorific value basis even high Asian LNG prices are lower than global bunker fuel prices. As a result there have been recent developments to promote use of LNG as a bunker fuel. The scope for displacement of bunker fuel oil by LNG is potentially huge - excluding LNG carriers there are currently only 20 - 25 LNG-fuelled vessels in operation - less than 1% of the total commercial marine fleet. However, LNG as a bunker fuel faces a number of challenges; notably the investment required in ships propulsion and fuel handling systems and in bunkering facilities, plus development of new international safety regulations, and LNG availability. Given the potential advantages of LNG as a bunker fuel and the pace of recent developments, the probability of LNG displacing oil as the preferred fuel will continue to increase. However, given the challenges faced, to what extent can LNG as a bunker fuel develop by the end of decade? This paper will discuss the advantages of LNG as a bunker fuel, challenges faced for widespread implementation, and the pace and potential for LNG to displace established fuels.

INTRODUCTION
Annex VI of the International Maritime Organization (IMO) International Convention for the Prevention of Pollution from Ships (MARPOL) entered into force in May 2005. The mandate limits the sulfur content of marine fuels on a global basis to 4.5%. That limit was then lowered to 3.5% sulfur from January 2012. Annex VI also imposed a 1.5% sulfur limit on marine fuels in Emission Control Areas (ECAs) effective May 2006. That limit was reduced to 1.0% sulfur effective 1 July 2010, and will be further reduced to 0.1% sulfur beginning January 2015. There are four (4) ECAs in effect: the Baltic Sea since May 2006, the North Sea since November 2007, North America (US and Canada) since August 2011, and U.S. Caribbean since January 2013. As a result, the effects of Annex VI sulfur reductions and initiatives to adopt lower sulfur fuels have been largely limited to the ECAs.

The larger effect from Annex VI will come when the requirement to reduce sulfur content of marine fuels to 0.5% on a global basis effective 2020. However, implementation of this major change depends on the outcome of an IMO low sulfur fuel availability study to be completed in 2018. If IMO decides there is insufficient low sulfur fuel available, the 0.5% sulfur limit can be delayed until 2025. The issue for ship owners and operators is how to find alternatives to economically meet the low sulfur fuel mandate about to be imposed by Marpol Annex VI.
In the short term, ship owners and operators are switching from traditional residual bunker fuel during ocean passages to low sulfur fuels when operating in ECAs. For the longer term ship owners are studying alternative approaches to meet the environmental requirement for the post 2020 or 2025 era; these include

- secure a reliable and affordable source of Annex VI compliant liquid fuel;
- consume high sulfur residual fuel and add SOx emission reduction equipment such as scrubbers to meet the SO2 emission requirements;
- shift to an alternative low sulfur fuel. LNG is one alternative attracting attention because of its low sulfur content and its price, which is lower than the traditional residual oil based bunker fuels.

OBJECTIVES

As a result of several factors, LNG is being touted as a viable alternative for ship owners and operators to meet the Annex VI low sulfur fuel requirements both for global trade and in ECAs. This paper examines a range of issues, both pro and con related to using LNG as a marine fuel. We intend to discuss at a high level:

- the drivers for increased use of LNG as a marine fuel;
- alternative approaches to meeting IMO Annex VI requirements and their comparative economics;
- uncertainties related to the timing and application of low sulfur fuel requirements;
- estimates of the potential demand for LNG as a marine fuel;
- availability and cost of LNG as bunker fuel; and
- the impact of LNG demand for marine fuel on global LNG demand and supply.

DRIVERS FOR LNG AS MARINE FUEL

LNG has been used to fuel diesel propulsion systems of LNG vessels since delivery of the Provalys in 2006. Today 48 existing LNG ships operate with dual fuel and tri-fuel diesel electric propulsion and another 85 LNG ships are on order. In view of the proven success of LNG as a fuel in marine diesel engines, ship owners have already constructed an estimated 30 LNG fueled ships and have ordered more than 30 additional LNG fuelled ships. The two primary drivers that make LNG appear an attractive alternative to meet the Annex VI sulfur in fuel oil requirements are:
1. LNG allows ships to meet MARPOL Annex VI requirements for both worldwide trades and operation in ECAs as its sulfur content that is well below the Annex VI requirements for ECAs. Moreover, LNG reduces NOx emissions to levels that will meet MARPOL Annex VI without need for after treatment.

2. In some markets, natural gas and LNG are lower priced than high sulfur marine fuel oils on a heating value basis.

There is no doubt of LNG’s low sulfur content. The specification of LNG in numerous LNG Sale and Purchase Agreements translates to about 0.004% on a mass – mass basis, which is well below the 0.1% S required in ECAs from 2015. There are at least three (3) alternative approaches to meeting MARPOL Annex VI requirements, and ship owners must assess the relative costs of the approaches and future bunker fuel and LNG prices before taking a decision.

---

**Figure 2. MARPOL Annex VI – SOx reduction alternatives**

The relative low price of natural gas and LNG compared to current high residual bunker and distillate fuel prices in the U.S and Europe has added to the attractiveness of LNG as an alternative marine fuel.

---

**Figure 3. Fuel Cost Driver – Fuel Oil vs. Natural Gas Prices**
As shown in figure 3 above there is also a clear economic incentive to consider LNG as a viable alternative fuel on the basis of its price. In the U.S. Henry Hub natural gas price is approximately 30% of Intermediate Fuel Oil (IFO) 380 in the Gulf Coast. In the U.K. the discount is not as large, but is still 30% below bunker fuel price. However, we must consider that natural gas must be purchased, liquefied, stored and delivered to a site that can fuel ships. That requires LNG infrastructure investment, and recovery of those costs to supply LNG in competition with bunker fuels that are supplied through existing infrastructure. The costs must be evaluated.

The situation in Asia – Pacific is not as clear. LNG prices are higher than IFO 380 price, but lower than Marine Diesel Oil. While the comparison is an LNG – Fuel Oil comparison rather than a natural gas – Fuel Oil comparison; there will be a requirement to develop LNG bunkering capacity and facilities. Asian LNG buyers’ LNG import capacity is heavily used to import LNG for electric power generation and distribution by pipeline to city gas systems. These facilities are not likely to be available to provide bunkering services.

![Comparison of LNG supply cost and alternative fuels](image)

**Figure 4. Comparison of LNG supply cost and alternative fuels**

Poten’s estimate of infrastructure costs to liquefy natural gas, store and transport LNG to fuel ships, when added to feed gas costs makes LNG competitive with MDO in Rotterdam, but questionable in comparison with IFO. In Asia LNG is an attractive alternative compared to HFO prices, but higher priced than MDO. Although the competitiveness of LNG seems assured in the U.S., but will LNG be sold at a “reasonable” return on investment or will it be priced in competition with alternative fuels? A recent article reported that LNG for road fuel use sold at a 30% discount to diesel fuel. However, that same LNG price was equivalent to nearly $20.000/MMBtu while Henry Hub price was below $4.00/MMBtu. The point is that low natural gas price does not necessarily convert to low LNG prices.

**ESTIMATED DEMAND FOR LNG AS MARINE FUEL**

To date LNG fuel initiatives are largely regional. Ships deployed in trade routes between ECAs or ships trading entirely within ECAs such as ships trading from the Baltic Sea to North Sea and English Channel routes are already living with a 1.0% sulfur in fuel oil requirement for all or a substantial portion of their voyages. Initiatives by ship owners and governments have already resulted in construction and operation of LNG fuelled ships and development of small scale LNG supply and fuelling infrastructure within these ECAs, which became effective in 2006 and 2007. LNG fuelled ships are now being ordered for ships trading entirely within the North America ECA in response to U.S. Environmental Protection Agency regulations and introduction of the North America ECA from August 2012. However, not all ships are candidates for LNG fuel.
Figure 5. Global Ship Movements per Year

As shown above routes between Western Europe and the U.S. East Coast; Asia to the U.S. West Coast and continuing to the Gulf and East Coasts; Asia to Western Europe via Suez Canal and return; Middle East to Western Europe; and Middle East to Asia are heavily travelled international routes.

To develop potential LNG demand, Poten assumed only new-builds would utilize LNG as fuel as conversions are costly both in conversion costs and out of service time and technically challenging. We then focused on:

- Ships employed in ECA to ECA trades for ships delivered as early as 2015 as 1.0% sulfur limits already apply in ECAs;
- We assumed that the Global reduction to 0.5% sulfur in marine fuels would be delayed until 2025 based on results of the 2018 IMO review of low sulfur fuel oil availability;
- We assigned a realistic market share to LNG fuel in competition to low sulfur fuels and high sulfur HFO with scrubbers

Figure 6. SOx limits
Container ships, bulkers, and tankers were our focus as they are engaged in ECA to ECA trades and, in the case of container ships, have fixed routes that involve spending considerable time in ECAs before a relatively short duration trans-Atlantic passage to another ECA. We also examined bulkers and tankers that have fewer ECA to ECA voyages, but represent a significant portion of the world shipping fleet. Poten believes that orders for LNG fuelled ships will increase when the implementation date of the global 0.5% sulfur in fuel implementation date is certain.

Poten’s demand projection is that LNG consumed as marine fuel will reach 1 million tonnes in 2020 and will increase rapidly to 8.5 million tonnes by 2025.

We also project that Europe and the U.S. will rely primarily on domestic natural gas production to produce LNG for marine fuel. Asia Pacific, on the other hand, will have to rely on LNG imports at prices set in the Asia Pacific market.

A number of other projections of LNG demand as marine fuel have been published and these vary based on assumptions made with respect to:

- global economic activity and resulting shipping and shipbuilding activity,
- absolute fuel prices
- relative LNG and natural gas price compared with oil price;
- regulatory activity specifically as it relates to environmental issues,
- costs to outfit conventional ships to use LNG as fuel;
- cost of LNG fuelling infrastructure, and
- LNG fuel availability

Results of these analyses have a wide range of projected LNG demand.

- 0.7 to 66 million tonnes in 2025 depending on scenario
- 8 to 33 million tonnes in 2020 depending on scenario
- 65 million tonnes in 2030
UNCERTAINTIES

Different outlooks for marine fuel will arise from one’s view on resolution of uncertainties.

Timing of 1% Sulfur fuel requirement entering into force

Figure 1 above shows the first uncertainty associated with application of Annex VI provisions – timing. What will be the result of the low sulfur fuel availability review and when will the 0.1% sulfur requirement become mandatory? IMO is required to complete a review of the availability of 0.50% sulfur content fuel by 2018. Based on the results of such a review, the Parties to MARPOL Annex VI will decide whether the global cap of 0.50% can be enforced from 1 January 2020. If not, the 0.50% sulfur global cap will be enforced on 1 January 2025 without any additional review. The dilemma is that ships are required to use lower sulfur fuel oils, but refiners are not required to supply them. In fact, refiners have been reticent to move ahead with multi-billion dollar investments to supply low sulfur marine fuels. Figure 2 above shows a key reason for their response. Residual bunker fuels have a lower price than the crude oil feedstock to their refineries.

Expansion of the number of ECAs

A second issue is the uncertain pace of expansion of ECAs, that would require use of 1% sulfur fuel from July 2010 and 0.1% sulfur fuel from January 2015. Figure 8 below shows: existing ECAs, potential new ECAs, and the world’s major bunker ports. Few large bunker ports are located within ECAs, and estimated 24% of bunker fuels purchased annually come from ports currently located within ECAs. Expansion of ECAs to encompass Asian ports, which supply 32% of world bunker sales and Middle East ports that supply 12% of world bunker sales would increase and speed the transition to lower sulfur fuels. However, implementation of new ECAs depends on Parties submitting a proposal to IMO to designate new ECAs; it is not an IMO led initiative.

Figure 8. Existing and Possible Future Emission Control Areas (ECAs) & Major Bunker Ports

International Regulation

IMO, recognizing the need for regulations of non-LNG ships that use LNG as fuel and engage in international trade, adopted Interim Guidelines on Safety for Natural Gas Fuelled Engine Installations in Ships in 2009. IMO also convened a working group to draft an International Code of Safety for Ships Using Gases or Other Low Flashpoint Fuels (IGF Code) with a goal of completing the work in 2014. While the Interim Guidelines are a workable solution for domestic trades, how
broadly accepted are they in international trades? If the IGF Code requirements are more stringent than those of the Interim Guidelines, what will be the effect on ships built under the Guidelines?

Which Comes First?

Port infrastructure to produce, store and transport LNG and fuelling berths, barges or vessels will be required to reliably and economically bunker LNG fuelled ships. Ship owners will not construct LNG fuelled ships without confidence that LNG supplies will be available throughout its route at economic prices. Developers will be reluctant to invest in LNG fuelling infrastructure until they are confident there will be a market for LNG to fuel ships. Coordination and cooperation between port developers and ship owners will be particularly difficult with ships in international trades.

LNG Supply and Pricing

Various estimates of annual consumption of fuel oil for marine fuel are reported. The IEA reports that bunker demand in 2010 was 235 million metric tonnes, comprising approximately 180 million tonnes of residual fuel based products and 55 million tonnes of distillate fuel products. This is equivalent to about 180 million metric tonnes of LNG - nearly 75% of worldwide LNG trade in 2012.

Worldwide LNG demand is projected to grow at more than 5% annually through 2020. Asia – Pacific LNG demand in 2012 represents nearly 70% of global demand and Poten projects that Asia – Pacific demand will continue to pace global demand. Supply must expand rapidly to meet worldwide demand and premium priced Asia Pacific demand in particular.
Poten estimates that about 80% of total LNG sales are made under long-term LNG Sale and Purchase Agreements; the remainder is sold on spot and short term transactions. With the size of the global bunker fuel market equal to about 70% of the global LNG market, a significant shift from marine bunker fuel to LNG would require a similar increase of LNG supply.

Does spot and short-term LNG supply provide sufficient supply security for ship owners to order newbuilds designed to operate on LNG, and for developers to design and construct LNG bunkering infrastructure and facilities?

Will new LNG supply develop in response to potential demand for LNG as fuel and who will act as the aggregator?

SUMMARY

MARPOL Annex VI is a bold move by the IMO and the parties to Annex VI to reduce air pollution from ships including SO\textsubscript{x}. Sulfur content in marine fuel will decrease as Annex VI regulations tighten. The question for the LNG industry is what role will LNG play in the marine fuels market and when.

Figure 11. Natural Gas & Oil Benchmark Projection

We suggest that due to an absence of initiatives from Asian governments to request that their territorial waters be designated as ECAs, the pace of change will be slow and the solutions regional.

Spurred by government initiatives and financial support, LNG has made important inroads in the Baltic Sea, the North Sea and English Channel, and will expand its role.

Similarly, LNG initiatives are being taken in the U.S. by vessels that operate within the 200 mile ECA limit. The reasons due to both are regulatory compliance and economics.

Figure 11 shows Brent crude oil price, Henry Hub and NBP natural gas price and Asia Pacific and European LNG prices projected through 2025. The economic rationale for regional solutions is clear. Low natural gas prices in the U.S, and LNG prices below Brent crude oil price in Europe provides incentives to move to LNG while meeting the 0.1% sulfur limit that will become effective in 2015. It is more difficult to make a strong economic argument in Asia Pacific as oil indexed LNG prices reduce the economic incentives. Although we anticipate that the 2020 deadline to meet the global 0.5% sulfur in fuel limit will be extended, the 2025 deadline looms ahead, and LNG will have a role to play.
This paper highlights five uncertainties affecting the decisions for both shipowners and bunker fuel providers in global growth of LNG as marine fuel. Shipowners are faced with three alternatives to meet a regulation with an uncertain timeline for global application. Regional ECA initiatives will lead to increase LNG utilization. This has occurred in Scandinavia and appears to be developing in the US though neither of these cases will impact the global LNG trade as reliance will be primarily on locally produced LNG. The global outlook, however, will remain fog bound and no clear fuel choice will emerge as shipowners will opt for flexibility in their ship orders until Annex VI timing and application are finally settled. Given the considerable uncertainty around both fuel price differentials and regulations, a strategy of flexibility will prove key.