ABDULLAH BIN HAMAD AL-ATTIYAH INTERNATIONAL FOUNDATION
FOR ENERGY AND SUSTAINABLE DEVELOPMENT

Issue 18: February 2018

Al-Attiyah Foundation Research Series

Expert energy opinion and insight

Clearing the decks: Marine fuel specifications

Pollution from the world's shipping fleet is having a significant impact on human health and the environment. For the last decade, the International Maritime Organisation has been wrestling with policy and regulatory measures designed to help mitigate the impact of high carbon dioxide, sulphur dioxide and particulate emissions which arise from burning marine fuel oil bunkers. This report briefly examines the issues, the mitigation measures being enacted and the implications for refiners and ship owners and operators.

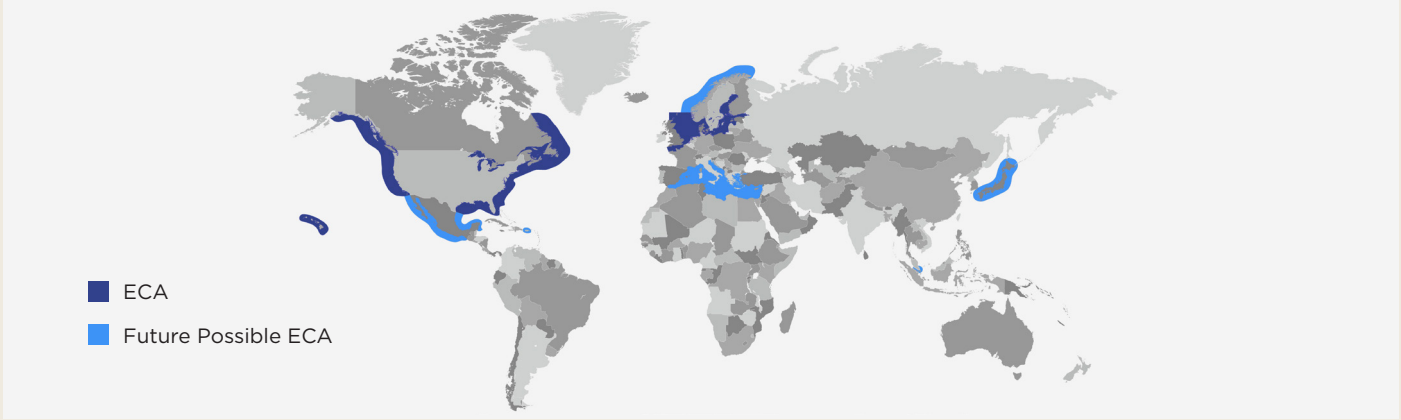
Changes to marine fuel regulations mean a big shake-up for shipping

Ships are one of the last bastions for high-sulphur fuel oil. They consume as much as 5 million barrels per day (bpd), out of 8 million bpd of fuel oil consumed worldwide in 2016. Sulphur combustion creates acidic oxides of sulphur, contributing to air pollution with considerable impact on human health and the environment. In a recent report published in February 2017 in the internationally recognised Nature Communications journal by James Corbett[1], the impact of shipping pollution on human health was summarised in stark terms: it is the source of 130,000 premature deaths from cardiovascular complications and is responsible for 14 million cases of childhood asthma. Two-thirds of the world's population live in coastal zones which contain 70% of the global shipping fleet.

The International Maritime Organisation (IMO), a 171-member United Nations agency, has been looking for ways to reduce the industry's environmental footprint against a background of increasing tonnage with attendant increases in carbon, sulphur dioxide and particulates emissions. Assuming full compliance, the IMO policy goals will, according to Corbett, save lives from premature death from a 30% reduction in particulates which will reduce the incidence of asthma by 50% after 2020.

Under the IMO's new regulation put forward to members in October 2016, the current maximum permitted sulphur content in fuel of 3.5%, must fall to no more than 0.5% from 1st January 2020. The average sulphur content in marine fuel is currently 2.45%. Some sensitive Emissions Control Areas (ECAs) along US and northern European coasts and some Chinese ports have already introduced mandatory levels that are considerably more stringent. In those zones, the maximum sulphur content of marine bunkers must be not more than 0.1%, but these zones represent only about 25% of world marine fuel demand. Corbett's work suggests that the health impact of the IMO regulations will be particularly positive along the Red Sea, Arabian Gulf, India, Java and East Asia.

FIGURE 1: **EXISTING AND PROPOSED EMISSIONS CONTROL AREAS[2]**



[1] Nature Communications, Volume 9, Article number: 406 (2018)

[2] Korea LNG Bunkering Industry Association

FIGURE 2: **SHARE OF MARINE INTERNATIONAL BUNKER FUELS AND LOCATION OF TOP 20 BUNKERING PORTS AND THEIR LNG AVAILABILITY**[3]

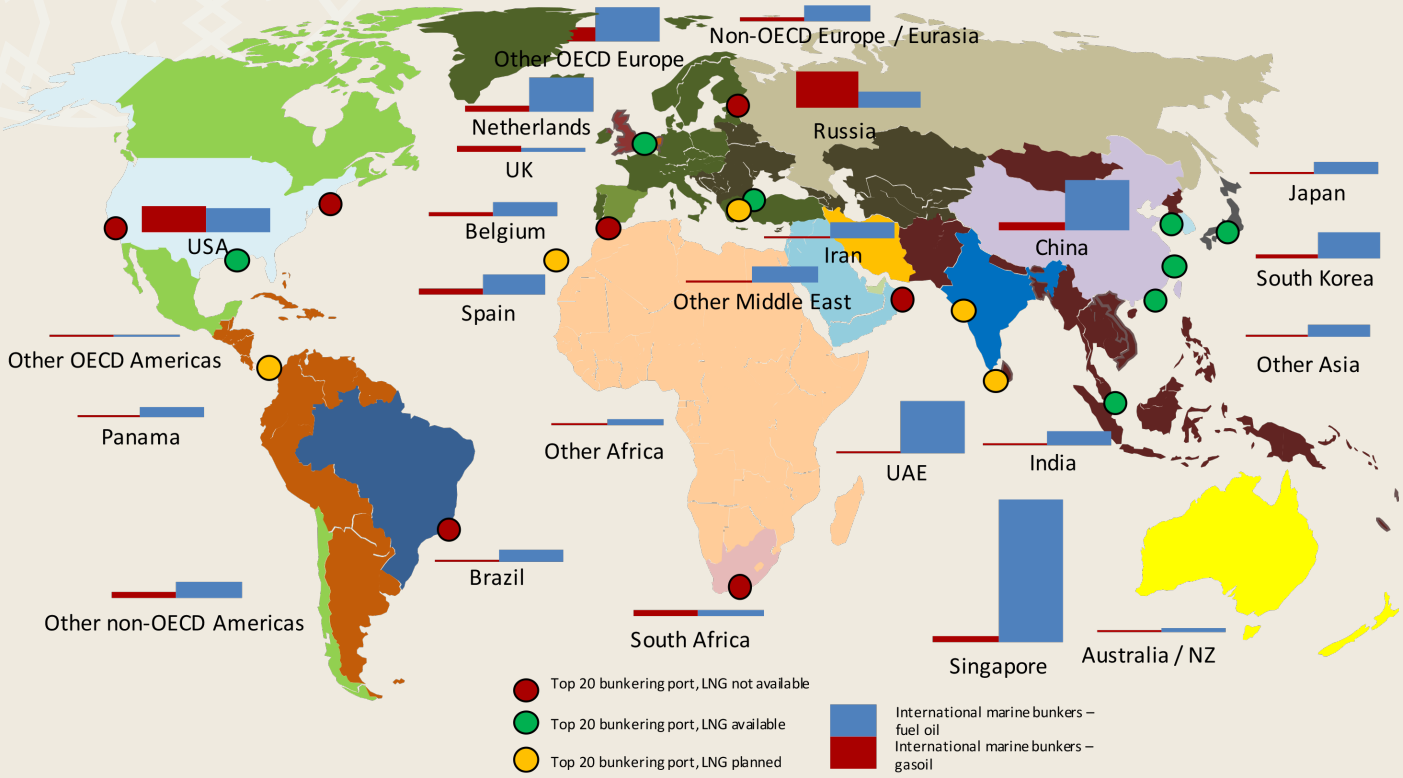
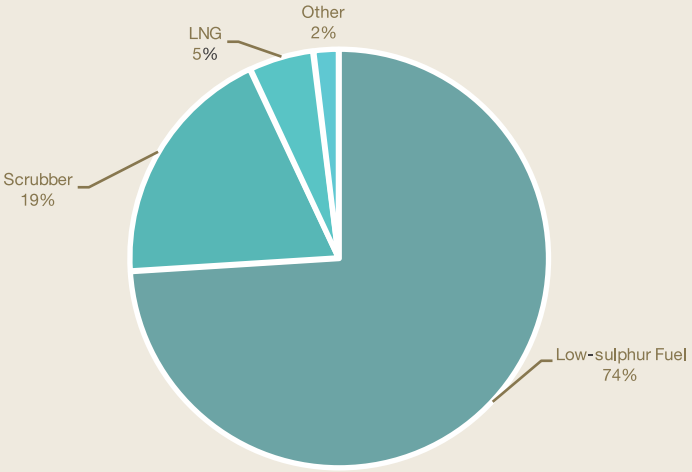


FIGURE 3: **SHIPOWNERS' COMPLIANCE INTENTIONS**[4]



Shipowners have several imperfect options

Shipowners have three options to cope with the new regulation. First, they can use lower-sulphur fuel, either marine diesel or low-sulphur heavy fuel oil. Secondly, they can fit 'scrubbers' to their exhaust systems (either retroactively or on new-build ships), to wash the sulphur oxides with sea-water and sodium hydroxide, enabling them to continue burning high-sulphur fuel oil while meeting the new emissions limits. This can allow ships burning even 3.5% sulphur fuel-oil to comply with the 0.1% specification in ECAs.

Or, thirdly, they can turn to an alternative fuel entirely: liquefied natural gas (LNG), batteries (for short ranges), or possibly a synthetic fuel such as methanol or dimethyl ether (DME).

The unspoken fourth option is that unscrupulous operators in less monitored areas may continue using high-sulphur fuel oil illegally, or may simply choose to pay fines if these are set too low. Enforcement of the existing ECAs has been patchy, with some countries setting fines too low for deterrence.

None of these options are ideal, so a mix of all will be adopted. So far, shipowners are mostly opting for low-sulphur fuels (FIGURE 03). The price of marine diesel and low-sulphur fuel oil is likely to escalate sharply as the ban comes in.

So far, few shipowners have chosen to install scrubbers, either retroactively or in new builds due to adverse economics. For new builds, it costs $3-5 million per vessel, more for retroactive applications. Prevailing shipping rates and squeezed margins represent barriers to capital investment, a stiff investment at a time of shipping over-capacity. It also complicates operations and logistics. 1500 scrubbers have been installed to meet the existing ECAs, and yard capacity would enable no more than another 3000-4000 by 2020, out of a total global fleet capacity of about 52,000 merchant ships. Just 20,000 of these ships burn 80% of the bunker fuel oil used worldwide.

[3] International Energy Agency statistics. Excludes domestic (non-international) shipping use. LNG availability refers to existence of an LNG import facility at that port; LNG bunkering may not yet be available.
[4] UBS

Assuming these figures are accurate and compliance is high, global shipping demand for high-sulphur fuel oil, which could then only be burnt in ships with scrubbers, would fall to about 1 million barrels a day. Nevertheless, the use of scrubbers is more straightforward than LNG, as retrofitting has lower capital costs and space requirements, and ships can continue with traditional bunkering logistics.

The substitution of marine bunkers by LNG, which contains no sulphur, and produces less carbon emissions relative to traditional bunkers, may be attractive at prevailing fuel prices. But risks associated with the relative price of fuel alternatives, and the high hurdle rates to remunerate investments in both LNG bunkering and ship conversions present significant barriers. Conversion of an existing 8000 TEU[5] vessel from marine oil bunkers to LNG is likely to cost at least $25 million, a large expense for a vessel that typically costs about $80 million to construct.

Classification agency DNV has launched a design and certification process for an LNG-powered 16,300 TEU container ship, which would have a range of 15,000 nautical miles. Such a ship could travel from Rotterdam to Tokyo via the Cape, or from Houston to Singapore, without refuelling.

About 103 LNG-fuelled ships are operating and 97 are on order globally, still a very small part of the fleet. The largest group is passenger ships, with 72 in service or on order. LNG-ready container ships are gradually entering service but there are only about 14 on order, and they are typically dual-fuelled, with the capability to use marine gasoil. LNG is most suitable for LNG carriers themselves, ferries, and container ships serving point-to-point major routes between ports that have LNG available. Owners of LNG vessels are likely to want to keep the tanks small to limit the reduction in cargo space, which will necessitate more frequent refuelling.

Conversion or new-build of vessels, either with LNG or scrubbers, poses a difficult problem for ship-owners. They do not pay the fuel costs themselves, but charters, 80% of which are for two years or less, are typically too short to pay-off such investments.

To get around this problem, some banks have been proposing 'green lending' schemes which invest in upgrades, and split the savings between ship-owner and charterer. Better measurement of actual fuel consumption makes such approaches more viable. In February 2018, bunker fuel prices in the main hubs were as shown in TABLE 1[6]. Marine gasoil has a premium of between $4.20-7.42 per MMBtu over 380 cst fuel oil – it is 45-80% more expensive.

CME futures prices[7] can be used to demonstrate how these bunker prices are expected to evolve in 2020. For January 2020, prices for 380 cst fuel oil, 180 cst fuel oil and marine gasoil are respectively $6.18, $6.46 and $12.39 per MMBtu. This indicates a dramatic increase in the premium of gasoil over fuel oil, from about $4/MMBtu before the IMO regulations come in, to about $6/MMBtu afterwards, i.e. a 100% premium.

For comparison, LNG prices in late 2017 were around $9.50/MMBtu, similar to fuel oil but much cheaper than marine gasoil. Ultra-low sulphur fuel oil (ULSFO, 0.1% sulphur) is not widely available, but in Rotterdam, an ECA, 180 cst fuel oil was about $9.85/MMBtu in January 2018, while ULSFO was about $14.15 per MMBtu, suggesting little if any cost advantage over gasoil.

A container ship of 8000 TEU would consume about 150 tonnes of fuel per day, and might be sailing for 280 days per year. At current bunker prices, annual fuel costs are estimated to be about $15 million for heavy fuel oil, or $24 million for gasoil. However, by January 2020, such costs might be expected to escalate to about $11 million of heavy fuel oil, $23 million of gasoil, or $18 million of LNG.

The change will affect oil producers, refiners and traders too

The shake-up in specifications will have a major impact on the global refinery business and associated oil product markets. Forward prices show a sharp decline in high-sulphur fuel oil prices post-2020 while gasoil prices are approximately flat, causing a widening differential between the two.

Refiners have three options to meet the increased demand

TABLE 1: **BUNKER FUEL PRICES, FEBRUARY 2018**

Price	Fuel oil 380 cst		Fuel oil 180 cst		Marine gasoil	
Port	$ / MT	$ / MMBtu	$ / MT	$ / MMBtu	$ / MT	$ / MMBtu
Houston	342.5	8.63	413.5	10.42	575.0	13.79
Santos	364.5	9.18	396.0	9.98	692.5	16.60
Rotterdam	350.5	8.83	376.5	9.49	545.0	13.07
Piraeus	370.0	9.32	392.0	9.88	567.0	13.59
Fujairah	369.0	9.30	430.0	10.83	667.5	16.00
Istanbul	375.5	9.46	375.5	9.46	595.0	14.27
Singapore	371.5	9.36	402.0	10.13	570.0	13.67

[5] Twenty-foot Equivalent Units

[6] Bunker Ports News Worldwide
[7] CME

for low-sulphur fuels. First, refiners can invest in the additional crackers, cokers and visbreakers that would be required to upgrade heavy fuel oil to gasoil. However, the traditional 'hydrotreater' unit will be insufficient to reduce sulphur content in most residual fuels below 0.5% without additional capital investment in a hydrocracker.

Secondly, refiners can build fuel-oil desulphurisation units, which are hardly used at the moment (just 0.1 Mbpd of global capacity), and then blend the output with gasoil. Such strategies not only require major investments with long lead-times, but they also face other obstacles, such as a lack of hydrogen for hydrotreaters in some areas.

Thirdly, refiners can run sweeter crude slates. Only a few crudes can produce 0.5% sulphur fuel oil without residue upgrading and/or desulphurisation[8], and these crudes will become increasingly expensive post-2020.

Otherwise, to get rid of surplus fuel oil, refineries could invest in fuel oil destruction, for example using it to power cogeneration – but that does not yield any more compliant fuel for the shipping industry.

Challenging plant and market economics, wafer-thin margins and strong competition for refinery capex have meant that refineries have made only slow progress so far towards the investment required in new desulphurisation. This, coupled with the long lead times associated with bringing any new plant on line means that the industry is unlikely to be fully prepared for the changes that will take place in 2020.

Producers of exceptionally low-sulphur heavy crude oils may benefit from premium pricing of their grades, while producers of high-sulphur crudes and operators of simple refineries suffer. Medium/heavy sweet crudes suitable for producing large volumes of low-sulphur diesel and fuel oil are quite rare – some examples include crudes from Argentina, Brunei, China, Congo, Indonesia's Duri, Malaysia's Tapis and Norway's Heidrun and Troll. But even Ekofisk crude, with 0.21% sulphur, produces residual fuel oil with 0.69% sulphur, non-compliant without further treatment.

The price of the middle distillate complex in general may escalate as prices for high-sulphur residual fuel slump, raising costs for shippers. On the other hand, unwanted high-sulphur fuel oil may return to use for power stations in areas without strict emissions policies.

Increased refinery output of sulphur will further reduce its price, already under pressure from the by-product of new sour gas developments. If the regulations result in a long-term reduction switch of about 2 million barrels per day of shipping demand from high- to low-sulphur oil, the refining industry will produce more elemental sulphur, adding approximately 2 million tonnes per year to this market (in 2016) of 63.4 million tonnes.

The overall effect of the IMO regulation on product pricing will be complex. If a wide differential persists between high- and low-sulphur products, it will eventually encourage new refining investments. But it will also guide ship-owners to install scrubbers where economically feasible. Increased demand for gasoil may in the end force prices of middle distillates up relative to other fuel, with implications for diesel for road transport and kerosene for air travel.

Some regions will not have low-sulphur fuels readily available. Traders, bunkering and storage companies will see an opportunity to serve this expanding market, including by blending high- and low-sulphur grades. Major fuel suppliers such as ExxonMobil and Shell are studying the grades they will offer to ensure full compliance before the 2020 deadline.

Trade flows in oil products are also likely to shift. At the moment, Russia is a key exporter of fuel oil to Europe and Asia. But, after 2020, only Asia will be self-sufficient in marine gasoil and low-sulphur fuel oil; the Middle East will be a net supplier, while all other regions will have to import their needs from elsewhere.

The LNG industry can gain in the longer-term

As discussed, LNG currently fuels only a very small part of the global fleet. However, proponents of greater LNG use in shipping include major LNG-exporting countries, notably Qatar, and leading LNG-producing companies. The new regulations are an opportunity for them to expand their share of the shipping market, attractive as a source of new demand, helping them to expand their business and support prices even as new LNG supply enters the market. It also offers potential for developing interesting ancillary businesses in LNG bunkering, storage and trading.

Major ports are interested in installing LNG bunkering, for instance Singapore which announced its plans in October 2017[9]. The six largest bunkering countries cover 60% of demand – China, Netherlands, Singapore, UAE, US and South Korea (FIGURE 2), all of which have LNG available, though not necessarily yet at all ports. The UAE's main bunkering port of Fujairah does not currently have access to LNG. At the moment, East Asia and Europe appear suitably served, but Latin America and the Cape of Good Hope route do not.

Though many ports are considering installing LNG bunkering, its availability at a few major ports covering points such as Rotterdam, Singapore, Shanghai and Houston may be sufficient for most long-range logistical needs of cruise ships, containers, bulk carriers and tankers. Short-range vessels such as ferries, tugs and offshore supply vessels, though, may need fuel at smaller ports.

The prevailing lower cost of LNG on a like-for-like energy basis has already made it an attractive option even before the IMO change. However, when the additional capital and operational costs, and the loss of some cargo space, are factored in, few shipowners have been willing or able to commit to the investments required.

[8] Mike Stockle and Tina Knight, Foster Wheeler

[9] Marine Insight, World's Largest Bunkering Port to Supply LNG to Ships By 2020, January 2017

The price of LNG is still widely linked by formula to oil, particularly in many long-term contracts with Asian buyers. However, with the emergence of an increasingly deep and liquid LNG market, gas-to-gas competition is leading to spot sales at more competitive prices derived from the prompt market. For ship charterers, buying oil-indexed LNG could ensure that they remain competitive against oil-burning competitors.

Qatar Petroleum has recently pointed to the potential of LNG consumption by shipping fleets and has analysed the impact of this new segment through to 2030. In response, QP has taken initial steps to form a JV with Shell to develop LNG bunkering infrastructure around the world . As the world's largest LNG producer, Qatar has a clear strategic interest in boosting the use of LNG. The new IMO regulations may be the catalyst that LNG needs to achieve market penetration into the marine bunkers market.

Major progress on advancing LNG as a marine fuel will require proponents to support it: developing LNG storage and bunkering facilities at major ports, making LNG bunkering vessels available, and encouraging training in the use and safe handling of LNG. Such major LNG exporters may wish to convert their own fleets to LNG, or at least ensure that newbuilds use it. They could consider funding lenders who pay for LNG conversions or new-builds, in return for a share of the savings. Joint ventures or partnerships with major ship-owners, particularly environmentally-conscious ones such as cruise liners, ferries, and visible worldwide names such as Maersk, can help accelerate LNG's adoption. The more ship fleets convert to LNG, the greater will be the incentive for other ports to offer it.

Policy is likely to see further changes

The IMO's next move is likely to be against carbon dioxide emissions, to meet increasing climate change scrutiny. The global shipping sector contributes 3% of global greenhouse gas emissions. From 2019, larger ships will be required to record their fuel consumption data, and from 2023, the IMO is expected to adopt a more comprehensive strategy on greenhouse gas emissions. The EU has for now excluded shipping from its emissions-trading system, but it may include it if the IMO does not take action in 2023.

Use of marine diesel or low-sulphur fuel oil or scrubbers will not cut CO_2 emissions; LNG[10] would reduce them by about 28%. This should also weigh on decisions between ordering ships with LNG tanks or scrubbers. For now, scrubbers may be good enough, but in the longer term, lower greenhouse gas emissions will be required.

Corbett's study finds that even with the 0.5% sulphur standard, shipping emissions will continue to cause significant mortality and morbidity. Therefore further action, perhaps further extension of the 0.1% sulphur ECAs, is likely at some point, which would further favour scrubbers and LNG over fuel oil or gasoil blends.

Conclusions

Although most of the shipping industry is preparing for the introduction and use of new regulations requiring the use of low-sulphur fuels from 2020 onwards, progress has been slow. Uncertainty over payback times, owner-operator mismatches, and the difficulty of securing funding, mean that there has been relatively little conversion of existing vessels to use LNG or scrubbers.

However, for new-builds, it can be increasingly expected that scrubbers or LNG will be considered. Given the wide price differential between low-sulphur fuels and traditional bunker fuel oil, shipowners who have moved proactively should enjoy a strong competitive position until others catch up. Ship operators should not simply expect that compliant fuel will be available at all localities – this requires coordination with bunkering companies and in turn with oil storage operators and traders.

Major LNG exporters, both companies or countries, can gain from encouraging its use as a zero-sulphur and lower-carbon fuel. They need to support the prerequisite design, regulation, implementation and supporting infrastructure.

Bunkerers and oil storage operators also have opportunities from the fuel change-over – including offering gasoil, low-sulphur fuel oil, blending services and LNG. Major ports need to adapt now to avoid being left behind.

Complex refiners will benefit from being able to provide low-sulphur fuels, while others may consider upgrading when price differentials make it attractive. Again, the early movers are placed to capture substantial gains.

The entry into force of the IMO regulations will shake up the shipping sector. It will also have knock-on effects throughout the whole refining value chain. Even fuel users outside the shipping industry should be prepared for possibly sharp and unexpected changes in prices and differentials for some more environmentally compliant products and the middle distillate complex.

Assuming compliance to the new 2020 policies is robustly enforced, the shake-up in the marine fuels sector will test the ingenuity and adaptability of both the fuel supply and shipping industries. Those companies that are commercially advantaged, flexible and prepared ahead of time will be best-placed to capitalise on the new IMO sponsored policies..

[10] Shell, Qatar Petroleum and Shell Form LNG Marine fueling venture, June 2017