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A comparative analysis upon the utilization of exhaust gas cleaning systems, LNG fuels or conventional fuels as the most viable options to comply with the new IMO Low Sulfur Cap Regulations

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Abstract: Since the decrease of the global sulfur limit from 3.5% to 0,5% by the International Maritime Organization on 1-1-2020, the ship-owners and carriers are obliged to elect between the three available options in order to comply with the present regulatory amendments. The first available option is the utilization of exhaust gas cleaning systems, also called "scrubbers". By the use of these filters, the vessels are able to burn high sulfur fuels while the sulfur surplus and other dangerous chemicals are evaporated by spraying alkaline water via an open loop, closed loop or hybrid systems. The other option is the use of LNG as fuel, a viable option connected with the constant expansion of the global LNG supply infrastructure network. This network is yet in a developing status, as the majority of the LNG vessels are primarily coastal vessels operated in European waters and many supply ports worldwide have not yet developed full-scale LNG supply facilities and proper equipment is not yet installed. The final option is the utilization of conventional fuels, low on sulfur emissions, such as MGO and ULSFO. The major issue is the availability and the cost of those fuels, with the refiners being unable to forecast if they should produce more low-sulfur fuels to meet potentially higher demand. By the comparative analysis of those three options, pursuant to distinct indicators, their viability will be evaluated and a thorough proposal for their utilization will be provided.

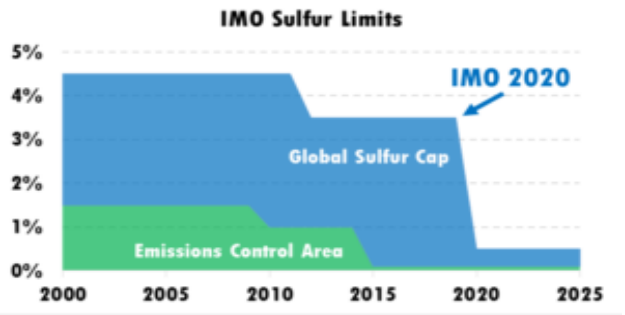
Keywords: IMO 2020 Low Sulfur Cap, Scrubbers, LNG fuel, MGO, ULSFO

1. Introduction

The International Maritime Organization, as of 1st of January 2020, imposed a new maximum global upper sulfur limit of 0.5% on marine fuels, decreasing the previous limit of 3.5%. This present change of global sulfur emission limit is part of the IMO's response plan to the constantly arising environmental concerns, deriving from the harmful emissions from ships. The final deadline of 2020 was confirmed at the seventieth meeting of the IMO's Marine Environment Protection Committee (MEPC) taken place in October 2016. The present stricter sulfur regulations have made vessel owners and carriers unable to decide which of the available options is the most beneficial and at the same time successfully complying with the new IMO regulations. At the same time, the refiners are considering if they should be focused on the production of more low-sulfur fuels or if they should be focused on the production of high-quality fuels to meet a potential higher demand. The two sides are expecting a historical change on the market of shipping fuel supplies. The present issue with the 0.5% sulfur maximum regulation is that it has become a "riddle" for refiners, being the primal fuel suppliers, and ship-owners, being the major shipping fuel buyers, where suppliers cannot commit on the exact quantity and quality of fuel they should produce as buyers are not being able to predict the actual demand (Bilgili, 2021).

In the graph below, the change of sulfur limit is depicted in yearly basis. We notice that the decrease of the sulfur limit in 2020 is much higher and more immediate that the previous of 2012. We also notice that the same limit in ECAs is much lower and that all the amendments took place few years before the minimization of the global sulfur cap. We could assume that the applied ECA limitations were used as an incentive for the further limitation of the global sulfur cap.

Sulfur Limit per annum



(IMO, 2020)

The refineries despite not being affected by the same regulations as vessel owners, are indirectly affected by those regulations, as their commercial interests are

subject to the demand of the shipping market, thus they are forced to successfully satisfy the market needs for achieving notable profits. The shipping companies, which are the most directly affected stakeholders of the IMO regulations, should take in consideration the 0.5% global sulfur cap and incorporate necessary amendments to their standard operational processes and additionally to also satisfy the present 0.1% sulfur limit when entering the designated ECAs (Chen et al, 2018).

In practice, there are three options that ship-owners can consider to successfully comply with the present regulatory amendments. Initially, ship-owners can install specific gas cleaning systems on their vessels. Then, there is the option of investing on compatible high-quality fuels, with a significantly higher cost. Finally, ships can utilize pure LNG gas as an option of fuel, investing at the same time in "eco-shipping" trend (Li et al, 2020).

2. Analysis of ship-owners' available options for compliance

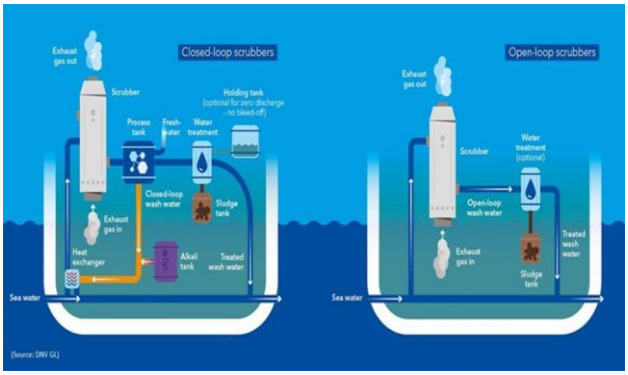
2.1. Emission reduction technology through the use of filters (Scrubbers)

The utilization of the new technology of exhaust gas cleaning systems, which is also well-known as filters (Scrubbers), is a presently developed option for vessel owners, with many benefits. When these filters are installed onboard ships, the vessel owners can continue to burn fuels with high concentration of sulfur and at the same time, through the utilization of those filters, comply with the 0.5% sulfur limit (Abadie et al, 2017). The reduction technology works by spraying alkaline water on the exhaust of a boat to abolish sulfur and other malicious substances, either through i) an open loop system, ii) a closed loop system or iii) a hybrid (open and closed loop) system. The utilization of those filters can lead to the elimination of the majority of harmful emissions from vessels, with the leading manufacturers being able to provide systems that decimate the 97-98% of sulfur oxides (SOx) and at the same time the 70- 80% of the particles (PM), being the largest part of the visible smoke (Zis et al, 2020). Despite the initial heavy investment ranging from $ 5 million to $ 10 million per ship, subject mainly to the quantity and the capacity of the main engines, installing a "washing machine" is definitely an economically beneficial option. According to a Wood Mackenzie report of 2020, vessel owners should be able to achieve a 20-50% investment return, subject to standard investment costs, a possible spread in fuel price and the market trend and consecutive shipping company strategies, which will affect the overall fuel consumption.

The election of filters to be installed could be halted by a possible stagnation of shipping companies' cash flow, the feasibility of manufacturers to produce an equal quantity of these special filters to the market needs and other technological uncertainties, as an outcome of applying those filters to different types of ships and engines. Additionally, another issue is also the availability of space in shipyards, able to implement the necessary conversion/installation of those filters, when a large number of ships is sent simultaneously.

In the picture below, we notice that the main difference between an open and a close loop system is the addition of a process and an alkaline tank before the next step of water treatment, making the process of closed-loop system prospectively more efficient. At the same time, with the expansion of hybrid systems, the technology around scrubbers became much more complicated, subject also to the final design-in develop from each manufacturer.

Confrontation of the two basic types of filters, open against closed circuit.



(DNV GL, 2020)

2.2. Use of liquefied natural gas as fuel (LNG)

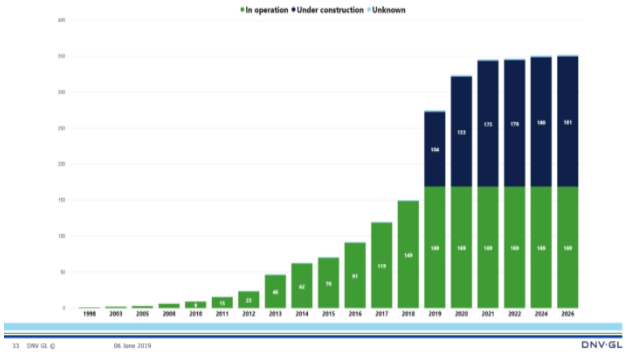
The concept of vessels burning LNG as fuel is linked to the development of a global LNG infrastructure and fuel supply network, which is presently under construction. The global LNG supply infrastructure is deemed to be under development for the last decade, as many LNG vessels are presently coastal vessels operated in EU and the world's prominent supply ports are not yet fully invested to the development and installation of full-scale LNG infrastructure and supply facilities. It is evident that quite few countries, such as Singapore, Japan and the Netherlands, plan to expand upon the development of LNG supply infrastructure in the near future. However, there is no evidence or a clear indication for the development of an organized global LNG network of infrastructure, to consider LNG fuel a viable option. The only facts are that the interest for LNG is concentrated on the development of FSRU platforms, necessary for the transshipment of LNG as cargo and also that some shipping companies are investing on utilizing LNG as fuel on LNG carriers (Zhu et al, 2020).

The main issues for the utilization of LNG as fuel are i) the need for further construction of dedicated storage space, ii) a global strategy and cooperation between port facilities to create a supply chain able to facilitate the market needs, iii) further investment upon the development of proper machinery and ship supplies, suitable for all types of vessels and most importantly iv) the need for extensive and costly modifications to the existing fleet and port infrastructure. The costs for LNG fuel suppling and refueling include delivery of clean gas

to the import terminal, downtime charges, the need to construct LNG fuel tanks and the necessary equipment for the transshipment of LNG fuel from the port facilities' tanks to the vessels. In addition, market of fossil fuels is volatile, thus there might be phases, such as the present period with Corona virus, where the market has dropped significantly and consecutively make the economic business case for LNG fuel less attractive. Another issue is that the current fleet has not installed proper equipment for utilizing LNG as fuel, thus major modifications will be needed, with the inclusion of specified machinery and LNG tanks, abiding stricter regulations and at the same time training of crew will be of outmost importance, considering the risk that this kind of fuel imposes (Zis et al, 2020).

The utilization of LNG as fuel is much more viable for new-building vessels, rather than converting the present fleet. This option will enable port facilities to predict and satisfy more efficiently the market demand, by gradually developing and expanding the port infrastructure. Additionally, relevant regulatory provisions regarding LNG as fuel are not yet fully developed, taking into consideration that LNG poses a greater threat than the conventional fuels, being capable for severe environmental hazards. (Li et al, 2020).

Fleet of gas-powered ships per year.



(DNV GL, 2020)

As it is evident from the graph above, the utilization of LNG as fuel is on the rise. Currently the vessels that operate with LNG fuel are mainly LNG carriers, which take advantage of their infrastructure for LNG cargo handling. In 2020, we notice that the number of ships operated under LNG fuel is equal to the ships in-order with the same equipment installed and that this trend is continued to the next years. We can easily assume that LNG as fuel will gradually expand and may even replace the conventional fuels, but without further expansion and development of port facilities and investment on technology to develop proper machinery for all types of ships, LNG as fuel is not a viable option for the global shipping fleet presently.

2.3. Compatible fuels

The simplest option for the global fleet to abide the new sulfur cap regulation, without the need of modifications, installments, or investments in specific equipment, is to switch to MGO or ULSFO fuel for combustion, which are inside the scope and limits of the new regulatory provisions. As an outcome, the utilization of those fuels, which are more qualitative and with minimum containment in sulfur and other pollutants, further increases the operating costs of the shipping companies, which have the option to absorb those costs or to transfer them to the carriers (Abadie et al, 2017).

The demand for heavy fuel oil and other conventional fuels in Asia is decreasing steadily in the recent years, dropping by 25% from 2011 to 2020. The HFO imports to Asia - mainly Singapore, Japan and China - averaged about 6.92 m. tonnes monthly in the previous year, from a monthly average of about 8.5 m. tonnes between 2011 and 2012 (Chu et al, 2019). Operators can obtain ULSFO with a maximum sulfur content of 0.1%, a fuel that is in use in ECAs and is considered an alternative and most economically beneficial option to MGO fuel. The ULSFO is a fuel, with quality located between MGO and HFO fuels. The ULSFO fuel is proved to contain lower sulfur than HFO but at the same time higher viscosity and low volatility than MGO. The differentiation of quality, crated by refining, distinguish the ULSFO fuel, which typically trades at $ 22 pmt or more at the MGO in Rotterdam. In 2020, the use of ULSFO had an increase of roughly 10% per year in the North Sea region and ARA (Amsterdam Rotterdam-Antwerp) and increased by about 2% worldwide, according to data from Veritas Petroleum Services (VPS).

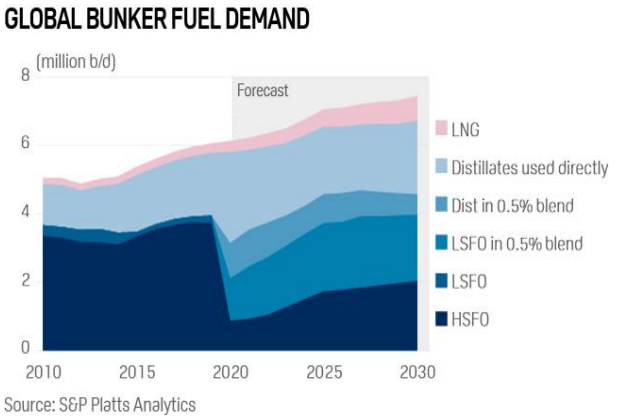
By 2020, there was approximately 900,000 bpd ULSFOs available on the market with various flow optimizations. According to Wood Mackenzie's confirmed forecast: "If there is a tough deadline from the IMO in 2020, we expect that MGO demand could increase from 1.3 million barrels per day in 2019 to 3.4 million barrels per day in 2020". This new demand, following the compliance with fuel demand from the shipping sector, has brought a major change for refineries. Refineries are called upon to continually increase global refining rates to historic levels, without being able to forecast the market demand, while the ship owners are exploring the other options available as alternatives. Additionally, the market is expected to forgo major changes with Singapore, being a major fuel supplier in the area, to lose a portion of the market share to China, with the latter being able to provide more qualitative fuels in higher quantity and lower price (Zis et al, 2020).

It is expected that China will continue to have an abundant supply of MGOs and is in more favorable position that Singapore to attract fuel buyers and to sustain and satisfy a possible increase in demand. Singapore, which is presently one of the largest supply ports worldwide, should reuse a portion of the existing storage tanks and other available infrastructure to prepare for the transition from the existing HFO to new MGO tanks (Zhu et al, 2020).

In the graph bellow regarding global bunker demand, we notice in 2020 a substantial decrease of HSFO from nearly four mil. Tons to less than one mil. Tons, with

LSFO and other variants, taking it's share of the market. It is evident that the global bunker fuel demand will increase rapidly over the next ten years, with most of the market focused on more qualitative fuels. The utilization of filters will not affect severely the fuel market, it will only give the option to the vessel owners to use fuels of less quality, avoiding possible fluctuations of the market of MGO and LSFO while sustaining a market share for HSFO and other fuel products of lower quality. Finally, as it is already mentioned, the market share of LNG fuel is expected to have a substantial increase of the next decade, while the orders for new-building vessels operated with LNG fuel will enter the market, but this increase won't be enough to satisfy the rapidly increasing market demand or to even absorb a portion of the other products' market share.

Forecast of fuel demand per annum



(S&P Platts Analytics, 2021)

3. The result of the application of the regulation

The new sulfur cap brought many changes to the already volatile shipping sector, creating many alternative options with no distinct best or unviable solution. Should refineries decide to decrease HFO fuel production, predicting a significant increase in market demand for MGO fuel, shipping companies which decided to install filters may struggle to find HFO fuels in reasonable for the quality offered price (Halff et al, 2019). The increase of market demand in MGO may even cause issues for the stocked supply of HFO fuel. Specifically, the supply owners, mainly being countries and refineries, will be faced with a dilemma to further refine HFO or to sell it in the market and to decide if they will amend their strategy and turn to MGO for stock supply.

At the same time, it is not clear which portion of ship owners utilizes filters presently and if this portion will increase or decrease in the future. Should this portion increase, the MGO prices will drop as the market share will move to HFO as cheaper solution, but if the portion of shipping companies using filters drops, then the MGO market will continue its upper trend whereas the HFO will face a significant price reduction. It is evident that LNG fuel production, despite being the most environment-friendly option, is not able to satisfy the market needs, mainly because of the lack of proper facilities, infrastructure and a global strategy to turn the shipping sector the most environmentally sustainable option.

At present, refineries do not take huge investment risks by altering their production strategy, while vessel owners are hesitant to systematically follow one of the options available, thus, despite the drop of HSFO demand, the rest of the market is stabilized in the previous trend, with the shipping companies shared between using filters or fuels of higher quality. Based on the forecasts available, the majority fuels will follow the previous trend with the LNG fuel rapidly expanding its market share after 2025 and following an upper trend, being the dominant or even the only fuel in 2050 (Zhu et al, 2020).

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