ΠΑΝΕΠΙΣΤΗΜΙΟ ΠΕΙΡΑΙΩΣ

ΤΜΗΜΑ ΝΑΥΤΙΛΙΑΚΩΝ ΣΠΟΥΔΩΝ

ΠΡΟΓΡΑΜΜΑ ΜΕΤΑΠΤΥΧΙΑΚΩΝ ΣΠΟΥΔΩΝ
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ΝΑΥΤΙΛΙΑΚΗ ΔΙΟΙΚΗΤΙΚΗ

How IMO 2020 Regulations Will Impact Shipping Companies

Δήμητρα Τσιάκα

Διπλωματική Εργασία, που υποβλήθηκε στο Τμήμα Ναυτιλιακών Σπουδών του Πανεπιστημίου Πειραιώς ως μέρος των απαιτήσεων για την απόκτηση του Μεταπτυχιακού

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This Diploma Thesis was approved unanimously by the Three-Member Committee of Inquiry appointed by the GPA of the Department of Maritime Studies of the University of Piraeus in accordance with the Rules of Procedure of the Postgraduate Program in Shipping Management.

The members of the Committee were:

- ……………………………… .. (Supervisor)

- ……………………………… ..

- ……………………………… ..

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Περιεχόμενα

Περίληψη
Η ναυτιλιακή βιομηχανία αντιμετωπίζει μια ακόμη πρόκληση από την αμετάκλητη ημερομηνία επιβολής του ΔΝΟ για το 2020 η οποία ρυθμίζει τον περιορισμό του θείου στα καύσιμα πλοίων και έχει οριστεί για την 1η Ιανουαρίου 2020. Σύμφωνα με τον κανονισμό 14 του παραρτήματος VI της MARPOL, η περιεκτικότητα σε θείο των εκπομπών αερίων δεν πρέπει να υπερβαίνει το 3,5% m / m. Ο κανονισμός αυτός έχει πλέον αλλάξει και από την 1η Ιανουαρίου 2020 το όριο μειώνεται σε 0,5% m / m σε περιεκτικότητα σε θείο. Αυτή η εργασία ασχολείται με τους πιο πρόσφατους κανονισμούς για τις εκπομπές θείου και τις επιπτώσεις που θα έχουν στη ναυτιλιακή βιομηχανία και τα εμπλεκόμενα μέλη. Οι ναυτιλιακές εταιρείες και οι πλοιοκτήτες κλήθηκαν να κάνουν μια επιλογή που θα τους επιτρέψει να λειτουργούν τα πλοία τους εντός των νέων ορίων. Θα έχουν τη δυνατότητα να επιλέξουν μια διαθέσιμη μέθοδο συμμόρφωσης. Αυτές οι μέθοδοι μπορεί να είναι καύσιμα με χαμηλή περιεκτικότητα σε θείο, όπως MGO, εναλλακτικά καύσιμα όπως LNG ή εγκατάσταση συστημάτων καθαρισμού αερίων στα πλοία τους, κοινώς γνωστά ως scrubbers. Επιπλέον, οι κατασκευαστές και προμηθευτές καυσίμων είναι υπεύθυνοι να συμβαδίσουν με τις αλλαγές στη ζήτηση και την προσφορά καθώς και τις ανάγκες για ασφαλή προϊόντα υψηλής ποιότητας. Στη συνέχεια θα αναλυθούν οι νέοι κανονισμοί με τις επιπτώσεις τους και τις διαθέσιμες εναλλακτικές λύσεις.

Λέξεις κλειδιά: ΔΝΟ, περιβάλλον, θείο.

Abstract

Since the irrevocable date for the enforcement of IMO 2020, which regulates the restriction of Sulfur in marine fuel, has been set for 1 January 2020, the shipping industry faces yet another challenge. Regulation 14 in Annex VI of MARPOL, states that sulfur content in gas emissions must be no more than 3.5% m/m. This regulation now has changed and starting January 1st 2020, the limit is lowered to 0.5% m/m in sulfur content.

This thesis discusses the latest sulfur emissions regulations and the impact this will have on the shipping industry and the parties involved. Shipping companies and ship-owners were asked to make a choice that will allow them to operate their vessels within the new limits. They will have the option to choose an available method of compliance. This could be low sulfur content fuels such as MGO, alternative fuels such as LNG or installing gas cleaning systems on their vessels, commonly known as scrubbers. Furthermore, fuel manufacturers and suppliers of bunkers/refineries are responsible to keep up with changes in demand and supply as well as the needs of high quality and safe products.

The new regulations among with their impacts and the available alternative solutions will be analyzed.

Key words: IMO, EGCS, environment, Sulfur.

Introduction

In general, shipping is subject to a variety of rules and laws. There are always new parameter and changes with ultimate goal the protection of the environment. Modern business components and the nature of trade, as well as the importance of environmental protection, create an ever-changing, often contradictory situation which is called upon to be handled by shipping management companies and all involved parties.

The focus of this paper will be on the MARPOL VI Regulation 14, regarding Requirements for control of emissions from ships and specifically Sulfur oxides (SOx). ‘’Regulation 14.13 of MARPOL Annex VI, stipulates that the sulfur content of any fuel oil on board ships must not exceed 0.5% m/m from 1 January 2020, except for ships using ‘equivalent’ compliance mechanisms.’’(International Chamber of Shipping, July 1st 2019). Shipping companies, ship-owners, cargo owners etc. need to comply accordingly and make their fleet meet the new standards.

The first chapter will present the connection of the shipping industry and the environment, explaining what reasons made this change inevitable.

The second chapter will cite the past IMO changes that led to the new IMO 2020 regulations that will be described in detail. Furthermore, the factors that could influence the decision making of the liners, considering the alternatives utilized were investigated.

The third chapter will present and compare all the alternatives compliance methods. Also, it will focus on discussing the aforementioned options in more detail advantages and disadvantages, something very important is the decision process.

The fourth chapter will provide an overview of the parties involved and how many of them will need to adapt to the new regulations, what options will be applicable to them and what decisions they will need to make in order to achieve compliance.

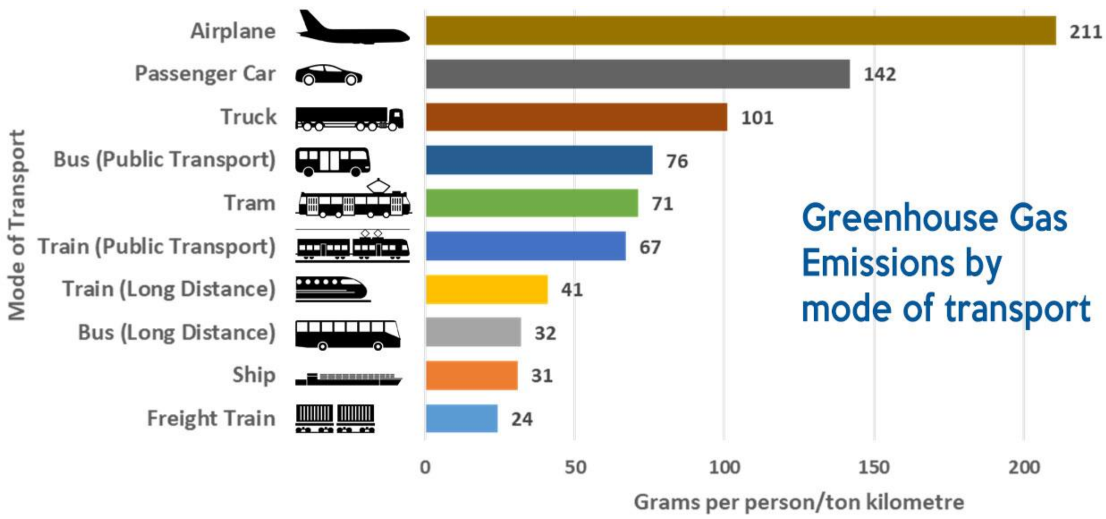
The final chapter will present the guidance on the development of a ship implementation plan given by the IMO in order to assist shipping companies with a smoother transition to the new sulfur era.

1. General Outline

1.1. The environmental impact of the shipping industry

The shipping industry has evolved and became more efficient over the past decades. In fact, compared to other means of transport (i.e. rail or flight), the shipping industry as a whole has a lower consumption level. The reasoning behind this is that the maritime sector provides efficiency per unit that is being transferred. Nonetheless, while maritime transport is considered to be the most environmentally friendly among the given alternatives, the tremendous effects on the environment must not be overlooked (Nikolakaki, 2012 and Worldshipping.org, 2018).

There are many ways that the seaborne trade can harm not only the marine environment but also the surrounding and wider environment. A very common operation that cause pollution is the ballast/deballast and the wastewater discharge back to the sea or ocean. Ballast water discharge contains viruses and bacteria that can affect negatively the aquatic ecosystem and cause serious health problem to people. Furthermore, according to researches, the cruise line industry discharges approximately 255,000 US gallons (970 m^3) of greywater and 30,000 US gallons (110 m3) of blackwater into the sea every day (Walker, 2019). This water is actually sewage and the pollutant substances, which contains, can contaminate water and fisheries with a big chance of entering the food chain and producing risks to public health. But the most commonly associated pollution with the maritime industry is obviously, oil spills and their devastating effects. Apart from the fact that they are poisonous to aquatic life, polycyclic aromatic hydrocarbons (PAHs), the components of crude oil, are very hard to clean and last in the soil and marine environment for years. A widely known example of the oil spill pollution is the Exxon Valdez incident. This accident has become one of the world's largest environmental disasters caused by human error since the tanker spilled 11 million gallons of crude oil in to the waters of the Gulf of Mexico. The disaster was so immense that the full effects of the accident is still unknown.



Picture 1: Emissions by mode of transportation (source:EPA)

1.2 Shipping industry and atmosphere pollution

The shipping industry, on top of the marine pollution, is also a significant source for air pollution. Maritime operations are responsible for almost 2.7% of worldwide CO2 and up to 9% of SO_2 emissions. Air pollution from vessels is generated by diesel engines that burn high sulfur content fuel oil, widely known as bunker oil, producing sulfur dioxide, nitrogen oxide and particulate, in addition to carbon monoxide, carbon dioxide, and hydrocarbons (Walker T., 2019). According to the European Parliament sulfur oxides emitted by ships are caused by the high concentration of sulfur contents in marine bunkers. Marine fuels contain 2.7% m/m sulfur or 27000 ppm while the sulfur limit for diesel fuel is 10ppm.

These harmful SO_2 emission can result in problems both for the environment and public health. High concentrations of sulfur can destroy trees and plants by damaging foliage and decreasing growth. SO_2 and other oxides of sulfur can lead to acid rain that may harm the ecosystem. Also, these oxides usually react with other compounds of the atmosphere and form particles that reduce visibility (haze) in many big cities, where their concentration is higher. These particles are also responsible for staining and damaging stone and other materials, including culturally important statues, monuments and buildings.

In conjunction with the problems in the ecosystem, the health risks that are created by SO_2 and other oxides of sulfur contribute to make the atmosphere hostile for people. Even short-term exposures to SO_2 can have negative effects to the human respiratory system and create difficulty in breathing. Individuals with asthma, especially young children, are very sensitive to these SO_2 effects. Many health practitioners consider SO_2 to be the most dangerous to human health, compared to other atmospheric pollutants. Sulfur dioxide causes irritation to the skin and mucous membranes of the eyes, nose, throat, and lungs. When it is found in high concentrations it can cause inflammation and irritation of the respiratory system, especially during heavy physical activity. Some of the symptoms could be: pain when breathing deeply, coughing, throat irritation, and breathing difficulties. Moreover it can affect the function of lungs, intensify asthma attacks, and aggravate heart disease.

Unfortunately, the transportation industry is causing huge problems in the ecosystem. Particularly, the seaborne trade is destroying both the marine environment and the atmosphere. Sulfur emissions are very common nowadays, especially with the maritime industry worsening the existing problem. It can cause damage to whole populations, especially to the elderly, children and people with respiratory and cardiovascular diseases.

2. IMO regulations

The purpose of this chapter, is to describe the path that led to the IMO 2020 regulations. The change we are facing today is something that has been under consideration for years and years. Also, in this chapter I will cite what are the factors that will influence ship-owner to comply with a specific available compliance option (discussed in chapter 3).

2.1. IMO regulations over the years

Numerous international organizations have the goal to advance and grow financially as well as protect human life and the environment. The International Maritime Organization along with the EU has imposed regulations and limits on sulfur emission by ships in order to mitigate their hazardous effects.

This is not the first time that something like that has happened. The effort of protecting the environment has been continuous over the past decades. It is an ongoing change with new parameters, regulation and limits, that are being imposed every time so as to allow the involved parties to have the time to comply and adjust accordingly.

The first milestone was set in the 1970s, when 71 countries adopted a global convention for marine pollution prevention. MARPOL is a series of regulations with aim to eliminate marine pollution from oil spills mostly, as a result of the activities of ships or as a result of accidents. At first the regulations were more general and were not strictly about air pollution but year by year the concerns about the atmosphere increased. This led to another milestone, in September 1997, when MARPOL was again revised and the International Maritime Organization (IMO), incorporated the Annex VI to the International Convention on the Prevention of Pollution from Ships (principally known as the MARPOL Convention) (Airclim.org, 2017). The objective of MARPOL Annex VI was the introduce new restrictions that would lead to the reduction of vessel-originated emissions, most importantly Sulfur, nitrous oxides (SOx and NOx) and particulate matter particles. Emissions responsible for damaging the ozone of the atmosphere, which are considered to be root causes for several environmental and human health issues (IMO, 2016).

The Annex VI came into force in May 2005 and it is actually the first Sulfur cap, which restricted the amount of Sulfur contained in marine fuels, to 4.5%. These initial limits on sulfur concentration in fuel oil were covered in Regulation 14 of Annex VI. At the same time, the regulation introduced the emission control areas (ECA), in which the vessels were compelled to burn fuel with a maximum percentage of 1.5% of Sulfur (Gard.no, 2004). Presently, some notable ECAs include the Baltic Sea, the North Sea, and the North American ECA, covering the most of the US and Canadian coastline and the US Caribbean ECA (Küng, 2018). Later on, in July 2008 the Marine Environment Protection Committee (MERC), introduced the Revised MARPOL Annex VI (IMO, 2016). This new regulation changed again the sulfur cap to maximum permitted content in the marine fuel, to 3.5%. In 2010, even stricter limitations were imposed and the sulfur limit changed to 1% m/m in ECAs and later, in 2015 to 0.1% m/m.

2.2. IMO 2020 regulations

As the implementation date for a significant reduction in the sulfur content of fuel oil used by ships, 1 January 2020 was set in a landmark decision for both the environment and human health. The decision to implement a global sulfur limit of 0.50% m/m (mass/mass) in 2020 was taken by the International Maritime Organization (IMO), the regulatory authority for international shipping, during its Marine Environment Protection Committee (MEPC), meeting for its 70th session in London (IMO 2016). The change is the most significant one, thought-out these years of continuous effort. The IMO Secretary-General Kitack Lim said: "The reductions in sulfur oxide emissions resulting from the lower global sulfur limit are expected to have a significant beneficial impact on the environment and on human health, particularly that of people living in port cities and coastal communities, beyond the existing emission control areas". The 2020 deadline was decided in the 2008 amendments. Upon the adoption of those amendments, it was also agreed that a review should be undertaken by 2018 to assess whether there would be sufficient fuel oil available to meet the 2020 date. If not, it could be possible to postpone the date to 2025. Under the new global cap, ships will have to use fuel oil with a sulfur content of no more than 0.50 percent m / m, compared with the previous 3.50 percent limit, which has been in place since 1 January 2012. The usage of main/ auxiliary engines and boilers is included in the definition of "fuel oil used on board." This requirement can be met by using low-sulfur compliant fuel oil and other methods, which are going to be discussed in detail in chapter 3. There can be exceptions, only when there are safety concerns, SAR operations or mechanical issues. Furthermore, a fuel quality certificate should be provided by the supplier during re-bunkering, as well as an International Air Pollution Prevention Certificate issued by the Flag Administration, indicating that the ship is using compliant fuel or that it has the necessary cleaning equipment on board in accordance with the emission regulations.

IMO Global		SECA/ECA	
Date	Sulfur %	Date	Sulfur %
Initial limits	4.5	Initial limits	1.5
Jan 1, 2012	3.5	Jul 1, 2010	1.0
Jan 1, 2020	0.5	Jan 1, 2015	0.1

Table 1: IMO fuel oil sulfur limits (source: ABS)

2.3. The process of decision making

There are numerous small shipping companies or single vessel ship-owners, who are using big and successful shipping companies as an example of what the best compliance option is. As the regulation enters into force, the companies ' competitiveness will depend on their ability to choose an appropriate compliance method in the midst of their ability to do so. Several theories suggest that small business decision-making is adjacent to investment practices that are followed by fellow companies. A determining drive of peer interaction among industry firms is the results of their investment strategies, such as profitability, market share, etc. Companies that do not hold large market shares, insufficient data are more likely to be available, making them more likely to emulate the investment actions of industry leaders and take advantage of the spillover effect resulting from disclosure of their strategies. Consequently, liner companies that are industry followers or have limited financial resources are more likely to be influenced by the leading companies (Chen and Ma, 2017). For example, COSCO chose to comply with the IMO regulations by using scrubbers, a small shipping company and its owner might believe that a company like COSCO would have adequate prospects and information to make such decision. This would result in the imitation of the compliance method of COSCO.

Secondly, the chartered proportion of the fleet and the type of charter contract is another major factor in the decision-making of the alternative method to comply with the IMO 2020. Maritime industry is a market characterized primarily by long-term contracts between the ship-owners and the vessel charterers. In other words, agreements between the parties are usually time charter contracts that allow charterers to fully deploy the vessel for a period of five (5) years or more, or bareboat contracts where the charterer leases the vessel unmanned and enters the ship-owner's role (Global Ship Lease, 2018). Under a time-charter contract, the charterer pays the agreed hire and embodies the operating costs, which means that the longer the contract duration, the greater the risk to the vessel's charterer. Similarly, the risk in bareboat charter is born entirely from the charterer in terms of the operations of the vessel and the shipping market in general (Stopford, 2013). In order to elaborate, companies that charter vessels under a voyage contract will not make any investments because it is not cost-effective, but instead opt for vessels that already comply or use LSF. On the other hand, firms that operate vessels under time charter or bareboat contracts are obliged to take responsibility for the ships ' full compliance with the regulations, which means that they could make investments in equipment such as scrubbers or LNG engines. The main reason behind this is that these types of contracts extend the charterers' exposure to any risks from shipping operations. The companies will be held explicitly liable for any fines arising from the unlawful conduct of travel, hence their disobedience to the Sulfur restriction on the marine fuel used (Westpandi.com, n.d.). In the event that the largest percentage of the company's fleet is owned vessels, it will be assumed for the simplicity of this research that the decision will be based on other factors, such as the simplicity of the alternative used and the average age and capacity of the fleet.

The average age of the fleet is another noteworthy feature of the company that can play a crucial role. According to the age of the ships, in order to comply with the regulation, the organization needs to identify which is the most effective way to follow. Considering the older containerships, one can understand that retrofitting is not a vital solution, neither scrubber technology nor LNG-fuelled engines. Investments on these vessels will not be rationalized as the procedure requires replacing fuel tanks and alterations or replacing the engine equipment completely. Clearly, these investments will hardly bring a positive return of investment during their remaining operational life. In this case, several studies have concluded that burning distillate or low sulfur fuels is the most appropriate method of compliance for older vessels (Lindstad, Rehn and Eskeland, 2017). Consequently, the installation of LNG engines is considered an appropriate form of implementation for new buildings and is the most environmentally friendly, in terms of a long-term investment strategy, compared to the installation of scrubbers or the use of cleaner marine fuels. However, like any other marine fuel price, LNG forecast depends on several other market factors, such as supply and demand for substitute fuels such as shale gas, resulting in uncertainty about future bunkering costs (Acciaro, 2014). Similarly, installing the exhaust gas system in new buildings is a more justified investment because of the perception that when installed in new buildings, the scrubbers have an operational lifespan of about 15 years. Later on, the companies will have to choose whether to reinstall scrubbers or comply with fuel. On the contrary, the scrubber technology retrofitted on the existing fleet is considered to have a twelve-year time-cap utilization, while the installation process is estimated to cost 40% more than in newbuildings (Jiang, Kronbak and Christensen, 2014). Understandably, the rest of the vessels ' operational life determines the investment's attractiveness and the benefits that may result from it. The global container fleet is currently quite young at an average age of 11.55 years (UNCTAD, 2017). With the technology's estimated four-year return on investment (ROI), retrofitting appears to be a sensible solution to meet the requirement of the regulation, provided the vessel has a service life of more than four years (Jiang, Kronbak and Christensen, 2014). Thus, the fleet's average age is an aspect that needs to be considered in the ultimate selection of the shipowner. The vessels ' TEU capacity is another factor that should be considered in deciding the most appropriate method of enforcement. The installation of scrubbers, for example, is adjacent to high investment costs. Furthermore, it requires sufficient space and is heavy, which may result in reduced loading capacity and consequently reduced profitability of the vessel (Hilmola, 2015). Likewise, LNG-running engine installation and incorporation in the current fleet would result in the same outcome. Considering this factor, liner companies that suit the loading ability of a typical container ship sailing between European ports (5,000 TEUs) will not be able to reduce their operating capacity and will most likely opt for the use of Marine Gas Oil (MGO) as an alternative to HSFO instead of retrofitting (Jiang, Kronbak and Christensen, 2014).

Last but not least, the investment capacity of the companies as a variable for decision making is something that needs to be considered by the ship-owners, in order to make the right choice. The estimated retrofitting price for exhaust gas equipment will rise to USD 8 million for a 20,000 TEU container ship, which translates into an expected investment return period of 6 to 7 months (Vis, 2018). Accordingly, the installation of the scrubber equipment produces a high cost of installation and maintenance that is difficult to estimate because it depends on factors such as the age and size of the subject vessel (Acciaro, 2014). On the other hand, being fuel-compliant requires no installation of equipment and the cost difference in bunkering expenses incurred by the liners can be passed on to the charterers in the form of freight surcharges (UNCTAD, 2010). However, most liner companies, particularly Asia operating firms, do not disclose their investment information or annual financial reports, considering this variable to be unfit to be applied to the entire list of investigated firms.

3. Compliance options

Taking everything into consideration, ship owners will have to choose the best solution to comply with the new rules. They have to really contemplate which available method of compliance will be followed, having in mind that this is going to be a difficult period for most of them, as there is the chance that some of them will be driven out of the market, in case they lack the investment capability to follow IMO 2020. The vessels themselves differ because not all ships have space for installing scrubbers or LNG engines. However, it is not yet clear whether the correct equipment is available to modify or retrofit existing vessels at the time of the decision. In addition, the implementation time can vary depending on how many construction or retrofit orders are requested, the market demand and the relatively low availability of yards. Finally, the age of a ship is highly important in the overall decision. Usually, vessels are serviceable for up to 25 years. However, when undertaking specific voyages, their lifespan can be reduced to 20 years, due to technology, the nature of trade, its developments and the market trends. The decision is based on the market conditions and circumstances in which the ship operates and who will be responsible for the purchase of bunkers, depending on the type of contract existing. For example in the case of time charters, where charterers are likely be responsible for the bunkering fees, owners would be less likely to proceed with the installation of scrubbers on board. In a nutshell, the type of strategy the owners will chose in order to comply, depends most importantly on the vessel type, size, operational patterns and age. On this ground, in this chapter the alternatives that ship-owners currently have available, will be discussed.

3.1. Scrubbers

This option is available to ship-owners who in the future want to continue to use HFO. In this case, in order to comply with the 2020 regulations, the vessel will have to be equipped with appropriate exhaust Gas Cleaning Systems (EGCS). Ship owners who are unwilling to handle the increased fuel costs or the fluctuations in their availability will have to install these systems on board, commonly known as scrubbers. In any vessel, scrubbers can be installed irrespective of type, size, age, second hand or newly built. It's a modification that doesn't change the main engine of the vessel's mechanical parts. Nonetheless, it requires many parts of the boat to be retrofitted and also requires extensive alteration.

Retrofitting scrubbers in the existing fleet allow the ship to burn High Sulfur Fuel (fuel with 1.5% Sulfur or higher) even when sailing in SECA zones while complying with the regulations. Since HSFO will remain an option, it will have to be implemented by operators who are willing to continue with it, this system requires no alteration of the engine or the fuel treatment plant. This could be a costly and time consuming operation, especially if retrofitting a vessel and also there are extra costs of maintaining the scrubber exhaust gas system. Whether it is a viable option will largely depend on the difference in price between high and low sulfur fuels.

At the moment, scrubbers, that are fit to be retrofitted on vessels, can be divided in three categories: open loop, closed loop and hybrid systems. Open loop is the easiest wet scrubber system because it uses only pumped seawater for scrubbing, then it is filtered and ultimately dispensed, while the sludge stays on deck, to be deposited in the respective port facilities (McMenemy, 2018). This type of scrubber can be used to comply with sulfur content by either 0.5 percent or 0.1 percent. Due to water disposal restrictions, the fact that it uses fresh water makes it easy to use but limits the areas where they can work. Closed loop scrubber system discharges just a small amount of scrubbing fluid as opposed to the open loop system. Instead, by chemically treating the liquid in the respective tanks, the fluid is circulated and re-used, fact that attributes to a decrease in the quantity needed and therefore in the size of the mechanism, amid with the energy required (McMenemy, 2018). On the other hand, the fact that a constant intake and discharge of water is required can be inconvenient at times. The fresh water intake is crucial to purification, meaning that if the surrounding water quality is not correct, the system might not perform as it should. There is also the issue of waste removal. Not all ports will permit water containing sulfur to be discharged anywhere.

Closed loop scrubbers utilize the same principal. The water is chemically treated with caustic soda injection. This acts as the scrubbing agent and is circulated within the system requiring only minimal water intake. This bypasses the process of waste treatment and discharge in the ocean. However it creates a problem with the space requirements on board for the installation of the extra holding and treatment tanks Closed scrubber systems are suitable in areas with water discharge restrictions, as all procedures are carried out on board without the necessary discharge. Before disposal is possible treated water is transferred to a storage tank. Given the availability of all required components, hybrid systems can fall under this category as well.

Ultimately, the hybrid system is a mixture of the above two types, enabling the transition between open and closed loop service, allowing the ship to reap the benefits of both types of systems (Valmet.com, 2018). There are also dry scrubbers besides the wet scrubbers. These gases in water are not saturated. Instead, they use ceramic pipes that absorb and dissolve the SOx in the passing gas. The waste thus produced has the advantage of being low in volume, making it easier to store before discharge. As always, dry scrubber systems require systematic maintenance. They usually consume less energy overall but are much heavier constructions compared to the wet systems.

A number of modifications need to be made to install a scrubber system. In vessels already in service, this is more evident as they will need to be retrofitted. This installation will already be planned for newly built vessels. Retrofitting requires the removal of the vessel's funnel, deck platforms and ladder, as well as of the exhaust pipes. This is on order to install new components such as deck extensions, sludge tanks, water circulation tanks, the scrubber itself and extra water pipes (Bureau Veritas).

In general, the decision on what type of scrubber will be used depends on many factors. It should take into consideration the vessel's existing equipment, its operating paths, major and normal call ports, water treatment systems and local regulations, as well as the potential loss of cargo space due to the extra space the cleaning system takes up. It is a high cost investment that could potentially increase the second-hand value of a ship if the demand at the time of sale is favorable. Nonetheless, additional training and familiarization of the crew is needed. It includes extra costs such as the aforementioned chemicals and lubricants but also leads to higher energy consumption and comes with the added cost of waste treatment and removal. Scrubber systems can have drawbacks as well. Especially given the changing theater of bunkers globally, this will affect availability and costs. In general, heavy fuel oil will be a fuel of ' ' second grade " which means suppliers will not prioritize circulation. Also an EGCS is able to contain one type of negative emissions, meaning that although SOx emissions will be contained, it will have no effect on NOx emissions. The pricing of new types of fuel is another major factor. At least initially, the market price is likely to experience a spike in bunker prices. However, if the trend remains the same and there are no severe price fluctuations, scrubber installation will not have benefited ship-owners who have chosen this method. As a procedure, installation and retrofit is costly and time consuming. It requires the vessel to remain off hire for an extended period of time and the cost may vary between $2 million and $10 million per vessel. So for a company, especially those with large fleets, it is an important investment decision. Most ship owners, however, move away from such options. The explanation is that charterers usually incur bunkering costs. Moreover, such a decision entails increased maintenance costs and the need for more crew training. Smaller and older ships are not appropriate for this type of repair, bearing in mind the OPEX of the ship, the annual service days and the payback time of the expenditure in the scrubber. As mentioned above, whether this will be a trade-off between higher fuel costs (compliant fuels) and higher investment costs (scrubbers) remains to be seen.

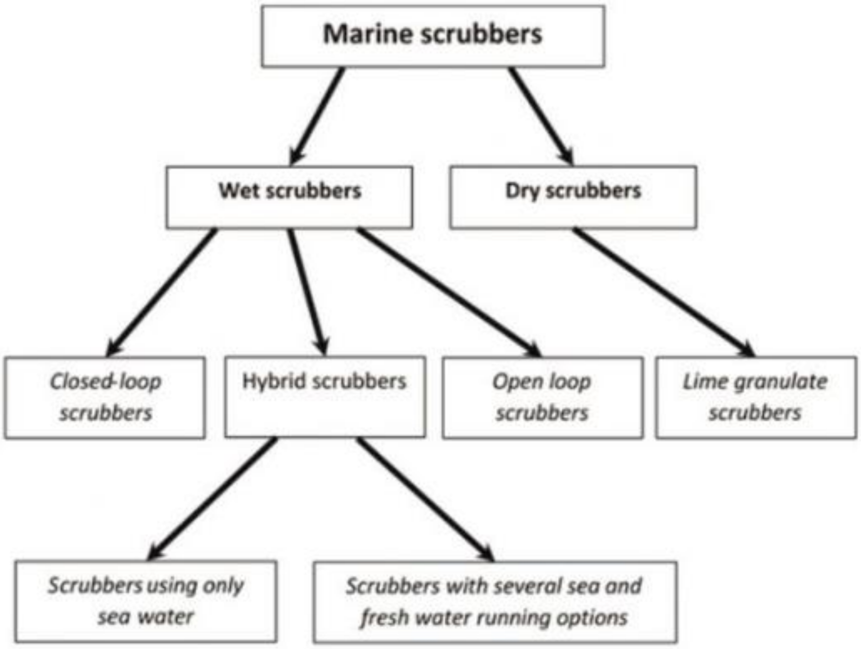


Figure1: Classification of marine scrubbers and their operational principle (source: marineisight.com)

3.2.1. IMO scrubbers' guidelines

The following provisions have been retained, among other sections: the recommendation to IMO Administrations to collect data on washwater discharges in accordance with Appendix 3 of the guidelines allows this criterion to be subsequently reviewed by the IMO, taking into account any advice from the Joint Group of Experts on Scientific Aspects of Marine Environmental Pollution (GESAMP). The approval schemes are identical to those applicable to diesel engines under the IMO NOx Technical Code (NTC), authorizing technical manuals, granting certification (Scheme A) and continuous enforcement checked by parameter tests and continuous monitoring.

The two EGCS schemes apply the following concepts:

• Scheme A based on initial emission performance unit certification together with a continuous check of operating parameters and daily exhaust emission monitoring.

• Scheme B based on continuous exhaust emission monitoring together with a daily check of operating parameters.

In both cases, it is important to track and record the condition of discharged washwater used in the scrubbing process.

<u>Schema A:</u>

For Scheme A approvals, the EGCS must be certified to meet the manufacturer's emission limit value (the ' certified value ') for continuous operation with fuel oils of the specified maximum sulfur content of the manufacturer over the range of declared exhaust gas mass flow rates. Alternatively, by undertaking emission testing at the highest, intermediate and lowest capacity ratings, the manufacturer can obtain a ' product range approval ' for the same scrubber design. This certification can be carried out before or after installation on board and is approved on behalf of the vessel's flag Administration by issuing a serial number-based SOx Emissions Compliance Certificate (SECC). The approval basis and the operating and maintenance parameters of the EGCS, together with the survey procedures, shall be included in the EGCS-Technical Manual for Scheme A (ETM-A), which shall also be approved by the Administration or RO acting on its behalf. After installation the EGCS should be tested to ensure that it is installed in compliance with the ETM-A and has the correct SECC. This would make it possible to amend and reissue the ship's MARPOL Annex VI International Air Pollution Prevention (IAPP) Certificate to reflect the EGCS installation. Subsequent surveys will be carried out at the annual, intermediate and renewal intervals of the usual MARPOL Annex VI survey. Continuous compliance is verified through continuous monitoring of EGCS operating parameters, daily exhaust emission controls and continuous washwater discharge monitoring. The shipowner is required to maintain an EGCS record book to record and make available for inspection at EGCS surveys the maintenance and service of the EGCS. The form of this record book is to be approved by the Administration and may be part of the maintenance record system planned by the vessels.

Scheme B

Scheme B EGCS does not need to be pre-certified to meet the emission limit value, but must demonstrate compliance with the required equivalent emission values for the fuel sulfur content requirements 14.1 and 14.4 of MARPOL Annex VI Regulation 14 at any point of load, including during transient operation, by verifying the SO_2/CO_2 ratio after the scrubber has been complied with in Table 2. This must be done on an ongoing basis through the use of an ongoing exhaust gas monitoring system approved by the Administration that records data at a rate not less than 0.0035 Hz. Similar to Scheme A, Scheme B EGCS units should be issued with an authorized EGC Technical Manual -B (ETM-B) detailing the operating parameters and limitations of EGCS. The EGCS is to be surveyed after installation and at the usual MARPOL Annex VI Annual, Intermediate and Renewal Survey intervals, in the same manner as Scheme A is surveyed for issue of the IAPP Certificate. Continuous compliance is checked by continuous monitoring of exhaust emissions, regular spot checks of the operating parameters of EGCS and continuous monitoring of the discharge of washwater.

Fuel Oil Sulfur Content (% m/m)	Ratio Emission SO_2 (ppm)/CO_2 (% v/v)
4.5	195.0
3.5	151.7
1.5	65.0
1.0	43.3
0.5	21.7
0.1	4.3

Table 2: EGC System Sulfur Content Emission Equivalence (source: ABS)

3.2.2. Required EGC system documentation

A SOx Emissions Compliance Plan (SECP) shall be approved on behalf of the Administration for ships planning to use an EGCS in whole or in part to comply with Regulation 14 of MARPOL Annex VI and shall outline the compliance process for all fuel oil combustion machinery installed on board. In addition, for each mounted EGCS, an authorized Onboard Monitoring Manual (OMM) shall also be retained on board the ship. The vessel's flag State should approve the OMM and include the following parameters:

- Sensor data used in the EGCS emissions monitoring system, including service, maintenance and calibration.
- Positions where the exhaust and washwater measurements and any necessary support services or systems are to be taken.
- Data on the analyzers to be used in the emissions and washwater systems, including operation, service and maintenance requirements.
- Procedures for analyzer zero and span checks.
- Other information and data necessary for the proper operation and maintenance of monitoring systems.
- Details of how to monitor the monitoring systems.

Table 4 outlines the authorized EGCS documents to be on board a ship using EGCS under the 2015 Guidelines Scheme A or B.

Document	Scheme A - Parameter Check	Scheme B - Continuous Monitoring
SOx Emissions Compliance Plan (SECP)	X	X
SOx Emissions Compliance Certificate (SECC)	X	
EGCS Technical Manual, Scheme A (ETM-A)	X	
EGCS Technical Manual, Scheme B (ETM-B)		X
Onboard Monitoring Manual (OMM)	X	X
EGC Record Book or Electronic Logging System	X	X

Table 3: List of Required EGCS Documentation (source: ABS)

3.2.2. Emissions monitoring

With EGCS operating on distillate and residual fuel oils, compliance with exhaust emissions from the measured SO2/CO2 concentration ratio with the corresponding fuel oil sulfur content is checked. The appropriate SO2/CO2 ratio in the exhaust of a diesel engine and the corresponding sulfur concentration in the fuel is shown in Table 2 of the Guidelines. If the exhaust from the scrubber has the same or lower SO2/CO2 ratio as that tabulated, e.g. less than 4.3 for a ship operating in an ECA where fuel with a total sulfur content of 0.1 percent is appropriate, the scrubber shall be deemed to be equal. Verification by the SO2/CO2 ratio makes exhaust emissions much easier to verify. Appendix II of the Guidelines accounts for the derivation of this ratio and its applicability to standard marine fuels and shows the relation between the 6.0g / kWh recommended by the original MARPOL Annex VI specifications based on a brake-specific fuel consumption of 200g / kWh. For those scrubbers where the exhaust gas cleaning process can affect the amount of CO2 in the exhaust gases, the concentration of CO2 should be determined before the scrubber and the concentration of SO2 should be calculated correctly after the scrubber.

3.2.3. Washwater discharge criteria and monitoring

For a variety of reasons, the IMO Guidelines define the standards regarding washwater discharge quality and monitoring specifications. Regional, federal or state regulations can set additional limits on washwater. In the voyage of a boat, ship-owners and vessel managers are advised to test the specifications for each of the intended ports in vessel´s voyage.

3.2.4. Data monitoring

As part of any EGCS implementation, the Guidelines allow data recording devices to be installed. Some of the basic system data to be continuously monitored and automatically registered are described below:

- When the system is in use, time against Universal Coordinated Time (UTC) and vessel position by Global Navigational Satellite System (GNSS) position.
- Washwater pressure and flow rate at the inlet connection
- Exhaust gas pressure before and pressure drop across the scrubber
- Engine and/or boiler load(s)
- Exhaust temperature before and after the scrubber
- Exhaust gas SO2 and CO2 content
- Washwater pH, PAH and turbidity

The data storage system should be reliable, tamper-proof, read-only, and able to record at a rate not less than 0.0035 Hz. It should be able to prepare documents over specified periods of time and the data should be maintained for a period of not less than 18 months from the reporting date. If the unit is changed during this period, the ship-owner should ensure that the required data are kept on board and are available as they might be required. The system should be able to download in a readily usable format a copy of the recorded data and documents. At the request of the flag Administration or Port State Control (PSC) authorities, the copy of the information and documents should be provided.

3.2.5. U.S. Environmental Protective Agency (U.S. EPA)

The EPA's Vessel General Permit (VGP) 2013 regulations cover scrubber washwater discharge limits, which have some variations compared to the IMO guidelines. The differences include the pH of the washwater ejected from the scrubbing process to be measured at no less than 6.0 at the overboard discharge of the ship and no other pH determination methodology would be acceptable. Within 3 nm of U.S. coasts, this provision will apply. For more detailed and specific requirements, along with reporting procedures, the specific sections of the 2013 VGP, such as 2.2.26 Exhaust Gas Scrubber Washwater Discharge and other related sections, may be referred. Beyond the range of 3 nm, the United States. On a case-by-case basis, the Coast Guard may consider alternative calculation-based methods and/or computational fluid dynamics or other proven analytical algorithms for checking washwater discharge requirements for the pH of exhaust gas cleaning systems in accordance with Section 10.1.2.1.2 of the 2015 Guidelines.

3.2.6. Waterwash residue

EGCS washwater residues are to be collected on board and delivered ashore at suitable reception facilities required to be delivered to MARPOL Annex VI by administrations under Regulation 17. It is not allowed to spill these contaminants at sea or to incinerate them on board. The Guidelines also mandate that such contaminants be processed and disposed of in the EGC Record Book, including the date, time and place of shipment. The EGC Record Book may form part of an existing logbook or recording system as authorized by the Administration.

3.2.7. EGCS system approval

There are two basic parts to obtain full approval of an EGC system: the statutory MARPOL approval process covering the aspects of environmental performance and approval of the rules of the individual society. Such factors are protected by form certification from a classification society in accordance with any other mandatory or voluntary criteria to which the EGCS supplier wishes the material to be certified. Full type approval would include design assessment, validation or form testing and manufacturing tests as specified by the MSC.1/Circ.1221 IMO for type approval. Additional requirements for flag administration may also cover aspects of environmental performance or general arrangements for EGCS. Where appropriate, a classification society can grant approvals in its capacity as an RO on behalf of an administration. The verification that an EGCS meets the MARPOL performance approval criteria defined in the Guidelines requires a number of steps. Additional requirements for flag administration may also cover aspects of environmental performance or general arrangements for EGCS. Where appropriate, a classification society can grant approvals in its capacity as an RO on behalf of an administration.

3.2. LNG

Liquefied natural gas offers an alternative to no sulfur pollution and almost zero emissions of NOx. The current world fleet does not make extensive use of LNG. Nevertheless, new builds are becoming increasingly interested in using LNG as the main navigation oil. Extensive modifications would be required in the case of existing vessels to make them efficient. LNG storage can take up to twice the space conventional fuels might require, because of the extra storage tanks for cooling and insulation and the extra pipes. In addition LNG is not readily available in large quantities in most ports of convenience and its distribution and storage at bunkering ports is a matter of adequate safety. The infrastructure needed to store and transport LNG at the different ports has been improved and extended in recent years. Furthermore, vessels with the capacity to burn LNG, are the appropriate option for ship-owners who wish to expand their orderbook (Grimmer and Myers, 2018). The explanation for this argument is that LNG is an attractive alternative, supported by the European greenhouse gas emissions reduction plan (Xu, Testa and Mukherjee, 2015). LNG fueled engines in vessels can attribute to a diminution of the CO_2 emissions to nearly 0%, however sufficient bunkering stations and infrastructures in ports is regarded as an imperative prerequisite for the option to be viable in a large scale in the maritime world (European Commission, 2013). The process, however, is quite difficult due to the cost and difficulty of retrofitting modern engines built with requirements for oil fuel consumption. While LNG vessels tend to be an acceptable route to be pursued by newbuildings, it would be an omission not to mention the high cost of retrofitting LNG in the existing fleet, which is the biggest a deterrent factor for many ship-owners.

3.3. Low sulfur fuel (LSF)

As mentioned earlier, maritime companies have the option of using cleaner marine fuel in terms of Sulfur consistency. Amid the low Sulfur content fuels that can be utilized, are the Low Sulfur Distillates (LSD), blend of LSD with high or low Sulfur fuel oil (HSFO and LSFO respectively) (Seymour, 2018). For safe operations, handling and coming fuel will be even more critical. In addition, since they are essentially new products, long terms stability remains to be established. Following the conducted studies, which inferred that the refinery sector is capable to adjust promptly and meet adequately the awaited demand for low Sulfur fuel, the option to switch to compliant fuels seems the most rational for the ship-owners (Jordan and Hickin, 2017). And the reason is that LSF can be used by most engines after required modifications but at the same time it is likely to expect an increase in the dependency of the vessels' operational expenses on the anticipated rise of the LSF. Finally, it is a new product, which means that there is no track record and also new ISO standards will have to be introduced, so that quality control of the bunkers received is reassured. As of now ISO 8217 does not cover all safety aspects related to the new compliant fuels that are about to be introduced.

3.4. Marine gas oil distillates

The decision to use distillate fuels could lead to a high increase in fuel costs due to their already higher price and will probably require engine modifications to include a fuel treatment plant due to their low viscosity. Fuel tanks will have to be carefully washed, as with any gas change. Nonetheless, the main concern will be the fuel supply and pricing in bunkering ports. Analysts estimate that the price difference between heavy fuel and distillates will be high in the first few months after implementation.

Ultra-Low Sulfur Fuel Oil and Marine Gas Oil are both viable and compliant fuels with a sulfur content of 0.5 percent m / m. In practice, a mixture of distillate and residual fuels will have to be the new compliant fuels in the form of ULSFO. This blend requires the proper structure, viscosity, size, flash point and compatibility with other different fuels for fuel interference purposes, of fuel intermingling.

MGO is, like diesel, a distillate oil. Nonetheless, market penetration is somewhat limited due to production complexity. It is an expensive choice for a main fuel that also requires specific lubrication4 but can be used anywhere as its sulfur content varies from 0.1% to 1.5% m / m (Anish, 2018). On the other hand, it is vulnerable to bacteria contamination. Contamination in the engine or clogged fuel filters can lead to unstable combustion. In addition MGO has a lower viscosity than the one fuel pumps are designed with, leading to corrosion and attrition due to the lack of proper lubrication. This is the reason engines running on MGO require additional lubricants, which in turn leads to extra costs. This is why engines running on MGO require additional lubricants, resulting in additional costs.

It is possible to produce fuel with a sulfur content of 0.5 percent m / m. Nevertheless, the desulfurization process required to remove excess sulfur quantities is extremely expensive and therefore not suitable for widespread use. It would have a significant impact on the market from such a higher price. The disparity is quite clear, even with the current prices (2019). As of now, IFO and MGO are the two main categories of fuels, with prices for the former fluctuating in the USD 410 area, while the latter in the USD 670 area5.

Of course, one of the options available to ship-owners after January 2020 would be to continue to use a combination of heavy fuel and MGO, striving for a sulfur content level of 0.5% m / m. This is common practice today, used by ships while transiting SECAs, where sulfur content still includes 0.1 percent m / m. The following are the most common combinations of oil (Chamber of Shipping, July 1st 2019):

- Marine Gas Oil (MGO) – the base of low sulfur content so far
- Marine Diesel Oil (MDO) – a mix of MGO with Heavy Fuel Oil
- Intermediate Fuel Oil (IFO) – a mix similar to MDO but with less MGO
- Medium Fuel Oil (MFO) – a mix similar to IFO but with less MGO
- Low Sulfur Heavy Fuel Oil (LSHFO) – desulfurized HFO

Another alternative is to use ULSFO (Ultra Low Sulfur Fuel Oil) with a sulfur content not exceeding 0.1% m / m. It is already available on the market and used as a cheaper replacement for MGO in the ECAs.

Ship-owners and operators are strongly encouraged to ensure that the latest compliant fuels ordered are protected by ISO 8217:2017 in order to achieve greater and easier compliance.

Many oil majors and fuel producers have supplied samples of their new main fuel to the market already. BP, Exxon, Chevron, Shell and others, engine manufacturers and classification societies all provided technical information on new types of fuels and commented on potential problems that could lead to smooth vessel and engine operation. Extensive use of new types of fuel can lead to engine problems, as most engines currently in use are not designed to use MGOs or similar types of fuel as their main fuel. The implications this could have could theoretically spill over to the demands of charterers and owners about equipment malfunction, as well as to insurance providers, who will need a higher premium to cover the additional risks.

However, shipping companies must be cautious and even factor in any potential incompatibility of fuels with the above. A ship will be required to receive bunkers at different call ports, not always from the same manufacturer or supplier. As a result, careful monitoring is required of BOB (board bunkers) and bunkers to be delivered. Since fuel oil is rarely mixed in the fuel tanks, this practice is already in place. Fuel tanks should be inspected and cleaned on a regular basis. Extra care should be taken, however, at least during the initial transitional period. As far as possible, ship owners are also urged to choose bunker providers who can provide them with the same fuel value in a sustainable manner. If not, the fuel should be kept under control in separate tanks to avoid contamination and deterioration of the engine.

In the able below I highlight briefly the most important pros and cons of each available compliance method.

Compliance Option:	Pros	Cons
LSF	• Simple • Can be used by most engines after required modifications • In case of increased procurement cost, can be passed as surcharges to charterers • Applicable to all vessels, independently age, type, operational route and size • Fuel supplier legally responsible for quality of fuel to meet the regulation's requirements	• Costs cannot be established yet • New products mean that there is no track record • Variable availability • Documentation and ISO standards still need to be configured • Possible that the increase of price after the regulation, will be too high
LNG	• Very good environmental imprint • No SOx emissions • Can lead to reduction of Green House Gas emissions • Port fees reductions as incentive • Lower prices than LSF and HSF	• Very costly investment • Suitable mostly for new built vessels • Extra space requirements on board for tanks and cooling • Danger in handling the fuel • Underdeveloped global LNG bunkering network
MGO	• Already useable by most engines	• Increased cost • May lead to mechanical and operational problems due to its low viscosity
Scrubbers	• Engines can still use existing, conventional fuels • Established availability of fuels (so far) • Relatively low fuel price (so far)	• High cost investment • Fuel consumption increase • Requires extra space on board • Requires chemicals and monitoring • High maintenance costs of the equipment • Uncertain disposal costs for sludge in terminals Shipowners legally responsible for the produced emissions

Table 4: compliance methods pros and cons

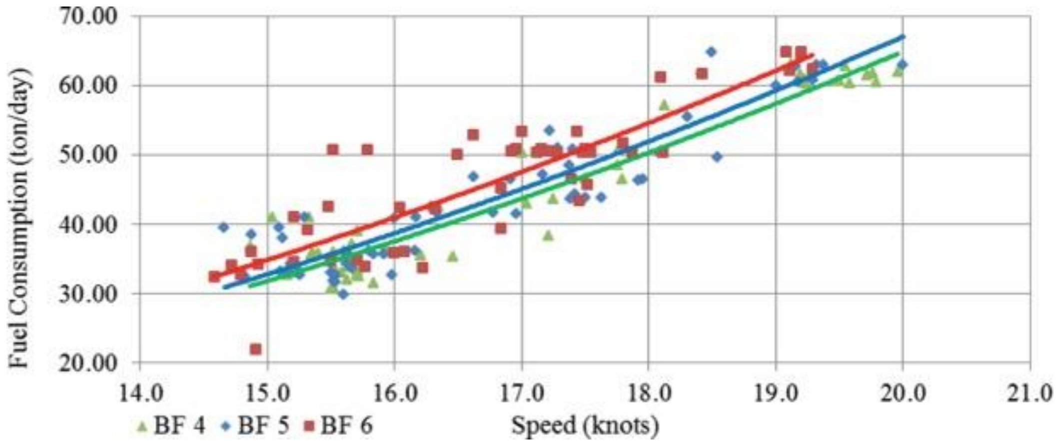
4. The effects of IMO 2020

As mentioned earlier, the latest sulfur content regulations have impacted all divisions and parties involved in the shipping industry and will affect them further. Management decisions and expansion will be influenced for shipping companies.

Investments, the composition of the fleet, trade zones, may all be subject to change. When it comes to meeting the new demand for compliant oil, bunker traders and distributors will face new obstacles. Charterers, flag states, and port state controls will have to adapt to accommodate the transition accordingly.

4.1. Freights

While vessel's capacity will remain somewhat stable in predictions, freight rates will rise significantly. It will cost the liner industry about $15 billion to remain in compliance with these new sulfur laws. Of perspective, following the sulfur pollution rules, a round trip to Asia to North Europe would cost an additional $1 million. It is important to note that the expected rise in shipping rates is coming high on the heels of recent attempts to add bunker charges by top carriers like Maersk, CMA, CGM, and MSC. The summer 2018 bunker surcharges demonstrate how unprepared shipping liners are in order to increase fuel levels. Also, a number of ships (in some estimates several hundred) will be out of the market at any time as ship owners hurry to equip their fleets. Ships that use the more costly low-sulfur fuel will operate at lower speeds so less fuel is consumed. This means that they will be able to make fewer voyages and thus decrease supply in the shipping industry. Older ships' scrapping will increase. It will be retired ships that do not have enough remaining useful years to justify equipping them with a scrubber, or are not profitable at higher fuel rates. And the supply of shipping will decrease further. All the above, constitute that the shipping availability will go down which means shipping rates will go up.



Picture 2: Fuel-speed relation (source:scincedirect.org)

4.2. Shipping Companies

Shipping companies (as owners ' managers) are called on in more detail to change their investment and bunkering plans to comply with the new regulations. It obviously depends on the company's management style and priorities. No simple solution can be found. Factors influencing these decisions are the structure, fleet, age, rank, area of service, form of hire etc. As mentioned above, shipping companies have options when it comes to adjusting.

4.3. Charterers

Charterers with ongoing hires lasting past 2020 will have to change their practices accordingly with the addition of the sulfur limit. This is particularly important as it involves not only the charterers themselves, but both parties involved, meaning also the owners of the vessel. In most charter parties there was not clear clause regarding the cost, type and quality of bunkers on board upon the vessel's redelivery to the owners. In the case of a time charter trip, given the relatively small employment period, cost of bunkers on delivery and redelivery is usually covered. Nevertheless, charter parties should be altered in cases of extended hire duration to accommodate the specific types and value of bunkers to be redelivered. Clarifications should also be made as to who of the parties involved should arrange and pay for the disposal of non-compliant fuel (if remaining), the likely undertaking of repairs induced by misuse of fuel and maritime safety issues, off hire times in the event that no appropriate fuel is readily available, who will be subject to possible penalties in the event of the use of non-compliant fuel.

4.4. Cargo owners

The shipping lines have made their intentions clear by putting in place additional surcharges to cover the additional costs they will incur to operate their ships on cleaner fuel. They have categorically announced that they will not pay for these costs alone as environmental protection the ultimate goal. So naturally either the seller or buyer will have to foot the bill for these additional surcharges. These type of surcharges will form an interesting part of price negotiations in a sales contract between a seller and buyer as these are new charges and may not have been included thus far in the negotiations

4.5. Bunker Suppliers

Bunker producers and distributors will have to adapt to changing conditions in the months leading to the full implementation of the sulfur limits. To owners and as a result charterers, fuel performance and reliability will be of great importance. Suppliers in terms of quantity, price, variety and flexibility will need to be able to meet the new demand. They are also responsible for providing a quality certificate for the bunkers supplied.

4.5.1. Fuel prices and availability

Bunker fuel prices have fluctuated. Over the past five years at least, fuel prices have been following an increasing trend closely related to oil prices. Nonetheless, this phenomenon can no longer give us clear forecasts of how prices will be impacted after 2020 with the introduction of new fuel regulations. It is widely expected that the transition to new forms of fuel will likely result in higher fuel costs for the industry. Increased refining needs to meet the new standards and the need for blends will likely force the market to move away from the established oil prices and create a gap, especially given the difference between the new types of supply and demand. As is to be expected, with the majority of ship owners moving to the use of blends, MGO demand will result in higher prices initially, stabilizing shortly after. Meanwhile, with HSFO seeing less vessel use, the price will drop, creating a greater gap between the two solutions for fuel. This gap and the length of time it becomes obvious will dictate who made the right choice.

If MGO prices remain sustainable, the market will conform. However if the difference remains wide and HSFO prices drop significantly, some owners may be forced to reconsider their strategies and opt for scrubbers instead. However, at that point the industry will have already moved on, perhaps making LNG a more attractive solution.

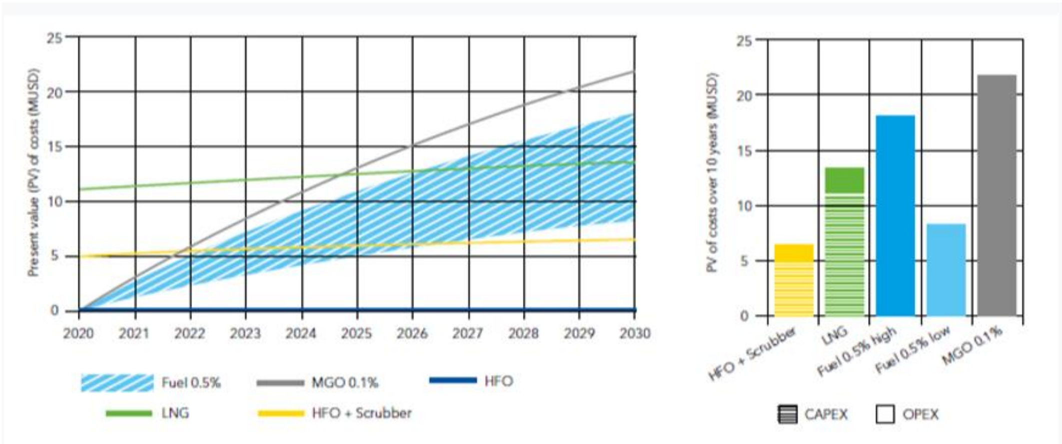
Meanwhile, with HSFO seeing less vessel use, the price will drop, creating a greater gap between the two solutions for fuel. This gap and the length of time it becomes obvious will dictate who made the right choice. On the other hand, most ports have already received new types of fuel. In addition to MGO and HFO, BP has already given VLSFO to most bunkering locations16 as an indicator. According to them, in the coming years, VLSFO will account for more than 50% of the market. Fujairah's port reported that as of February 2019, 0.5 percent of fuel blends should be available (BP, MARPOL 2020 and beyond).

Regardless of the ship-owners' choice of solution, the ship's operating cost will increase, whether by adding new equipment or using new fuels, the price of which may increase. For example, if a ship-owner decides to install scrubbers on a vessel, apart from the initial monetary investment, the demand for electricity will increase due to the additional pumps and similar costs will also be associated with the discharge of scrubber washings. Furthermore, it is expensive to maintain equipment, so all of the above factors must be taken into account when making such a decision.

It is a challenge to estimate the price of new oil. Historically, the price difference between the different distillates has been correlated, but the increased demand for new distillates and their mixtures will affect this correlation. What is certainly going to be noted is the increased price disparity between Heavy Fuel Oil and Marine Gas Oil's two key choices. The demand for fuel shifted to Marine Gas Oil and Marine Diesel Oil when the current limit was added to the SECAs. If this is the case, Marine Gas Oil's value will most likely rise.

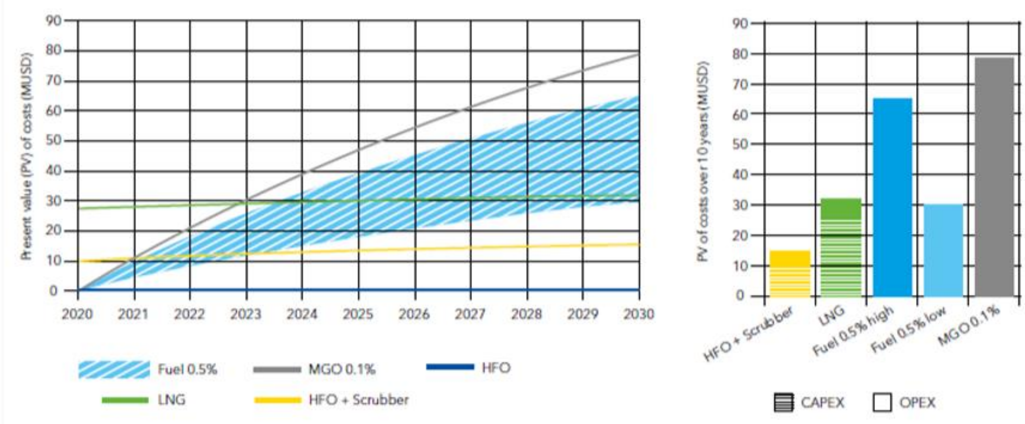
DNV GL17 has established three basic scenarios in an effort to provide guidance for the right decision for each type of ship. The price of heavy fuel oil is set at $ 300 / barrel, the price of compatible fuel ranges between 390 USD and 540 USD, so ranging from 30-80% above the HFO price while the price fuel for ECAs is set at 600 USD, 100% above the price of heavy fuel oil. The price of LNG is not specified, varying according to the quantity required. Consequently, for tankers it is calculated at + 10%, for containers at + 5% and for bulk carriers at + 15% over the price of heavy fuel oil.

More specifically, in the case of tankers the following results were presented:



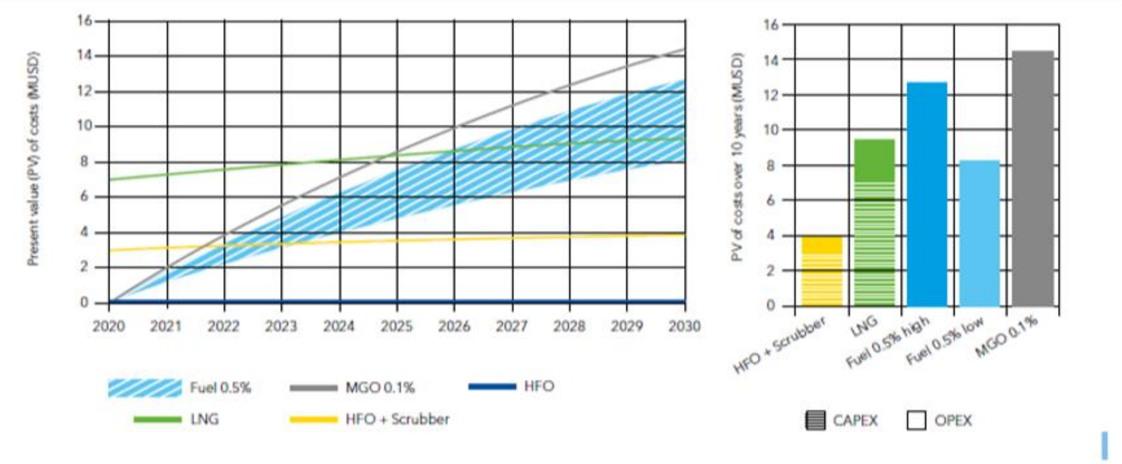
Picture 2: Comparative costs compliance methods over ten years for tankers (Source: DNV GL, Global Sulfur Cap 2020)

The charts show cost fluctuations, all the alternatives would have, based on a typical Aframax tanker over a period of ten years. The initial investment value in a scrubber amounts to around USD 5 million. The amortization duration ranges from 2.5 to 6 years depending on the price of the new fuels consistent with the value of a 0.5 percent new fuel. Following a similar pattern, the initial cost of investing in a new designed LNG engine amounts to around $11 million and the amortization duration varies from 6 years to more than 10 years compared to the new fuels.



Picture 3: Comparative costs compliance methods over ten years for containers (Source: DNV GL, Global Sulfur Cap 2020)

In a container carrier of 19,000 TEUs, the initial cost of investing in a scrubber is around USD 10 million, whereas its amortization duration varies from 1 to 3 years compared to that expected when using compatible oil. In the case of the conversion to LNG, the initial cost is approximately 28 million and the amortization period starts at 4 years and can take up to 10, depending on the new price. Understandably, this would be a better choice for a new built ship.



Picture 4: Comparative costs compliance methods over ten years for bunk carriers (Source: DNV GL, Global Sulfur Cap 2020)

In this case, the value of one scrubber is around 3 million USD for a standard Handymax bulk carrier, whereas its amortization period is 2 to 3.5 years depending on the high or low version of the compatible fuel price. The initial investment price of LNG engines is USD 7 million, whereas the amortization duration varies from 6 to 10 years.

4.5.2. Singapore spot market dries up

Spot supplies of high-sulfur fuel oil (HSFO) and low-sulfur fuel oil (LSFO) are drying up in Singapore as more buyers turn to term contracts before the IMO 2020 sulfur cap is implemented globally. Many ship-owners have no scrubbers installed and intend to destroy whatever HSFO supplies they still have on board their ships at the latest by Christmas. "We buy less HSFO on spot these days, as most of our bigger vessels were filled up recently before the persistent prompt constraints in Singapore", one buyer said (argusmedia). HSFO's prompt stocks in Singapore started to contract dramatically in July as the IMO-adjusted market capsizes sulfur content in marine fuels from 3.5pc now at 0.5pc on 1 January. Delivered bunker premiums have remained high on supply availability concerns in Singapore, the largest bunker port in the world. According to Argus data, the premium of delivered 380cst HSFO to cargo prices so far in November averaged $81/t, a tenfold increase from this year's average premium in the first six months. "The switchover is making it difficult to optimize barges, and the few players that still have HSFO in storage tanks and are able to deliver it are basically determining prices and earning very good margins. Prices have not yet come down in line with fundamentals", a trader said. Other ports in Asia also affected the tightness of the HSFO market in Singapore, with several Chinese ports struggling with terminal and barge congestion. Delivered HSFO in Shanghai, Zhou Shan, and Hong Kong have so far this month averaged $41/t, $24/t, and $15/t premium to Singapore, Argus data show. Instead, some shipowners tried bunkering in Fujairah, where HSFO bunker prices are close to Singapore's $100/t discount, mainly due to abundant regional supplies. Since early October, demand for LSFO has picked up strongly in Singapore. Consumption is no longer limited to those who use the fuel for testing purposes or travel to the emission control zones (ECAs) of China. Instead, owners have started to seriously clean up their tanks and are now consuming larger LSFO stems for longer journeys. Deliveries that were previously locked in on a term basis, with fewer owners willing to buy on the spot market, meet a growing share of LSFO demand. This trend will continue to escalate in the near future, with ship-owners increasingly concerned about the supply of LSFO beyond the first quarter of 2020. This will push buyers to tie up most of their IMO-compliant fuel requirements through second quarter and beyond term contracts. Owners agreed on LSFO's term contracts until March at discounts of around $40-50/t on the price of gasoil cargo. According to Argus data, spot prices for LSFO averaged a $30/t discount on delivered low-sulfur marine gasoil (LSMGO) so far in November. "The majors have been locking in term in order to secure volume, which we have done too, but we have made sure to have some HSFO and LSFO spot barrels for sale as well in order to enjoy these high premiums", a supplier said.

4.6. Flag States and compliance options

The different governments of the Flag State will oversee the implementation of the new regulations. The IMO and the PSC have no jurisdiction nor procedures to implement the limits. The need for bunker suppliers to provide a quality certificate for the fuel supplied is an initial step towards compliance. Flag States must also issue the IAPP–International Air Pollution Prevention Certificate, which recognizes that the vessel in question uses fuel in accordance with the new regulations or otherwise has adequate equipment installed. An exception is possible when, due to unavailability, a specific ship cannot be supplied with acceptable fuel. The application for FONAR–Fuel Oil Non Availability Report covers this. However, the purpose of the IMO is to create a standard global PSC practice12. Airborne detectors or remote sensors can be used on bridges and port entrances by Port State control. Furthermore, regular inspections should be conducted and inspectors should be provided with sufficient training. Finally, vessel or operator non-compliance may lead to blacklisting.

4.7. Impact on emissions

The options made and the compliance strategies chosen will have an impact on vessel's gas emissions. In turn, this will affect the emissions of Green House Gas, SOx and NOx. Although the current regulations set a sulfur cap on emissions, it is highly likely that several additions and modifications will be made in the future, including others. Following this train of thought, each method, while achieving the main goal, has potential impacts on other aspects. The desired effect of limiting sulfur emissions to the desired level is achieved by switching to MGO, distillates or blends as expected. The overall picture, however, is hardly affected as there will be no improvement in emissions of NOx and GHG. A similar calculation is made in the case of exhaust cleaning methods, with the added effect of rising GHG emissions due to the additional pressure on engines. Obviously, implementing LNG as the main propulsion fuel would be the most environmentally friendly approach. It has virtually no emissions of sulfur, significantly reduced emissions of nitrogen, and a potential reduction in GHG emissions. However, as discussed above, it is still debatable whether LNG can be used as the cornerstone of maritime propulsion fuel.

5. Ship implementation

In October 2018, the Marine Environment Protection Committee (MEPC) and the IMO approved the ‘’Guidance on the development of a ship implementation plan for the consistent implementation of the 0.5% sulfur limit under MARPOL Annex VI’’. In order to facilitate compliance, the IMO has established guidelines that include a conceptual framework for an individual ship-specific Ship Implementation Plan (SIP) that is approved for use by shipping companies. The program is not mandatory and is not subject to flag state approval or recognized organization (RO) approval. 18It contains guidelines and recommendations, encouraging ship owners to develop implementation plans for their vessels and achieve an as smooth transition as possible to the new types of fuel. The program addresses issues related to the use of compliant fuel oil and how any safety risks associated with such fuels can be defined. Items protected by the program may include:

1. Risk assessment and mitigation plan (impact of new fuels)
2. Fuel oil system modifications and tank cleaning (if needed)
3. Fuel oil capacity and segregation capability
4. Procurement of compliant fuel
5. Fuel oil changeover plan (conventional residual fuel oils to 0.50% sulfur compliant fuel oil)
6. Documentation and reporting

In addition, the IMO has developed two guidance reports to implement the SIP:

- Impact on Machinery Systems

(IMO Guidance MEPC.1-Circ.878 Annex, page 8 Appendix 2)

- Tank Cleaning
  (IMO Guidance MEPC.1-Circ.878 Annex, page 10 Appendix 3)

Particulars of ship

1. Name of ship:
2. Distinctive number or letters:
3. IMO Number:

Planning and preparation (before 1 January 2020)

1 Risk assessment and mitigation plan

1.1 Risk assessment (impact of new fuels): YES/NO
1.2 Linked to onboard SMS YES/NO

2 Fuel oil system modifications and tank cleaning (if needed)

2.1 Schedule for meeting with manufacturers and/or classification societies:

2.2 Structural Modifications (installation of fuel oil systems/tankage) required: YES/NO/NOT APPLICABLE

If YES, then:

2.2.1 Fuel oil storage system:

Description of modification:

Picture 5: Ship implementation plan example (source: IMO)

5.1. Issues relating to use of sulfur compliant fuel oil

-All fuel oil supplied to a ship shall comply with regulation 18.3 of MARPOL Annex VI and chapter II/2 of SOLAS.

-Meanwhile, operators could consider ordering fuel oil specified in accordance with the ISO 8217 marine fuel standard.

In preparing and implementing the 0.50 percent sulfur limit requirement, the following potential fuel-related issues may need to be assessed and addressed by ships:

- technical capability of ships to handle different types of fuel (e.g. suitability of fuel pumps to handle both higher and lower viscosity fuels, restrictions on fuels suitable for use in a ship's boilers, particularly the use of distillate fuels in large marine boilers);
- compatibility of different types of fuels e.g. when paraffinic and aromatic fuels containing asphaltenes are commingled in bunkering or fuel oil changeover; handling sulfur non-compliant fuels in the event of non-availability of sulfur compliant fuels; and
  - crew preparedness including possible training with changeover procedures during fuel switching from residual fuel oil to 0.50% compliant fuel oils

In addition, the ship implementation plan could be used as the primary method to define any particular safety risks associated with sulfur-compliant fuel oil as applicable to the ship and to establish an appropriate action plan to address and mitigate the identified concerns. Some examples:

- Procedures for separating various types of fuel and fuels from different sources.
- Comprehensive procedures for evaluating compatibility and extracting fuels from different sources to ensure compatibility.
- Procedures for moving from one type of fuel to another or a fuel oil known to be incompatible with another fuel oil; plans to address any mechanical constraints with regard to the handling of specific fuels, including ensuring that the minimum / maximum fuel oil characteristics identified in ISO 8217 can be handled safely on board the vessel.
- Procedures for verifying the performance of fuel oil machinery with characteristics not previously experienced by the ship.

Conclusion

In conclusion, the protection of the environment is a major concern for internationally recognized organizations. Over the past few years, the IMO has tried to reduce the environmental burden of maritime trade by implementing stringent legislation. Although shipping accounts for less fuel consumption per unit compared to other means of transport, it has high percentages of high sulfur emissions. These emissions can be transported over long distances and can cause hazards to the environment and health. In 2008, MARPOL Annex VI was adopted to address this, reducing ships ' sulfur emissions. Those levels will be 0.5% m / m of sulfur content outside ECAs and 0.1% m / m of sulfur content within them as of 1 January 2020. Ship owners will have to choose how they want their vessels to operate after 2020. Due to the uncertain efficiency of compliance methods and the questionable availability of compliant marine fuel on a global scale, shipping companies in the liner industry, particularly small stakeholders, adopted a reactive approach. For this reason, the way firms respond to the regulation can affect transported volumes and change market shares. A change in the market shares of the liners may theoretically result in a change in the structure of the industry. Although most of them have already decided, it remains to be seen what the bunker, freight and commodity market's initial response will be. In cases where compliant fuels are selected, transition costs are relatively low, but maintenance will cost more. Lubricants are going to play a greater role in the successful use of new fuels. Furthermore, the mixing of different types and qualities of fuel can lead to mechanical problems and contamination of fuel. For ship owners, the other option will be to install scrubbers. Such systems allow the use of old conventional fuels as they keep the ship compliant by purifying gases. However, scrubbers are expensive to install and maintain, while also requiring installation time during which the vessel is not in operation. At the same time, there are a lot of things to take under consideration except for the cost like washwater, monitoring, reports etc. This may be a decision with a considerable amount of risk. Bunker prices, on the other hand, will play a key role in this change. The evolution of fuel prices is what actually will determine which option is better. When compliant fuel prices remain low, or at least close to current prices, there will be an initial gain to owners who choose not to invest in Exhaust Cleaning Systems. The main concern will be availability and monitoring of fuels. On the other hand, when prices rise, at least initially, the winners will be owners who have decided to install scrubbers. Charterers are going to look for them, choosing to use traditional fuels because of their cost. In this case, though the balance may change, based on the fact that owners will try to push for higher freight and hire rates, especially since such vessels will be limited in number, due to the retrofitting costs of the undertaking and the associated risk. The implementation and compliance of the new regulations will be another major concern. Until now, vessels had been obliged to carry bunker delivery notes on board, stating the quality of the fuel they carry so that their corresponding flag state administration could issue them with the appropriate certificates. Fines and inspection procedures have not been fully clarified, which means that there is a possibility after January 2020 of non-compliance and infringement of regulations. As with shipping, this question cannot be answered correctly or incorrectly. Each alternative has advantages and disadvantages and risks associated with it, as I have mentioned before. The best option, particularly for owners, would be the one that corresponds more closely to the needs, age, scale, and future plans of their fleet and their prediction of market trends. It will take several years to show the impacts of the new limits and regulations. It will take time to assess who had, and how significant, financial gains and losses. Therefore, it will be a matter of discussion in the coming months and years whether the caps have achieved the goal of lowering harmful emissions and what other problems they might create. Ultimately, as with all shipping improvements and considering modern developments in the form of SOLAS, water treatment systems, environmental protection, reduction of pollution and safe business management, every effort should be made to avoid and prevent potential hazardous incidents and events. This can be achieved by a risk assessment of the new procedures in which a company is required to participate. Through this, companies ensure that all threats are identified and recognized and alternative procedures are implemented on their own to minimize their exposure to hazard and treatment and to prevent any malfunctions and deviations from their practice standards. In fact, companies were strongly advised by the IMO to establish a Ship Implementation Plan (SIP) in the months preceding and leading to the final implementation of the 2020 sulfur cap. The mechanism through which a company can achieve compliance with the new regulations is defined in it, whether with new compliant fuels, alternative methods of gas cleaning or conversion to other forms of propulsion fuels. In conclusion, earlier it is created, the sooner it is reviewed, modified and introduced, resulting in a prompt, seamless, cost-effective and secure transition by 1 January.

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