

UNIVERSITY OF PIRAEUS



DEPARTMENT OF MARITIME STUDIES

MSC IN SHIPPING MANAGEMENT

THESIS TITLE: “SCRUBBERS IN SHIPPING”

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Subject Thesis ‘Scrubbers in Shipping’

has been submitted to the Department of Maritime Studies
of the University of Piraeus as a requirement for the obtainment of the
MSc degree in Shipping Management.

Piraeus

October 2019

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PREAMBLE

The Dissertation Thesis has been conducted based on the material available by all possible sources. It tries to bring as much as possible information regarding the scrubbers in shipping issue that is one of the major (if not the major one) themes in all the small and big gatherings, forums and symposiums of the shipping world. It involves many different issues, technical, economic, predictions, freights, market analysis and more and it can be considered a part of the biggest change in shipping in the last decades. Scrubbers are presented as a solution to the future headaches that the majority of the shipping world will face after 1st January 2020. All the opinions were selected and presented in a critical way presenting positive and negative aspects.

Acknowledgments

At this stage I would like to express my sincere appreciation to Professor D. Polemis for his inspirational ideas on subject Thesis and his useful guidance.

Furthermore a great appreciation to all the support in all aspects from Prof. A. Pantouvakis and for the constant positive response.

A great thanks to the Tripartite Committee Members that are the reviewers of subject Dissertation Thesis, for their contribution to the development of scientific mentality and scientific results.

“Dedicated to the ones supported me throughout this endeavor.”

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ABSTRACT

Objective

The objective of this Thesis is to present the reactions and tendencies of the shipping market towards the installation of a scrubber system onboard vessels, the alternatives offered by the market in order to meet the requirements of IMO 2020 0.5% sulfur cap. Furthermore presents the alternatives in comparison with the scrubber fitting, financial solutions for the installation of scrubber system and environmental concerns from the use of the system and disposal of it's by products. Thoughts in the long term that are discussed frequently in the international shipping forums and in private by the involved members are also presented. The main essence is to present the scrubber system from an objective point of view and how it was perceived by the many.

Research question

What was the shipping market influence after the introduction of scrubbers as an alternative offered in order a vessel to be in compliance with the IMO 2020 0.5% Sulfur regulation to be implemented in January '20 .

Method and Limitations

The method used is the daily updating information research based on media reporting and official announcements, research papers by institutes, world well known media experts in shipping, shipping companies official sites, banks, oil majors sites and articles, shipping market specialists resources and personal experience as a professional in shipping industry.

This research Thesis is limited to the shipping market influence by the introduction of scrubbers as alternative to the IMO regulation compliance. Although comparative with other alternatives, it is not extended to technicalities or concludes the efficiency of the scrubber system onboard vessels or promotes it as the sole solution or best alternative for the specific regulation compliance.

Conclusions

Although different opinions exist, there are facts like the Sox reduction by scrubbers, the pressure of the ship owners to take a decision, the financial institutions supporting, the shipping market trying to follow and read

the signs, the oil majors imposing a new type of fuel leaving many questions unanswered. The above constitute the shipping reality that we will deal with.

ΠΕΡΙΛΗΨΗ

Σκοπός

Σκοπός της παρούσας εργασίας είναι να παρουσιάσει τις αντιδράσεις και τις τάσεις της ναυτιλιακής αγοράς για την εγκατάσταση ενός συστήματος καθαρισμού καυσαερίων στο πλοίο, τις εναλλακτικές λύσεις που προσφέρει η αγορά προκειμένου να ικανοποιηθούν οι απαιτήσεις του ανώτατου ορίου θείου 0,5% του κανονισμού του IMO 2020 που θα τεθεί σε εφαρμογή την 1^η Ιανουαρίου του 2020. Επιπλέον, παρουσιάζει τις εναλλακτικές λύσεις σε σύγκριση με το σύστημα καθαρισμού καυσαερίων, τις οικονομικές λύσεις για την εγκατάσταση του συστήματος καθαρισμού και τις περιβαλλοντικές ανησυχίες από τη χρήση του συστήματος και τη διάθεση των προϊόντων του από την λειτουργία του. Οι σκέψεις για το μέλλον που συζητούνται συχνά στα διεθνή ναυτιλιακά φόρουμ και ιδιωτικά από τα εμπλεκόμενα μέλη παρουσιάζονται επίσης. Η βασική ουσία είναι να παρουσιαστεί το σύστημα καθαρισμού καυσαερίων από αντικειμενική άποψη και τον τρόπο με τον οποίο ο ναυτιλιακός κόσμος το έχει αντιληφθεί.

Ερώτημα έρευνας

Ποια ήταν η επιρροή της ναυτιλιακής αγοράς μετά την εισαγωγή των συστημάτων πλύσης καυσαερίων ως εναλλακτική λύση που προσφέρεται προκειμένου το πλοίο να συμμορφωθεί με τον κανονισμό του IMO για το 2020 για το 0,5% θείου που θα εφαρμοστεί τον Ιανουάριο του 20ου.

Μέθοδος και Περιορισμοί

Η μέθοδος που χρησιμοποιείται είναι η έρευνα με βάση τα μέσα ενημέρωσης και τις επίσημες ανακοινώσεις, ερευνητικά κείμενα από ινστιτούτα, παγκοσμίου φήμης εμπειρογνώμονες των μέσων μαζικής ενημέρωσης στη ναυτιλία, επίσημες τοποθετήσεις ναυτιλιακών εταιρειών, τράπεζες, πετρελαϊκές εταιρείες, άρθρα ειδικών, αλλά και η προσωπική μου εμπειρία ως επαγγελματία Ναυπηγός στον ναυτιλιακό κλάδο. Αυτή η ερευνητική εργασία περιορίζεται στην επιρροή της ναυτιλιακής αγοράς με την εισαγωγή των συστημάτων πλύσης καυσαερίων ως εναλλακτική λύση στη συμμόρφωση με τον κανονισμό του IMO. Αν και συγκρίνεται με άλλες εναλλακτικές λύσεις, δεν επεκτείνεται στις τεχνικές προδιαγραφές ούτε καταλήγει στην αποτελεσματικότητα του συστήματος πλύσης καυσαερίων στο πλοίο ή το προωθεί ως τη μόνη λύση ή την καλύτερη εναλλακτική λύση για τη συμμόρφωση με τους συγκεκριμένους κανονισμούς.

Συμπεράσματα

Αν και υπάρχουν διαφορετικές απόψεις, υπάρχουν γεγονότα όπως η μείωση των εκπομπών Sox από τα συστήματα καθαρισμού καυσαερίων, η πίεση των πλοιοκτητών για λήψη αποφάσεων, η υποστήριξη από τα χρηματοπιστωτικά ιδρύματα, η ναυτιλιακή αγορά που προσπαθεί να ακολουθήσει και να διαβάσει τα σημάδια, οι μεγάλες εταιρείες πετρελαίου που επιβάλλουν έναν νέο τύπο καύσιμα αφήνοντας πολλά ερωτήματα αναπάντητα. Τα παραπάνω συνθέτουν την ναυτιλιακή πραγματικότητα με την οποία θα ασχοληθούμε.

INTRODUCTION

Modern day shipping is used to changes others more rapid or innovative others more slow and conservative. Taking the example of the Ballast water treatment system installation, a similar global project imposed by IMO and U.S. EPA and USCG, shipping community requested from more flexibility. Makers of systems too and shipyards followed requesting more time. Their appeals were heard. Although the impact in shipping was huge since it led to scrapping of vessels, loss of assets value, increased new orders BWTS fitted etc. the shipping industry had enough time to digest and implement with it's pace. The new sulfur implementation date came just a few years ago, when everyone was expecting a similar slow adaptation. None was and still many are not ready to understand and implement correctly. Scrubber came as the easy alternative solution for everyone. The majority of shipowners had and still has a different opinion. Approaching all the possible opinions and stances of the institutes and people involved.

Subject Dissertation Thesis consists of 7 chapters trying to make analysis of every aspect of the wider sector called or influencing Shipping in total in connection with the introduction of scrubbers as an alternative to the IMO 2020 0.5% sulfur cap. The first chapter focuses on the explanation of the IMO regulation requirements. The alternative solutions for the compliance with the new standard limitations in Sox emissions and the greenhouse gases. It also explains the scrubber in a simple way, how it works, the basic principals and the types of it available for the marine sector of industry.

The second chapter approaches the influences that the introduction of scrubbers brought into shipping, the main trends, the reactions, the grouping of the shipowners and other institutes either for or against the specific solution.

In the third chapter are presented the costs involved in the process of installing a scrubber and what can derive from such a decision, the main points including the selection, the shipyards, the preparations, key notes and many more. Such a selection is not just a straight forward decision and so far has shown differentiation of opinions even within the same companies.

The fourth chapter takes into account and analyzes the economic and funding aspect of the scrubber fitting. What economic changes are expected or has this choice already brought. New ideas on funding and who is involved under what scheme.

The fifth chapter is depicting the 2 main environmental approaches. The one side showing that there is no harm in the air and scrubbers indeed do what they promise they do and the other side presenting the facts or the fears that although air is clean sea gets polluted by the use of scrubbers.

Some interesting approaches simple questions and facts received from the market are presented in the 6th chapter. Although simple questions, it presents in a very accurate way the main concerns of the ship owners and operators. The role of the oil majors and real problems that all shipping industry is expecting from the use of the new fuel or scrubbers.

Finally at the seventh chapter conclusions are presented. Market has not seen yet the results. Speculations are all over the shipping community and industry. We are just a few months close to the implementation date where all will begin and see the facts.

CHAPTER 1 - THE IMO REGULATION, SCRUBBERS EXPLAINED AND THE ALTERNATIVE SOLUTIONS

1.1 MAIN FACTS

The shipping industry can be described as a sector of global economy that incorporates many innovations and changes. Several changes can be tracked back decades ago and implemented slowly, while monitoring the efficiency of this change and adaptation onboard vessels. The necessity of such innovations and changes can be traced in the need for improvement of the life of the seamen, the safety of life at sea, the safety of vessel and avoidance of pollution, security issues and many more.

Once a necessity appears, relevant regulatory bodies in cooperation with the flag administrations, port states, other administrations and external technical bodies are describing the new need and the relevant solution. As somebody might understand a solution to be agreed by different administrations with different backgrounds and interests is a difficult case. What makes all the parties work together is the need for a viable solution to a problem appeared. The result of such commissions can be a series of rules or regulations defining the problem and its aspects and at the same time explaining the solution/s to the problems and other alternatives. Such initiatives are meant to assist to the implementation of new regulations, application method suggested to the involved parties and the final result together with the framework including control of requested achievements.

Under all the regulatory bodies IMO is the organization responsible by UN for the matters of sea and generally environmental and health issues connected with sea activities. As such body is entitled to investigate improved solutions for reduction of emissions and its effects in sea and air as well as their influence in human and rest of lives.

1.1.2 THE REGULATION

The IMO legislation has released the MARPOL Annex VI regulation for the control of exhaust gas emissions control and reduction related. Namely Sox NOX And other gaseous pollutants (including volatile organic compound, toxic remnants, heavy metals etc.) should be monitored and reduced as released in the air (and at sea).

The new rule will be in effect from 1st January of 2020. Implementation involves all shipping as it refers to all vessels around the world thus making it a very important issue for the whole shipping community. As it is described the specific regulation reduces furthermore the sulfur content of the fuel used from 3.5% m/m as it is until today to 0.5% m/m to all outside ECA areas. As somebody can suppose, the implications are huge

and involve the petrochemical industry, the shipping industry, environmental organizations, shipyards, technical companies and a lot more not seen in front but for sure exist actively in the background.

1.1.3 THE ALTERNATIVE SOLUTIONS

The IMO members have contributed to establish a regulation that can be viable and gives alternative solutions to the industry users. The disruptions that may arise by such a change that involves about 70.000 vessels worldwide holding the global merchandise are huge. That could involve shortage of fuels, problems in the engines of the vessels resulting black outs in the middle of the ocean and thus characterizing the condition as dangerous for the life at sea and many more examples that may affect daily life and the normal uninterrupted international commerce.

In this respect, the new regulation referring as 0.5% Sulfur Cup, is not just a straight one way regulation but has it's alternatives. Apart from the usual fuels deriving from oil products from refineries, there are the methanol alternative fuels with proved results, the LNG fuel that is rising steadily as the main alternative and green fuel of the vessels and exhaust gas cleaning devices named scrubbers in the industry which was the exhaust gases from the main engine and auxiliaries (boilers too) before released in the air.

1.1.4 SCRUBBERS

The solution that involves the washing of the exhaust gases is far more complicated than it just sounds. Already tested in land facilities, it is a challenging innovation for the marine industry since the environment, the facilities and communications during a voyage as well as the consequences from a systems failure can be proved huge.

However it is a reliable solution up to the point of technology know how. The systems mainly used in marine environment have 3 main categories and a few subcategories.

Namely the open loop systems the closed and the hybrid are the main ones followed by the inline and parallel gas insertion types. Manufacturers of such systems are big technology and engineering companies worldwide known and even smaller companies focused on the specific market and the need risen from the regulation. There are tricks and tips do's and don'ts and many options for those who will consider to install such a system. When coming to cost and available financing then things are getting more complicated since involved parties must consider factors such as type and age of vessel, cost of system and cost of installation, freight rates, general strategy of the company just to list a few.

1.1.5 SHIPPING INDUSTRY INVOLVED

The implementation date is just some months deal and everyone in the shipping market has taken a decision. Or almost taken. Some have taken partly a decision and just wait the results in order to mitigate risk, and plan next steps. As it is the new regulation has created the scrubbers debate that has been in the center of the

shipping communities discussions for the last years. It involves investment from ship owners side, research with financial support from the manufacturers, rearrangement of the shipbuilding industry for the incorporation of the new retrofit projects around the shipyard's of the world, newbuilding orders. Re arrangements of the strategic approaches of the markets by those installing a scrubber on their vessels and expectations of increased profits in contrary to the ones that will follow the new fuel solution hoping for normal fuel prices in near future.

The debates are intense and some predict disastrous conditions if not install scrubbers while others take things more from a distance point of view or – seeing and doing. Financial institutes are involved and green technology/politics are promoted through the system's installation. New opportunities and re arrangements in the market for the companies expected or just wishing contributes to an uncertain environment.

What is more, the scrubber solution for the compliance with the new regulation has created new tendencies and opportunities in the market that are uncertain if succeed or fail.

1.1.6. THE IMO REGULATION

As per in all cases the IMO is working constantly on the way of reduction of harmful results from the shipping industry in air and sea. The Marpol Annex VI was an early adopted regulation aiming for the reduction of emissions and methods to control the air emissions from vessels, namely the Sox NOX, VOC, ODS, emissions from incinerators onboard vessels. These are related with the environmental impact, the human health and global air pollution. The Annex VI entered into force on 19th May 2005 and it's revision with stronger requirements was adopted in October 2008.

The regulations came into force since 2010 and amendments were adopted since then adopting new ECA areas and stricter control rules as well as the energy efficiency requirements.

In the latest version adopted, the contents of vessels' fuel oil sulfur content is deteriorating from 3.5% m/m as it is until today to 0.5% m/m from 1st January 2010.

As per IMO's targets, that change seen as a further improvement to the already strict rules resulting a better environment, reduction of pollutants and improvement of health for the populations. The implementation of the new 0.5% rule is unavoidable since it was decided to be implemented in 2016 by Marpol parties. In case some member would like to propose an alternative date or else, then a proposal should be submitted by a member state at least 6 months before implementation. The proposal would be discussed by the member parties and if any regulation decided to be adopted (or any change, postponement) should be announced and implementation of any amendment will be in force at least 16 months after adaptation. Although legally there cannot be any change in implementation date, there is always a provision for any probable postponement due to serious reasons e.g. in this case unavailability of the appropriate 0.5% FO, which will be submitted from the technical consortium of the member states in cooperation with external technical

bodies e.g. Classification Societies. The IMO's MEPC 70 in October 2016 decided, after studies on the availability of fuels, that implementation date can be 1st January 2020.

Under the new regulation all vessel will have to comply with the new sulfur limit and use fuel oil of 0.5% for the main engine, auxiliary engines and boilers onboard (including incinerators). Exemptions are granted in cases of danger of the vessel or saving life at sea or at any case where the ship's equipment is damaged. Special permissions by flag administration can be granted for the use of higher sulfur content fuel in the case of scientific or technological approved projects aiming for the reduction of emissions or engine technologies. Vessels can obtain even lower emissions if using alternative fuels as described, referring to methanol, L.N.G. etc.

Alternative method is also the exhaust gas cleaning systems named scrubbers which are approved by flag administrations. After the implementation date, vessel using the compliant fuel must state in their BDN's the content of sulfur in the bunkers received, the IAPP certificate will incorporate section mentioning the sulfur content fuel that vessel is obliged to use. The Port State Control around the world can use extended approved methods for the controlling of emissions from vessels approaching their territories. Similarly Port States or Flag Administrations can apply penalties to the violators. Relevant guidance for the implementation of the 0.5% m/m limit has been released by the IMO's sub-committee on Pollution Prevention and response. Assessment must be submitted to the administration of vessel, incorporating all actions taken in order to accept the new fuel. Furthermore all preparations and risk assessments must be clearly stated by the vessel in order to prevent any pollution and damage to the environment as well as the protection of life at sea. Change over plans and tanks segregation is submitted to the administration and verified by external body for adequacy. Unless the vessel is equipped with a scrubber system, prohibition of non-compliant 0.5% fuel is imposed. Samples and testing are incorporated in order to ensure the compliance. Those using an exhaust gas cleaning system, must make sure that maker and specific type is approved and certified by administration bodies and Classification societies. Onboard testing will lead to certification and approval of the system as using scrubber able to reduce the SOX emissions as the Annex VI describes. Regarding the fuel oil availability, IMO has taken measures in order to ensure that member states and the industry will have sufficient time to have available quantities with specific quality of the new fuel in it's ports and terminals. Relevant circular for the assurance of the quality of bunkers taken on board, has been released by MEPC and MSC 101 and has been distributed. The ECA areas under the Annex VI are the Baltic Sea, the North Sea, the North American area (USA and CANADA coastal areas) and the U.S. Caribbean Sea. The fuel intended for these areas is the same as used today with 0.1% m/m of sulfur content. (IMO 2020 sulfur limit FAQ, 2019)

1.2 WHAT IS A SCRUBBER –EXHAUST GAS CLEANING SYSTEM

1.2.1. FUNCTION PRINCIPAL

Basic principal of scrubber or more scientifically Exhaust Gas Cleaning Systems is as it implies the cleaning of the exhaust gases of the internal combustion engines onboard vessel plus the gases produced from the heating of boilers either Auxiliary or Composite.

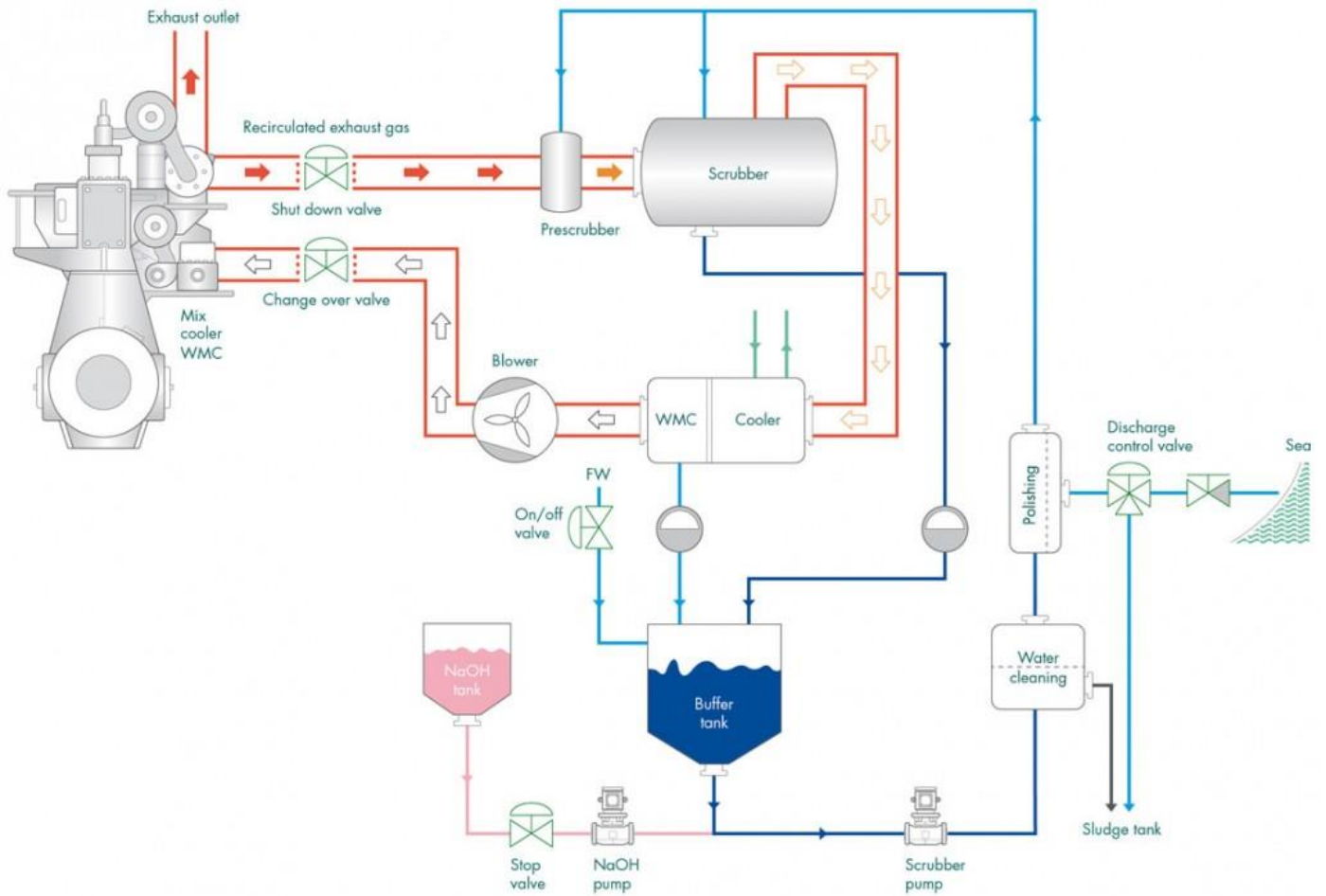
Internal combustion engines onboard a vessel are the main engine and the auxiliary engines mainly. The usual arrangement is 1 main engine and 3 auxiliary engines for the vast majority of vessels now sailing. Of course there is the increase of electro-propulsion systems such as in modern LNG/LPG carriers that may include more than 1 main engine and more than 3 Auxiliary engines. In any case whichever is the arrangement and combination all such engines produce gases that include sulfuric substances released in the air. Those gases are the result of burning fuel oils (any kind) and only the percentage of sulfuric content plus the condition of engine's components signifies the content of sulfur oxides percentage in the exhaust gases. Boilers have similar function that through burning fuel oil are boiling water inside the boilers producing steam for the needs of the vessel such as cargo or fuel heating. The exhaust gases are directed in same way to the scrubber too.

The main concept of Gas cleaning is very simple and implicates a washing procedure of the gases with water spray, reserving the sulfuric compounds leaving the rest of the gases to flow and be released in the air free from them.

The compounds are collected in a tank and either hold there or directly discharge in the water.

The whole process will need a washing tower where the water spray of gases will take place, the gases directed to the tower, pumps for water, maybe a cooler, sensors and other components that control the effectiveness of the system, sending indications, reports and alarms as necessary. At this point is worth to mention that through these control systems authorities and owners are able to make controls and ensure the correct function of the system. In case of outside the limits result then penalties are implied.

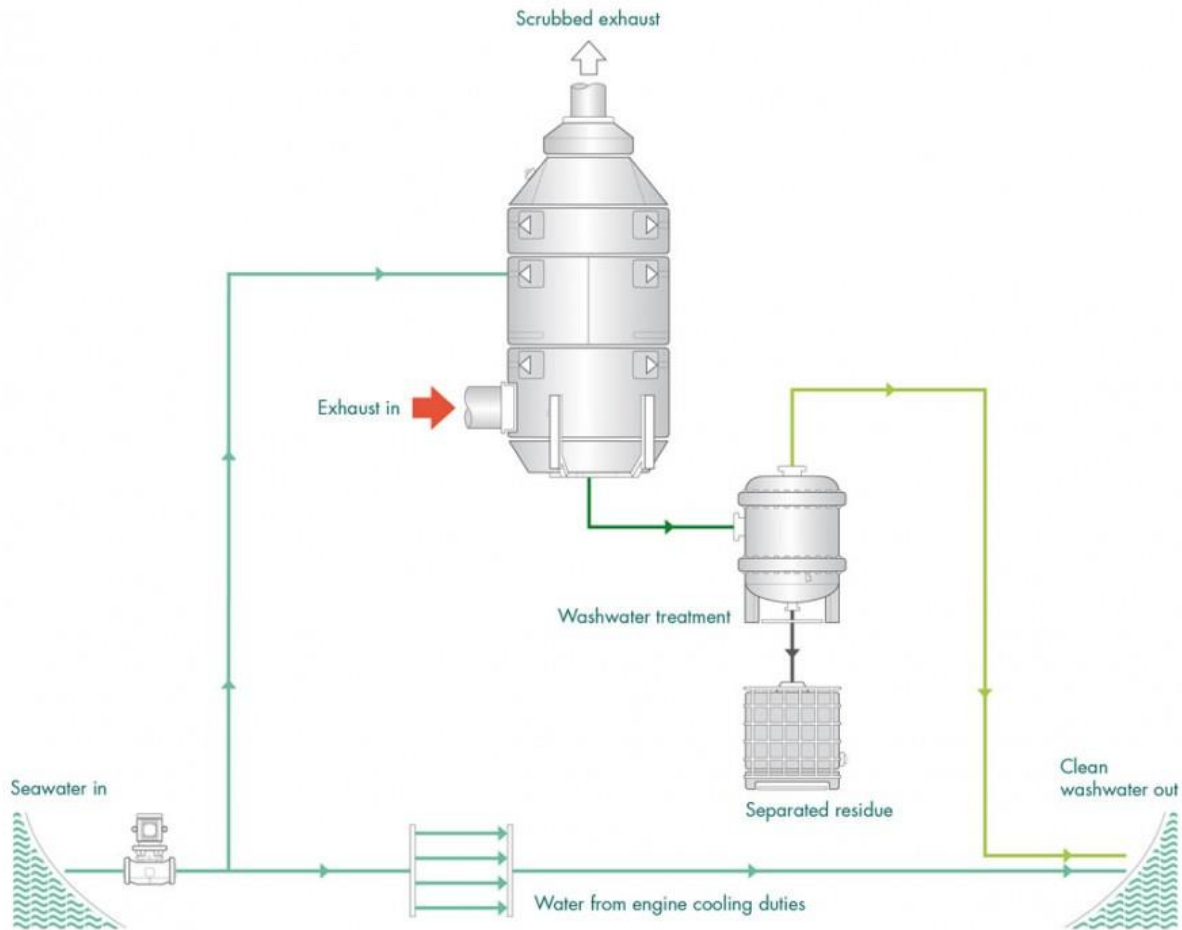
In modern marine installations there are 3 basic distinguishing types based on the way they handle the residues from cleaning of gases and 2-3 different types referring to the way the exhaust gases are directed into the scrubber unit tower.



1.2.2. TYPES OF SCRUBBERS

1.2.2.1 OPEN LOOP

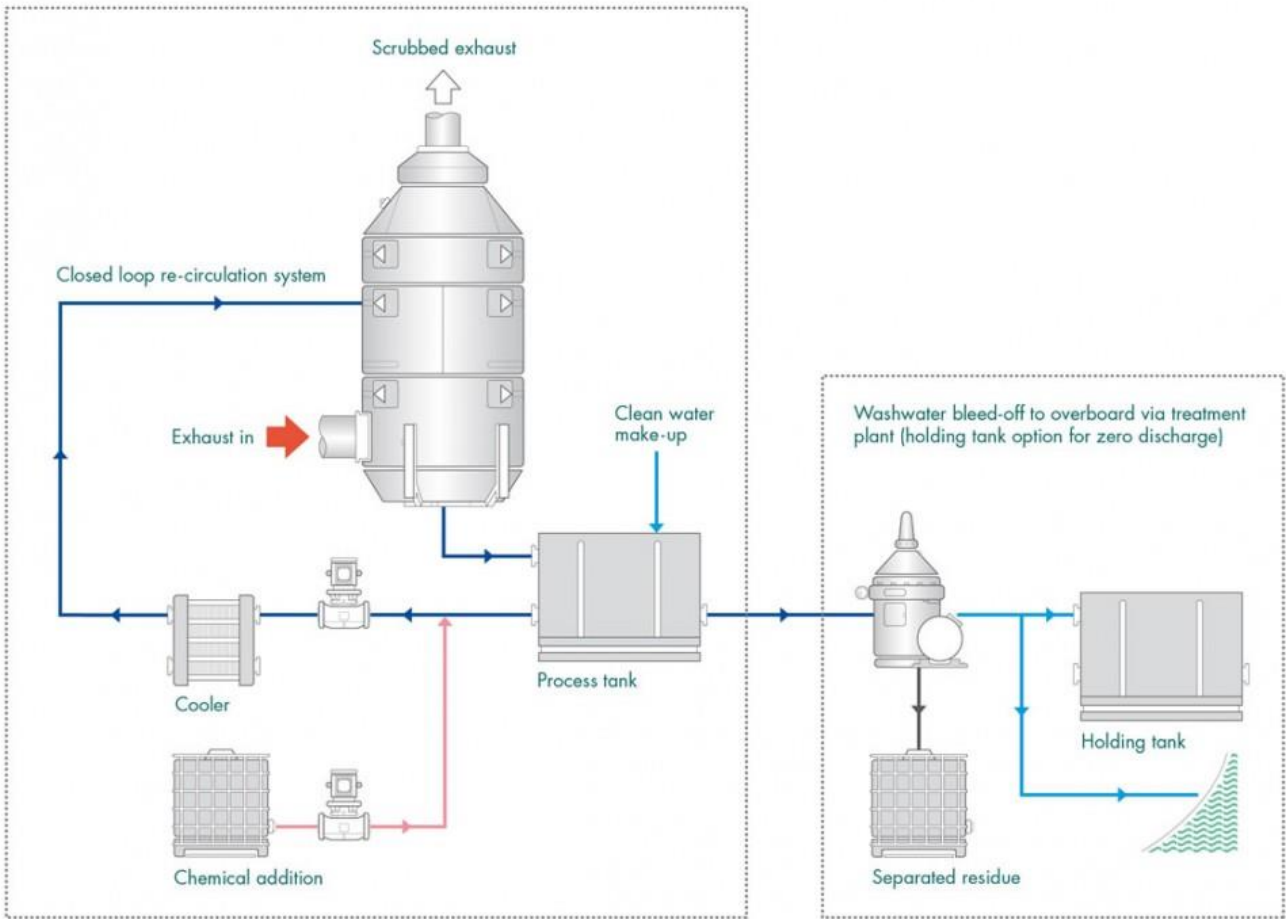
The simplest type is the open loop type referring to the way the water washed exhaust gases are directed at sea after the procedure has been completed. In the case of open loops the water is passing through a cleaning tank that has limited holding capacity and discharges the residues immediately at sea (see below scheme)



1.2.2.2. CLOSED LOOP

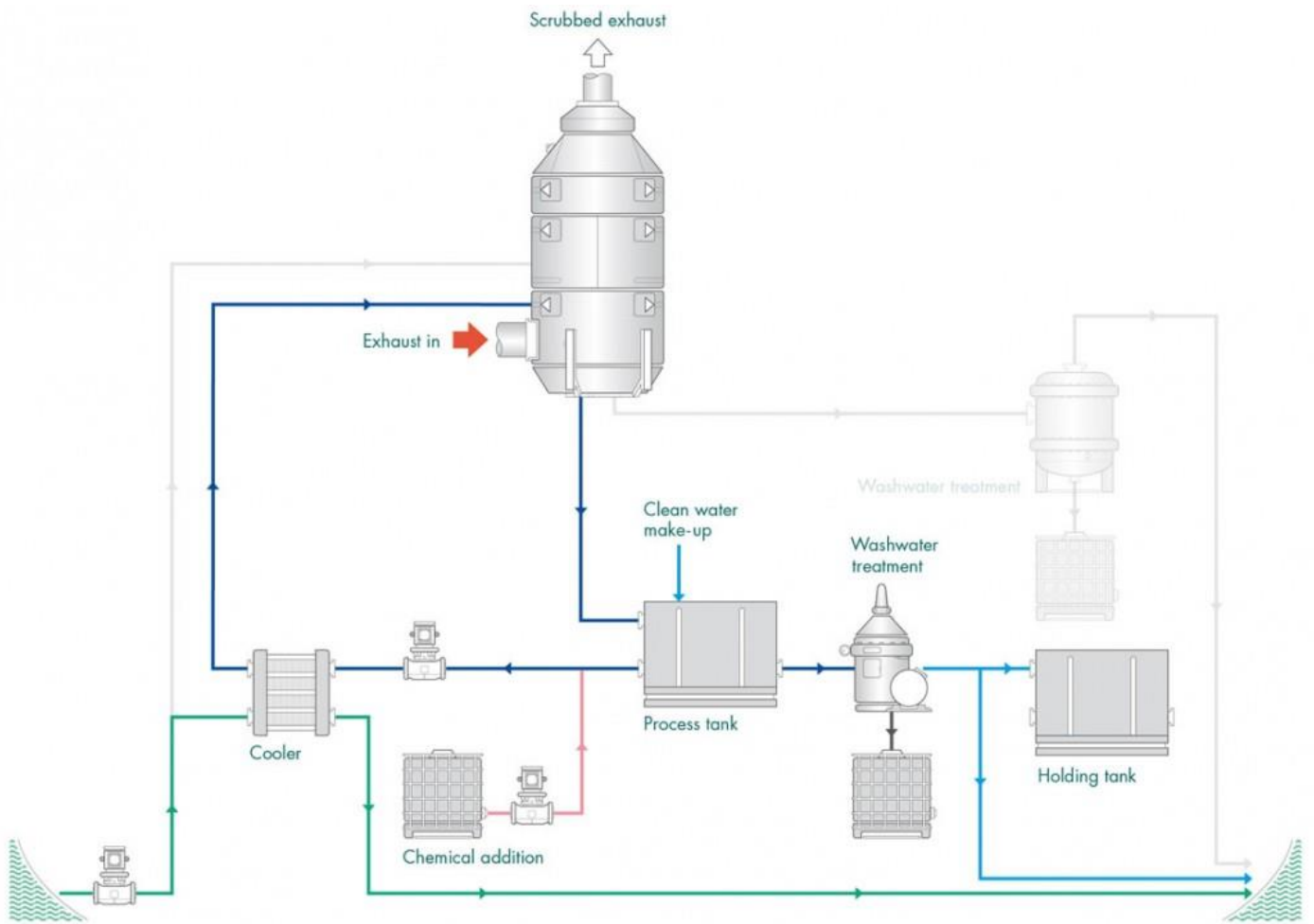
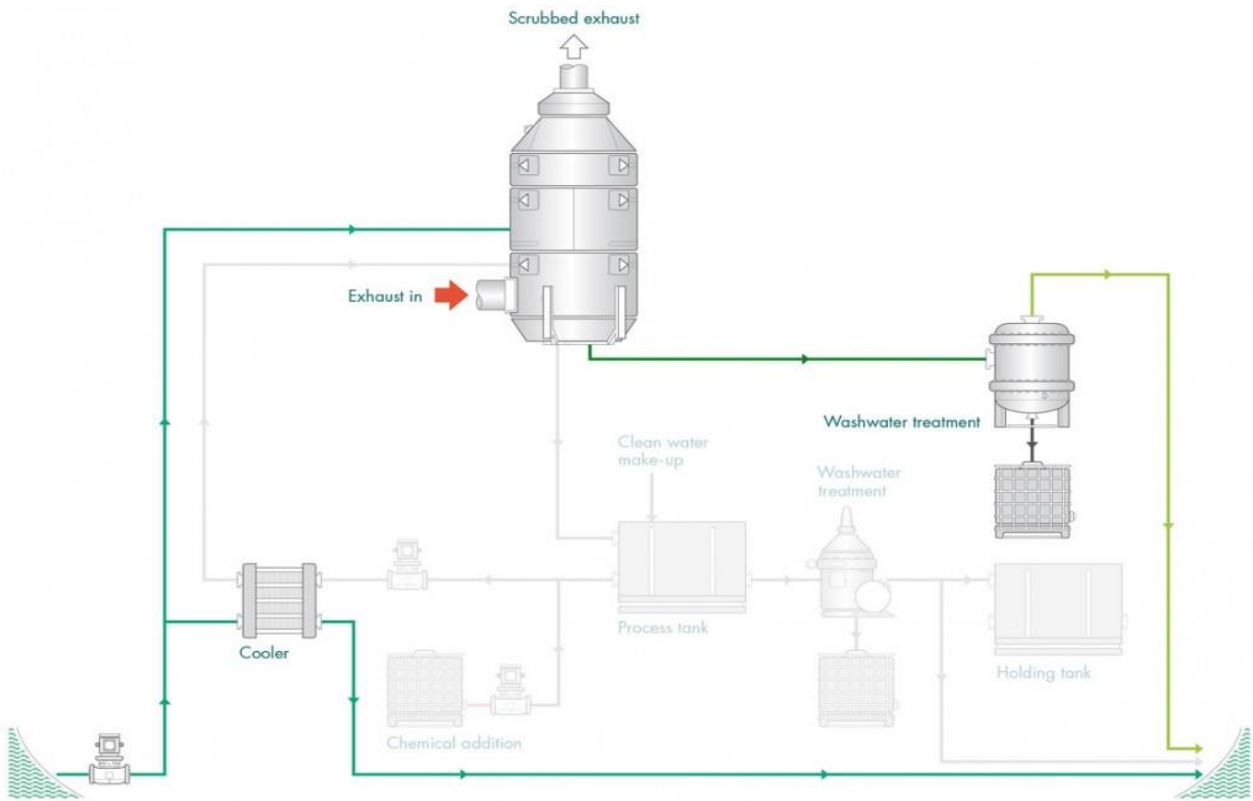
The closed loop is based approximately in the same concept but with the ability to keep the cleaned water in a special dedicated holding tank. Residues after separation is again kept in a holding tank and is discharged at shore facilities.

The water after cleaning through chemical and mechanical separation and treatment is re used for constantly. There is always the ability to replenish lost water due to various reasons. The water can be held in the holding tank or being discharged in facilities. This type is slightly more expensive than the open loop and it needs installation of separator, pumps, cooler, tanks etc. not to mention the increased automation and control systems necessary.



1.2.2.3. HYBRID

The last of the 3 basic types is the hybrid type that incorporates both of the open and closed loop systems in the same system giving alternative variation of use depending on the area of discharge and relevant restrictions.



(Sargun Sethi Marine insight, October 20, 2019)
 (www.egcsa.com-technical gallery, 2019)

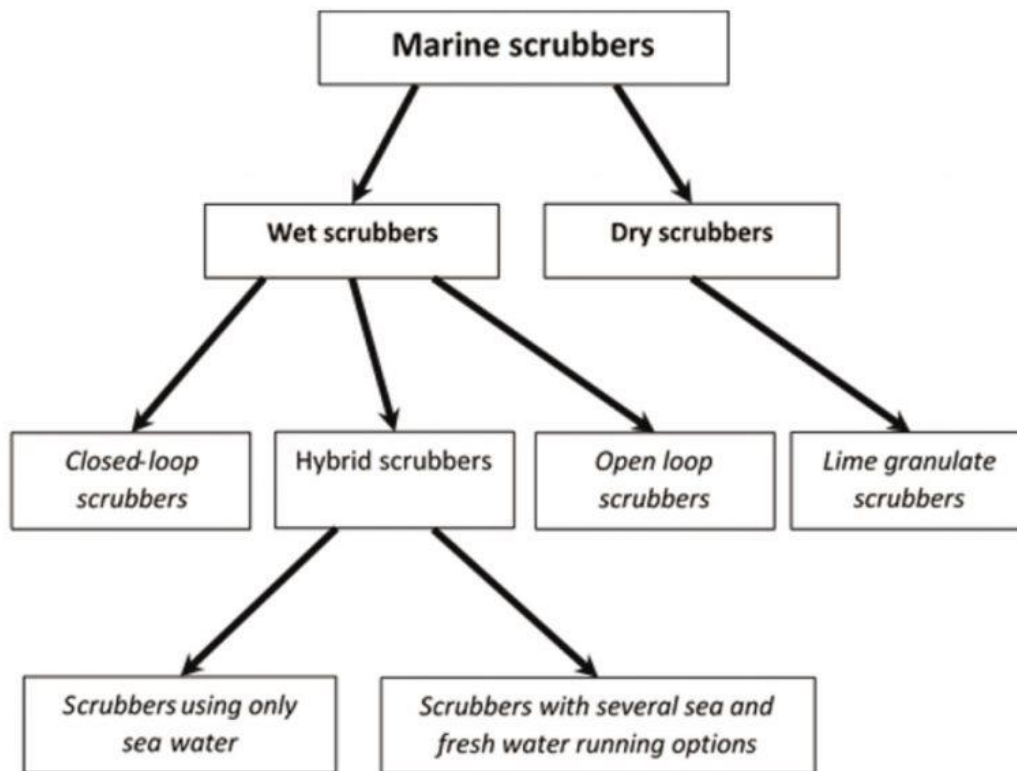


Figure 1: Classification of Marine Scrubbers based on their operational principle.

[www.egcsa.com-technical gallery,2019](http://www.egcsa.com-technical_gallery,2019)

1.2.2.4. IN LINE - THROUGH

Other sub categories of scrubbers are based on the arrangement of gas flows.

The simplest one is the through method meaning that gases are passing directly in line with the exhaust pipes of the vessel. That method is the cheapest one and it was initially the most preferable. Several tests and under actual conditions showed an increase of gas backpressure, and concentration of corrosive remaining of the wash waters leading to corrosion of the bottom plate of the scrubber tower. Furthermore wash waters were reported to return to the main engine exhaust pipe leading to corrosion phenomena too.

Of course industry developed new materials more resistant to corrosion and redesigned the original flow through systems.

1.2.2.5. U TYPE

Another type is the u type based on the concept of side entry of exhaust gases into the scrubber tower before the nozzle field. By having this arrangement the backpressure of the gases is eliminated and the wash waters are concentrated inside the bottom of the scrubber tower initially and then drained to tank or sea through dedicated piping system. It is a more advanced system that again needs corrosion resistant materials for the bottom of the scrubbers and has an increased price due to the fact that this area is constantly under corrosion attack.

1.2.2.6. PARALLEL

Some companies have developed their own systems that are based on the previous 2 basic designs but bear characteristic unique features. These are usually more expensive versions comparing to the previous two.

1.2.2.7. SCRUBBER MAKERS

According to EGCSA there are 24 Scrubber maker members from all over the world.

Most reputable are Wartsila, Alfa Laval, Yara, Feen and a list is complemented with other smaller companies.

The first 3 companies cover more than 50% of current production and demand of the market with rest following.

Some of them have developed their own technology of exhaust gas cleaning and others use the standard wet or dry arrangements and principals.

1.3 ALTERNATIVE CHOICES

Scrubbers are basically small refineries onboard vessels cleaning the residuals from the gases and sulfur substances instead of doing so in a refinery at an early stage. By doing so industry has transferred the obligation of reduction of sulfur content to the vessels by installing a cleaning system. The cost of the sulfur reduction now is transferred to the ship owner and finally to the customer. By this way the fuel industry is keeping prices of HFO in normal levels, since it would need extra cost of transportation to the refineries and back to bunkering ports. Even if such a system cleans the gases, the residues from the process must be disposed off, either at sea or at shore facilities for further treatment. Indeed it is achieved the controlled emissions of sulfur origin but pollution of the environment is still apparent.

In any case the production of the new fuels has an environmental impact at the refineries since more energy will be consumed and more emissions will be released in the atmosphere just to produce this environmentally friendlier fuel.

1.3.1. MGO

In search of available alternatives in the market, in order to avoid the uncertainty of an investment such as the exhaust gas cleaning system installation the shipping industry will tend most probably to other alternatives. Those worrying about the results of applying either new fuel type on their main and auxiliary engines or install a huge device worth some millions without guaranteeing a result and with uncertain return period of investment, tend to adopt the MGO solution.

This fuel is already in market for a long time and tested in actual conditions. No matter what problems appear every now and then, ship owners, engineers and captains seem to trust this fuel alternative more than a new type that most probably will create problems while in use.

The MGO is a light distillate and therefore of better quality. It has a good combustion behavior proved in almost all marine diesel main and auxiliary engines for more than a decade. Furthermore it has a sulfur content of 0.1% placing it at the top of the environmental concerning minds. Despite the good features it comes in an expensive price that can be even 50% more than the HFO according to today's market prices. So there is a known risk that actually it can be easily calculated by the ship owner.

The conservative strategy recommends minimum risk taken until we see the first results of the industry's innovations. Furthermore by that they are avoiding the children's illnesses until all cures will be found and applied.

The almost double price it can pose a negative perspective but comparing with the alternatives it can be more reliable and less costly at the end of the day. Thinking of the spread between the ULSFO and HFO and the possible or probable estimated problems resulting costs, additional spares, delays etc. it might come to the conclusion of equal cost in at least 2 year time but with minimum or no surprises.

In the case of scrubber installation the costs might be the same until the repayment of investment meaning 1.5 to 3 year time depending on vessel's type etc.

Again the risks are less comparing with the scrubber installed vessels. Furthermore it guarantees that even if more strict regulations will be imposed, MGO will comply and these are the really good news. Another considerable aspect is the availability in all ports which makes it again a trustworthy option of main fuel.

Price range of MGO at major port hubs may range from \$584/mt in Singapore, to \$563/mt in Rotterdam and \$684/mt in Fujairah and \$625 at Las Palmas.

1.3.2. LNG

In search of alternative fuels ship owners together with shipbuilders have opted for other alternative fuels, with considerably less environmental footprint.

One increasing in popularity option is LNG as main fuel or alternative and in combination with existing ones. In recent years the increase in demand of LNG is obvious. More vessels are ordered with engines that can burn LNG solely or as an alternative with other fuels. The new LNG carriers, a market that expands significantly have this option burning LNG from the cargo tanks making them quite economic since LNG as a fuel is about 20% cheaper than HFO. In the newbuilding stage it is much easier to apply such an alternative although still expensive. The new engines that will be selected can have this option if ordered like this or can be modified by maker with replacement of specific equipment and engines' parts. The sulfur emission regulation is covered completely by the burning of LNG making it a clean choice. However, the lack of extended bunkering network it is making it a difficult to find fuel. In case of an LNG modification of Main Engine and auxiliaries, the cost can be equivalent to a scrubber system. However it is a tested fuel, with no significant problems and reliable. The cheaper price is making it attractive to ship owners that want to avoid the unpleasant surprises of high fuel prices. At the moment an average global price can be set as \$520/mt. Still prices are not the only factor involved as many technical issues of the way LNG combustion and carriage are playing a significant role.

1.3.3. SLOW STEAMING

Other options that have been proposed but still not considered as a mainstream alternative include slow steaming. It has been proposed by several Greek owners (T.Veniamis, 2018-2019) as an environmentally friendly and cost effective alternative to the existing proposed alternatives. So far no positive reactions have been raised. By slow steaming the total gas volumes are reduced exponentially resulting footprints that match the IMO Sulphur cap regulation numbers. No any major modifications are necessary. It has been used many times in the past and the negative aspects are already known. It is therefore easy to predict and take measures against the negative results such as lubricity issues, cat fines etc. Furthermore the market at least of the bulk carriers and tankers are all well aware of slow steaming and at some points it is requested by charterers due to reduced costs.

1.3.4. DUAL/TRIPLE FUEL

Facing the challenges of the new fuels vs scrubber fitting, engine makers, shipbuilders, shipowners and operators have pushed the technological advances further more requesting for more alternatives. The ones existing are convenient for time being but cannot ensure the constituency in the forthcoming decades given legislation updates concerning GHG and environmental issues. Engine makers (MAN-ES, 2019) have taken into considerations all the skepticism of the market, the requirements by shipyards and Classification

societies. Their engine making experience on alternative fuels has given a rise in the Natural Gas (methanol)/Propane Gas (ethanol) internal combustion engines combined with MGO and Bio Diesel/Ammonia fuels as alternatives or complementary. More over the biggest marine engine builders have a lot of experience in propulsion systems in LNG and LPG carriers that due to the nature of their cargo, have combined the Natural/Petroleum Gas as the main type of fuel burned in their engines while a smaller amount of MGO is used as an igniter inside the combustion chamber. Such engines are called dual fuel or triple in case they can burn other fuel as alternative such as ammonia or biodiesel. There are two main types of such engines the high pressure following the diesel cycle with higher Capex (for a Suezmax tanker difference of price with Otto engine could stand between \$600.000 to \$2 millions) (MAN-ES, 2019) and lower Opex and the lower pressure engines of Otto cycle with lower Capex and higher Opex. As the alternative fuels have their advantages and disadvantages. As main advantage can be considered the compliance with the 2020 sulfur cap and the avoidance of any new fuel implications as already described (instability, compatibility etc.). As disadvantage can be considered the increased purchasing/installation price of such an engine comparing with a normal diesel engine and the limited network of suppliers plus technical issues of gas burning in atmosphere, increased fuel tank capacity to accept the extra gas as fuel reducing space and volume of cargo carried and many more.

In any case it is a technology appreciated and increasingly demanded by the market steadily.

According to well reputable engine maker study on suezmax tanker, the cost of fuel for such engines (methane and mgo as pilot) range between \$4.1 to 4.5m/annum which can be competitive at the time being comparing with exclusively MGO or VLSFO used. (MAN-ES, 2019)

1.3.5. NEW VLSHFO

The main competitor of the HFO/Scrubber solution is the new type fuel of 0.5% as imposed by relevant legislation. These type of fuels are consisting of different types of distillate blends or residual fuel blends. Cat fines are the least to consider although exist in high quantities depending on the method of production. Cat fines create problems in the main parts of the engine leading to frequent failures. The compatibility between different blends if in any case/anyhow mixed even in small quantities, is the biggest issue that everyone is concerned about in shipping industry. In case of a non-compatible blend mix then the resulted fuel can clog the main engine and auxiliary engine filters leading to M/E /A/E failure instantly. The way to process the new fuel blends is same with HFO/MGO, depending on many factors but the results are still uncertain. An ISO for such fuels is not available and will not be at least for the first months/couple of years. That is a major drawback for owners willing to invest in the new type fuels. The main positive aspect will be the widespread availability in supply chain all around the world in comparison with the still unknown availability of HFO.

CHAPTER 2 - INFLUENCE IN THE SHIPPING MARKET

2.1 HOW WAS ACCEPTED BY THE MARKET

Every major change in the shipping industry is welcomed with skepticism rather than pure enthusiasm. By the time of announcement by IMO the intention to change the Sulfur emission limits by reducing the sulfur content in the fuel oils of marine/shipping industry, everyone was believing that such a major change it will not come too soon. So no one was really worried that it would be obliged in a short time to follow the specific rule. Surprisingly it was adopted and deadline arranged for 2020 without any extension period and without any flexibility. Having the example of BWTS and the long period for implementation plus the extensions granted, this 2020 was a big shock finding others unprepared and others had already taken sides. Moreover the blocks or groups of interests if somebody can say so, had different strategies, different approaches based on their interests and obligations.

The Greek group could be described as a conservative group following the changes and adopted with slow tempos. That strategy has been proved for decades very efficient since Greek companies avoid to take the risk and pay the price of failures of new systems and rules.

From the other hand the North European group (if exists such) including Scandinavian companies and German companies are more positive to environmental rules and regulations adoptions. Furthermore the groups of companies belonging to shareholders, funds, consortiums appeared positive to “green” changes for marketing reasons.

The far-east companies meaning the Japanese and Chinese companies although skeptical they have similar approach but for other reasons. For seeing an industry explosion that will benefit the shipping industry of their countries and having direct access to scrubber makers and shipyards they see a positive outcome from this new regulation.

2.1.1 THE GREEK SHIPPING COMMUNITY

The Greek group consists of some hundreds of small to medium size companies with fleets of 1 to a few 10ths of vessels mostly bulk carriers and tankers.

Been in a competitive environment that demands excessive investment on existing vessels resulted a negative view of the idea of scrubber retrofit.

The cost of the system plus the drydocking plus the off-hire period plus the potential problems plus the necessity to burn the new fuel with high prices in case of system failure, has supported this negative view. In many cases the Greek companies are self-funded since decades or have already a bank loan struggling to repay in a devastated shipping market after 2008 is not an option and can be proved catastrophic.

The cases of loans are prevailing due to the fact that after the 2008 funding was really difficult to find and when found terms are unfavour. Markets have not fully recovered and even if increased comparing to 2008, still are not that profitable.

Adding the fact of high competitiveness since many vessels exist but cargoes are not covering the available deadweight, investing at least \$1 to \$7millions for just one ship sounds out of any logic.

On the other hand the price of the new fuel oils have not yet been stabilized or even presented. In any case the price will be somewhere around MGO and HFO of the market. Some arguing for even higher prices but still no proof. This risk can be undertaken by the majority of the Greek ship owners since as with any change, the market will sooner or later will self-balance. This would mean that prices will reach a normal range meaning acceptable range in the forthcoming few years after the implementation. Hoping that market will find it's pace as per previous cases they are reluctant to proceed with the exhaust gas cleaning system installation no matter what the marketing people present.

Another smaller but more influential group of Greek interests shipping companies, are those having a shareholders base or they are in stock exchange markets or they are big groups or mergers or simply having a profitable long time charter with a charterer demanding a scrubber installation. Those cases represent the minor but as expressed more influential core of Greek shipping companies seeing positively such an investment. Those are the ones presenting such an idea as brilliant and necessary, usually presenting the benefit of cleaner/greener environment with scrubbers' use.

After the realization of the BWTS installation, such a change came to short.

The majority of the Greek ship owners in the ship owners association are still complaining about the obligatory nature of this regulation that came into force too early leaving them unprepared (Charis Floudopoulos ,2019). Even those having a positive eye on the matter are complaining to IMO body for the limited time for decision. Since shipyard slots for such a retrofit project are not available and many shipyards are declaring fully booked for 2019 and some even for 2020, installation is not feasible on time. The extra expenses for burning compliant fuel until the day of retrofit increases the investment to high prices, resulting reconsideration if not cancelling. Furthermore the negative wing of the ship owners are worrying about the available HFO in the market after a few years since majority of vessels are not going to install a scrubber as the numbers show. That is a major drawback for the Greek ship owners that has a solid ground. Despite the assurance by the oil majors for continuation of HFO supply, no one is guaranteeing that HFO will be available at all ports and at quantities covering the demand.

2.1.2. GREEK COMPANIES WHICH INSTALLED OR WILLING TO INSTALL SCRUBBERS

Even though the Greek shipping community has accepted reluctantly the new IMO 2020 Sulfur Cup, indeed some of its distinguished representatives have changed their preference. This change of preference might not be reflected in the 100% of their fleet, however it was a big step towards the new regulation. Presenting some of the most influential Greek Ship owners/Greek companies such as: Seanergy, installing 5 S.Korean

made systems in Chinese shipyard on 5 cape size bulkers during 2019 at the cost of \$12.5m, with plans installing scrubbers to more of its fleet's vessels (Stamatis Tsantanis Jan.2020). In this project, charterers have undertaken the cost of equipment purchase and installation. Following Costamare equipping 5 of her post panama vessels of 5 and 6 years old vessels with relatively good hire of more than \$40.000/day.

One of the supporters of scrubbers, Mr P.Hatziioannou of Safe Bulkers will equip until end of 2019, 19 of vessels of its fleet with Alfa Laval scrubber at Cosco shipyards in China (Marcus Hund,Sep2018). The cost for each system is approximately around \$2m. It is worth to mention that sizes are post Panamx, Kamsarmax and cape size. Similarly another supporter of the scrubber systems Mr. P.Pappas of Star Bulk Carriers has taken the decision of installation of such systems on its fleet having secured finance up to 75% of the total cost from external resources and the rest by company's finance. The cost of installation is expected to be not more than \$2m per vessel.

Another distinguished shipping company, Maran Tankers, has already progressed the installation on 36 of her vessels namely Aframax, Suezmax, mini Capesize, Cape size and Vlcc's since 2018. The retrofits are planned to be carried out at Singapore, China Dubai and Qatar.

The more eco-friendly Dorian L.P.G company, has ordered and will install within 2019 7 hybrid systems on board her vessels. The vessels were designed so and were "Hybrid Ready" something that brought the cost of systems purchase and installation at the height of \$20m, which is considered relatively low comparing with other similar projects.

Followed but not limited to Capital Product Partners of V. Marinakis, has agreed and planned to install 14 systems in equal vessels. On 5 of the company's vessels, hire has been agreed with charterers to be increased by \$4.900/day and all vessels will be ready by end 2019/early 2020.

Delta tankers and Marmaras have agreed for 1 Aframax and 9 post Panamax vessels to be equipped accordingly with equal scrubber systems.

The list with the Greek Shipping Companies turning towards Scrubber installation is getting longer with highly reputable ship owners appearing in it. However at the same time a big percentage of these shipping companies keep a big percentage of their fleet outside the scrubber installation bet.

2.1.3. THE NORTH EUROPEAN SHIP OWNER COMMUNITY

On the other hand the group of North Europe are welcoming (in general) the idea of scrubber installation. It is not new to hear in the shipping market such reaction. North Europe is more prone to adopt new clean technologies and search for innovations leading to reduced energy consumption and preservation of environment.

The most reputable scrubber maker are companies of North Europe and that is not a surprise. Furthermore they cover the majority of demand which is again not a surprise. Trading of in the area of North Europe and the combination of Cruise Line industry in the ECA/SECA areas, has led the ship owners of the area to adopt earlier than others the scrubber system. Since the big makers are in the area it is much easier to communicate and adopt these new technologies.

The cost per unit for such an investment could be easily controllable with a good pay- back period limited to a few years subject to good programming. At this point it is worth to mention that local banks have products such as green loans for adoption of green technologies, helping companies that cannot afford such an investment.

It is true that even companies like Maersk were reluctant at the beginning to adopt the new trend and agree to follow. The adoption came finally and decision was taken for the installation of such systems in a percentage of their fleet's vessels.

2.1.4. THE ASIAN MARKET

The reaction of the Asian market varies and was really interesting showing the completely different approaches of each ship owner, country of the company, the fleet, the contract etc.

As of this year's announcements the Japanese Ocean Network Express shipping management and ownership (acting as operators) cooperative company (a cooperation of NYK, MOL and K Line), a small percentage of their merged fleet is going to be retrofitted with scrubber systems. This percentage represents a small fracture of the total fleet about 5% or less. In general the liner company decided to comply with the new regulation by using the new fuels.

On the other hand the Hong Kong based Pacific Basin company, running Supramax and Handysize bulk carriers has decided to install scrubber systems on the majority of their Supramax bulkers simultaneously with BWTS. The combination of the 2 systems installation runs from the existing plan of BWTS installation in pre-arranged period in order to comply with MEPC 6.

Company is expecting a seasonal share and a penetration in the market during the periods of bigger size vessel's retrofitting and the fact that bigger size vessels will become more and more expensive.

Yang Ming Liner company has decided to proceed with the new fuel use in order to comply with 2020 regulation despite the losses of the previous year resulting from high costs and mostly increased fuel prices.

The moves of each company is not following any particular pattern but still the majority has decided to follow the compliance through VLSFO use.

(Worldmaritimenews, 2019)

2.1.5. THE REST OF SHIP OWNERS

Other ship owners and major players in the market, are approaching with a different mind. CMA CGM, the 3rd largest carrier by capacity, is backing up the use of LNG. New 22.000 TEU vessels are built with LNG fuel burning as the main fuel. Other option is followed by HMM company while equipping her new built 20.000TEU and 14.000TEU with a mix of alternative fuel and scrubber fitted vessels. According to Alphaliner data (Lee Hong Liang, 2019), 35.7% of containerships in terms of capacity have been equipped with scrubbers. According to the same sources MSC is materializing the biggest scrubber installation project with over 200 vessels to be scrubber fitted. Hyundai Merchant Marine is following with over 50 units installed or to be installed in the forthcoming months. (Surabhi Sahu and Sambit Mohanty, S&P, 2018)

2.1.6. SHIPYARDS

One of the shipping market great parts are the shipyards either for repairs or newbuilding projects. The already acquired experience with retrofits of BWT systems in the previous years, has assist the repair yards to undertake more easily the scrubber installations. Such technical projects can cost from a range of \$100.000 to more than \$500.000 in a Chinese yard at today's prices excluding the design and relevant expenses in most of the cases. As it is announced by repair yards representatives, the tendency of installation has increased their booked slots for at least 6 months ahead. Technical issues with installation delay the process in almost all repair yards. The New building yards on the other hand are having a slower pace in implementation and that is because the decision of scrubber fitting is taken by the owner who orders the ship. Although big shipyards like Hyundai Heavy Industries in S. Korea have ready designs in case owner will order scrubber fitted vessel, it is quite difficult to predict the maker in case owner has a preference. It is usual practice shipyard to have one or two options of scrubber makers for each six of vessel. The difference in price could reach a few millions of dollars depending on the maker and if any additional modification will be necessary. In Any case as somebody may understand, a scrubber system can represent the 5 to 10% of the final price of the vessel and so every part is really concerned. There are no safe data showing any increase of demand in excess in scrubber installation except the already described. Some Japanese shipyards are not installing any scrubber although might be requested by the owner. This comes from the fact that the percentage of scrubber fitted vessels are a small percentage still so the investment in design and relevant modification plans and application by shipyard side will impose big costs.

2.1.7. WHAT IS THE PROFILE OF COMPANIES SELECTING SCRUBBERS

It seems at a first glance that companies with specific profiles have been interested to install scrubbers. At least at the very beginning the companies decided to incorporate such an innovation were the cruise ship companies, liners and huge engine driven vessels namely VLCC's and Cape size bulk carriers. Of course later on the preference for scrubber installation expanded to smaller vessels too. Big number of same type vessels under same company having long time charter contracts or having contracted with oil majors are some of the common profiles selected the exhaust gas cleaning system fitting. Some of the prevailing company/fleet profiles are as per here below:

2.1.7.1. THE CRUISE SHIPS

The cruise and passenger shipping industry has increased over the last decades. The demand for more products appealing to larger number of clients has led to the creation of the huge passenger/cruise ships everyone can enjoy watching or participating in many areas of the world.

Many of those destination and travelling areas, if not all, are sensitive environmentally and therefore cruise shipping companies are always called to be covered and follow the international or national regulations for environmentally friendly and low emissions technologies.

In such areas the MGO use is mandatory increasing furthermore the overall cost of bunkers since prices are equivalent with the new low sulfur fuels and always more expensive than the HFO.

Cruise shipping companies are the earliest adapters of the exhaust gas cleaning systems for that reason. They have led the market in the early days when still the 2020 cup was not even in the news.

Nowadays as pioneers they have adapted this and other alternatives for cleaner fuel burning such as LNG or combinations.

In any case the installation of a scrubber on a cruise or passenger ship is a must option.

Furthermore the existence of a scrubber ensures the lower cost of fuels all around the world, minimizing the really high costs of running especially for cruise ships. The HFO quality is standard and although problems appear now and then in some areas (e.g. Singapore) the average is trustworthy.

Another good reason of adapting such technology is the increased risks taken by a cruise shipping company. When carrying passengers, every major equipment breakdown can cost lives apart from the immediate economic impact. In the case of the new fuels, such failures of main engine or auxiliary engines can be considered probable resulting high risk. The risk management of such companies are taking seriously such impacts and the probability to happen.

Nowadays the orders from the cruise ship companies have been a standard and have been overwhelmed by liners and bulkers (namely cape size) and big tankers (VLCC's) (Rebecca Moore, 2018).

Keeping a steady number of newbuilding projects around the world the category of cruisers although pioneer, now left behind in matters of comparative projects.

2.1.7.2. LINERS

Another segment of the shipping market is the liners-containerships. Once the 2020 cap started most of the well-known liner companies such as Maersk, Cosco etc. faced the new trend with skepticism. The new data shows a tendency turning positive for scrubber installations. Although the concerns of these companies have not been withdrawn, the tendency is clear. As for numbers, the 16% of global fleet of containers have installed scrubbers as of May 2019. The number of scrubbers installed or ordered to be installed on liners is of 840 pieces.

As example EVERGREEN a containership shipping company from Taiwan has decided to install scrubbers on 20 newbuilding vessels of 11.000TEU with price of \$5 million per vessel. In the announcement of Chairman Mr. Anchor Chang to shareholders, it is stated that this decision is based purely on the rising oil prices. (Naftikachronika, 2019)

2.1.7.3. ENLISTED COMPANIES

In case of the stock exchange companies (see example of DHT Holdings) decisions are taken based on the proof and dedication to the shareholders.

Such an act enables a project study and strong proof that every step is considerably studied and results are trustworthy. In the example of DHT releasing memo to its shareholders it is clearly stated that company has decided to go on with retrofits and newbuilding vessels installed with scrubbers. But this does not come alone since bunker tanks rearrangement has been decided in order to accommodate more fuel types for the countries that will follow stricter rules regarding the use of scrubbers.

In any case the commitment to the shareholders is essential and must prove that the company is taking all steps to protect its shareholder rights, predicting all possible future regulatory demands.

It would be worth to mention the clear statement from the co-CEOs of the company that DHT is not for nor against scrubbers. It shows the criteria are more economic due to obligations than the investment itself, the environment or any other strategy detached from profits.

Similarly Evergreen announced to its shareholders the installation of 20 systems on equal number of newbuilding 10.000TEU vessels in Korean shipyards. The decision is based on the rising oil prices and the unpredictable tax impose by US government to Chinese imported goods to USA and relevant response countermeasures of US goods taxation by China.

As stated by Mr. Anchor chairman of the company, this environment is creating uncertainty in the market. In order to keep profits rising the scrubber installation was the best solution. Mr. Anchor is expecting return of investment in 1.5 years after vessels start run again with scrubbers. (Martina Li, 2018)

2.1.7.4. CAPES VLOCs AND VLCCs

Shipping market responds in a different way depending on the deadweight referring to. During latest years decisions have been taken by all companies. The strategy of the big iron ore companies such as Vale has influenced the market especially the VLOC's. In its recent change of policies and establishment of new strategy in the market Vale has decided to proceed with long term contracts with numerous operators of VLOC's in order to cover the demand of the market in Iron Ore products. Based on the contracts existing which in this case are of 20-25years, Vale decided not to act as an operator since the expenses appeared to be higher if compared with the ones of outside operators. In search of vital solutions and reducing the costs for now and the future Vale has decided to proceed with scrubber installation onboard 48 VLOC new-buildings in various Asian yards. With the long term LOA reached a more profitable environment that can secure profitability. The use of LNG as a fuel and a combination of scrubber equipped vessels will ensure lower costs of fuel.

Similar moves have been contacted by another VLCC operator CMES running a fleet of 49 VLCCs. As a part of the company's policy for environmental and fuel optimization scrubber units are going to be installed on 10 newbuilding VLCCs. (Jason Jlang, 2019)

It can be seen a relationship between VLCCs/VLOCs with long term contracts and scrubber unit installations. As it is obvious an investment at the newbuilding stage with a secured 25 year contract with Vale, is the best security for repayment of investment in minimum time.

One more thing worth to mention is the raised funds for fleet expansion and scrubber installation on existing or newbuilding vessels under the mentioned time chartered conditions. Funds can be easily obtained since securities can be more easily determined by the lenders. In case of a loan that is meant mainly for a newbuilding project time chartered, a scrubber loan addition is possible. Securities can be more easily obtained.

2.1.7.5. COMPANIES DEDICATED TO DIVERSIFICATION

Being a part of the very competitive environment of shipping, especially in periods of recession, it can be proved catastrophic for the shipping companies that are not accustomed to create and follow strategies based on facts. The market position is one of the factors contributing to the plan of the strategy, future goals, the position of the company, the fleet and many other influential issues. One of the strategies a shipping company can follow is the diversification. When challenges appear like the 2020 Sulfur Cup and a great change is imminent the decisions on which side should be, might be the key to surviving. No matter if an investment is secured or not, or based on own means or external contribution, the success of an investment is not always secured. By diversifying choices somebody can minimize the risk of both (or more) choices. As with many examples in the particular 2020 case, owners had made choices by installing scrubber systems in some of the vessels of their fleet. After studies and after a market thorough inspection, somebody can

conclude that equipping larger younger vessels with scrubbers might be much more profitable based on the increased consumption, the time charter contracts duration and terms as well as the routes intended. The risk taken is minimized to the units that are less prone to change environment and are limited in numbers in comparison e.g. with Handymax bulkers. Similarly diversification in selection of technologies can lead to LNG fuel burning, eco-friendly anti fouling paint and separation with diverse technologies, different makers for same equipment onboard similar vessels.

In case of a scrubber failure to hold the investment, that will not affect greatly the rest of the fleet. The choice with the least loss will have to contribute to support of the other system's choice. Many companies are dedicated to diversification in order to promote openly the technological improvements implementation in their fleet and the green technologies in particular.

2.2. MAIN REASONS TO SELECT SCRUBBER

2.2.1. PRICES OF NEW FUELS

The most concerned expense of a vessel, is the fuel. Either in spot or in time charter it plays a very significant role. The price of fuels is determining the freights markets and the final income for the ship owners.

At this stage the market runs under speculations and various information arriving from all parts describing controversial conditions.

According to bunkering market, the prices at this period in the major ports around the world are as follows:

BUNKER PRICE REPORT 04.10.2019

Worldwide Ports

Port Name	FO380cst	FO180cst	MGO	LSMGO
Busan	430	457	613	614
Hong Kong	489	500	605	602
Shanghai	491	502	687	742
Tokyo	457	458	661	742
Singapore	394	451	584	583
Fujairah	368	389	684	685
Jeddah	437	447	691	
Colombo	489	458	704	725
Gibraltar	410	458	623	617

Istanbul	386	471	669	666
Malta	404	430	616	612
Piraeus	356	389	643	635
Antwerp	319	348	563	568
Las Palmas	413	438	625	610
Rotterdam	310	382	563	564
St. Petersburg	261	384	564	555
Durban		409	739	772
Richards Bay	543			
Suez	383	420	694	665
New York	436	463	613	641
Los Angeles	419	447	615	635
Houston	410	451	616	629
Panama Canal	443	478	653	653
Montevideo	546	575	800	
Santos	424	432	744	

(Spectra Fuels - Bunker Price Report - 04.10.2019)

According to bunkering specialists the new fuel prices are and will be at least in the beginning, very difficult to predict their prices and the price differences around the world's most busy ports. This conditions arises from the nature of the new fuels. Blended fuels are deriving from different types of fuel having produced in different ways. The final result and relevant prices will be relative to the mixed types of fuel, their ratios and the area to be delivered.

Predicting their price is only through speculations and even personal assumptions.

What is now considered more widely acceptable reference price is a spread between the HFO and the new VLSFO of course on the high side. Others consider a similar spread on the lower side in comparison with MGO which is again an expensive fuel oil more exposed to more volatility than HFO and thus more close to characteristics with the new fuel.

In any case everyone is expecting an initial spread of about \$200 to \$250/MT which will be gradually and hopefully be reduced to \$50 sometime in the near future e.g. in 2-3 year time.

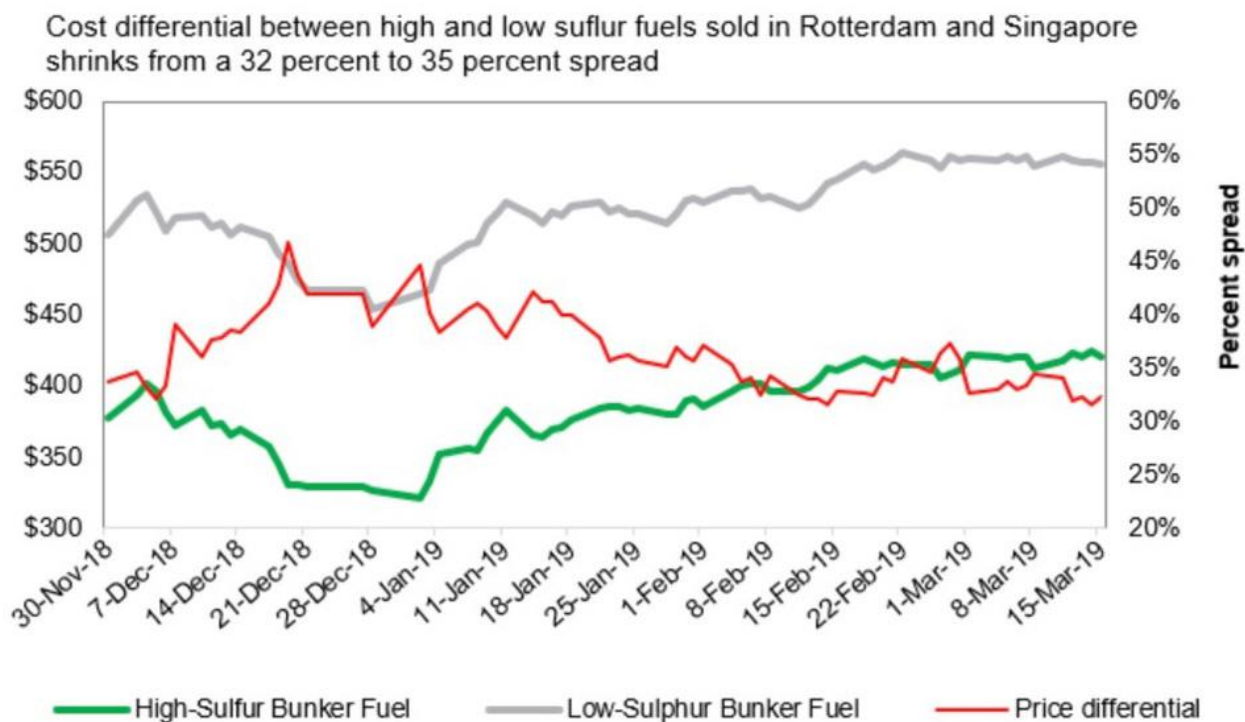
It is worth to mention that all these assumptions have a basis but no proof.

The demand of the new fuel is given since only a percentage of maximum 10-11% of the global fleet will have install scrubbers. That means the rest of the fleet is going to use the new fuel which will be the dominant fuel in shipping and therefore prices will be adjusted to the ones of the main shipping fuel.

Regardless of possible technical and supply problems that everyone is expected to face, everyone has

accepted the fact of this change. Some even speak for even stricter rules coming after the implementation and the initial failures recorded.

Shipping bunker market trades and consumes more than 250 million tons of bunkers per year. About 70% represents the HFO supplied and the rest is other distils such as MGO. The new Fuel will replace the old HFO for about 80% leading to a reduction of 80% of demand.



(Argus Media | © 2019 IHS Markit)

2.2.2. ALREADY SCHEDULED DRYDOCK FOR BWTS INSTALLATION

The shipping industry has gone through many major influences and adopts in the recent years. Apart from the 2020 sulfur cap, earlier obligations of shipping owners and operators was the installation of a ballast water treatment system. Such an installation process similar to the scrubber fitting, has influenced the whole schedule of shipping companies and shipyards worldwide. Needless to mention the amount of costs arising from the selection until installation and use of such systems.

The BWTS has similar needs of installation or even more in terms of preparation, 3d scanning, drawings approval and shipyard slot for dry docking. In order to be in compliance with the timelines imposed by

relevant regulations, all ship owners depending on their fleet characteristics have arranged relevant slot for the installation of such a system. The regulation referring to BWTS imposed the obligation to owners to install the system at first convenient dry docking.

Vessels need dry docking throughout their life time. Apart their planned dry dockings at special surveys in pre-determined intervals by Classification societies and flag administrations, there are other reasons too. Some of them is the retrofitting of the scrubbers and the BWTS. In case a company is already in the process of installing such a system and has already secured a slot, it is a good motivation to propose the installation of an exhaust gas cleaning system too. Considering the extra costs that could occur in case a wrong and out of time decision is taken for the installation of a scrubber, some companies had taken the advantage of an already secured slot.

2.2.3. COMPETITIVE ADVANTAGE

As reported by specialists in the shipping market, the installation of a scrubber system although seems challenging and it is indeed costly, however it is proved a premium advantage for the owners selected for it. As per all energy efficient, green technologies they are accepted by the chartering community with more positive results in aspects of freights and long term time charters.

The fact is that the regions that the trade is taking place for those selected the scrubbers have a demand for greener ships due to environmental concerns and the impact by local communities, governmental and intergovernmental authorities as well as independent environmental bodies monitoring all sources of pollution.

The impact of all the above bodies in the opinion build can have a huge impact on the commodities producers and distributors all around the world.

Furthermore the fines at all cases for the owners polluting can be significant and even can cost them their position in the area as major pollutant vessels which will not be preferred by charterers for obvious reasons. Furthermore a scrubber equipped vessel can offer cleaner services at lower prices since the HFO prices all around the world are lower in comparison with the new fuels.

By this is created a group of companies having an advantage in comparison with the rest that decided to follow the new sulfur cap of 2020.

Talking the numbers, according to MSI specialist (Will Fray, 2018) the time charter premium for vessels equipped with scrubbers can be for Capesize bulk carriers USD 12,100/day, for a Panamax USD 6,800/day, Ultramax USD 6,300/day and Handysize USD 5,100/day.

These benchmark rates are considered attractive for installing such a system since it covers well enough the whole project's financial and running costs aspects.

2.2.4. INCREASED AFTER SALES PRICE

The expected increased price as a second hand vessel is one of the main factors a ship owner considers when taking the decision to install a scrubber. The added value of a vessel is considerable factor by some owners. Especially when decisions are coming closer to the final date then all the scenarios and the future response of the second hand market is taken into consideration. By adding a scrubber on the ship's mechanical system it is that by many as increasing the value of their asset. This added value can be depicted in the immediate and future second hand market, in the contracts signed but still this cannot be proved. So far the second hand market has not faced an increased amount of scrubber fitted vessels on sale. So all the above can be considered well calculated assumptions.

It is globally assumed and partly proved that the most advanced vessels especially in the environmental sector are more preferable by charterers. In the long term this tendencies seem to work towards this direction. Owners of vessels equipped with scrubbers, are expecting a return of investment not only through increased freights due to the above mentioned tendency but also due to the aftersales preference for up to date vessels. The added value in the second hand market is obscured since subject case is still ongoing. However in comparison with older similar cases, a price difference of 1-5% in total price on the higher side can be achieved if vessel is equipped with latest technology and compliant with latest regulations. Similarly in newbuilding projects the price as sold during construction can be increased about 1-10% in comparison with non-scrubber equipped sister vessels.

2.2.5. GREEN TECHNOLOGY PROMOTION AND ENVIRONMENTALLY SENSITIVE IMAGE

Once a ship owner decides to follow a strategy towards green solution/ save energy, many consider the best solution at this moment is the selection of a scrubber system.

Those who believe that a scrubber system is more effective than the new Very Low Sulfur Blends are supporting their opinion on scientific researches and simple calculations that indeed have some basis. Norwegian and Swedish research laboratories have conducted studies regarding the Greenhouse gases emitted by vessels and the toxicity of effluent released by open loop scrubbers in the oceans. Both have come to the conclusion that either Greenhouse gases are reduced compared with the burning of low sulfur fuel oil and furthermore, the sea are not becoming contaminated with any substance, effluent or compound material from the direct release to the sea.

The promotion of their positions to their customers is strong and supports the green orientation. Charterers are always keen on protecting their interests against any ship owner that does not respect the environment, avoiding taking measures to avoid an oil spill, maintaining machinery for better efficiency and less emissions etc. These politics are well respected and promoted in the market since environmental problems created in a port or at sea might result fines by the local authorities. Avoiding detention for cases of any pollution type even black smoke for moments in a port nearby residential area might have a great impact in the ship owning company and the carried cargo. Numerous incidents have been recorded e.g. in Rotterdam

where just a cold starting of an auxiliary or main engine at MGO produces black smoke for seconds (a normal condition) and authorities have removed the vessel from the quay due to residents complains. The impact is further more severe in ECA areas, and special marine protective area, coral reefs etc. where the Environmental Organizations are struggling to keep a balance. Being disrespectful to the local environment shows disrespect to the local society and consequently that arises protests against not only the vessels visiting the area but also the product provider and the shipper. The impact could be huge under certain circumstances and even shareholders could be restrained from applying openly their trust by supporting subject companies involved.

The image can be hurt in cases of companies that use HFO even with scrubbers and they want to promote an environmentally concerned image to their shareholders and their customers.

The brand name of a company takes a lot of work in order to be built. Promotion in the market takes a lot of effort and investment. Shareholders are following and decide the next moves based on the presented evidence. Promoting a Green strategy and ethics as a strategy is a smart move in today's market that needs investments and proves. Taking the side of the scrubbers it might turn tricky. From the one hand it might show emissions concerns therefore satisfying the shareholders but from the other hand somebody might point out the use of the dirty HFO which sounds controversial with the general policy and applied strategy of the company.

2.2.6. REDUCED PROBLEMS WITH MACHINERY IN COMPARISON WITH NON-SCRUBBER FITTED VESSELS (USE OF THE NEW ULSFO)

In comparison with the existing problems of scrubbers, the market is predicting, that the use of new type fuels will result extended problems in the vessel's machinery. This comes not without grounds since every new fuel, especially of low sulfur and thus lower lubricity, is creating new problems that takes time to be solved permanently.

The New type fuels are blends that although the oil majors assure their combustion ability by diesel engines, still are not tested extensively and in volumes under actual conditions.

The noted and alerted compatibility between different fuels and stability issues can very easily lead to failure of major parts of Main Engine such as fuel pumps and that consequently can lead to shut down of main engine, auxiliary engines, subsystems' failures. This eventually leads to black out that could cause serious accidents or incidents at sea, at port, during operations or bunkering. This type of problems are considered more serious by far comparing to the problems connected with scrubber failures.

Some examples are the failure of a main engine fuel pump due to lack of lubricity, clogging of filters can cost technically a few thousands of dollars.

In the uncontrolled environment of the ocean it can cost tugboat services translated to several hundreds or millions of dollars and needless to say the ship itself if major items will fail.

The cost of repairs from a main engine specialist can cost tenths of thousands of dollars (can begin from \$20k and up to several hundreds of US\$ depending on the extent) and implications to the vessels obligations. The charter party obligations not met can be also translated into several millions of US\$.

2.2.7. DIVERSIFICATION

In the beginning of the Sulphur cap implementation preparations, many companies had their arguments which resulted negative opinion on the specific technology. Since a few years already passed and although still there is not the wave that many shipping factors were expecting, those shipping companies changed their strategy towards the technology and decided to fit scrubbers. This change of opinion is based on the concept of diversification of fleet as a strategy in general. The strategic decision of installing different systems (in this case scrubbers) on a percentage of someone's fleet, reduces the future risks. Especially in a very uncertain future market, this approach is the best, Of course somebody must take into consideration all the factors such as age of the vessels, charter party obligation, trading pattern, type and size of vessel and many more. By that saying the result can be the minimizing of losses from either being totally on the one or the other side. When the fuel prices will be high a percentage of the fleet will be running with HFO resulting a counterbalance to the increased expenses until oil prices will drop to more normal levels in comparison with HFO prices. Furthermore, the diversification strategy derives in some of the cases from the specific routes necessities and the availability of the new fuel in the region. In the case of specific routes such as inside ECA areas, then maybe scrubber installation is one way solution. In the case of availability of the new fuel in a specific region or the higher prices this will be given is a negative drawback directing to scrubber solution.

2.2.8. COMMITMENT TO SHAREHOLDERS FOR BEST ECONOMIC SOLUTION

Shareholding companies, related with shipping business as with all business sectors, are committed to their shareholders for best economic results annually. The constant annual positive results, are difficult to be obtained as somebody may understand. However the commitment is constant and solutions can be found through innovation, energy efficiency systems installation etc. Scrubber it is considered by a part of the world leading shipping influencers as one of the energy efficiency factors. Despite the initial investment, the savings can be huge due to the low price of the existing HFO as main marine fuel. The price difference is at some cases calculated even half of the new VLSFO, resulting huge savings from year first after installation and running of vessel. Furthermore if combined with a long term time charter, shareholders can be satisfied with positive results.

2.3. TENDENCIES AND CONTRACTUAL ISSUES IN THE SHIPPING MARKET

While many operators in the shipping market are expecting big changes and adjustments in the global shipping market, there are evidence that are controversial.

Traditional small shipping companies of Greece running fleets of older bulk carriers up to Panamax size are watching the changes without being able to react. Following and complying with the new fuel regulation through adopting the new fuel seems like the only reasonable strategy to follow. Self-finance of a scrubber system retrofit is not easy and bank loans are not easy to achieve when we are discussing for small fleets of some age. On the other hand companies with extensive newbuilding projects, listed in the NYSE are more prone to get involved. The market experts are isolating numbers when see a company's move. If 10 vessels out of 200 of a company are going to be equipped with scrubbers then this is the news. The information is spread in the market without taking into consideration the very important details such as the entity itself and organization that takes such a decision, the fleet characteristics, the timing for the specific company, their economic results and obligations/commitments etc. Seeing orders or intentions to order systems is characterized by some as a wave coming. A wave that none knows for how long and to which direction might go. The timeframe of scrubbers' existence in the market onboard the vessels it is strictly committed to the regulation it is serving. In case of stricter regulations then the owners will have to upgrade the system, at a cost if such ability exists in terms of technology and/or financially. In this equation we must mention the environmental factor since nothing is yet clear about the environmental footprint of the scrubbers. If new technologies appear in the market of prices of oil will steadily fall to reasonable prices then who is going to use the old controversial scrubbers is a question to answer. (GoltenS,27/10/2018)

2.3.1. THE INFLUENCE IN THE FREIGHT MARKET

Another aspect specialists and ship owners foresee is the shortage of specific tonnage (e.g. Capesize B/C's) for a specific period. During the installation and until the delivery of the vessel after retrofit, some 20 to 40 day might pass. The sea trials will reveal the efficiency of the system itself. Failing to follow the 2020 cap limits can and has already been reported, to repeat tests and adjustments until reaching those limits. The result is more idle days for the specific vessels and more hiring days for the free tonnage at the same period in the market. Furthermore the overbooking from 2019 till 2020 and maybe until 2021 will create a shortage of tonnage in the market that vessels with no scrubbers system schedule will take benefit from.

In any case the new regulation can lead to possible increase of scrapping older vessels with high consumptions and even boost the newbuilding sector with newer more efficient engines, readily for triple fuel including LNG.

Reports and estimations of market expert from Swiss Marine Mr. Joe Tobin the freight market will not face any disruption or surprises remaining unchanged from the new fuel change. The study is based on the existing orders of almost 300 Capesize bulk Carriers already ordered and will install scrubber system (Coaltrans Blog, 2018)

. This number represents a 22% of the global capsize fleet. The days of missing tonnage from the market and representing percentage will be depicted as 0.4% /week which it is obviously insignificant.

Expected Freight changes in the market after the implementation of 2020, are all subject to every owner's perspective. Taking into consideration each category's features and response to scrubber installation e.g. Capesize B/C's results may vary based on the factors involved. Majority of ship owners are using the spread between the HFO/IFO and the new VLSFO and that is only estimation, in order to evaluate their investment. Furthermore the spread is used to determine the freight height and how it can be shaped.

Based on the assumptions that the spread will be about \$200/MT for at least 2 years since implementation, freight rates are calculated. Result is that seems more profitable to install a scrubber unit which will be paid off in about 2 year time. (John Yallouridis, 2019)

Some shipowners and market specialists consider that the \$200/MT spread is conservative and might appear even close to \$600/MT. That would mean that the scrubber fitted vessels will be always busy at that period since they will be preferred instead of the more expensive running with VLSFO. Taking into consideration the percentage of scrubber equipped vessels of a category e.g. Capesizes from the about 2.000 Capes, a 22% will be fitted with scrubbers until mid. 2020.

This percentage is far less than the dominant 78% of the non-scrubber fitted ones that most probably will shape the freight rates. Given the price difference will be higher for the VLSFO then all freight rates no matter for scrubbed or not will rise unless the later ones will accept lower freights for their vessels in order to remain competitive. In any case the demand will not be covered by the 22% of the Cape's fleet.

The increased cost for the shipowner it is most likely to be transferred to the customer as it is always the case. Increasing the freights will create a new balance in the market as it was always the result. The factor that will most likely reshape the market balances is the fuel prices in depth of more 2 year time.

Regarding the tanker's sector and the world scale calculation it will be very difficult to define the right one based on the 2 basic (3 actually) fuels used.

Trying to predict the forthcoming demands in the shipping market is not 100% safe but can show tendencies. The major problems that appear due to tonnage shortage for periods of time, can be counterbalanced from an unpredicted reduced demand of cargoes due to slow economical growth of e.g. of China or the U.S.A. sanctions imposed to China, Russia etc.

2.3.2. THE CLEAN SHIPPING ALLIANCE

The new factors entered the shipping community has led many of the players and main formatters of policies, to form alliances in order to protect their positions and their interests. Shipping companies like Oldendorff, Star Bulk Carriers, Grimaldi group, Cargill and Greek shipping companies/owners/operators Chandris, Delta Tankers, Capital Ship-management have formatted the alliance named The Clean Shipping Alliance with the goal to inform and distribute to fellow companies, organizations, authorities and the

industry the results from the use of scrubbers onboard their vessels promoting the systems' installation as a green solution. The big support on the selection of scrubbers retrofit instead of refined products of Low Sulfur fuel oil is based on scientific studies showing that by adopting the scrubber solution, less greenhouse gases are emitted in the air by minimizing the refineries energy to transport, refine to Low Sulfur distillates and again distribute the products around the world. On the other hand other strong and influential companies and entities are promoting alternative ways to withstand the new conditions created. Such a major influencer such as Mr. John Fredriksen of Golden Ocean and Frontline and Trafigura (Soren Pico, 2019) which decided to proceed with the establishment of an as called "bunker venture" creating a global bunker supplier in order to cover the companies' fleet demand for steady supply of fuels. Furthermore such a strategic move will ensure that the quality of fuels provided in their fleet it will be the optimum since it will remain under control. As a long term plan, a bunkering supplier might mean that losses from wrong investments on the specific Sulfur Cap, might be compensated by fuel prices differences. Of course such an investment requires a good back up that Trafigura can provide. Other shipowners have in mind or already materialized plans to keep quantities of the HFO in bunker barges or bigger vessels, for future selling or use in their fleet. Depending on their pattern this kind of preparation can be considered smart, considering the availability of HFO in a specific area and relevant price difference if HFO will turn to be too expensive after some time.

2.3.3. BIMCO and INTERTANKO Q&A on Contractual issues on scrubbed equipped vessels

One of the sectors influenced already after the announcement of the implementation of the new regulation is the contracts and its effects. The shipping community has tried to find out the guidelines that will help them to approach more effectively the new contracts and deals to be agreed. As of that BIMCO and Intertanko had accepted numerous questions on fundamental issues when contracting which needed an answer. According to the Bimco and Intertanko release of contractual issues there are some basic guidelines categorized in 3 major teams: the General contractual issues the time charter issues and the voyage charter issues. All arising from the new regulation and the scrubber fitted vessels trend the answers are offered but all are subject to in this unstable environment.

2.3.3.1. GENERAL CONTRACTUAL ISSUES

Owners willing to install scrubbers onboard their vessels will have to bear the whole cost by themselves despite some time charter cases that charterers were convinced to undertake the installation cost after negotiations. In the case a charterer will require a vessel to install a scrubber based on the Elli and The Frixos case, as an argument basis, owners can still request the contractual worldwide supply of 3.5% fuel oil. In any of such cases there will be some kind of settling in the fuel oil price or the scrubber cost between

charterers and owners. From the part of charterer it is clear that no any lien over scrubber in the English law, even if contributed to the installation cost unless otherwise expressed in a contract. The responsible authority for the enforcement and control of correct application of MARPOL Annex VI are different in each country. In case of any incompliance fine imposed by a state over the ship then owners might be entitled to a charterer's indemnity. That is again on the charter party agreed. Another delicate but very important amendment is the carriage ban date entering into force after March 1st of 2020 and prohibits all vessels not equipped with a scrubber, from carrying fuel of more than 0.5% sulfur content. As it is understood, if any amount of such fuel remains onboard then should be removed incurring costs for the owner.

2.3.3.2. TIME CHARTER ISSUES

Clauses for scrubber fitted vessels should be approached in a sense of cautious including as General Provisions at least following recommended by INTERTANKO Bunker Compliance Clause for time charter parties or the BIMCO 2020 marine fuel Sulphur content clause for time charter parties. Furthermore the following items should be included and/or reviewed in a time charter contract: Full description of the scrubber system, with the maximum sulfur content fuel to be used (as given under guarantee by the maker even in cases of better performance at sea trials) and the relevant emissions to be released. The specification and characteristics of the system should be clear, substances necessary for the proper function of the system. For the cases of using off spec fuels (although clause should be entered as per previous above) fines imposed from authorities, detentions, removal of fuel oil in case of non-compatibility or other issues (non-compliance with Sulphur regulation). The fuel supplied must be in compliance with Marpol annex VI and local regulations and law. Relevant clauses under BIMCO and INTERTANKO recommended clauses should be incorporated. Special cases such as when a compliant fuel is causing damages would be wise to be incorporated and will be covered under the Intertanko Bunker compliance for Time charter parties and the BIMCO bunker quality and Liability The malfunction or complete breakdown of the scrubber and inability to use, maintenance cost allocation if scrubber was installed under the charterers or/and under owners finance, dry docking clause (include the scrubber installation and issues might arise from delays, malfunction, underperformance or else). Periods of maintenance can be discussed and agreed annually. For the cases of breakdown must be clarified if and how any days can be declared as off hire period. Vessel should be equipped with MGO for such cases too with spread of price of 2 fuel types bearing the owner. In case of no such provision then clause of consequences would be better to be considered. Performance warranties while vessel running with scrubber. Warranted speed might be influenced by the use of scrubber. Therefore provisions to be taken to ensure the underperformance will not breach any warranted speed or utmost dispatch provision. Disposal of waste responsibility including the time loss and all relevant arrangements and costs to be undertaken including cases of penalties arising from non-existing facilities in ports of call. Responsibility for provision of agents and chemicals in case necessary for the good

performance/function of the scrubber system, as well as their expenses and supply ports would be good to be clarified.

For the avoidance of any implications from non-compliant fuel used non complying with the MARPOL Annex VI reg.14 and/or18, provisions should be taken to cover the cases responsibilities in case of non-compliant fuel supply by charterers and/or allocation of fault (supplier/crew/charterer) in charter party.

2.3.3.3. VOYAGE CHARTER ISSUES

In the cases of scrubber breakdown or malfunction and consequent non-compliance with MARPOL Annex VI, owners will bear the weight of responsibility and consequently all contractual obligations if not otherwise expressed in a charter party. Such consequences are on the usual clauses to be met by the vessel such as the laycan, deviation for bunkering of low sulfur fuel and breach of utmost dispatch, about entering the port or giving valid notice of readiness, whether the laytime and demurrage runs at port. Similarly owners can confront a breach of contract for the warranted speed with consecutive risen damage claims from charterers and/or third party BoL holders. In the case of not available low sulfur compliant fuel at the bunkering port, owners should be ready to bunker MGO and running of vessel under such fuel until next port with compliant fuel. Expenses of course will be bore by the owners. Deviation clause should include a provision for such case. Relevant P&I club should be informed in advance about such deviation cases. For the case of malfunction of breakdown of scrubber the laytime, demurrage and force majeure clauses must be considered and reviewed. As general recommendations for ships equipped with scrubber, issues such as: Indemnity provisions for non-compliance covering loss of time, fines penalties, damages resulting from the non-compliance Liberty and deviation clause for cases of deviation for bunkering of compliant fuel or MGO and bunker adjustment factor clause should be reviewed.

CHAPTER 3 - COSTS INVOLVED AND INSTALLATION CHALLENGES

3.1. RETROFITS CHALLENGES

Given the choice to install an exhaust gas cleaning system in an existing vessel results more of just the cost of the system itself. From technical point of view although almost everything is feasible subject to good preparation in terms of complication, costs and technical issues, it is a challenging project.

After the selection of the system to be installed based on the type of vessel, size, trading pattern, market orientation etc. the preparation for installation begins with a technical study based on the preliminary

feasibility study provided by the scrubber maker at the early stages. The technical company usually an independent bureau will collect the system's drawings and the vessel's drawings making a preliminary study and giving a preliminary basic drawings portfolio. This is based on the specification agreed between maker and owner and preliminary result will be accepted by both parties subject to any comments and improvements.

3.1.1. COST OF A SCRUBBER

The cost of a scrubber unit depends on some factors such as size, gas flow type, general type (open, closed, hybrid) the number of units ordered, the time of the order placement etc.

The size depends on the engine, auxiliary engines and boilers size. More significantly the size of main engine plays the major role. Apart from that the main engine tuning (meaning in how much of the output percentage e.g. 75% the main engine is set to run at most of the times) the pattern of auxiliary engines use (e.g. while at sea maybe using 2 of the 3 at 60% of their output each).

That will finally give the volume of exhaust gases and the temperature of the gases.

This condition gives the flow of the gases and based on these facts the size of scrubber is decided and the mode of function.

Cost of a unit could start from \$1 million and can be up to \$7 million.

Systems from Wartsila and Alfa Laval are most expensive, comparing with similar systems of other companies offering their own developed solutions and being highly reputable.

Depending on the size of the vessel, the relative scrubber units of U type, from Chinese maker have indicative prices as follows:

VLCC :	\$1.9m
Suezmax:	\$1.6m
Mr Tanker:	\$1.57m
VLGC:	\$1.52m
LPG:	\$1.45m
Capesize:	\$1.54m
Panamax:	\$1.44m
Supramax	\$1.34m

3.1.2. COST PER TYPE

The comparison of the types of scrubbers shows that open loop scrubbers are the least expensive ones as the most simple with minimum requirements.

They are followed by the closed loop and finally the most expensive ones the Hybrid systems.

The flow through type systems in terms of Gas flow direction are the cheapest ones followed by side and U type systems.

Prices vary significantly from maker to maker and combination of above technologies.

The factor of ordered units is apparel here too.

3.1.3. COST PER BUILDER

Examples

Indicative prices per builder for Open U type scrubber referring to Suezmax tanker as per early 2019 prices:

Hyundai: \$2.2m

Alfa Laval: \$1.7m

Wartsila: \$1.8m

Yara: \$1.48m

Feen: \$1.35m

Delivery time about 6 months but as per latest market information almost all makers are fully booked until mid. 2020.

3.1.4. COST OF BUYING THE MAKER

In the unsteady and uncertain market influenced by the IMO 2020 sulfur cap, all companies have responded in a different way depending on their strategy.

One of the most uncertain factors is the availability of scrubber systems for installation onboard their fleet on time. Furthermore if there is a specific preference of a technology offered by a maker giving a competitive advantage then options are more. As reported some owners have decided to enter into the scrubber building market by acquiring a percentage of one or more companies building such systems. Similar attempts (successful or not) have been reported to be applied for subcontractors of major components of such systems such as pumps and electronics.

Such a strategic move ensures steady production and supply of the systems for the fleet of the acquirer. Furthermore ensures the on time delivery of the systems and moreover the right to decide the best option of installation yard.

The strategic materials and electronics used for the construction of the components are closely controlled by the buyer which gives a competitive advantage in the market. The quality of the products can be closely monitored and intervene if and when necessary. The uncertain environment deriving from the available systems in the market on time of demand vanishes to a big extend with such move. Furthermore

It has the effect of controlling a share of the scrubber makers' worldwide market and consequently a share of the shipping industry. Any delivery of a system in the future in a competitor at convenient times will have a

positive result for the ship owner. Additionally a percentage of profit of the competitors will come to acquirers via the Scrubber maker company. The initial investment will be repaid very soon through this method depending of course on many factors such as rights to impose opinions and directions as shareholders and/or members of board of Directors.

In one occasion Frontline bought 20% stakes in Feen Marine Scrubbers. (Worldmaritimenews, 2018)

In cases of smaller makers such an economic agreement is vital for their survival within this competitive industry with big manufacturers. Another positive view of this move is that the shipping company is securing the long life of the scrubber maker, together with the services provided, in case of a scrubber system failure onboard their vessels. In any case this is a win-win deal for both sides, securing vitality of the project and long lasting support from maker.

3.1.5. 3D SCANNING PROCEDURE

In order to achieve the feasibility study a preliminary 3d onboard scanning is agreed.

Technical companies offering such services use advanced 3d scanning machines and drawing software in order to depict in actual 3d the components installation position inside engine room, pump room and any other place onboard vessel that system, regulations and other restrictions are requiring.

The 3d scanning will result a study that will propose best alternatives for positioning of system's elements onboard. Apart from that the result will calculate the additional elements such as piping and cabling that will be used in order to make the system ready to use. The result study will be processed with special software resulting all the above and will be presented to owner. Usually a consultation from maker is good to be achieved in order to ensure that as per acceptable by owner's and technical company 3d scanning, system can work properly and no any major objections appear. Costs can be between \$10.000 to \$30.000 for a single vessel and additional \$2.000 to \$5.000 for each consequent sister vessel. This service is obligatory. Although it does not represent the highest cost, it is indeed an additional obligation of the owners.

3.1.6. TECHNICAL COMPANIES INVOLVED-TECHNICAL PREPARATION

At the stage of technical study the features of the system to be installed are collected usually by a technical company cooperating with the maker or that is suggested by owner subject to no objection by maker for reasons such as not knowing the system well, no good reputation in the market, avoiding delays in the project etc. The usual market trend is the study and installation of the system to be awarded to the technical company completed the 3d scanning.

Based on the 3d scanning results and agreed alternative version to be applied the first preliminary basic drawings are released and presented to owners. Main features as well as major modifications on existing installations of vessels are presented and finally agreed.

After their agreement the technical office is given the green light to proceed with the production of full detailed drawings that will be used for the preparation of parts and the installation at the shipyard.

Completing the full set of drawings, a procedure that might take from 2 to 4 months, they are submitted to vessel's Class for approval and comments to be implemented if any. That procedure might take several months too.

In general the whole study procedure including the Class approval might take 6 to 8 months. It has been reported a big volume of work transferred to the Classes' bureaus trying to cover the increased demand for such approvals resulting delays in the whole process.

The original approved drawings now can be transferred to the selected yard either directly from owner or through the technical office prepared them. Shipyard will study and revert with any comments in order to understand and finally quote for the job. All parts must be according to drawings and readily available when the vessel will arrive at the shipyard.

Shipyard's preparation of components, schedule and system delivery on time is very crucial for the smooth operation of the project and successful completion.

The technical preparation can cost well from \$30.000 up to \$250.000 or even more depending on many factors such as size of vessel, modifications, available space, the area to be conducted and many more.

3.1.7. AVAILABLE SHIPYARDS

Some of the issues arising when finally somebody takes the decision to install an exhaust gas cleaner system onboard a vessel or a fleet, is the place that this work can be carried out. Availability of proper shipyards to give berth and/or drydock to vessels is a complex issue. If the drydock is forced meaning outside the normal period of vessel's drydock that incurs some additional costs apart from the scrubber retrofit itself. The arrangement and securing of a slot in a shipyard that can accommodate e.g. a VLCC only for a retrofit in a berth is complicated matter and decision for a shipyard since it will occupy lay-berths in a busy with drydock shipyards exploding its schedule. The drydocking schedule of the shipyard must be modified such in order to accommodate the extra vessels for retrofit. In case not adequate berth available due to vessel's size or busy schedule can create a shortage of retrofit installations on time for some of the owners. That would mean that for a period of time within 2020 those vessels with a plan to install a scrubber but unfortunate enough not to secure on time, will have to burn the new fuel for a period of time until completion of retrofit. That means extra costs on the already expensive retrofit. The cost of retrofit works in a shipyard (e.g. in Chinese shipyard) for a VLCC can reach \$1.000.000 and that is for the case of a well programmed project. A capesize bulk carrier retrofit works can cost similarly up to \$800.000. Smaller sizes can be in the region of \$620.000 to \$750.000.

3.1.8. AVAILABLE SLOTS

One of the principal problems that shipping industry has faced in the process of being prepared for the 2020 sulfur cap, is the availability of shipyard slots in order to accommodate the vessel for subject retrofit. As all

shipyards make their planning based on previous experience and clients' list the additional capacity looking for a berth and in many cases a dry-dock slot too, many shipyards are overbooked leading to not available slots in the market for such projects. The annual planning of each shipyard is based on the sizes of berths and dry docks plus the labor capacity available. The new demand for additional slots has created a state of insecurity for ship owners and delays in the installation of systems that maybe have been ordered 1 year ago but due to unavailability of free slots, before the final implementation date, delays occurring leading to additional costs due to bunkering of the new fuel types with increased prices until completion of retrofit. It has been reported that in some shipyards in Far East the waiting list might be up to 1 year after ordering the slot.

Moreover the fact that big shipping companies running large number of vessels, in their search to secure slots for their fleet, have approached major shipyards and have secured numerous slots for a considerable amount of time. Given the priority offered to the big shipping companies, smaller ones with only 1 or 2 vessels can wait enough before even securing a slot a year after or at least several months.

This condition can be translated in millions of dollars spent in new type fuels considering 6 to 12 months waiting time until retrofit completion. For sure that is a considerable amount of money outside the initial budget of any company.

3.1.9. CONVENIENT AREAS

Apart from the availabilities on time, another issue shipowners face is the convenient area of shipyards' locations. Depending on the trade pattern of the vessel or fleet of a company, vessel/s might have to deviate significantly even 20-30 days in order to reach shipyard appointed for the installation of the scrubber. If such deviation and arrangement of retrofit is within the timeframe then the costs will be translated in prices of HFO and in worst case scenarios a ballast voyage up to the shipyard resulting an even more increased cost of fuel spent. The even worst case scenario is this deviation ballast trip to be carried out with new type fuel resulting extreme costs.

3.1.10. EXPERIENCE ON INSTALLATION

Shipyards undertaking such projects as an exhaust gas cleaning system installation are constantly asked if any record of such completed projects exists. In fact only few shipyards have experience in such retrofits and usually are the big shipyards of China, Singapore and less in other areas of the world. Even if a shipyard has experience, it might be limited to one type of scrubber, one maker and even more limited to one type and size of vessel making each one a specialist. That results an insecurity from owners side about the success of the installation, the time keeping in shipyard and final results and approval by Class. Any delays in schedule and failure of achieving the expected or promised results by maker and shipyard leads to disputes and implications for the ship owner. A day delay might result a few thousand up to a few 10ths of thousands of dollars loss due to loss of daily freight or implications in case of time chartering agreed terms. Such

conditions are increasing the total cost of the project. Shipyards tend to avoid undertaking projects that do not know the maker or the type of scrubber in order to avoid implications and even legal disputes with owners that can harm their reputation. Furthermore a significant delay of a project for any reason might disrupt their schedule leading to losses and guarantee claims.

Such claims can reach daily a few thousands up to several thousands of dollars per day depending on the market freights of the period or agreed hire of the vessel including any warranty obligations.

3.1.11. TECHNICAL KNOW HOW

Even though well-known shipyards are undertaking various projects including ballast water treatment system installations, major modifications of hull, conversions etc. in cases like scrubber installations things are different. This is due to uncertainty of result and the fact that scrubber makers can guarantee the result subject to correct installation based on strict instructions. That creates a demand for strong know how shipyards ready to undertake such a complex project involving accurate installation of a 10 to 16 meters pre constructed device with high complexity of sensors and parameter settings. Even though maker's technicians are undertaking the final parameter settings and adjustments, the deep knowledge of the system is a must for a shipyard to be appointed.

3.1.12. CONSTRUCTION AND DELIVERY TIME OF SYSTEM

Every such system as an exhaust gas cleaning system, is a simple and at the same time complicated construction involving steel construction, stainless steel/duplex parts, moving parts, spray nozzles, extended piping and accurate fitting, electronics, sensors, controller cabinets, valves etc.

All these components are either constructed by the maker or ordered to subcontractors. Materials to be used in each case should be ordered and delivered on time either for the erection of the tower or the erection at the shipyard. Similarly all electronics, pumps, pipes, special parts should be readily available on time in order to cover the demand. If not then delays in the delivery schedule might occur. In such cases the whole schedule of an installation project goes well behind resulting increased costs for the owner unless these can be covered through a predicted clause in the contract signed between owner and manufacturer or/and the shipyard.

In any case delivery time is significant and at the moment it is equal to 6 up to 1 year time after order which complicates the whole process more.

The construction in the manufacturers' facilities is a complex work that includes also in house testing. Transportation takes place in pre-arranged dates in order to follow the shipyard's schedule and delivery to be on time. Furthermore this schedule must not be disrupted leading to blow off of shipyard's schedule of workflow and yard storage.

3.1.13. OFF HIRE VESSEL'S TIME

Selection of system has been completed, relevant negotiations with maker ended successfully all preparations done, system arrived at the shipyard and all piping and cabling is ready. What is missing is the vessel to reach the shipyard. A usual time for the installation and trials after completion is about 20 days with variations between 15-17 days up to 30 days. (Caraig Jallal, 2019)

This time is an off hire period of the vessel that even if it is planned, it is not welcomed since it reserves the vessel for a significant period especially in low market days resulting loss of possible freight or hire. That loss is calculated in some several thousands of dollars added to the bill with title "Scrubber installation". In worst cases, if planning went completely wrong a vessel could end up having a second dry dock within a year (one scheduled e.g. special survey and one for the scrubber retrofit) or for 2 consecutive years (same as above) which increases the total off hire time resulting losses. Estimation and examples per type of vessel:

SUPRAMAX	average freight \$12.000 x average days off hire 20 = \$240.000
PANAMAX	average freight \$12.000 x average days off hire 20 = \$240.000
CAPE SIZE (Australia to China)	average freight \$6.000 x average days off hire 20 = \$120.000
AFRAMAX	average freight \$30.000 x average days off hire 20 = \$600.000
SUEZMAX	average freight \$35.000 x average days off hire 20 = \$700.000
VLCC	average freight \$25.000 x average days off hire 20 = \$500.000

(Baltic Exchange Freight Market Reports Jan 2019)

An example of costs involved in a scrubber retrofit in Chinese shipyard:

For a VLCC a Chinese U type system may cost around \$1.900.00m.

The 3d scanning and engineering about	\$200.000
Retrofit works by shipyard and other subcontractors	\$965.000
Total:	\$3.095.000m

For a Capesize a Chinese U type system may cost around \$1.540.000m

The 3d scanning and engineering about	\$ 200.000
Retrofit works by shipyard and other subcontractors	\$770.000
Total:	\$2.510.000m

Retrofit contract dues can be settled as 30% at signing, 10% at vessels' redelivery and the rest 60% can be arranged amicably at monthly installments (including any interest involved).

SHIPYARDS

List of the busiest shiprepair shipyards that undertake scrubber retrofit projects:

1. CIC Changxing
2. Drydocks World Dubai
3. CMHI (Shenzhen)
4. Huarun Dadong
5. Fujian Huadong SY
6. Shanhaiguan SB
7. Zhoushan Xinya
8. Besiktas Shipyard
9. Longshan Shipyard
10. IMC-Yongyue

(Craig Jallal, 2019).

3.2. NEWBUILDINGS- INSTALLATION OF A SCRUBBER

3.2.1. INSTALLATION BY SPECIFICATION

Apart from the retrofit on existing vessels, the installation of a system can be carried out at the newbuilding stage. As somebody might imagine, the selection of a system at the stage of contracting the vessel is much more convenient for the owners and for the newbuilding yard too.

Shipbuilding yards are usually proposing one or two makers based on their experience on installation, best cooperation and easy fitting in their design. Moreover they can propose different makers for different sizes and types of vessels again for design and vessel's available spaces reasons.

One of the factors contributing to the selection of maker by yard apart from the installation features and the trust to the maker, is the reputation of the system in the market since constant breakdowns can result bad reputation and guarantee claims by owners' side. Furthermore an unreliable maker can affect the shipyard's schedule with delays of deliveries and that could lead also to guarantee claims by owners if milestones not kept.

At the newbuilding stage and since shipyard is arranging the whole process, the price of the system, another major factor of selection, can be significantly reduced comparing to later retrofit installation. Needless to say the more comfort work procedure that will be followed by shipyard in the installation comparing to a ship

repair yard struggling to complete the retrofit on time. More highly skilled labor of newbuilding yard, more flexibility, easier access to materials and the knowhow of their own vessel's design features contributes to a more successful installation with less implications for the owners.

There are the cases that owners are requesting another maker outside the yard's maker's list, based on their preference or previous experience and uniformity of fleet's equipment. Such cases can be declined by shipyards due to the fact that a new unknown system needs several rearrangements and redesign of vessel's compartments and piping arrangement that increases the price of the vessel significantly and creates an additional volume of work for the shipyard for just one project. Of course not all shipyards will decline such a proposal based on the client and units to be ordered. The new system could be relevantly easy to be adopted to the vessel's design but these are case by case.

One of the reasons of a declined system by a yard is also the production line of the scrubber maker and how it will be possible to provide the system on time without any delays.

There is also the case of shipyards choosing not to install scrubbers at all for strategic reasons. One of the main reasons is the cost of their product meaning the vessel can be increased significantly from 2 to 6 million \$ making their product uncompetitive in the market.

Another major reason is the uncertainty of reliability and efficient function of the system throughout vessel's life time. Shipyards tend to work with makers that have a long term relationship and are considered reliable in the market. That increases the value of their products and their good reputation in the market.

In the case of scrubbers, since it is not a system already used for several years or decades no one is sure about its actual results and the synergy with the rest of the installed equipment on a specific design.

Another reason is the delivery deadlines that influences the schedule of the shipyard.

If shipyard cannot control the scrubber maker's deliveries' schedule then it becomes uncertain if they can cover their obligations and this leads most of the time to shipyard's losses.

3.2.2. INSTALLATION BY OWNER'S OR CHARTERER'S REQUEST-ALREADY CONTRACTED VESSELS WITHOUT SCRUBBER-IMPACT ON CONTRACT

There is always the case where owners will request the installation of a scrubber after a contract is already signed and does not provide any.

In such cases the impact for both sides it will be huge. Adopting an additional piece of machinery will require new calculation of consumption both as current and fuel. In any case several modifications and machinery upgrades could be required leading to an unequal increased price of the final product that might not be attractive anymore for the owner. Similarly yard has to book the system on time and adopt all its components in her design and at the same time make several studies and approve drawings via Classification Societies. As somebody can understand such an extended modification at a later stage of an already contracted newbuilding is not feasible and worthy for any party unless a charterer is demanding through a

contract or an order is too attractive in means of units ordered. In such cases the project of newbuilding installation is approached by another angle and more effort can be expended.

There are the cases where ship owner is demanding the installation of a system or even a specific maker due to their good relationship with scrubber maker or even being under their ownership or partnership.

Such cases are not rare especially at the later stage as the implementation date is closer. Depending on the market demands, the contracts of the newbuilding vessels and the charterers requirements.

As a cost it can be absorbed by the increased number of the order and the constant supply chain secured by the owner's contract with the maker. The costs can be shared and negotiations can lead to reduction of prices even at 30% less and even financial assistance and favorable repayment terms through bank loans or maker through bank loans for the owners. Many such schemes exist in order to promote and support the specific industry.

3.2.3. THE HYBRID READY SOLUTION

In search of a reasonable investment that will not increase the risk of repayment is the installation of an open loop system which is the cheapest of all the 3 main types but with Hybrid ready to install peripherals. Such a solution can be considered quite smart for those decided to go for the scrubber but not all the way until will be absolutely necessary. The costs of dry-dock and installation of a system that can be modified to Hybrid together with any necessary fittings that demand dry docking are already paid. In case of future more strict regulations that will impose Hybrid systems onboard vessels, almost everything will be ready and only a few modifications and equipment additions will be carried out. Most probably in a next scheduled dry-dock the modification can be completed and vessel will be in compliance with the more strict future regulations.

The cost of an open loop for a VLCC as a system can reach \$2 million and with the additional fittings for hybrid modification can end up to \$2.5 to \$3 at this stage.

The costs are split in this way and if not necessary then then no further actions needed.

CHAPTER 4 - ECONOMICS and FUNDING

In the process of selecting whether to install or not an exhaust gas cleaning system, several factors are taken into consideration. In general when selecting to install such a high volume and relatively heavy equipment onboard a vessel will result limitations in cargo accommodation and load-line reassignment.

In the case of an ULCV this deterioration of cargo capacity can result a reduction of 200 containers at least according to Alphaliner.

Calculating the lost cargo over the years somebody can conclude whether the investment of scrubber installation has a positive or a negative outcome. Apart from the initial system installation cost that in this case can reach more than \$10 million, adding the lost cargo over the lifetime of the vessel, the technical malfunctions and consequent costs and even fines, the final true cost of this system goes higher enough than the presented price. The comparison with the new fuel prices, even as estimates at the moment, is easy enough. (Costas Paris, 2018).

4.1. SECOND HAND MARKET

The second hand market is now creating a new segment for the vessels equipped with scrubbers, promoting their preference in this time charter market. The security of using HFO is creating a trustworthy investment that can be easily evaluated and future gains and losses can be more easily calculated.

At this point although a few thousands of systems installed, experience from their use is diverse and many times confusing. Despite that, the installation of a system coming from a highly reputable maker, is always a plus in the market and a sign of trustworthiness for the buyer/owner.

Having the above in mind the higher prices for acquiring such an asset have boosted and diversified the second hand market.

	Jan 16 - Feb 16	Jan 17 - Feb 17	Jan 18 - Feb 18	Jan 19 - Feb 19
Handysize sales	21	40	34	15
BHSI average	221	433	561	404
Supramax sales	19	26	27	18
BSI average	335	733	882	663
Panamax sales	13	23	19	19
BPI average	353	943	1,369	848
Capesize sales	28	16	9	2
BCI average	245	1,179	1,891	1,311
Total no. of SnP deals	81	105	89	54

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Earlier this year the report of SnP market has presented a drop in sales showing negative intentions in the market. They are related with lower rates of this year. The scrubber installation has not generated any SnP transaction. As far as it concerns the cape size bulkers, the condition is even worst with only 2 transactions recorded at the 1st 2 months of 2019. Even though prices should be more attractive e.g. a Chinese 2012 built Supramax cost \$9m by 2017 and a Chinese Supramax 2011 built fixed in 2019, \$9million showing no improvement in the market. Prices are remaining relatively steady showing reluctant to change or any intention to second hand tonnage. In relation to scrubbers installation it could show that freight market is keeping a steady condition. Especially for the Capers. Although in better position than 2016, still no interesting changes since 2018, for the age of 5 vessels. The specific group of vessels with the specific age can be considered 1st candidates for the scrubber installation. (Barry Parker, 2018)

Indicative Market Values (\$ Million) - Bulk Carriers

Vessel 5 yrs old		Mar-19 avg	Feb-19 avg	±%	2018	2017	2016
Capesize	180k	31.0	31.0	0.0%	35.0	31.1	23.5
Panamax	76K	16.0	16.0	0.0%	18.7	18.1	13.6
Supramax	56k	16.0	16.0	0.0%	17.7	16.5	12.7
Handysize	30K	13.3	13.3	0.0%	15.0	13.0	9.9

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4.1.2. THE AGE OF THE VESSEL AS A FACTOR TO DECIDE THE INSTALLATION OF A SCRUBBER

Many theories and predictions have been published. Discussions after discussions and presentations over the last couple of years and even today, months before the implementation each of involved parties are coming to different conclusions.

It is clear that several factors play a big role for the decision making but some of the factors are more decisive. As time passes, the characteristic of vessel's age is one of the most catalytic to decide. Vessels over 15 year's age, in the existing market, will not give back the investment in such time where owners will take premium profit from their investment. In cases of VLCC's of 10 years old with retrofit system of about \$5 million, the repayment time depending on the year of installation (before/after 2020) can determine the viability and worthiness of the investment. The system retrofit within 2019, then investment could return in 1 year time, keeping the same average HFO prices, with no interruption of available bunkers around the world. Annually a \$13.699 payback of the investment and still have a profit covering rest of expenses. Market of VLCC's as of 08/2019 for 270,000mt US Gulf to China is being assessed at \$5.4m, up \$100k from last week, although, at the time of writing there is a report of a Korean charterer fixing at \$5.85m US Gulf to Korea for mid-September loading according to "Baltic Briefing Tanker Report Week 31".

The newbuilding is even more on the positive side since the same system and installation will have a reduced price due to early booking of equipment, shipyard's preparation etc. and therefore the investment e.g. of \$3.5 million (instead of \$5 million) is much probable to be returned in less than 1 year time.

On the other hand the vessels of 10 years old that still have not secured a slot or even worst a system, might have to re consider the investment. In this case they will have to calculate and take in consideration the additional expenses for the new fuel oil that will be consumed until the time of completion of retrofit. At the moment a difference of about \$200/MT HFO/VLSFO multiplied by 60-70MT/day gives an additional cost of \$13.000/day as average on top of the HFO bunkers price.

Calculating 200 days in 2020 until the vessel will enter shipyard to complete the retrofit a sum of \$2.600.000 must be spent additionally from the HFO prices.

It is obvious that in this case the price is still within the limits for a relevant quick return of investment, it begins to approach a number of \$10 million if off hire period added. In this case it is most uncertain for owners if to proceed or not.

For the vessels of less than 10 years old the conditions are more favor although the price difference premium to be paid does not making the investment after 2020 so attractive at first.

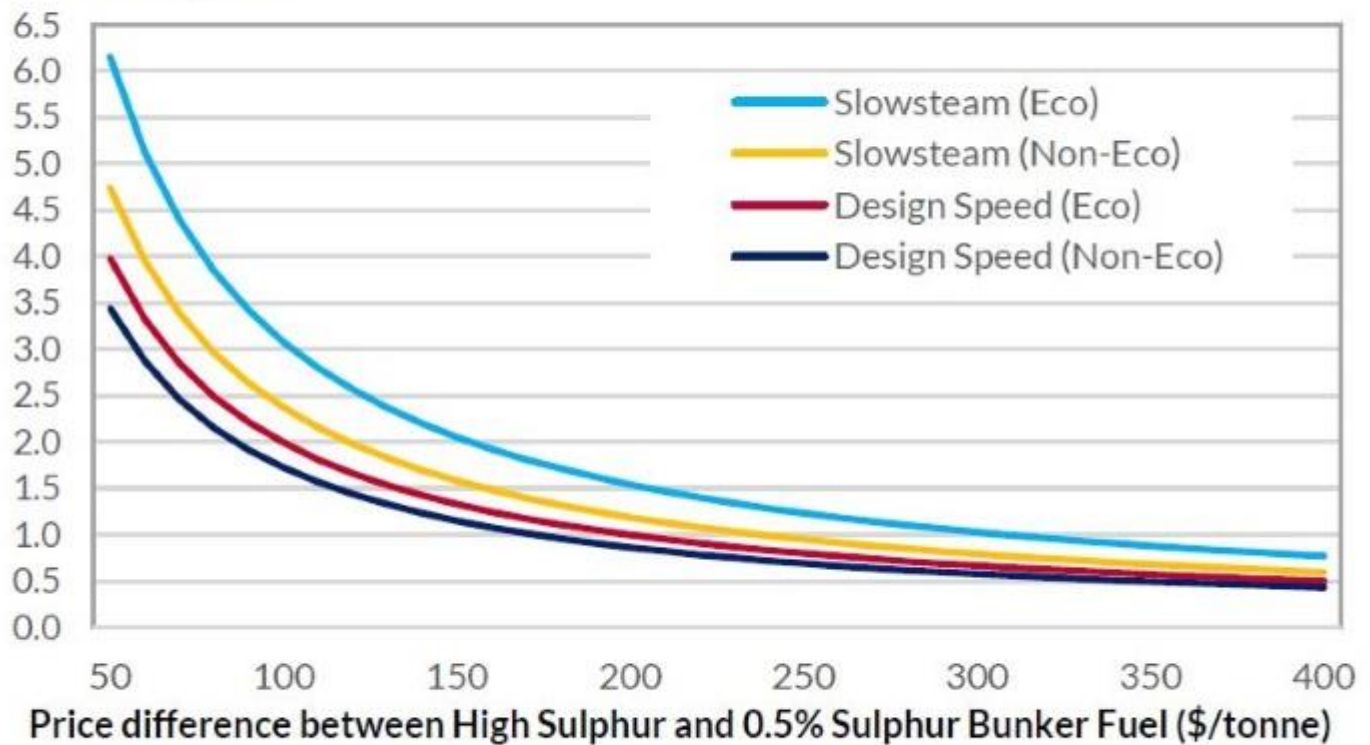
4.1.3. CHARTERING AND PAY BACK TIME-REPAYMENT PERIOD

Specialists in the chartering and freight market are monitoring changes predicting future behaviors and results. One of the most difficult conditions in the last years is here and reflects the inability to securely predict the freights formation over the forthcoming years of 2020 implementation. The struggle of all parties to format a strategy that reflects the actual condition of the market is obvious. This leads to various models that everyone is free to follow bearing the cost of his decisions. The chartering and freight market specialists have only tendencies of the market to consider. The numbers that play some role such as the price of HFO the price of scrubbers and retrofit of today are given and more less can give some secure prediction in concern of the costs involved. But this is the only information they can trust. Capers are showing a tendency for installation of scrubbers but still only 22% of the global Capers fleet is eligible to install. The freight formation and differentiation for Capes with or without a scrubber is not possible to predict. Preference to those with scrubbers by time charters might be given due to the fact of HFO's lower price. But that's only one factor. If the charterer will have to contribute to the installation of the scrubber then the numbers change. Depending on their mutual agreements a 100% funding is possible by charterer given the fact of secured freights for at least the end period of repayment of the investment. In other terms this might work for limited time. After that a more economic solution might appear for them and follow accordingly. The ship owner might not have any obligation from that time on but he might have to face an extreme competition from other more economic vessels or they might find themselves confronting a more strict to comply regulation. In such case they will have to follow this vicious circle or sell the vessel (or scrap it). If freight rates in the time charter market will remain low then spot market will not be so attractive for ship owners. Having nothing at the moment about formation of freight they cannot decide either to invest in scrubber and become competitive (for how long) or follow the new regulation as the big mass and wait for the formation of increased freight based on the assumption that the majority will impose the new trend and height in the market.

VLCC Scrubber Repayment Period

Calculations are based on retrofitting an existing tanker

Number of years



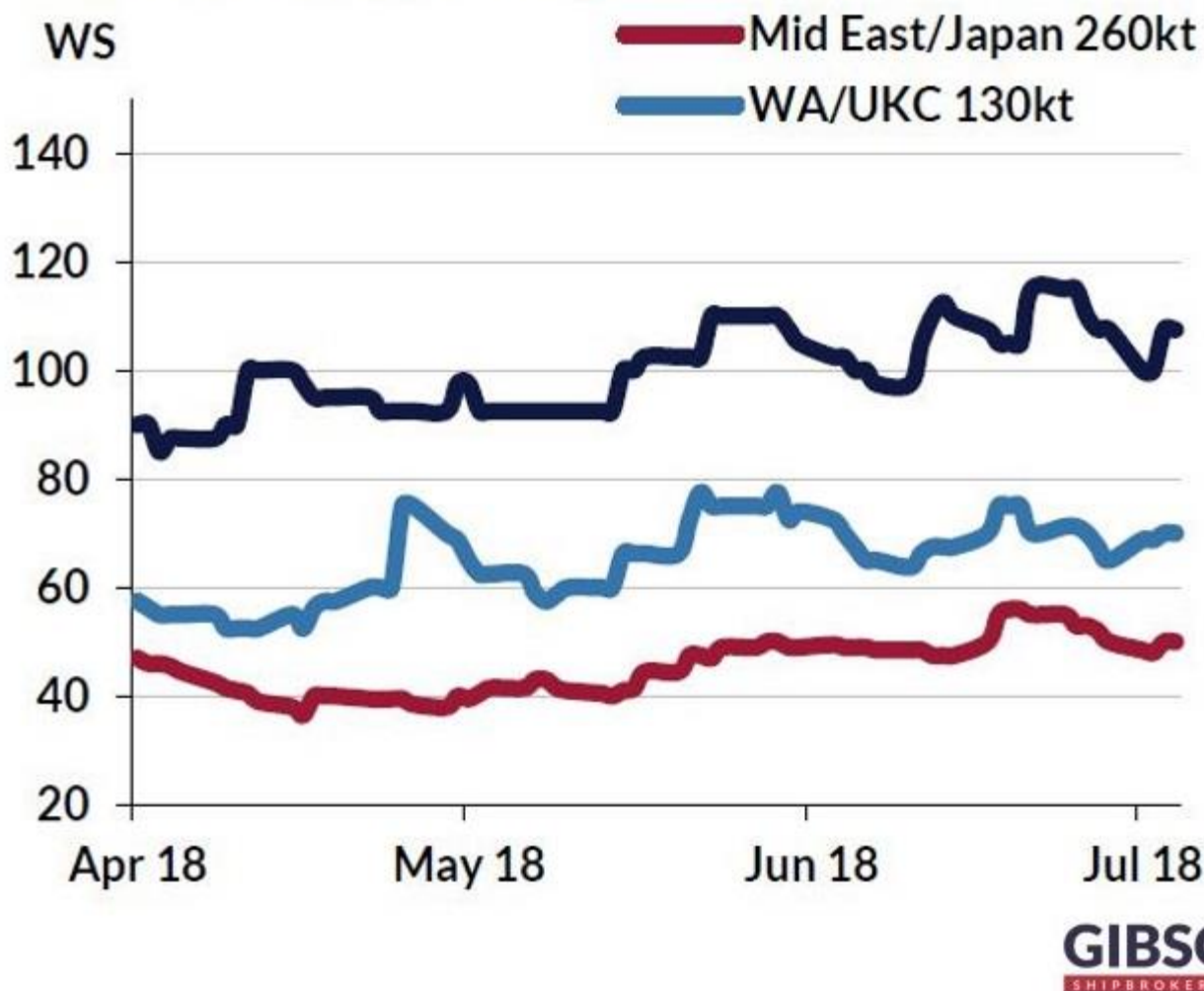
GIBSON
SHIPBROKERS

As per the graph of Gibson Shipbrokers, 2018, repayment period for an existing VLCC installing a scrubber system, can vary from 3.5 to 6.2 years depending on the pattern of speed that the vessel is following. Given the numbers, and considering that nowadays VLCC's over 15 years are more hard to be chartered in the spot market and time charter freight is well below the average in the market, a 10 year old VLCC will be very hard to close its life time with a positive sign.

The differentiation of freight between tankers especially VLCC's that are equipped with scrubbers and those not are difficult to be predicted. In any case the local authorities e.g. USCG will show their preference and oil majors will follow trying to be in compliance and not risk at all. Such cases were seen in the BWTS selection period and that pushed many ship owners to specific technologies and makers at least at the beginning. Similarly the new gas cleaning systems and their technologies as well as their makers can be in favor or not. Since many new players are right now in the market selling certified products but not really tested, failures will be apparent. This might lead to preference to clean fuel vessels instead of "cleaning the fuel" vessels. In such conditions daily fixture or world scale for a VLCC from West Africa to Europe or USA it will be very difficult to be determined in the first 2 years. Surprisingly this period will be enough for those invested to start recovering and those followed the VLSFO seeing the prices of fuel being lowered down. In that case the results for freights will be to be stabilized. Some speculate that through this even

small competition between vessels equipped and those not, will keep all freights down. If we bear in mind the percentage of scrubber equipped vessels, we can conclude that almost nothing is changing and therefore no big changes in the freight market will appear. The only change might be the reduction of income to ship owners per vessel no matter equipped or not.

Crude Tanker Spot Rates



4.1.4. SHARING THE COSTS WITH CHARTERERS

When coming to time line and owners have to decide the installation or not, some of the usual ideas is the sharing or complete undertaking of this retrofit by the charterers. In order to submit such a proposal a good calculation of future costs of new fuels plus the consequences (e.g. breakdowns) and comparison with the installation cost and saving on fuel costs might convince the charterers. Even more the decision of undertaking such a project in terms of finance, might lead to a longer term time charter contract, favoring both parties. (David Glass,5 October 2018)

4.2. BANK LOANS

At this stage companies decided to follow the scrubber retrofit have to establish a well support financial liquidity schedule. The sources must be secured and agreement terms either loans or shareholders contribution for sure will be rather strict. For companies accepted in the stock market e.g. of New York, with constant reliable presence and proved profitable plans normally funding and financial support would not be a problem. Surprisingly the financial support for the specific projects is not coming easy. Market reports have shown different ways of securing cash flows for the forthcoming years of scrubber retrofit action. Bank credits come always first in mind and terms can be easily manageable if company is highly reputable. However if the investment is scarce then loans cannot be the only source of funding. The market shares information from various financial plans and mixes which are very interesting such as sale and lease back options such as Scorpio Company has already been materialized. Other companies decided to announce offering of common shares and by that securing if possible several millions of dollars. Of course such public offerings are ran by well reputable companies dedicated for this reason and even more trustworthy companies acting as managers of the offering securing the whole process.

The scanning from financier's side of such a project file for approval is not an easy issue as the IRR must be attractive, such as in case of bigger vessels and combined with NPV of the systems can lead to a positive outcome for the owners.

As in all assumption proposal based portfolios, the factors can change significantly resulting a whole complete result than the initial calculated.

Scrubber makers can offer reasonable bank loans with adjusted to customer pay back terms e.g. Yara cooperates with Export Credit Norway which can support clients of Yara, in order to place their order in this Norwegian company. Such a loan is offering favorable fixed or variable interest rates, covers up to 85% of contract value and other favorable conditions trying to attract more customers that are not able to pay for the system at once or they do not have direct access to financial institutions. As per bank's description the main characteristics of such a loan could include a maturity of 5 to 8.5 years per single loan depending on many factors. Fixed interest loans are possible through commercial interest reference rate e.g. in 2017 the CIRR was at 2.28% for NOK loans and at 3.02% for USD loans. The Norwegian Export Credit Guarantee Agency or other acceptable commercial banks must guarantee such loans and rates are kept excluded of guarantee premiums as per bank's info. Such loans can be offered as single ones or for the entire fleet of a shipping company, not only located/based in Norway but all around the world, supporting the Norwegian Scrubber makers for selling their products.

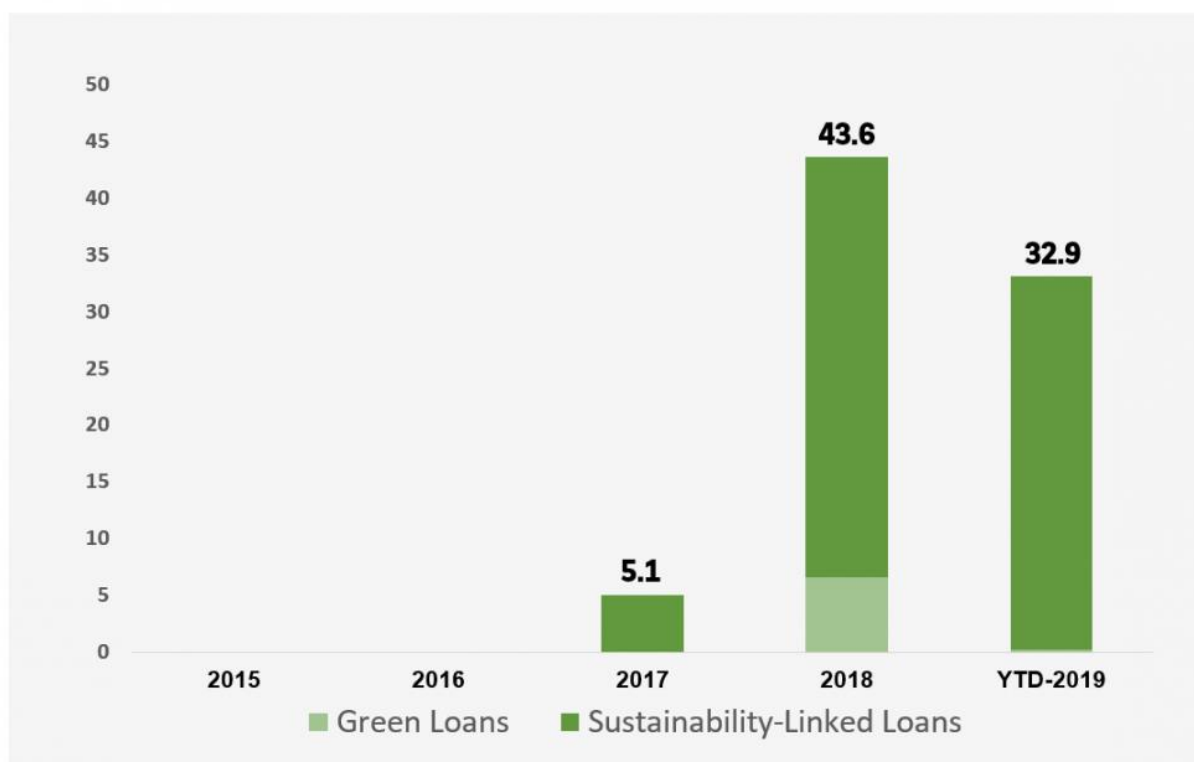
The group of North European countries are always showing a sign of cooperation and support of their products. In the case of scrubbers, the main makers as already mentioned, are of north European origin so the local bank cooperation is an innovative scheme to support these scrubber makers. Furthermore the promotion of the green technology is obvious in the whole process. Of course some might conclude that the

whole scrubber promotion is a constructed alternative, promoted to IMO by this group of companies and local banks which could be valid.

4.2.1. GREEN LOAN PRINCIPALS

According to bank loan market the financing of a scrubber retrofit cannot be financed by standard ship mortgage loans. This is an obstacle when in search of securing funds for the retrofit projects. Green loans are one of the products that an owner might obtain for this purpose. It has been shown that consortium of Banks either acting as main or second loan banks are usually taking over such investment portfolios with other partners acting as Mandated Lead Arranger, Facility Agent and Coordinator. The team of banks cooperating for the execution might include more than 3 highly reputable banks such as DNB Bank, BNP Paribas Bank etc.

Sustainable Loans Raised (USD bn) by Issue Type



Source: Bloomberg New Energy Finance, as of June 3rd 2019

Green loans if to be achieved and agreed is one of the tested methods to cover the expenses of scrubber retrofit. As per NYK recent \$80.6 M green loan ranked Green1 shows complete compliance with the Green Loan Principles.

This kind of Green products are offered by financial institutes and their goal is to support Green projects at any stage even as re financing existing ones. Such loans can be characterized as green (European Commission, 2017) when they cover the 4 Green Loan Principles as presented by the Loan Market Association. These 4 core components are 1. The Use of Proceeds, 2. Process for Project Evaluation and Selection 3. Management of Proceeds and 4. Reporting. Briefly explaining the core elements that justify a green loan is 1. The loan must be used for a Green project, 2. The environmental objective, the strategies based on, the criteria of selecting such a project, the goals must be presented by the borrowers to the lenders in order to convince them about the project, the intentions and the final outcomes as well as the environmental risks taken into consideration, 3. Transparency during the installments, procedures followed by both parties and the final reach of each installment to the addressed stage of the project is mandatory. 4. Follow up and monitoring of green projects either per stage or per outcome in the short and long term by keeping records on key performance factors are methods of verifying the necessity and viability of projects. External reviews from external independent bodies either reviewing the project about viability or terms, internal standards review, certification if in line with external standard of such loans and rating of the study and implementation.

Such practices by the borrowers are ensuring that the terms and conditions of their loan are kept and representing the practices worldwide. Furthermore their project is connected with international Green project standards given them the opportunity to achieve the best through a process of loan request from the market.

At this point it would be worth to mention that such huge amount loans involving several millions of dollars to be invested by an organization or a company, are usually arranged by banks in cooperation. Such loans are called syndicate loans and are involving several banks each one contributing to the loan according to a pre-arranged and agreed plan. When such funding is needed can involve a fixed fund or a credit line or a combination. Such loans can be available when specialized banks need to be involved for specialized projects. Furthermore by that arrangement the risk is limited.

Interest rates of such loans can be fixed or variable based on LIBOR or other similar interest rate benchmarks. The lead bank is usually offering the biggest share of the loan or is offering specialized services and duties. Because of the nature of such projects by large companies or institutions the syndicate tries to spread the risk of borrowers' probable default to as much as possible lending sources such as funds or pension funds or other institutional investors. (Marcus Hand, 2018) , (Barry Parker, 2019)

Financial and law firms specializing in shipping loans have expressed their concerns about the type and characteristics of a loan based on the profile of owner and the vessel. Big challenges appear when the owner holds already a mortgage and requests additional credit for such an installation of equipment. In the field of securities the things start to be even more complicated if subject vessel is under a shipyard credit or a finance lease or simplest when exists a second mortgage. The priorities in such situations are not easy to be

accepted. In cases of bankruptcy a second financier under the laws of USA referring to bankruptcy, will be held well back from the rest as the installed equipment is considered a part of the vessel after installation. As described above the conditions arising are not attractive for financiers. (Barry Parker, 2018), (Jamey Bergman, 2019)

4.2.2. NEW FINANCING SOURCES

The E.U. through the European Fund for Strategic Investment Green Shipping Guarantee Program has been set as a foundation serving this cause. Supporting the Scrubber fitting on vessels with the eye set at reducing the GHG and Sox emissions. A sum of \$US860m has been gathered in cooperation with other counterparts public or private in order to serve the cause. The European Investment Bank and ABN Amro Bank are supporting investments on green technologies onboard vessels covering the scrubber installation too. External partners can take over the analysis of the environmental and sustainable credentials of companies willing to install scrubber systems. The EIB has spotted the deficiency in financing the European fleet initially, for the installation of green technologies. Having been alerted, initiated an investment plan of \$172m with ABN Amro back in the 2017.

4.2.3. SHAREHOLDERS

Securing loans for installation of systems on existing vessels is a common trend. In search of securing finance back up shipping companies might appeal to their shareholders and even to institutes that have already supported the purchase of the specific vessels. Such a move which for sure is thoroughly investigated as a scope and return of investment by the financiers, is possible depending on the agreed terms. For sure such a move involves increased risk for both parties since the initial investment is again open. The increase of borrowing level with new terms and repayment future unknown might add uncertainty in the market. However since this method is a good market option, big companies materialize such after careful consideration. In case of systems group purchasing for the installation on the fleet, banks or shareholders might be reserved and ask for securities and documentation before, during and at the completion of the retrofits. This step control enables them to control the stream of loan money to the purchasing shipping company, reducing the risk of failure and fraud. The step financing as terms is stricter and well documented evidence will enable the release of next stage's cash. The risk of whole project financing fraud is diminished since the ship owner is bind with many obligations before releasing the funds repaying each completed stage of the project. As per Spliethoff company some owners are having as a main target the building of a Green company's name in the market aiming for an increasing share in the market with a competitive advantage – environmentally advanced, friendly and experienced.

(As mentioned in the case of Spliethoff company) fleets involved in trading in ECA /SECA areas will have to be arose on environmental issues and thus the selection of innovative green technologies is one way selection road. Taken into consideration the trading area and by incorporating as early as possible green solutions protecting the environment (or creating less harm) such moves result companies' of pioneers. The choice of funding through a loan is one of the few ways to carry out such a long term and complicated venture that technical financial marketing and business features as well as predictions of future conclusions. As it appears the North European companies trading in the local North protecting areas had quite early felt the need for an organized plan in order to confront the forthcoming legislation regarding emissions control. Same appears for the Banks that have cooperation with shipping companies meaning they understood the significance and the opportunity to fund such a venture. The long term loans agreement for the retrofit of scrubbers (and ballast treatment systems) can be considered as an innovation and as a new product offered by banks in the unstable environment of shipping.

4.2.4. EIB AND ING GREEN SHIPPING FINANCE

Green sustainable finance products are offered by consortium of Banks to the international shipping market clients interested to invest in the upcoming events. Such products are offered by the European Investment Bank in cooperation with ING of Netherlands in a joint effort to support actively the whole initiation of the IMO. Having secured a worth to mention Euro 300m finance backing the offers will be equally treated. In their to institutions' agreement, contribution is 50%-50% making a strong joint green – scrubber supporting hub. It's initial target are the ship owners with European continent interests and are actively seeking to finance newbuilding and scrubber installation. Connecting the control of emissions and protection of environment with shipping, one of the major contributors of CO2 emissions, the strategic move to support such initiatives has already lead to finance of several projects such as the Spliethoff retrofitting project of a e110.4m loan for the installation of scrubbers on 42 of their fleet. The EIB will contribute with a percentage less than 50% of the total e110m.

CHAPTER 5 - IMPACT ON ENVIRONMENT

5.1. WHAT MEANS A BAN OF SCRUBBER EQUIPPED VESSELS IN INLAND WATERS OF A COUNTRY AND THE IMPACT IN INTERNATIONAL COMMERCE/SHIPPING MARKET

Since the introduction of the 2020 regulation and the preparation works followed until the implementation date, all members involved are having a struggle to be in the right position when this change will take place. As every party has created strategies and decisions based on their needs, everyone is monitoring the changes constantly. It is a fact that some changes although discussed are not still put under their actual dimension. Almost all parties have mentioned or just thought that the regulation regarding the emissions can be even stricter in the future. None can tell how strict they can be those regulations, when are they going to be proposed, how much will be the implementation preparation period, if they are going to be applied globally or in some areas, who will be obliged to comply and which authority will impose such.

All the above are the actual thoughts and discussions of each of participants of shipping industry. Yet is coming a day just before the implementation date and some new factors are entering the game. The new factor is the ban imposed by several countries in the use of open loop scrubbers in their territorial waters. In fact in specific territorial waters and not all of the water area of this state. In any case that is a huge impact considering that subject countries are very important for shipping. Such countries as Singapore, China, Germany, Taiwan cannot be left without attending their words, intentions and acts. Singapore has announced the ban of open loop scrubber discharges in her port territorial waters and some special maritime areas. Similarly China announced that after implementation discharges from open loop scrubbers will be banned from Bohai gulf, Yangtze river and other similar areas of high importance, high traffic and pollution trying to preserve it's already weighted natural resources. Taiwan announced same the prohibition of open or any other discharges from scrubber equipped vessels during their passage from her territorial waters. Germany has declared the ban or deterioration of scrubber discharges for specific area in rivers leading to Hamburg port and its wider area.

Similar measure have been taken by Fujairah Port, UAE in a statement released earlier this year. Irish port of Waterford followed prohibiting the release of open loop scrubbers wash waters in the area. Some NGO from Germany, France and other European countries have requested the ban of scrubbers in Europe and in ECA areas and some even taking further, requested Mediterranean Sea to become an ECA area.

None can blame those countries for acting such and protect their environment even if this is the second in row reason. But how this can affect shipping?

Almost 70% of shipping is passing through Singapore every year and even if not having any commercial activity such as bunkering, the fact is that it does pass.

In case special areas are designated for non-discharging then vessels will have to keep in their holding tank the wash-waters until get out of the territory. Even worst if they have to stay for port activities and/or

bunkers they have to keep them maybe until extinct of tank capacity. That would mean an additional cost for the vessel and the ship-owner to land facilities. If any company has usual trade in the area and Singapore is met quite often then owner might think to install at a second stage a hybrid system. Those with hybrid ready systems installed they are in better position since not much (about \$1m) will be reinvested to make it hybrid. For those already installed just an open loop it can become financially tragic. From just expanding their tank capacity (needs afloat repair team or shipyard) to the extension of their system (if possible) to hybrid is a major cost and additional headaches such as days off hire ,extended modifications etc.

Somebody watching those news might decide not to proceed with scrubber installation and burn the new fuel oil. That might be a major change of strategy. Especially if China and Taiwanese straights will prohibit the discharge of such scrubbed water, then many of the owners trading in the area, even before in favor of the system, they might decide not to proceed. Same is for Germany accepting one of the major volumes of the shipping commerce in Europe. Such bans are obvious that they will appear sooner or later for many reasons.

5.1.1. WHAT IS THE STRATEGY BEHIND THESE MOVES?

Following those restrictions and bans all around the world in major ports and wider areas somebody might think that this might be followed by other states too. For sure this condition leads to questions. The reason behind these questions is to find a pattern and based on that to react promptly. Such strategies can be imposed by countries for purely environmental reasons. Fishing resources are one of them. Protection of fishing resources from potential pollution of the seas by the wash waters of scrubbers has a good foundation. Especially in the South East Asia, fishing is a major economic activity and is directly connected with the surviving of their people since fish production is major diet product. In deterioration countries must find other suppliers outside the country with relevant increased costs. This shift can have a political aspect since a nation's major diet products can be a weapon of political pressure against the state.

If we choose to see a more commercial aspect of these bans, in case of Singapore, as a major bunkering hub in the world, state's income is directly connected with the amounts of petroleum products sold and their respective prices. In the new era after 2020, the new fuels will have at least for the first years a significant increased spread comparing to the HFO. This will continue for later years too even with less spread. In any case the outcome will be positive for the state. Imposing such strict bans, is pushing owners furthermore not to install scrubbers, creating a general fear that even if you install it there will be some rule to cancel your investment. Less scrubbers means more new fuel consumption and more such clients for the Singaporean bunkering market.

Similarly a new fee can be applied for those that cannot comply with their ban rule in their territorial waters. Additionally and as an alternative they offer land facilities to receive their wash water in excess of a fee again in favor of the state imposing the ban. On top of that the exclusive use of MGO in such areas such as in German waters, might be the local industry support. The production of MGO in the area and consumption

by the visiting vessels entails some form of support to the internal interests of the state. Assuming that the above are only a fracture of actual intentions and strategies, the scrubber installation decision becomes more and more complicated.

5.2. DISCHARGE OF HOLDING WATER

One of the main issues and basic concern brought up quite early was the environmental impact of wash waters at sea and the marine environment.

If we could approach the scrubber installation issue in pure environmental aspects then research should be carried out by independent bodies in order to conclude. Such studies have been carried out, taking into consideration many factors such as sulfur content per volume of wash water discharge, concentration of heavy metals, other substances from soot, the dilution of them in the sea water etc. In open Ocean the dilution of the discharged wash water is high and no trace can be detected in just minutes after a discharge. But what about more closed sea areas? What about ports and congested water ways with minimum refreshing of sea water.

Scientists have carried out studies and the results are controversial.

Recent Japanese government studies have concluded that the influence on the marine environment from the discharges are not destroying the sea life, sea bed and marine environment even at ports. This study has been carried out with the support of the Japanese government and has been conducted in Japanese waters. It is fair enough for local use and convenient for shipping since it can accept all scrubber equipped vessels.

The Dutch research organization CE Delft has conducted a similar study with similar results pointing out that the environmental footprint at sea water is within the regulatory limits.

From the other hand, a German research study conducted at congested areas with already lowered environmental quality, has come to conclusion that in closed sea water structures such as the Baltic and northern sea, with marine environment already affected by wastes, the waste water discharges can further harm the environment.

The debate has grounds for both sides providing evidence of scientific proof. The local concerns and protection of special areas such as the Baltic is in high priority by the local States and their people since it influences the quality and their future of their lives.

5.2.1. DISCHARGE OF SCRUBBER SLUDGE

Another issue arising from the scrubbers use is the production of sludge after the washing procedure. The remaining sludge, a mix of light carbon residues, heavy metals and other substances, cannot be discharged into the sea or burnt at incinerators. That creates an additional problem for the vessel in terms of tank capacity for holding the sludge until proper facilities found. In the case that such facilities cannot be found

in the vicinity then things can be complicated since authorities must be informed and a fine or other unnecessary and un-favor arrangements might be requested. The facilities to accept such sludge are a matter of port authorities. Ports are allowing companies to receive and dispose such sludge, by providing relevant licenses. According to today's legislation, there is no specific category for such sludge disposal facilities. That means that no one knows exactly what will be necessary in order to discharge/dispose the sludge ashore. Needless to say that for small ports or unmanned ports, the disposal to facilities of scrubber sludge becomes non-realistic. Such a problem can have great impact on a decision of scrubber installation since frequent visit ports with no such facilities might be the key factor of rejecting such an investment. The environmental impact of the sludge discharge is still not obvious since not many studies have been contacted and consequences are only hypothetical at this stage. From the other hand, reception facilities might give rise to another sector, that of environmental disposal of such substances with new companies under specific regulations, acting as cleaners of the scrubber residues, contributing in economy and environmental protection. In other instances, the sludge could be accumulated in desert areas, polluting the land and water. Such a result will be against the spirit of the IMO 2020 Sulfur regulation and in general the word of IMO.

5.2.2. SULFURIZATION OF WATER

Main concerns about environment lead to hypothesis of contamination or pollution of water with Sulphur remnant from the scrubber cleaning process. Scientists have concluded studies showing different results leading to confusion the shipping world.

The increase of concentration of Sulphur in the water is something that easily somebody can understand when a vessel is discharging constantly during her voyage and while at port in some areas. As studies have concluded, throughout a voyage a vessel can discharge such amounts that although great in volume, their fast diluted in the ocean leaving practically no trace. But what about the closed areas or ports as there the water is not easily refreshed and big concentration of vessels is going on?

The answer is that indeed there will be an increase of sulfur content in the area resulting unbalance for the maritime environment. That could harm the sensitive microorganisms of the local microenvironment, increase temperature of the sea. Depending on the local micro sensitive factors, a balance might be broken with disastrous results (sea communities of corals). Such experiments are difficult to be conducted vastly and with actual targets. Results can be taken only after extended use and local observation.

5.2.3. INCREASE OF WATER TEMPERATURE

Similarly with the sulfur concentration, is the concern about the oceans warming.

Again studies might take individual cases and study each vessel separately in a big pool called open-ocean. In those cases, there will be no increase of sea temperature since vessels discharges are local and diluted quickly. In the case of a closed area where trading is high such as in Singapore, in North Europe and Baltic states, then the increase of sea temperature due to discharges is apparent.

The environmental concerns should include the condition of the sea and the effects of discharges. Globally warming of water is monitored and even 0.5 degrees Celcius increase might result melting of ice in northern, unbalance of sensitive eco systems, suffocation of valuable sensitive organisms etc.

5.2.4. LOCAL MARINE ENVIRONMENT REDUCTION OF QUALITY

Numerous studies have been conducted regarding the effects of the wash waters of scrubbers. Independent laboratories such as Norwegian Sintef have conducted and published a study showing that the sulfur emissions are reduced more compared with the emitted sulfur oxides from low sulfur fuel oil burning. That practically means that the main goal of IMO Sulfur Reduction is achieved with the use of scrubbers and air quality is getting improved. Less Sox Nox and CO2 emissions are released of up to 75% are released when using exhaust gas cleaning system is the conclusion. As the whole process is reaching it's peak, everyone involved is seeking for a scientific proof in order to support any commercial or technical decisions. Furthermore, when strategies of companies are involved and could be changed due to a regulation of such importance, it is evident that all parties involved will support any scientific research supporting this kind of strategy change. As all complicated and sensitive equipment that are meant to measure the emissions from a vessel, there is a constant need for their reliability. Scrubber systems are using such equipment such as sensors, sampling points, automation systems, chemical scanning devices etc. They are considered accurate but very sensitive especially in the marine environment. Authorities are using the results of such devices' measurements in order to make sure that the scrubber is working properly. Air emissions as well as washing water residue release are controlled through sampling points. Constant wash water residues are necessary in order to measure the PH (acid or alkaline), PaH levels (dissolved hydrocarbon), turbidity level (referring to clarity of water). Particulate matter is scientifically proved that is less in the exhaust gases of Scrubbed HSFO than with LSHFO. The Swedish Environmental Research Institute IVL has released a series of studies with results on economic and environmental aspects of the scrubbers use. One of the main targets of those studies were to prove the efficiency of the system in reducing the Sox emissions to equal of that burning VLSHFO and it was proved to be achieved (83% lower). Similarly the total hydrocarbon release in comparison with the VLSHFO emissions at the same rating of Main Engine was 40% lower. The particulate matter emissions, Sulphur in particles, PH and rest of carbon emitted were higher in the case of scrubbers. The emissions testing method however was reported to be uncertain of it's results. Other main concern that has brought numerous debates in the shipping industry is the water released effluent. The toxicity issues that could be resulted are still under investigation. In the same research the concentrations of copper and mercury are increased after the scrubber. Furthermore the lightest hydrocarbons are not efficiently removed as expected. Toxic effects from the effluent from scrubber after release in water were observed in the younger copepods mortality rate which was increased. Even the least concentrations effluent was proved toxic for the specific organisms. Another organism tested in reaction to toxicity by the effluents

were the mussels ability to attach to the ground under specific concentrations. In general the toxicity results in water were found more than expected based on the previous research on specific substances of the effluent. Such a toxic wash water can be proved harmful for the plankton around the vessel's area. As research concludes wash water concentrations in closed sea/port areas where many vessels are releasing open loop (mostly) wash waters can be proved an altering factor for the marine environment. The economic results of the study showed that indeed the calculations that prevail in the market regarding costs while running with scrubber and HFO, are less by almost E1m in comparison with the use of VLSFO. The study was based on a closed loop system and if considering for open loop then a further reduction of about E0.5m is expected. However the closed loop systems have additional costs for chemicals and other substances for the correct function of the system. If consider the outside costs involved, not directly related with the operation of the system but with the management of the wastes produced and thus facilities necessary, then the costs increase, for a closed loop system, by E0.5m/year in comparison with low sulfur fuel use. The desulfurization of emissions by scrubber system in use is proven, however the costs for health and environmental issues are increased. This fact is related with the rest of the emissions that remain untreated by the scrubber but are less in the exhaust gases of the VLSFO and the additional fuel necessary for the running of the scrubber system. As regards to the pollutants discharged in the water and therefore the external costs involved for both open and closed loop systems, it shows that the costs related to toxicity pollution of water are double in open loop systems.

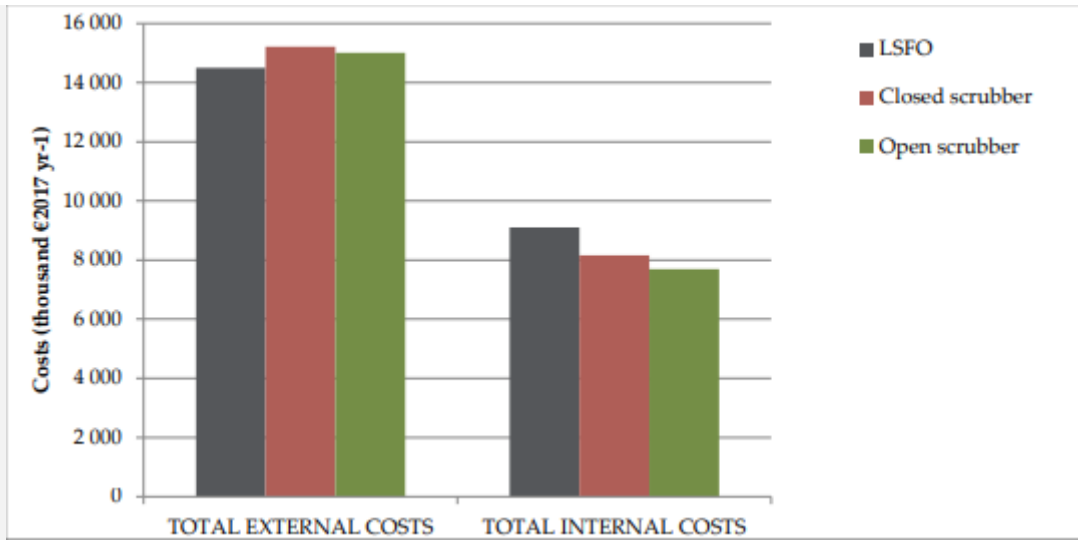
Test	LSFO	LSFO	LSFO	LSFO	HFO up-stream scrubber	HFO up-stream scrubber	HFO up-stream scrubber	HFO down-stream scrubber	HFO down-stream scrubber	HFO down-stream scrubber
Engine load	85%	75%	50%	34%	76%	49%	32%	76%	48%	41%
CO ₂ (kg/kWh)	0.60	0.60	0.66	0.79	0.62	0.69	0.85	0.62	0.69	0.74
SO ₂ (g/kWh)	0.36	0.36	0.4	0.48	10	12	14	0.06	0.03	0.02
SO ₃ (g/kWh)	b.d.l.	b.d.l.	b.d.l.	b.d.l.	0.37	0.13	0.16	0.08	0.05	0.06
NO _x (g/kWh)	11.8	9.73	11.9	15.4	11.0	12.6	16.3	10.9	12.4	14.6
nmHC (g/kWh)	0.24	n.d.	0.30	0.45	0.36	0.30	0.40	0.16	0.24	n.d.
CO (g/kWh)	0.42	0.53	0.88	0.96	0.93	1.72	1.87	0.79	1.40	1.50

Credit: Environmental Research Institute IVL

Table 3. Results from chemical analyses of the water entering the bleed off treatment unit (BOTU) on Stena Britannica, the effluent water for discharge, the seawater and the calculated reduction efficiency of the treatment system on board.

Parameter	BOTU feed	Effluent washwater	Seawater	Reduction efficiency (%)
Turbidity (NTU)	255	9.3	<2	96.4
pH	5.1	7.6	7.9	
Alkalinity (mmol·L ⁻¹)	0	6	2.5	
NO ₂ ⁻ *(mg N·L ⁻¹)	<30	49	<30	>-64.6
NO ₃ ⁻ *(mg N·L ⁻¹)	27	<1	<1	>96
Microtox (EC50, 5 min) (%)	13	15.5	>45	16.1
Al (µg·L ⁻¹)	120 000	8 300	39	93.1
As (µg·L ⁻¹)	66	20	1.9	69.7
Cd (µg·L ⁻¹)	0.34	<0.2	0.11	>41.2
Cu (µg·L ⁻¹)	41	150	17	-265.9
Cr (µg·L ⁻¹)	90	9	<1.2	90
Ni (µg·L ⁻¹)	7 400	830	0.61	88.8
Pb (µg·L ⁻¹)	18	<6	0.098	66.7
V (µg·L ⁻¹)	27 000	9 800	3.7	63.7
Zn (µg·L ⁻¹)	1 200	<70	6.2	94.2
Hg (ng·L ⁻¹)	1.9	5.2	0.84	-173.7
S (mg·L ⁻¹)	22 000	19 000	1 100	13.6
Total hydrocarbon (µg·L⁻¹)	211 960	7 103_{max}/6 499_{min}		96.9_{max}/96.7_{min} %
Fraction of different sizes of hydrocarbons :				
Aliphatic >C5-C8 (µg·L ⁻¹)	<4.0	<4.0	<4.0	-
Aliphatic >C8-C10 (µg·L ⁻¹)	<4.0	49	<4.0	<-1125%
Aliphatic >C10-C12 (µg·L ⁻¹)	1 400	2 900	<10	-107.10%
Aliphatic >C12-C16(µg·L ⁻¹)	6 800	1 700	<10	75.00%
Aliphatic >C16-C21 (µg·L ⁻¹)	23 000	<100	<10	>99.6%
Aliphatic >C21-C36 (µg·L ⁻¹)	95 000	720	<30	99.20%
Aliphatic >C36-C40 (µg·L ⁻¹)	24 000	<100	<10	>99.6%
Aromatic >C10-C12(µg·L ⁻¹)	860	630	<10	26.7
Aromatic >C12-C16 (µg·L ⁻¹)	4 900	500	<10	89.8
Aromatic >C16-C21 (µg·L ⁻¹)	16 000	<100	<10	>99.4
Aromatic >C21-C36 (µg·L ⁻¹)	40 000	<300	<30	>99.3
Naphtalene (ng·L ⁻¹)	18 000	4 400	<5.0	75.6
Acenaftylen (ng·L ⁻¹)	3 900	360	<1,0	90.8
Acenaften (ng·L ⁻¹)	35 000	2 100	<1,0	94
fluoren (ng·L ⁻¹)	49 000	3 200	<1,0	93.5
fenanthren (ng·L ⁻¹)	520 000	10 000	<1,0	98.1
Anthracen (ng·L ⁻¹)	16 000	400	<1,0	97.5
Fluoranthen (ng·L ⁻¹)	99 000	220	<1,0	99.8
Pyrene (ng·L ⁻¹)	360 000	540	4.3	99.9
Benzo(a)anthracen (ng·L ⁻¹)	210 000	210	<1,0	99.9
Chrysen (ng·L ⁻¹)	400 000	330	<1,0	99.9
Benzo(b)fluoranthen (ng·L ⁻¹)	100 000	100	<1,0	99.9
Benzo(k)fluoranthene (ng·L ⁻¹)	21 000	70	<1,0	99.7
Benzo(a)pyrene (ng·L ⁻¹)	39 000	<100,0	<5,0	>99.7
Dibenzo(a,h)anthracene (ng·L ⁻¹)	17 000	<100,0	<5,0	>99.4
Benzo(g,h,i)perylene (ng·L ⁻¹)	76 000	<100,0	<5,0	>99.9
Indeno(1,2,3-c,d)pyrene (ng·L ⁻¹)	20 000	<100,0	<5,0	>99.5

Credit: Environmental Research Institute IVL



Credit: Environmental Research Institute IVL

CHAPTER 6 - THOUGHTS IN THE LONG TERM

6.1. IS SCRUBBER A LONG OR A SHORT TERM SOLUTION?

When coming to evaluation of an investment either at early stages or at already completed ones, there are always unanswered questions. Especially at early stages or just before the beginning of the return of investment period, these questions might lead to wrong assumptions or wrong results. Scrubbers are coming in the shipping market in a take it or leave it sense or do it now or lose it forever. Somebody must have very solid grounds to reject such a proposal especially at periods where somebody is searching to make the difference in the market. When all vessels have same characteristics, the ones that they have less consumption are the winners. So installing scrubbers gives a plus to the owner of the vessel due to the reduced fuel price for the forthcoming years. The specialists in the market, are calculating a minimum of 3 to maximum 10 years of a price difference between the new fuel type and the High Sulfur already used in maritime sector. It is clear that the high sulfur wins in this competition. But none knows for how long. It would be easy to apply prediction tools based on previous experiences. The fact is that since a scrubber investment will require 1 to 3 years of repayment time, the fuel prices will play a significant role. But they are not the only fact. If freights move further lower than even the scrubber installed vessels will not be profitable. This will lead to mortgaged vessels or debt companies with a system onboard that none will wish to buy as a second hand. Even if chartering would prefer the freights will not cover the costs.

As it seems, based on opinions of INTERTANKO, the Korean Register, and other bodies with access to all levels of shipping and industry, the scrubber solution it was and still is an intermediate solution (Kim Yeon Tae 2018) (T.Veniamis, 2019) for a smooth transition to a new 0.5% era.

As the fuel prices will progress it will not be a big price difference for as long as the HSFO will be in the market. The experts consider a difference of \$80-\$100 at the time where the HSFO will stop existing in the market. Considering the fines to be imposed in case of non-compliance, the risk is high for anyone. The wide availability of the new fuel will cover the 80% of vessels despite the initial supply problems which are unavoidable. The cost of scrubbers should be going lower with the time as long as remains a quick repayment investment. If conditions change then predicting to keep a vessel in an unsecured market for more than 5 years it is useless. Even today no one can predict the market condition in the next 3-5 years. Given only the orders in the shipyards you can only predict the new vessels, the possible over 20 year old vessels to be scrapped and their relevant balance. Since almost all shipyards have a booking agenda for maximum 3 years ahead, the rest of predictions are uncertain. Even the long time chartering contracts e.g. 10 years cannot impose any rule since they are limited in the market considered exceptions. Therefore many are considering that the scrubber solution is considered a solution with limited life time.

The companies supporting the industry, the big makers are 3-5 with the rest of 25 companies following but with results that are not satisfactory. In order to improve the product and be certified it will take several

years which are not in hand e.g. for a vessel of 8 years old planning to install a system in 2021 by then aged 10.

The prices of the systems are not in free fall as many expected since the big manufacturers have the biggest share due to their reliability and service/spares network and guarantees. This is keeping their products high in price in contrary with the new comers willing to cover the demand but with inferior products and even worst service/spares network/guarantees. Needless to mention the fines from malfunction. The new improved materials are not easy to find and are way too expensive. So this investment if not for the quickest recovery it will not be considered and investment in a few years' time. Of course no one really knows what the future will bring, if more strict rules will come, if new technology can be installed in existing scrubbers that will allow them to continue burning the HSFO for as long as they like.

Whichever will be the choice today, new alternatives are coming with less implications such as LNG which might overcome much more quick than we think the existing technology and the even stricter to come legislation.

6.1.1. IS IT WORTH THE INVESTMENT?

When coming to this question a lot of opinions appear and a lot of controversies.

Since the early days even before the implementation of the 2020 rule a lot of studies were published by independent or “independent” bodies, research centers, specialists, professionals etc. All of them in good faith and will described their own perspective ambition and projecting of the future. In order to make a well argued research you need to have the exact numbers so when calculating the result will be accurate.

In the case of scrubbers versus new type fuels the basic numbers and basic future changes are missing making the predictions uncertain. In fact all predictions seem to work and to be out of line at the same time depending on the perspective of one looks at it.

The information and data on which a company will be based in order to take a decision either to install and in which percentage or not is a multifactor issue.

In cases of older vessels that have already completed a lifecycle of 10 years most probably it is not really worthwhile since the ROI will not be covered soon. Furthermore it is not sure that it will mean vessel will become more attractive in the market since it will still be an old vessel and comparing with other newer vessels will have higher consumption. This is the case of time chartering. In the case of spot market it might give some positive push appearing an improved image in the market and making sure that such a vessel equipped with scrubber will be able to be accepted in the specific port of call.

From owners' perspective and for the spot market independently from type and size of vessel, one of the most important features of the vessel is the consumption of fuel. Either HFO, M.G.O or new L.S.H.F.O consumption is a very big cost. The price comparison can convince everyone making a simple study. At the moment prices of fuels are unknown and any hypothesis can mislead. Furthermore no one is able to predict

the price increase or decrease pattern over the years, during crisis in periods of increased demand or in periods of reduced availability. Such cases can easily appear at any moment since technology of blended fuels is still improving and there is no feedback from use problems that might appear. This database will take long to be built and to be evaluated leading to improvements on production and use.

From the other hand the prices of a scrubber, installation costs and HFO prices are more or less given at this moment and the near future. Therefore it is easier to predict the costs incurred per annum and easier to predict these 3 elements' synergic costs. But even with this given pattern more factors are getting involved such as uncertainty of HFO supply at all ports after a given time, the efficiency of the system installed meeting the requirements and the costs incurring if not meeting the demanded requirements, local regulations with stricter demands, availability of systems to be installed on time, system's reliability over the years and service costs, the breakdown pattern of the system and the consecutive costs for low Sulphur fuel use during those periods, peripheral consumables etc.

It seems that scrubber fitting worth the investment since the direct costs are in hand and easily calculable. Despite that, the companies interested to fit such systems either have an obligation for environmental care or are following the market trend that requires every environmental innovation to give added value to the vessel and the company.

Shipping companies choosing the new type fuels can calculate only the avoided costs for not installing a system and relevant costs incurring by this bur remaining uncertain about the future running costs.

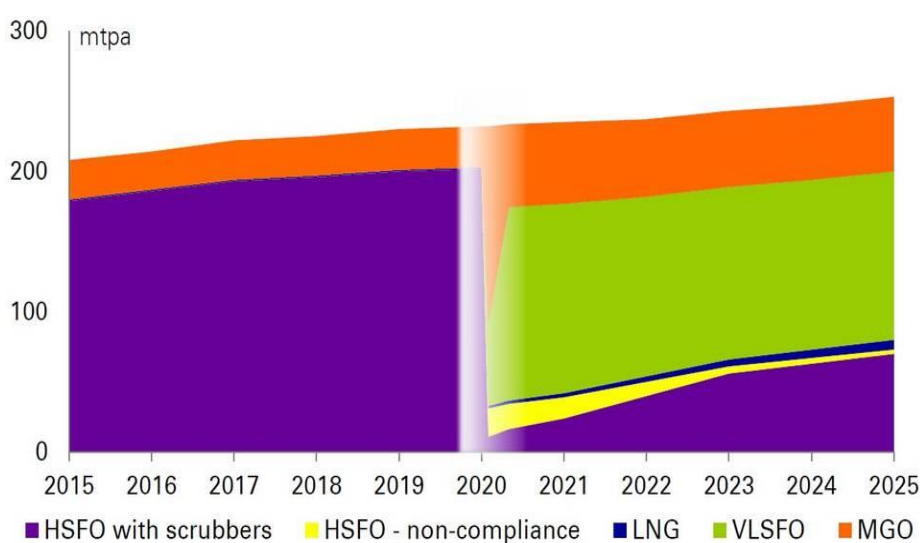


Photo: PR-grafik: BP

English Edit: Daniel Logan Berg-Munch

6.2. WILL EXIST ENOUGH HFO IN THE FORTHCOMING YEARS AND AFTER?

This question appeared since the beginning of the new rule since no one has the internal information from the oil majors and their future planning. Their future planning requires heavy investments in refineries and relevant infrastructure for production of the new fuel oils while at the same time their existing facilities must continue to produce the existing HFO for marine and industrial use.

Someone could note that there is a controversy or conflict of oil majors' interests if when promoting the new fuel oil in order to supply the market with compliant fuels and at the same time support the existing HFO production and supply chain.

Their strategy is no yet understood although obliged to produce the new fuels they support the existing market's demand with their older established products.

At this point it is worth to note that the HFO products are distributed in industry and marine sector in a ratio of about 90 to 10 which consequently would result a steady production for the forthcoming decades. This is the main assurance given with an indirect way to the marine market for the continuation of supply of HFO. From another perspective and analyzing the supply chain of marine fuels, providers of fuel oil, distributors, barge owners might decide to tend to trade more the new fuels since the profit might be higher due to most probable higher prices than HFO.

That would result a technical shortage of HFO in major bunkering destination ports such as Singapore, supporting the local economy in weigh of ship owners and charterers. This technical shortage might be inevitable and can create confusion and tendencies in the market such as change of bunker destination, increased costs for scrubber fitted vessels, reduced earnings for ship owners and therefore re arrangement of strategies, selling of vessels etc.

So far Oil major companies have not opened their plans to the market except the ones that assures that supply will not be affected.

6.2.1. AVAILABILITY OF THE HFO IN THE DESIRED PORTS

Assuming the installation of scrubbers onboard Cape size bulk carriers is a must and as it seems a small but respectful percentage is going to be equipped with such cleaning device until mid/end 2020.

Major concerns arise from the insecurity if HFO bunkering will be available at ports in Australia, China and Brazil. Following the legislation none really knows if the above countries will allow the use of open loop scrubbers or even hybrid ones but with small holding capacity. In order to protect their facilities and marine environment the selling of HFO for marine use might be prohibited in their ports apart from the discharge of water from Scrubbers. This combination will lead for sure this percentage of scrubber equipped vessels out of a big share of the market. As we may understand such a condition could lead in scrapping of scrubber equipped vessels sooner even before the investment will be repaid. Furthermore, if IMO decides to imply

even stricter rules than one of the 2 categories (scrubber installed or not) will have no choice than to scrap. Depending on the actual result of the emissions from a scrubber or directly from engine, it will be decided if a vessel is acceptable or not. In case of scrubber maybe system will need extensive modification in order to accept the even stricter rules. Failing will mean scrapping of the vessel.

The bunkers providers although willing to cover the HFO demand as much as possible, it is mentioned that maybe it will not be that easy. If a provider will decide to satisfy the HFO customers, then he must keep a completely separate supply chain. The HFO and the new type fuels should not come into any physical contact even their residues. That means separate tanks, separate piping system onshore and offshore, separate bunker barges and all the support it takes. How many physical suppliers are willing to invest in such a market when the big share will follow the new Low Sulphur Fuel. (Shurabi Sahu and Sambit Mohanty, 2018)

6.2.2. MAIN SUPPLIERS, SINGAPORE PASSAGE DEMAND AND SUPPLY OF HFO-THE OIL MAJORS MOVES

As the time of IMO 2020 regulation coming into force is a few months far, Oil Major companies and the rest of oil producing companies are struggling to fulfill their mission: to supply on-time the right fuels, in the right compliant description, in the right quantities in the most of the ports around the world.

This is a great goal to be achieved and as it seems almost everyone involved is really concerned about the readiness of the oil companies. Some have already produced a product compliant with 2020 sulfur cap with characteristics 0.34% of sulfur content, viscosity 323 cst at 50oC and density of 932.7kg/m³ at 15oC. The refineries in Manaus have produced this first batch and as stated, the company will stop producing high sulfur products after the implementation of the regulation. The influence in the market is easy to be conceived.

In the same wavelength Shell Marine has presented the Shell Alexia 4 cylinder oil, a new product to be used in marine engines burning the new compliant 0.5% fuel. New products are in the process for been delivered to customers at major ports firstly such as Singapore and gradually to all the rest of the world. Estimations of new VLSFO quantities available in the market in 2020 are rising up to 700.000 bpd that can reach up to 1.3 million bpd in 20125 as Raystad Energy Research and analysis has released.

Similarly the new compliant fuels are ready after extensive sea trials for worldwide distribution.

Products of BP will be available initially in U.S. Seattle, Panama, South Africa Ports, Oman, Netherland and Belgium Major Ports, Chinese ports including Hong Kong, Singapore Australia and New Zealand.

The availability date is still unknown and major hubs are missing from their initial supplying ports list.

The Exxon Mobil is declaring ready at end of 2019 to supply it's new compliant fuel distributed in 10 points around the world including Singapore. As it seems the oil major companies will begin with a limited number of ports to supply their new products. Those ports are some of the major hubs around the world and by the time their availability will expand to almost everywhere. Major concern is mentioned about the percentage of vessels equipped with scrubbers since it will be limited. Still no any clear statements about the availability of high sulfur fuels has been announced by any of the companies.

Similarly Total is planning to supply VLSFO at a 75-85% total production in comparison with a 10-20% of high sulfur fuel oils showing a clear direction towards the compliant fuels.

6.2.3. TECHNICAL ISSUES AND PREPARATION FOR THE NEW LOW SULFUR FUEL OIL-USING THE NEW TYPE FUELS (NECESSARY MODIFICATIONS AND ADJUSTMENTS).

Tanks arrangement of the vessel in an already constructed vessel and relevant piping/machinery/pumps involved were so designed at the time of building in order to accommodate 1 or 2 types of Marine Fuel Oils. Presently the new Very Low Sulfur Fuel types have a different consistency that makes them prone to levelling due to instability and separation due to incompatibility when two different supplied fuels are supplied. Practically that means that two or more different types and supplies of fuel cannot be mixed in the same storage tank and any other tank such as settling tank. That mentioned leads to a clearly operational and financial question of if finally a company chooses the 2020 compliant fuels then how the different supplied grades/types or supplied quantities per stem will be arranged onboard vessel in order to avoid the above mentioned implications? That would mean a separation of tanks as designation only and further use of only one fuel at a time for each tank. That means that each time vessel receives bunkers there must be at least an empty tank (completely empty tank with no residues and no un-pumpable quantity remaining from previous fuel) in order to accommodate so. If not then the remaining ones in the specific tank must be pumped out (as best practice) given to shore facilities –if such exist and owners can bear the cost. Moreover-and here is the hard thing- even if such arrangements can be executed and are all well prepared then comes the question- do the vessel's tanks have the adequate volume to accept the quantities of each parcel in order to carry out the specific voyage? When vessel was built since only HFO and MGO was obliged to be used and the quantity of HFO was much prevailing compared to MGO for each voyage, tanks were arranged in such quantities each that did not affect the voyage. Furthermore the transferring from one tank to another was not prohibited and therefore it was a common practice. With the new 2020 compliant fuels this Is not the case leading to solutions such as separating or extending bunker storage existing tanks. Practically that means vessel should add, move or remove bulkheads and piping in a shipyard or dock for a couple of days up to some weeks in order to adjust the quantities. Vessel will stay off hire for that period and result can be from successful to failure technically, operationally and commercially wise on long and short term. Mentioning the above if so decided to proceed with such modification, new piping lines or modification of existing ones must be carried

out. Needless to say that all the above need modification plans, Class approval and implementation in a shipyard with unknown result.

The compatibility and instability issues of the new compliant fuels can create damages on the main engine aux. engines pumps and various other components and machinery that come to direct contact with them. There is no guarantee given by any engine maker so far that the engines will run smoothly burning the new fuel. Same for other makers such as pump makers. Engine of vessel might face problem with non-combusted fuel, lubricity and cat fines leading to increased maintenance costs, more unscheduled stops for repairs leading to increased off hire times. Insecurity can be built with all mentioned conditions and situations to be faced and market might turn to scrubber bearing vessels in order to avoid such problems.

Some companies have decided to increase the amount of MGO onboard for emergency situations leading to increased cost since price of MGO is very high even today.

The prices of the new compatible fuels still are uncertain and will be somewhere around HFO price and MGO price with tendency to the highest of two. In this case the bunker costs are for both owners and charterers increased comparing to the past. This condition also might lead charterers prefer vessels with scrubbers for the obvious economy of using HFO lower priced fuel. Another issue is the availability of subject new fuels all around the world at every port especially at the busiest ones and at the adequate amounts in order to cover the demand.

So far the Oil Major companies are assuring that there will be enough for anyone almost everywhere during 2020 and progressively in short term all the demand will be covered. At this point would be good to mention that the amounts of Fuel Oil consumed by ships all around the world represents a fraction of the produced HFO which is mainly supplied to land industry.

So far the industry has not issued any ISO guideline to be followed when checking the new fuels for stability, compatibility, combustion issues and lubricity. Furthermore since yet are not tested in the ships' engines no one –starting from the makers – knows what will happen. The cost of failures will be huge to be carried out by anyone and the consequences unknown but for sure on the negative spectrum.

6.3. PROBLEMS APPEARING AND CONNECTION WITH PRICE UNIT

As for every new technology, in order to be adopted it takes several time before released to the consumers. The reason is the extensive testing in laboratories and control of results. In the case of BWTS, the tests for each system takes about 1 year of extensive tests in controlled and expert laboratories.

In the case of exhaust gas cleaning systems, although that as a concept it is not new and relatively known in the market, however in the case of installation onboard the vessels it is challenging. Many problems have been reduced such as but not limited to sensor failures, rapid corrosion, break down of moving parts, inability of electronics cooperation and so on. The industry has invested great amounts of cash on development and now are obliged to upgrade their systems with new improved sensors and electronic for better control and analysis of data collected while system running. In addition the more exotic durable

materials highly resistant to corrosion must replace the previous ones. All such result another cost that has to be lifted by the maker and return through customers. Prices of the systems although initially were reducing presenting an attractive investment, as passing time and due to recorded failures of old systems, prices are increased after adoption of improvements.

Failures of systems already installed leads to increased maintenance cost increasing OPEX and fines by authorities.

Sensors are the main instrument of measurement of the gaseous sulfur content and therefore the heart of the system controlling its behavior, increasing or decreasing the cleaning water amount, sending the results to main control units.

In case of failure of such a sensor then the whole system can be considered useless until fixed and certified by maker in presence of Class surveyor.

Depending on which area (ECA or elsewhere), easy access of technicians (transportation can cost some thousands of dollars in the US Gulf), schedule and availability of technicians and Class surveyor, vessel's obligations are summarizing a good amount of thousands of dollars just for a malfunction of such a sensor. Needless to mention one more time the fines that local authorities can impose in the case of non-compliance.

CHAPTER 7 - CONCLUSIONS

7.1 REGULATION WISE

The reactions of the shipping market regarding the decided implementation date of 1st January 2020 were almost all to the direction of not enough time to fully implement. Almost all parties at least at the beginning faced the concluded day of implementation as not possible to achieve compliance by all parts involved but mostly by the shipowners. The fact that the initiative towards reduction of sulfur was ongoing for several years, however shipowners tended to believe that postponement will apply something that never came. No matter if more time would help for a smoother implementation, the global reduction of gaseous sulfur emissions is a good step towards the protection of the environment.

7.1.1. BASIC TARGET AND IF TARGET WAS ACHIEVED

The basic target behind the new regulation is the reduction of Sox emissions at this stage in order to move to de-carbonization the soonest. The implementation date was too close to the announcement date leaving only few years preparation to a market unprepared for such a step toward new lower sulfur fuels.

There are strong voices in the shipping market insisting that scrubbers are not offering a solid solution for the protection of the environment. These voices are holding their positions and explaining that since there are discharges in the sea that can or could harm the environment, the scope of the scrubber is not achieved. The group of scrubber installer shipowners are supporting their choice as the best at the moment, based on research studies and scientific papers released, insisting that no harm to environment can be resulted from their waste water. Either sides are well documented and no one can say for sure what will be the result after several years of scrubber use.

7.1.2. THOUGHTS ON SOLUTIONS AND THE SCRUBBER SOLUTION

Solutions offered in order to be in compliance are enough and offered as alternatives to scrubber. Namely the new type Ultra Low Sulfur fuels, the LNG/LPG, Dual/Triple fuel, Slow steaming are to name a few of them. The problems appearing from their use, the existing technology, the methods and combinations to reach the compliance threshold will be always a debate. Results are in general positive, but all alternatives including the scrubber need time to be tested in real marine conditions, under pressure of time and obligations.

As offered the scrubber fitting in combination with HFO and MGO as fuel, is in compliance with the relevant regulations. It does offer a secured solution, with known Main Engine good performance and controllable problems that almost everyone is well aware of them and can face them easily. The lack of surprises during a voyage, including machinery breakdowns, delays in deliveries of cargo, imposed dangers

to crew, ship and cargo are eliminated. Although an increase in consumption and an investment worthwhile some millions, it gives a trustworthy solution to those not willing to risk. The price of HFO and MGO in the market is given and most of the parties do not foresee any major change in the near future.

7.2. MARKET WISE

Mostly well established companies, known for their innovating spirit were the first to enter the scrubber fitting course. Followed by publicly listed companies, companies with green/environmentally sensitive policies, big size vessels owners with time charters with highly reputable charterers are the mainstream users of this solution. The shipyards although reluctant at the beginning, were convinced to follow the trend.

7.2.2. TENDENCIES AND INFLUENCIES

As with all innovations, shipping market takes time to adopt. Groups of common interests appear approaching the new facts from a different perspective. Similarly in the scrubber case, a small group was formatted supporting their decision of fitting in their fleets. Their main supportive evidence is the proved reduced SOx emissions. Investing in scrubbers has created 2 different teams in the same sector e.g. in the VLCC sector. The ones equipped with scrubbers are already ready and know the majority of problems that will face. The rest of the ship owners, which represents the majority, are almost ready and insecure about the forthcoming status and problems. The fact is that all different groups will have to face problems from practical ones onboard vessels from failures to regulation compliance ones leading to chartering, authorities and various implications.

7.2.3. THE NEWBUILDING, RETROFIT AND REST OF INDUSTRY SECTORS INFLUENCED

Ship repair yards' activities have been reported to be increased due to the additional dry-docking or berthing of vessels that will install a scrubber system. The unscheduled dry dockings have been increased the last 2 years and keep a schedule of fully or almost fully booked shiprepair yards until mid. 2020's. As of that the activities in the shiprepair sector has been increased altering the main scheduled drydocking even at the cases that somebody will combine the installation of a scrubber during a special survey. From the other hand, the newbuilding yards are not influenced since it is a matter of owner or yard to install this additional piece of equipment. Delays can be faced in the case that contracted vessels are requested to be equipped with a scrubber system at a later construction stage, but this is not the case. In general there was a boost up to some level in the shiprepair and in general in ship's machinery manufacturing sector.

7.3. ECONOMY WISE

7.3.1 INFLUENCE OF FREIGHTS

So far the market has shown a positive eye on the scrubber equipped vessels usually liners and big vessels namely VLCCs and Cape Size bulk carriers. Although charterers see green innovations onboard as a positive step, freight do not seem to follow as a separation factor. The freight market still moves as a whole, up or down, without showing a great favor to the scrubber users. Of course the time is still not mature for such separations, since the implementation date has not yet arrived and there are many still expecting the unknown. The market, namely shippers and charterers as well the owners that have financed their new building projects or a retrofit, are expecting a positive outcome above the average, once the implementation date will come.

7.3.2. BANK LOANS AND FINANCE

Regarding the banking sector it has given its point by offering products adjusted to the new green solution and policy of the companies. By these products, the green loans, are supporting actively a whole movement towards greener technologies and practices used by the industry. The new loans are designed by the well-known established bank institutes giving the chance to shipping industry to adopt such a behavior towards the environment by investing in scrubber technology research and fitting onboard vessels. The designed products are well adjusted to the shipping market environment and give the opportunity to new and older companies to invest in RnD. The European Union through the responsible organizations is supporting the whole effort either by loan products or by allowing other institutes to follow this green trend.

Projects agreed and running have been a various background of financing. Owners saw reluctantly the possibility to invest a sum of million dollars for a piece of equipment that will not guarantee, a quick repayment, a better position in the market and a compliance with regulations with no headaches including problems at sea. Banks appeared to be ready even with some delay, to offer products covering the needs for investment in this new scrubber technology. Based on the greener planet-less emissions-less pollution until zero concept, they are offering many bank products that can be seen as attractive. Same for the stock exchange companies that it is easier to reach a source of finance through their stock/shareholders and that was proved in many cases. Even scrubber makers have created financing programs in order to cover the demand and special needs of their potential customers which shows a strong marketing policy.

7.3.3. THE BUNKERS SECTOR

Following the general turmoil, but maybe more confident, the bunker sector, is moving towards a new type of fuel. It seems more profitable- and it is- comparing with the HFO supplied until today. Preparations to accept the new type fuels include new storage facilities, transferring piping and machinery network adjustment, barges adjustments for bunkering and a lot more to invest in order to be ready in January 2020. Bunker suppliers will control the percentages of fuel supplies around the world, which seems to lean towards the new type fuel as main fuel supply about 90%.

From the other hand the main oil producers and distributors up to some point, the oil majors, the refineries etc. have declared that everyone will be satisfied, there will be adequate amounts of all types of fuel at least in the major port hubs in the beginning and later on all around the world. The implications will be huge if a certain area will have increased demand of HFO for the scrubber equipped vessels- like south east Asia and Australia – but the supply will be limited.

7.3.4. THE SCRUBBER INSTALLATION AS AN INVESTMENT AND REPAYMENT PERIOD

The fact that a scrubber can be considered as an investment, has been debated vastly during the last years. As a retrofit it gives a prospect of differentiation and a green signature in comparison with the rest vessels not equipped with the system. The owners decided to install it are expecting better freights, preference as priority from their charterers and a better second hand market price. The repayment period as presented by everyone supporting the scrubber solution, tends to be from 1.5 to 5 years maximum for almost all types of vessels. For the majority of these owners, this period is considered well within the limits and gives them an optimistic view of their future and their choice. Repayment periods are only a few years to be proved once more scrubber equipped vessels are inserted in the market and the rest of vessels will have to use any of their competitive advantages in order to secure their share too.

7.4. TECHNICALLY WISE

7.4.1. THE SOLUTION OF SCRUBBER

After the introduction of the IMO 2020 0.5% sulfur cap shipping market entered a very uncertain period, with limited information available regarding the solutions offered. The new proposed and soon imposed fuels of reduced sulfur content m/m are still obscured of their efficiency, results during use, supply network, problems etc. The Scrubber alternative appeared with similar insecurities for the owners and operators. It demands a capital investment at newbuilding stage or at retrofit, which is considerable amounting some millions of dollars of expenditure. Technologically although tested, still some issues exist with their

reliability of materials, working efficiency, reaching the necessary imposed levels etc. The financing of installation especially for retrofitting nowadays exists and can cover under conditions, the demand. However there is still skepticism regarding worthiness of investment, depending on the freight market, return of investment and implications by under performance of the system resulting fines, new fuel supply etc.

7.4.2. OPTIMUM VERSUS ECONOMICAL

The availability of systems by the well reputable makers it requires some months more of patience until delivery and installation in comparison with less known and reliable makers. If combined with the observed ship repair slot un-availabilities within a logical period (e.g. within forthcoming months), some shipowner might take the decision to install a cheaper scrubber system, with less reliability. Actually this is a case that many shipowners are facing. Chinese scrubber makers are approaching their customers with an all-inclusive offer, containing a shipyard slot in preferable period. This condition has been proved tricky since subject systems are not the most reliable resulting frequent failures and even replacement of materials in just a few months use. Such an investment is of high risk and needs to be avoided or at least considered deeply by the owners.

7.4.3. CONSEQUENCES

The consequences of cheap solutions can be very expensive. Repairs of the scrubber systems might require several days of immobilization resulting loss of hire. Class surveyor mobilization together with repair team employs additional costs for the owner in the side of several thousand of US\$.

Delivery of necessary spares might be slow resulting vessel to run with the new type fuels incurring excessive additional costs apart from the already scrubber invested amounts. If all the above will be combined with any governmental fine, the whole condition seems catastrophic up to some level for an operator and even the charterers depending on relevant arrangements.

7.5. ENVIRONMENTALLY WISE

7.5.1. SCRUBBERS MEETING THE REQUIREMENTS

The scrubber systems in the market are certified by independent bodies as meeting the requirements. Since fulfilling the new regulation prerequisites anyone can install a system on a vessel. The practise has shown that although the technology is getting improved, failures still exist. Failures that lead to non-conformance with relevant limits mentioned in the IMO 2020 sulfur cap. System failures can lead to serious implications with local authorities, imposing fines or banning the vessel until malfunction is fixed. Of course this is

translated into losses for the shipowner. Every maker is guaranteeing its system under the wording of “proper use” which is very general. This insecure environment will continue to exist up to some extent until within the first couple of years of use.

7.5.2. ENVIRONMENTAL IMPACT RESEARCH RESULTS

Various studies on the environmental impact of the use of scrubbers onboard vessels burning HFO have shown that they are actually meeting their purpose. These studies, mostly conducted from research institutes in Europe and after the order of groups of interests, are correct in methodology and their results cannot be disregarded as fake or misleading. However the majority of the shipping industry-the shipowners- are supporting the opinion with numerous similarly accurate studies, showing a harm to the marine species environment by the use of scrubbers.

The impact of use of the scrubber systems onboard vessel is still under research. There are many studies that at some level are contradicting. As a system it does what it is built for: cleans the exhaust gases from the Sox emissions and the rest of particles related. Practically those are not emitted in the atmosphere. The opposition is focusing on the use of water-sea water- especially by the open loop systems, the majority of systems installed, proving from their sides, that the cleaned emissions residues are causing harm to the environment as disposed at sea or even to land facilities. Both groups have a scientific stronghold position supporting their decision. The actual results might be different after the extensive use of such systems by the thousands of vessels fitted. The actual measurable results will be obvious after several years of use.

7.5.3. FUTURE OF SCRUBBERS

As with every new technology that appears in shipping industry, scrubbers are systems covering a specific need. Until now the alternatives were few, adjusted to the marine environment. Installing this system onboard vessel, can protect the environment from gaseous sox emissions, resulting compliance with the new regulations. The mission of the scrubber is to clean the exhaust gases from such substances and this indeed is succeeded and this will continue for a long time. Only the petroleum industry and fuel technology will determine if a scrubber will be necessary in the next decades, depending on the prevailing marine fuel imposed by industry and environmental legislation. As for the time being there is a small but stable interest for installation by companies involved in Caper , VLCC, Liner and Cruise ship operation. Such companies have specific patterns of trading, with an increased percentage of long time charter parties and that would mean their demand for scrubber installation will be kept stable for the forthcoming decades.

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Appendix