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Mind the cap : case study of Sulpher 2020 cap for Vietnam tanker joint stock company

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Completed Dissertation

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MIND THE CAP: CASE STUDY OF SULPHUR 2020 CAP FOR VIETNAM TANKER JOINT STOCK COMPANY

By

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Declaration

I certify that all the material in this dissertation that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this dissertation reflect my own personal views, and are not necessarily endorsed by the University.

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Due to the lack of experience in doing talent as well as the limitations of knowledge, the shortcomings in the essay will inevitably be unavoidable. I hope to receive comments, suggestions and criticisms from professors to make the study more complete.

Abstract

Title of Dissertation: **Mind the cap: Case study of Sulphur 2020 cap for Vietnam tanker joint stock company**

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In the context of moving towards clean energy industry, from January 1, 2020, IMO requested for ships to use fuel oil with a sulfur content of 0.5% by weight, compared with 3.5 % The current. The International Maritime Organization (IMO) will apply a new sulfur threshold in global maritime fuel oil to limit air pollution by sulfur oxides from ocean shipping. This new requirement came from the recommendations of a subcommittee at the United Nations (UN) more than a decade ago and was unanimously approved by IMO in 2016. Ship owners around the world have many alternatives to HFO. However, only two of these alternatives are relevant to the economic situation and the situation of the Vietnamese fleet, which is to use exhaust filtration and switch to fuel with low sulfur content. Each plan has its advantages and disadvantages, so in the face of two options, Vietnamese ship owners need to have evaluation and analysis calculations to choose the most suitable plan for the fleet. as well as its form and economic potential

The following study evaluates the combination with SWOT and PESTLE. It also calculates future cash flows based on the data of VITACO company which invested in each project to draw accurate conclusions for ship owners about choosing alternatives HFO replacement to comply with sulfur cap 2020.

- *Keywords*: Low sulphur, IMO, Sulphur cap 2020, HFO, Scrubber, 0,50% m/m.

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List of Abbreviations

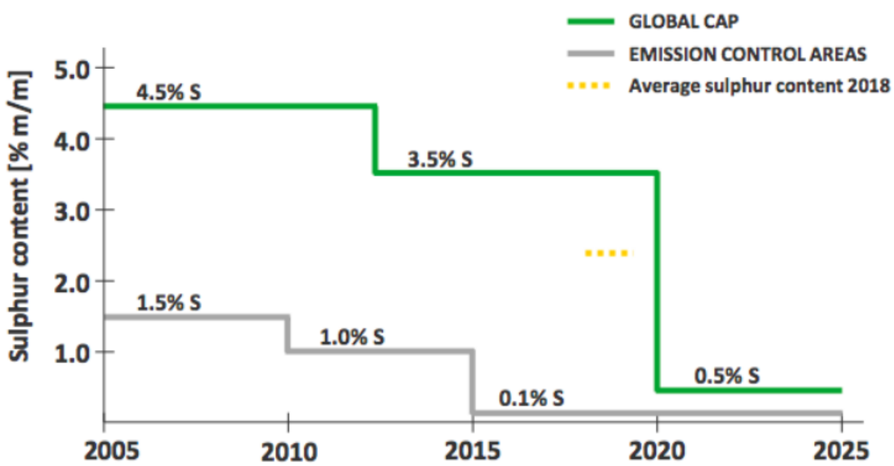
BAT	Best Advantage Technology
CAPEX	Capital Expense
CF	Cash Flow
CLE	Current Legislation
CSA	Clean Shipping Alliance
ECA	Emission Control Area
EGCS	Exhaust Gas Cleaning System
EIA	Energy Information Administration
HFO	High Fuel Oil
ICCT	International Committee on Clean Transportation
IFO	Intermediate Fuel Oil
IMO	International Maritime Organization
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
LSFO	Low Sulfur Fuel Oil
MDO	Marine Diesel Oil
MEPC	Marine Environmental Protection Committee
MGO	Marine Gas Oil
MLIT	Ministry of Land, Infrastructure, Transport and Tourism
NOC	No Control
NPV	Net Present Value
OPEC	Organization of Petroleum Exporting Countries
OPEX	Operation Expense
SO_2	Sulfur-Dioxide
TIW	Toxic Industrial Waste
ULSFO	Ultra Low Sulfur Fuel Oil
VLSFO	Very Low Sulfur Fuel Oil

Chapter 1 – Introduction

1.1 Introduction

Currently, shipping has become a primary industry of universal exchange and the worldwide economy. Over 90 per cent of world exchange is carried over the world's sea by 90 000 vessels (Oceana, 2018). All sorts of marine vessels utilize fossil fuel to run their machines, particularly fuel oil. The sulfur delivered by the vessels specifically impacts the worldwide climate and leads to ocean acidification. Sulfur oxides that are released from the vessel ought to be diminished to secure the environment and human wellbeing. From January 1, 2020, colossal shipping vessels must apply low sulfur fuel, at 0.5% such as marine gas oil (MGO) or ultra-low-sulfur fuel oil (ULSFO) to supplant overwhelming sulfur 3.5% which is broadly utilized today.

Figure 1: The level of sulphur Under MARPOL Annex VI- Regulation 14



Source: IMO (2018)

This conversion aims to reduce sulphur-dioxide (SO_2) emissions in shipping operations. Currently, the global shipping industry accounts for 13% of global SO_2 emissions each year.

Figure 2: Benefits of reducing emission to Global and ECA

	Global	ECA
NO_x (g/kW·h)	15–20%	80%
SO_x* (g/kW·h)	80%	96%
PM (mass)†(g/kW·h)	73%	83%

* Reduction relative to 2.7% sulphur content in fuel.
† Expected reduction of PM from fuel change.

Source: Buhaug et al. (2009)

Figure 3: SO2 emissions and control cost in Asia for 3 term: "Current Legislation" (CLE), "No Control" (NOC) and "Best Advantage technology" (BAT)

	1990	1995	2020		
			CLE	NOC	BAT
SO_2 emissions (million tons)	32.4	36.8	57.0	72.8	11.4
Emission control costs (billion US$ 1995)	2.6	4.7	13.0	0.0	78.3

Source: (Cofala et al., 2004)

- Applying "The 2019 Guidelines on consistent implementation of 0.50% sulphur limit under MARPOL Annex VI." Into Vietnam case

In spite of the fact that limitations on transport sulfur have been around for a long time in certain assigned regions (called zones of sulfur oxide outflows control – counting the Baltic Ocean, the North Ocean, North America and the Caribbean area – the restrain of 0.1% sulfur substance in marine fuel oil came into impact on January 1, 2015), the move on global models to utilize low-sulfur fuel oil has been very dubious. Taking after Annex VI of the International Convention for the Prevention of Pollution from Ships by the IMO (MARPOL Convention), on January 1 2020, the sulfur substance permitted in marine fuel oil is allowed. Utilization by all ships will be from 3.5% of the current volume to 0.5%.

From an environmental point of view, the restrain of sulfur content within the fuel oil of ships is 0.5%, regularly referred to as the “IMO Sulfur Limit 2020”, which is genuinely an unused wind, in trade environmental assurance of the sea industry. This choice highlights the preparation of the IMO to execute more naturally neighborly approaches. Sulfur emissions from ships are considered to be one of the most discussed components of contamination. They are destructive to both the environment and human wellbeing – for example, sulfur oxide can lead to respiratory ailments and contribute to acid rain.

In Vietnam, various trade businesses are concerned that the change to unused powers will influence shipping costs with this increment, in a few cases bookkeeping for 10-15% of cargo, cargo owners will without a doubt be fundamentally changed. It is not clear how much this increase can be interpreted into cost, but income and benefit of commercial companies will be significantly affected. The add up to fuel cost of the whole industry when applying the prevailing direction is approximately 10-15 billion USD. When there is a critical change in shipping costs, logistics businesses must moreover share a parcel of the increase with customers to implement this strict control of IMO; therefore, container lines around the world have begun to apply numerous arrangements. In specific, various companies have introduced sulfur filtration systems; this arrangement features a high introductory establishment cost and requires strict installation.

Figure 4: Price of other fuel to switch with HFO in USD and EURO

	HFO (1.5%) LOW	MGO (0.1%) LOW	HFO (1.5%) BASE	MGO (0.1%) BASE	HFO (1.5%) HIGH	MGO (0.1%) HIGH
USD	278	500	417	750	556	1000
Euro	193	348	290	521	386	695

Source: DNV, SAFER, & GREENER (2018)

1.2 Aim and objective

- Aim

This assignment will discuss main options for complying with the new 0.5% sulfur limit. First, owners can choose to switch from heavy fuel oil to low sulfur distillate oil (marine diesel oil, heavy fuel oil with shallow sulfur content or a mixture of high fuel content. Other low sulfur). Second, ship owners can use alternative fuels such as liquefied natural gas (LNG) – perhaps more suitable for newly built ships. The third option for shipowners is to continue to use high sulfur fuel oil (HFO) with new scrubber technology. Most of the information collected from IMO documents, the legal documents of Vietnam legislation and webpage reports from interest organizations or NGOs will provide the details about the effect of Sulphur oxides emission to the environment and human beings.

- Objective

Each option has its advantages and disadvantages. Owners must consider several different factors such as the age of the ship, the number of fuel tanks of the vessel, the company's commercial model and the availability of various fuel products. Some cautious ship owners have reorganized their fuel supply chain and network to ensure that by January 2020 their vessels can be supplied with compliant fuel. Other issues of concern are increased compliance of fuel prices and shortage of fuel supply.

From there, the author will have a more objective view to suggest appropriate methods for Vietnamese ship owners. The author wants to study and research the following points:

- Evaluating the impact of the low sulfur cap on freight rates (case study in Vietnam)
- Analyzing the potential factors that increase freight rates in the context of "low sulfur fuel" on shipping
- PESTLE and SWOT analysis between 2 options: alternative fuel and installing scrubber system

- Utilizing economic tools to caculate the cashflow to investment of each method.
- Give recommendations for shipowners in Vietnam to deal with the reduction of the amount of Sulphur in fuel

1.3 Research Contribution

The research helps shipowners identify exactly which projects are suitable for the fleet's financial and technical situation.

It provides a clear overview of utilizing scrubbers and switching to VLFO fuel to comply with a sulfur content of less than 0.5%, which IMO introduced

The research will accurately evaluate future cash flows after ten years for each project to comply with the sulfur threshold outlined in 2020 and consult the shipowner on choosing the best option for the company.

1.4 Research of methodology

1.4.1 SWOT analysis

The SWOT is a valuable instrument utilized to understand Strengths, Weaknesses, Opportunities and Threats in a commercial context or organization (Piercy & Giles, 1989). Through the SWOT analysis, the author will easily assess the strengths and weaknesses of each plan as well as the opportunities and challenges that ship owners face with each type of plan. The reason for SWOT analysis is to distinguish the qualities that each strategy brings and the confinements to be overcome (Valentin, 2001). In other words, SWOT may be a device to assist owners in evaluating and deciding what the most exceptional measure is.

Table 1: Factors of SWOT Analysis

SWOT ANALYSIS	POSITIVE	NEGATIVE
INTERNAL FACTORS (The real factors arise internally, etc.)	**Strengths** needs to be maintained, used as a background and leverage	**Weaknesses** needs repair, replacement or termination
EXTERNAL FACTORS (The real components emerge from the outside environment)	**Opportunities** ought to be utilized, prioritized and opportune captured; construct and develop on these opportunities	**Threats** These risks need to be included in the plan for prevention, response and management options

Source: Author (2020)

1.4.2 PESTLE analysis

The PESTLE examination considers the impacts of variables within the political – legal, economic, social and technological spheres. There are four variables that have a coordinate impact on financial segments (Rastogi & Trivedi, 2016). These components are outside the variables of the behavior and industry subject to the effect that it brings as an actual figure. Businesses based on these impacts will create arrangements and commerce exercises that suit them best (Perera, 2017).

1.4.3 Net Present Value (NPV)

NPV is interpreted as Net Present Value, which suggests the display value of the complete future project cash flow is marked down. NPV is not considered the most excellent strategy to assess the productivity of the arrangement (Lim, Park, Lee, & Park, 2006). Ordinarily, NPV is the most excellent strategy to determine the productivity of an organization

1.5 Importance of the investigation

The heavy fuel oil, such as crude oil is used as the primary type in the shipping industry. Sulphur is contained in crude oil which has an adverse effect not only for human health but also for the environment. The amount of sulphur oxides discharged by ships is the leading cause to make acid rain and acidification of the ocean. Moreover, air pollution is the result of the SO_x emissions discharged from vessels. SO_x emission reduction is the obligation of ship owners to improve the quality and protect the environment. Consequently, in 2005, the regulation of reducing sulphur oxides first entered into force through IMO, under Annex VI of the International Convention for the Prevention of Pollution from Ships (MARPOL). From 1 January 2020, the limit for sulphur in fuel oil used on board will be reduced to 0.50% m/m from 3.50% m/m (mass by mass) (IMO, 2019). This solution plays a significant role not only in protecting the natural environment from the SO_x but also taking care of human health.

1.6 Expected results.

The study predicts and analyzes the cost and prices of 2 investment options which comply with the new requirements of IMO in 2020. In terms of economic impacts, it directly impacts the freight, making the freight increase dramatically and playing an significant role for the benefits of many shipping companies. There are different methods for ship owners to deal with the "low sulphur cap"in 2020, including switching to low sulfur, installing scrubbers, changing to cleaner energy (LNG), transfering into the "low sulfur" fuel marine gas oil (MGO/LSMGO) (Vierth, Karlsson, & Mellin, 2015). The method which ship owners consider to choose also depends on the fuel prices, vessel structure or the place that ships usually operate. Each method has its disadvantages and its adaptability. Now the advantages and disadvantages of these three methods are analyzed, and owners can choose according to their characteristics.

Chapter 2 – Literature Review

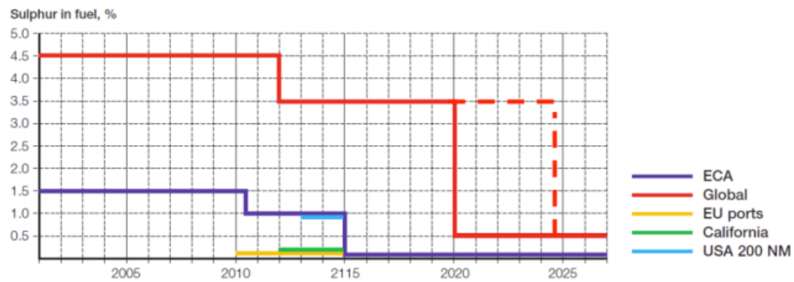
2.1 Sulphur cap overview

Shipping is a major source of Sox emissions outside the global environment in general and of Asia in particular (Arndt, Carmichael, Streets, & Bhatti, 1997). The emmision from vessels has very high sulfur content, which directly affects the ocean environment and quality of the air; therefore, emitting a large amount of $SO2$ in the environment affects the atmosphere and human health (Eyring et al., 2007). In the 1980s and early 1990s, the Asian economy experienced a dramatic transformation. The rapid growth of the economy caused shipping to increase by an average of 5.4% between 1988-1995 (Arndt, Carmichael, Streets, & Bhatti, 1997). Therefore, the amount of $SO2$ released to each school also increased by an average of 5.9%.

In the mid-1990s, the shipping skyrocketed due to the high demand for international shipping goods by sea, which caused the increase in sulfur emissions to the environment (Corbett & Fischbeck, 1997). At that time, most fleets around the world used cheap crude oil used in ocean shipping to constantly contain up to 5% sulfur (Arndt, Carmichael, Streets, & Bhatti, 1997). The amount of sulfur released during the process has caused global environmental pollution (Capaldo, Corbett, Kasibhatla, Fischbeck, & Pandis, 1999). It can be affirmed that this is one of the main factors causing serious pollution in areas with strong development of international shipping. Therefore, in order to protect the environment to limit the sulfur emissions of the shipping industry, new regulations have been introduced to limit the lowest level of sulfur emissions during transportation.

The International Convention for the Prevention of Pollution from Ships (MARPOL), limited the level of sulfur discharged from ships to 4.5%. However, this seems like weakness, so Europe has enacted stronger provisions to control sulfur emissions. From this point, MARPOL has informed that the Baltic Sea, the North Sea, the English Channel will be in the Emission Control Area and aims to reduce emissions by 1.5% or apply emissions control measures (Zetterdahl, Moldanova, Pei, Pathak, & Demirdjian, 2016). Europe has taken serious actions to raise awareness of ship's emissions that will affect the environment by strictly controlling the amount of sulfur emissions in transit. In 2012, the ECA introduced a new sulfur limit of 1.0% while the world's sulfur level was required to be controlled at 3.5%. (Bergqvist & Cullinane, 2013). In 2015, ECA continues to control the level of sulfur emissions at 0.1% in the hope of maintaining this level until 2026 (IMO, 2013).

Figure 5: The content of Sulphur limit in each region of the world



Source: IMO (2013).

While European countries are aware that the amount of sulfur emitted in the transport process is the cause of environmental pollution and have taken measures to prevent this problem thoroughly, countries in Asia including Vietnam has not yet been able to control the amount of sulfur emitted during transportation. According to a report, in 1998, sulfur emissions increased during shipping in Asia and the Strait of Malacca. (Arndt, Carmichael, Streets, & Bhatti, 1997). Ecosystems in surrounding areas are also on alert and will be destroyed because most of the SO2 released into the environment will form acid rain. The amount of sulfur emitted during transport was investigated as soon as the experts realized that the rapid increase in the amount of emissions in this area had a serious environmental impact

On January 1, 2020, in the event that authorization for the rest of the world is deferred to 2025, the unused regulation to diminish sulfur outflows from 3.5% to 0.5% (IMO, 2013). This direction features a substantial and coordinate effect on the shipping industry since over 90 per cent of world cargois carried at sea by 90000 vessels (Oceana, 2018). Most shipowners, shipping companies and ship operators have had to alter their fleets as well as their operation strategies to comply with the recent IMO enactment. This has seriously influenced the cargo rate. Most fleets in the world, and in Asia specifically recently, use the sulfur edge of 0.5 utilize rough oil to run the engines. Crude oil is cheap fuel, but the sulfur substance in raw oil is exceptionally high and influences human wellbeing when SO2 outflows are discharged into the environment during navigation (Wiberg & Fredriksson, 2018). Minimizing the amount of SO2 released into the environment when using crude oil is essential to reduce human health risks and protect the environment. In a study submitted to the IMO's Marine Environmental Protection Committee (MEPC) in 2016, it was estimated that in the absence of reduction of sulfur oxide (SO_x) emissions, air pollution linked to maritime traffic could cause more than 570,000 premature deaths worldwide from 2020 to 2025. The new regulation is expected to bring public health benefits, especially for people living near ports and routes.

2.2 Technology option

In order to follow the new regulations on the global use of fuels with a sulfur content not exceeding 0.5% by weight, ship owners have three main solutions as follows:

2.2.1 Switch to liquefied natural gas (LNG)

Using LNG fuel (Liquefied Natural Gas): this plan must replace the entire main engine system (Main Engine); Generator Engine and another Auxiliary Engine suitable (Lindstad, Rehn, & Eskeland, 2017). The cost of this conversion is very high and the LNG supply station is very small, so this option only applies to newly built ships and is not preferred for ship owners to choose.

2.2.2 Installing to filter tower system (Scrubber)

Using Scrubber installation (filter tower): This option can still use 3.5% sulfur fuel because the filter tower has filtered the exhaust gas by retaining Sox before the exhaust of the main machine equipment and transmitter is released into the environment (Vierth, Karlsson, & Mellin, 2015). However, the plan to install this new filter tower is hindered by the investment cost of about US $ 4-5 million and manufacturing time

(6 months) for installation (1 month), so few ship owners make this choice. If this option is chosen, the additional cost for transportation is the depreciation cost for the installation of the filter tower with the cost of about 4-5 million USD plus the cost of providing acid neutralizing chemicals (H_2SO_3 / H_2SO_4) borne + filter tower maintenance costs by year/cycle.

2.2.3 Switch to alternative fuel (VLSFO/ULSFO or MGO/LSMGO)

Using a plan to change the fuel using 3.5% sulfur with fuel less than 0.5% S (VLSFO-Very Low Sulfur fuel oil) or lower than 0.1% S (USFO-Ultra Sulfur fuel oil) or MGO/DO (0.1% S) (Vierth, Karlsson, & Mellin, 2015). The plan to use VLSFO, the main machine and the generator do not need much conversion as only a few small parts (cement, some spray) have to be replaced. The plan to use USFO or MGO/DO is a little more complicated due to low viscosity because high pressure pumps and transport pumps should be considered for leakage. Basically, conversion costs are low. The cost of VLSFO oil and USFO is higher than HFO-High Sulfur fuel oil

2.3 Challenge for Vietnamese Ship-owner to deal with New regulations

All of the above solutions have their own strengths and weaknesses. Shipping companies or ship owners (specially in Vietnam) can rely on the financial situation as well as the conditions of their fleets to choose best option. However, whatever method is used, it will deeply affect the freight rate, change costs, fuel costs and investment costs. Transport companies or ship owners should carefully consider the conversion to ensure the satisfaction of new regulation and minimize the factors that increase freight rates. However, no matter which option is chosen, the maritime industry will incur significant operational costs as clean fuels are more expensive.

Only with the new regulation, shipping businesses in Vietnam must compensate more than VND 220 million for a round-trip ship from Hai Phong to Saigon, not to mention a series of other costs attached.

For developing countries, including Vietnam, switching to a new fuel to replace crude oil is a big economic problem for transport operators and ship owners. Specifically, the new fuel will be more expensive than FO oil that the ships are using, on average about 100 USD/ton. According to calculations by the Vietnam Shipping Company (Vosco), one of the largest shipping companies in Vietnam today, in compliance with IMO regulations, Vosco has implemented a new fuel conversion and sub-implementation. However, this surcharge is only shared with shipping lines but cannot cover operating costs. The surcharges for empty containers and containers that are transported on all inland routes, Vosco currently collects 300,000 VND per container from the shippers. A container ship travels from Hai Phong to Saigon and vice versa using on average more than 80 tons of oil. Currently, the price difference of old / new oil is about 18,800 USD (equivalent to over 433 million dong). With transportation costs of about 800,000 VND per teus, minus the surcharges of 300,000 VND collected from goods owners, businesses still have to compensate losses of 500,000 VND per teus when using new fuel. That is not to mention, businesses still have to spend a lot of money to replace some spare parts, machinery components such as injectors and cutters to suit the use of new fuel.

In case of not using alternative fuels but installing filters, the installation cost is as expensive as a ship (Lindstad, Rehn, & Eskeland, 2017) This is a huge challenge for international shipping lines, especially those with small operating scale and weak financial potential (Vierth, Karlsson, & Mellin, 2015).

Another challenge for Vietnamese shipping enterprises is that most domestic fleets are “old” and outdated, many of which have ships of 15 years or more. Therefore, it will face a lot of disadvantages from new and more modern foreign ships. As Vietnam’s fleet is mostly second hand, using the LNG option is a huge challenge as LNG fuel is only suitable for newly built ships (Lindstad, Rehn, & Eskeland, 2017). According to the report of the Vietnam Register Department’s ship office another challenge facing the Vietnamese shipping industry is that the fleet is declining in number from 1,600 in 2018 to 1,568 at the present time.

Although the Vietnamese shipping industry has many development opportunities, domestic ship owners still face difficulties such as backward fleets and limited access to capital, thus hindering modernization. In Vietnam, many import and export businesses are concerned that the conversion to new fuels will affect shipping costs, especially at the end of the year when the volume of import and export goods is quite large.

Facing these challenges, the authorities have researched and proposed some solutions to help Vietnamese fleets meet IMO regulations such as using FO oil with 3.5% sulfur content and installing more systems. Filter sulfur in exhaust gas after leaving the engine uses DO oil with a sulfur content of 0.5%, or uses FO oil with additives or added chemicals to sulfur content in fuel standards (Zhu, Li, Lin, Shi, & Yang, 2020). However, the difficulty in the above options is the high cost and not every engine is suitable. Therefore, the Vietnam Maritime Administration has officially called on ship owners and stakeholders to accelerate the application of 4.0 technologies in the maritime sector.

In addition, the disaster of the Covid-19 epidemic is one of the causes directly affecting the shipping industry in general as well as shipping charges in particular. In addition to affecting routes to and from China, Japan and South Korea, Vietnam's leading trading partners, the epidemic also affects the entire regional and the global shipping market. Average sea freight rates continue to decline 80% since the outbreak of Covid-19. In addition, the supply of spare parts and supplies for repair vessels as well as the replacement and supply of crew members are facing many difficulties.

From there, the author will have a more objective view to suggest to the ship owner's appropriate methods for Vietnamese ship owners. The author wants to study and research the following points:

- Evaluating the impact of low sulfur cap on freight rate (case study in Vietnam)
- Analyzing the potential factors that increase freight rates in the context of "low sulfur fuel" on shipping
- PESTLE and SWOT analysis between 2 options: low behavior fuel and installing scrubber system

- Utilizing economic tool to caculate the cashflow to investment of each method.
- Give recommendation for ship owners in Vietnam to deal with the reduction of the amount of sulphur in fuel

Because most of Vietnam's fleets are mostly old vessels, it is not suitable to use LNG. Regarding the two measures of installing scrubbers and low sulphur fuels, there has not been a specific assessment to help Vietnamese ship owners to determine which is the best option both in terms of environmental and economic aspects. On the other hand, in the context of oil war between OPEC and Russia, a series of scrubber installation companies had to delay creating a phenomenon called "flood of cancelation of scrubber" to make way for fuel supply companies. Some shipowners who use the scrubber system are in a more difficult situation than ship owners who choose low sulphur fuels. However, this is a time-consuming phenomenon and it is impossible to determine which is the best option for ship owners. In order to help owners have a clearer overview of the two options, the study will compare and analyze the two options using both qualitative and quantitative methods. After determining the plan for the shipowner, the author can identify what factors directly affect freight rates in the context of the sulfur cap 2020 (Zhu, Li, Lin, Shi, & Yang, 2020). Based on calculations from economic tools and SWOT analysis, the author can easily propose to ship owners about choosing the best solution to suit the economy as well as environmental conditions of Vietnamese shipowners meeting the new IMO 2020 regulations

Chapter 3 – Comparisons between 2 scenarios: Low Sulphur Fuels and Scrubber Options of Vietnamese ship-owners to deal with new regulation in 2020

3.1 Overview of low sulphur fuels

3.1.1 Marine Fuels

Marine fuels, also known as bunker fuel, is a type of fuel used in maritime transport. Marine fuel is divided into two different categories:

- Heavy fuel oils include HSFO, VLSFO and ULSFO
- Oil is created by the distillation process (Marine Oil Gas (MGO)).

The blend of heavy fuel oils and distillation oils is called Marine Diesel Oil (MDO) or Intermediate Fuel Oil (IFO). MDO oil contains only deficient amounts of heavy fuel oil. Therefore, MDO distillate oils like MGO. The largest vessels in the world use heavy fuel oil or marine fuel oil to run the main engine, but for smaller ships or barges, it is not suitable to operate with heavy sulfur fuel oil (ASTM, 2010)

Crude oil will be taken to a refinery to conduct fractional distillation to produce products of crude oil or marine fuels following ISO 8217. Segmentation distillation will take place when crude oil is decomposed at a specific temperature after being heated. If the boiling temperature of the crude oil is exceeded, it will change to the gas phase. The residues, which after the distillation process are not converted to the gas phase, will be called residual fuel or heavy fuels oil. Over the next several stages, the sulfur content in heavy fuel oil will be reduced (Vermeire, 2012). Depending on the process of distillation or accumulation in excess, fuel is divided into 2 types: distillate fuel and residual fuels.

- Residual fuel was classified by ISO 8217 into 6 different fuels based on their viscosity including RMA, RMB, RMD, RME, RMG, RMK (ASTM, 2010). Fuel viscosity is calculated in square millimeters per second (mm2/s) Large, medium to low-speed marine engines often use residual fuel. Lighter fuels such as distillate fuel and residual oil which are less viscous, are used for smaller ships because larger ships using larger engines need to use the heavy engines of small vessels only lighter fuel is needed.

- Distillate fuel is classified into 4 types DMX, DMA, DMB and DMZ used for smaller engines such as (lifeboat/ emergency units) and is located outside the engine room. In practice, however, intermediate fuel oil (IFO) is used as a mixture of distillate fuel and residual oil. Currently the most widely used fuel in seaborne trade are IFO 380 and IFO 180.

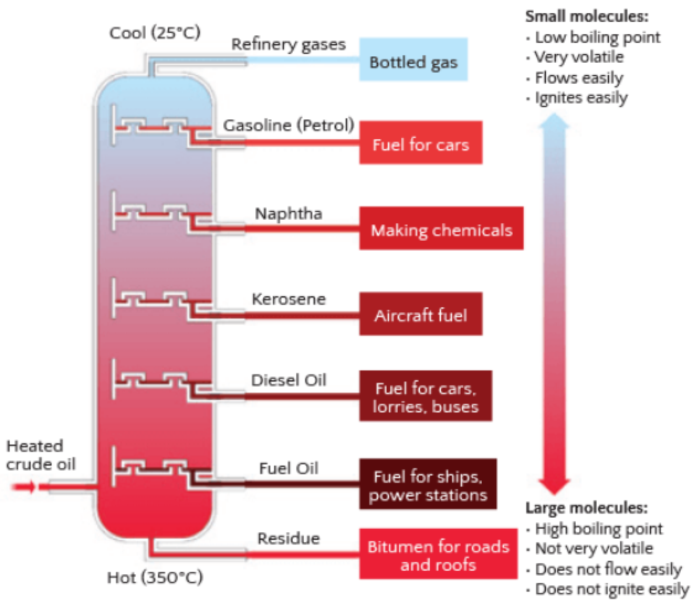
Table 2: Classification of Marine fuels.

Fuel Types	ISO Category	Viscosity (cSt) (at 50°C for Residual and 40°C for Distillate Fuels)		Sulfur Content (%)
		Minimum	Maximum	
Distillate Marine Fuels (DM)	DMA, DMB, DMX, DMZ	1.4	6.0	0.10 - ≤0.50
Residual Marine Fuels (RM)	RMA, RMB, RMD, RME, RMG, RMK	10	700	1.0 - 3.5
Ultra-low Sulfur Fuel Oil (ULSFO-DM)	DMA, DMX	1.4	6.0	≤0.10
Ultra-low Sulfur Fuel Oil (ULSFO-RM)	Mixed fuel with RM category	8	60	≤0.10
Very low Sulfur Fuel Oil (VLSFO-DM)	DMA, DMX	1.4	6.0	≤0.50
Very low Sulfur Fuel Oil (VLSFO-RM)	Mixed fuel with RM category	8	60	≤0.50
High Sulfur Heavy Fuel Oil (HSHFO)	RMA, RMB, RMD, RME, RMG, RMK	10	700	>0.50

Source: ABS (2018).

The standards for the regulation of emissions to the environment of sea transport and land transport are not similar. Most vessels today are run by heavy fuel oil with very high sulfur content (up to 4.5%) and worse quality than MDO. Because the price of heavy fuel is much cheaper than the price of MDO, ship owners still choose this oil to be the main fuel for running the engine. Because the sulfur content in heavy oil is so high, SO_x emissions into the environment are a major cause of global environmental pollution. Reducing the number of Sox emissions caused by heavy fuels, IMO has introduced regulations to limit sulfur emissions to the environment. In 2012, the IMO requested a reduction in sulfur emissions from 4.5% to 3.5% globally, and for ECA, the required sulfur level was reduced from 1.5% to 1%. From 1 January 2020, the world must accept the new sulfur level set by the IMO from 3.5% to 0.5%. In the ECA area, the level of sulfur emissions that have been requested to change since 2015 has decreased from 1% to 0.1%.

Figure 6: Distillation process of Marine fuels from Crude oil



3.1.2 Heavy Fuel Oil (HFO)

Heavy fuel oil is used in the main engine of medium and slow speed vessels. Prior to the IMO's new level of sulfur emission in January 2020, HFO was a widely used marine fuel. At a much cheaper price than MDO or MGO, HFO is used for ships when carrying transnational goods. After the distillation of crude oil, the residual oil is HFO oil (Jasper Faber, 2016). Depending on the quality of the crude oil to be distilled, the resulting oil product is of the same quality. For each different type of oil, the sulfur content contained herein will vary

Table 3: Classification of Måine fuels

Marine fuels	Max. Sulfur content
High sulfur fuel oil (HSFO)	3.5%
Low sulfur fuel oil (LSFO)	1.0%
Ultra-low sulfur fuel oil (ULSFO)	0.1%

Source: Author (2020)

- High sulphur fuel oil (HSFO)

  HSFO is one of three oil products formed by the distillation of crude oil. HSFO is a heavy fuel oil with the highest sulfur content but not as good quality as MGO or MDO. Therefore, the price of HSFO is also much cheaper than other clean and high-quality fuels. In response to the new sulfur standard proposed by IMO on January 1, 2020, ship owners must choose other fuels with a sulfur content of less than 0.5% to replace HSFO (Jasper Faber, 2016). However, there is still another option for ship owner to be able to use HSFO but still ensure compliance with the sulfur cap set by IMO. The scrubber has been introduced as a filtration system that allows the use of 3.5% high sulfur fuel but emits emissions in accordance with sulfur standards below 0.5%

- Low sulphur fuel oil (LSFO)

  If the sulfur content in the fuel oil is less than 1%, it will be called a low sulfur fuel oil (HSFO). Not only that, other marine fuels such as IFO 180 or IFO 380 are all sulfur removed (Jasper Faber, 2016). After the modification of the sulfur level in 2014, vessels can still use this maritime fuel to pass through the Emission Control Areas (ECAs) without fear of violating sulfur emissions.

- Ultra-low sulphur fuel oil (ULSFO)

  ULSFO is one of the fuels after distillation of crude oil. Unlike HSFO and LSFO, ULSFO is an oil fuel with the lowest sulfur content (containing 0.1% sulfur). From 1 January 2015, to follow with Annex VI of the MARPOL Convention, the vessel sulfur emissions must be less than 0.1% in ECAs (Topali & Psaraftis, 2019). As a result, HSFO and LSFO are no longer suitable for operating vessels in the ECAs area. Other marine fuels such as heavily desulphurization IFO may also be used as a substitute for HSFO or LSFO but are less commonly used for economic reasons than ULSFO. The price of IFO much more expensive than ULSFO. Because of the extremely low sulfur content of ULSFO, it is no longer known as a HFO. ULSFO and products formed after distillation of crude oil with a sulfur content of less than 0.1% are called ultra-low marine gas oil (Topali & Psaraftis, 2019).

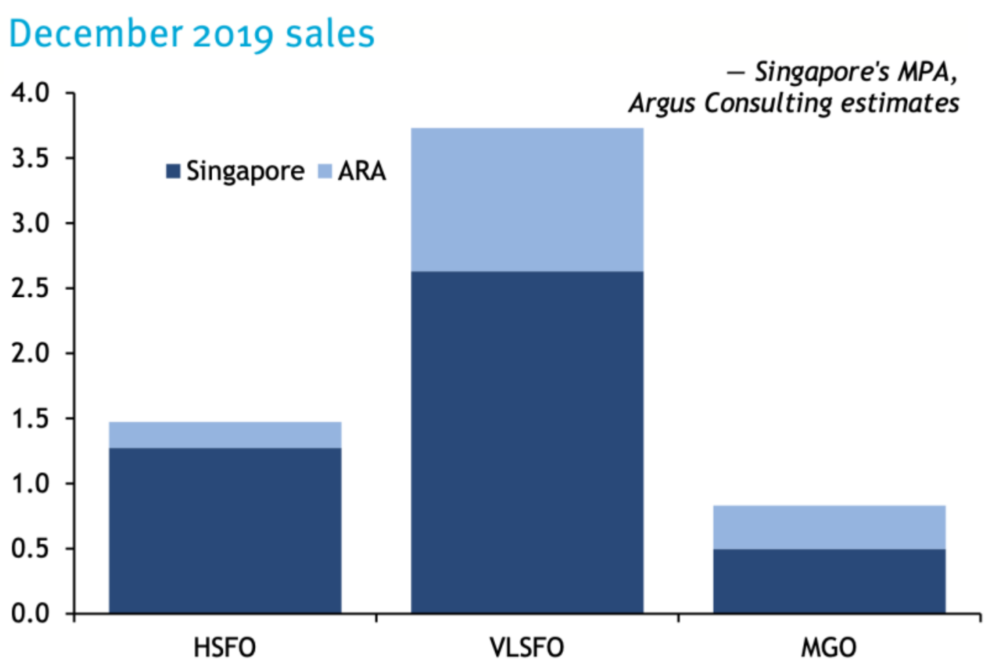
3.1.3 Marine gasoil (MGO)

Marine gasoil is a product of crude oil distillation. MGO has similar properties to MDO but is higher in density and must not heat up during storage. In addition, MGO and standard heating oil have common and interchangeable chemical properties in cases of MGO deficiency. However, to be able to replace each other, the ships must ensure that there are appropriate waste filtration systems suitable for each of these two fuels and appropriate sulfur content in them (ABS, 2019). Similar to HFO, MGO is also produced with different sulfur content and has lower sulfur content than HFO. The maximum permissible sulfur content in the MGO is no more than 1.5% and is suitable as a fuel to run vessels before the new sulfur standard is introduced on January 1, 2020. On the other hand, for ultra-low sulfur gases such as LSMGO, which only contains 0.1% sulfur is used in ports across Europe or the ECAs region to meet the sulfur standard for the ECAs (Wiberg & Fredriksson, 2018). However, after the IMO issued a new sulfur standard, the 1.5% MGO was no longer suitable for ship operations or it could still be used on the condition of a filter tower system or scrubber installation. Unlike HFO, the emissions of MGO are less sulfur and the sulfur content contained in MGO is kept very low, so the fuel is expected to produce less than the product of residual oil and MGO can be used more frequently. However, MGO and MDO are much more expensive than HFO (ABS, 2019). In April 2016, the price of MGO doubled compared to the price of heavy fuel. For economic reasons, before the introduction of the 2020 sulfur cap, heavy fuel was still used regularly in seaborne trade.

3.1.4 Marine fuels price

After IMO introduced a new regulation to permit sulfur behavior, ship owners began to find alternative measures to conform to this new regulation. Switching to alternative fuels is the most effective solution in this context and fuels with sulfur concentration below 0.5% are preferred to replace HFO with 3.5%. According to the accumulated data, in December 2019, VLSFO sales in Singapore and Amsterdam Rotterdam – Antwerp increased rapidly to 4 million tons, approximately two-thirds of total bunker fuel sales (Argus Media, 2019).

Figure 7: Sale of HSFO, VLSFO and MGO in December 2019 in Singapore and Amsterdam Rotterdam – Antwerp



Source: Argus Media (2019)

Based on the chart, it can be seen that in the fourth quarter of 2019 ship owners have actively changed fuel to meet the new IMO sulfur cap. Sales of LSFO fuel increased significantly compared to HSFO. Specifically in Singapore, sales of LSFO reached 2.7

million tons higher than HSFO and MGO fuels (Argus Media, 2019). The rapid increase in LSFO fuel demand has pushed up fuel prices. Specifically, at the beginning of the fourth quarter of 2019, VLSFO price was only at $ 57 / t cheaper than MGO 0.1% in Singapore and Amstedam Rotterdam –Antwerp market. However, in December 2019, VLSFO fuel price was higher than the 0.1% MGO price in Singapore market (Argus Media, 2019). The demand and price of LSFO fuel has changed abnormally so quickly because some ship owners have pledged to ensure the correct use of fuel with an acceptable sulfur concentration of less than 0.5% before January 1, 2020. As of January 2020, from data of the Maritime Port Authority of Singapore (MPA), fuels which contain lower sulfur level below 0.5% has sold a total of 3,185 million tons including LSFO and ULSFO (Thomas Cho, 2020). This figure is further increased when some ship owners do not use the method of installing scrubbers, but instead use alternative fuel to push LSFO's revenue up to 4.5147 million mt., accounting for 71% of total revenue (Thomas Cho, 2020).

3.1.5 SWOT Analysis

Table 4: SWOT Analysis of LSFO

Strengths	Weakness
• ULSFO 0.1% are generally slick distillates. In any case, they might moreover be crossovers – gas oil mixed with remaining oil. In stock, these fills work well with standard motor arrangements, even though they may require operational changes. • VLSFO 0.5% S is conceivable to blend appropriate remaining items with moo sulfur distillates to form high quality, compliant	• A few of the modern cross breeds utilize items not customarily used in marine applications, presenting vulnerability almost solidness, compatibility, and degradation • Since of the possibly high request for these powers, the marine segment may discover ULSFO 0.1% in competition with other businesses, and these powers will be a costly choice.

fuels. These mixes can contain up to 40% buildup, however still be kept underneath the 0.50% sulfur cap • LSFO and ULSFO are allowed in these strict regions. These fills contain less rate of sulphur and have little or no harm to the environment (IJERA, 2018) • LSFO and ULSFO keep the maintenance and the support of the ships which is less expense • According to DNV GL, a low-OPEX arrangement, which benefits proprietors who pay for fuel specifically	• The costs of LSFO and ULSFO are much more expensive compare to HFO
Opportunities • The bunker price movement reflects the chaotic developments that the bunker market has suffered. MGO LSFO, like all other fuels, is affected by the underlying oil market shock, but there are less volatility and fluctuations in the same price range in 2019. In contrast, the price volatility of HSFO has increased in recent months with	**Threats** • Utilizing alternative fuels should be carefully arranged and overseen. The risk that debilitate security or affect compliance must be identified and controlled. • Shipping companies must carefully assess the cost additionally the harm that the fuel may cause as they work on it (IJERA, 2018).

higher volatility in prices (Peter Sand, 2019).	• A few fuels may include more risk than fair, looking at the obtaining cost, which is why the proper choice is exceptionally crucial to benefit and pick up within the trade.

Source: Author (2020)

3.1.6 PESTLE analyses

- **P-POLITICAL**

Under the new regulations from the International Maritime Organization (IMO), from 1 January 2020, the sulfur substance of fuel oil utilized in sea shipping must be diminished to 0.5% from level 3.5% presently to limit the number of sulfur dioxide emissions to the environment. This provision is forecast to increase the demand for US light sweet crude oil, especially crude oil extracted from the Permian Basin of the United States. Besides, the completion of export pipeline projects along the US Gulf Coast will support the more favorable production and export of crude oil. Thanks to advances in shale oil production, the United States surpassed Saudi Arabia to become the largest crude oil-producing country in the world, with a record-high output of 12.3 million barrels a day. To comply with the new regulations, many ship owners in France have chosen very low sulfur fuel oil for their existing vessels, according to the Amateurs de France, representing service and transport companies.

- **E-ECONOMIC**

The generally yearly shipping expense may be higher, utilizing LSFO than employing a scrubber in conjunction with HFO. The whole yearly shipping costs for Stena Hollandica and Stena Britannica are anticipated to be 0.9 million € less per transport in the event that employing a closed-loop compared to running the ships on LSFO (SAFETY4SEA, 2019). The comparing decreased taken a toll in an expected situation with an open circle scrubber is 1.4 million €. Operation and administration costs are higher within the case of the closed loop scrubber, basically since of the expenses of chemicals such as sodium hydroxide (NaOH) required for the decrease handle.

It is exceptionally hard to estimate the advancement of the fuel costs and with its long-standing time price gaps between MDO, IFO and MGO. As specified prior, the cost of fuel could be a deciding figure at the side the demand/supply adjust for each of the marine fuel grades (Notteboom, 2010).

- **S-SOCIAL**

Geopolitical events have recently rocked the oil market. Still, fluctuations in the price difference between low and high sulfur fuels cannot be explained just by that – the uncertainty lies at the element of chaos.

The uncertainty of the upcoming sulfur content regulation in the forthcoming IMO 2020 (IMO2020) is having a significant impact on the bunker market. Meanwhile, low sulfur Gasoil (MGO LS) prices have remained mostly stable, with high sulfur content (HSFO) rates have been increasingly volatile in recent months. The price gap between HSFO-MGO LS, in some ports, widened to a level that exceeded the actual price of HSFO.

- **T-TECHNICAL**

Fuels which content low sulphur level will depend on nearby refinery setups; the quality of which may shift significantly on a territorial premise until particular guidelines/standards are given by ISO. Avoiding incompatibility, fuels from diverse providers ought to be kept isolated and not blended without testing (ABS, 2019). Mixing VLSFO and HFO is likely to make an unsteady oil. Moreover, ULSFOs can have compatibility issues with HFO, VLSFO, and indeed other ULSFOs. As 2020 brings a wider-than-ever assortment of fuels onto the showcase, ready to anticipate incongruence to ended up a more far-reaching and complex issue for the industry (Alfa Laval, 2019). Tanks ought to be cleaned frequently to lower the chance of slime shaping at the ocean. Moreover, teams will have to be especially careful about signs of incongruence when exchanging from one fuel to another. Ship operators ought to guarantee that diverse fills are isolated on-board which their tanks and fuel treatment lines are planned to work freely, to relieve dangers of clogging (Alfa Laval, 2019). If fuel mixing is unavoidable, compatibility tests ought to, to begin with, be carried out. Straightforward on-board tests are conceivable, but in-depth research facility testing can give more exceptional levels of affirmation.

- **L-LEGAL**

After 2020, the sulfur cap will be 0.5%, and the ECA limits will stay at 0.1%. The substitution fuel for assembly the 0.5% sulfur restrain will be ULSFO which may have a restricted supply after 2020 since not all refineries are prepared with behavior inaction capabilities. Ship owners ought to proceed to secure fills against ISO 8217:2017, as this Standard covers max 0.50% Sulphur fills within the same way that it covers present-day powers. The same necessities as of now characterized in ISO 8217:2017 for fills at the time and guardianship exchange (i.e., earlier to conventional on-board treatment sometime recently utilize, counting settling, centrifuging, filtration) will be appropriate to the max. 0.50% Sulphur fills, counting the Common Prerequisites beneath Clause 5 (IPIECA: Joint industry guidance on the supply and use of 0.50% Sulphur marine fuel, 2019)

- **E-ENVIRONMENT**

Distinctive natural impacts from working a transport on overwhelming fuel oil, besides a scrubber are compared with those from operations on low sulphur fuel oil

3.1.7 Oil price war between Russia and OPEC

Saudi Arabia launched an oil war with Russia after Moscow refused to participate in a plan to cut oil production with the Organization of Petroleum Exporting Countries (OPEC). Saudi Arabia, the leading country of OPEC, reported to diminish the oil price from 6 to 8 USD/barrel to clients in Asia, Europe and the US and reported an arrangement to extend generation altogether to over 12, 3 million bpd in April in spite of the worldwide financial downturn and declining oil request. In reaction to the move of Saudi Arabia, Russia too reported an increment in oil generation.

Excessive oil supply, while high inventories and the shock of COVID-19 epidemic impact on global demand, all three factors will certainly have a significant impact on oil prices (Bockmann, 2020).

In particular, in the context that the COVID-19 epidemic could lead the world economy into a new crisis, even a global recession, some investors believe that the decline in oil prices will continue. Fuel prices could be directly affected by the oil price war between the Saudi Arabia and Russia and the coronavirus. Oil prices began to slide as soon as the market opened trading on March, 9 with a reduction of about 20%, making US light sweet oil prices only traded at 32 USD / barrel, while Brent oil prices stood at USD 36 / carton (Bockmann, 2020). For the whole 9/3 session, oil prices dropped by 25%, the strongest level since the 1991 Gulf War.

After many ups and downs to March 13, US light sweet oil price stood at 31.73 USD / barrel and Brent North Sea oil price was 33.85 USD / barrel. In a week (March 9-13), the oil price lost 23%, and Brent oil price plunged 25%. These two oils marked the strongest drop since 2008 (Bockmann, 2020).

From February, VLSFO availabilities and freight boat conveyance plans were settled. Provider competition for VLSFO bunkers within the US Gulf picked up, and the VLSFO premium to HSFO started to narrow.

The costs of both VLSFO and HSFO could drop, which was encouraging within the wake of the Saudi Arabia-Russia cost war and coronavirus counter-measures. With the of expansion the coronavirus, the OPEC+ cost war has made a rough oil overabundance that might put descending weight on request for HSFO as cooker bolster, liberating up more HSFO for the bunker market (Content Marketing, 2020).

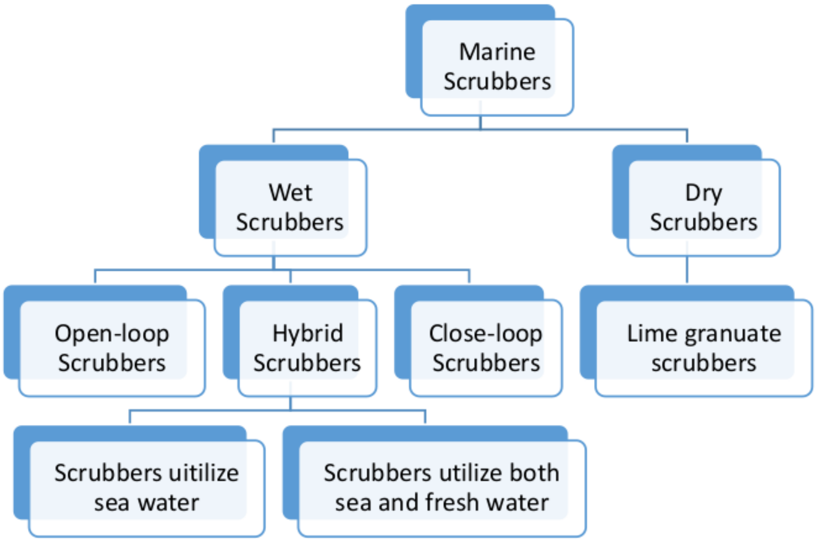
VLSFO misfortunes are moreover anticipated to deepen. The vessels run primarily VLSFO instead of HSFO or marine gas oil (MGO), as evidenced by measurements from Singapore, the most significant bunkering harbour in the world. Within the January-February period, VLSFO deals in Singapore accounted for 71% of add up to neighbourhood marine fuel request, with HSFO bookkeeping for 19% and MGO —

with a 0.1% sulphur substance — bookkeeping for 10% of deals (Content Marketing, 2020).

3.2 Overview of scrubber

If ship owners want to continue using fuel oil with a sulfur content higher than 0.5% after January 1, 2020, the vessel must be equipped with an Exhaust Gas Cleaning System (EGCS, usually called Scrubber). EGCS are utilized to evacuate particulate matter, and destructive components, such as sulfur oxides (SO_X) and nitrogen oxides (NO_X) from the debilitate gasses created as a result of combustion forms in marine engines, to execute contamination control (Sethi, 2020). These cleaning frameworks have been created and utilized to treat debilitate from engines, assistant engines and boilers, coastal and onboard marine vessels, to guarantee that no harm is done to human life and the environment by harmful chemicals. Marine scrubbers can be divided into Wet and Dry scrubbers. Dry scrubbers utilize strong lime as the soluble scouring fabric which evacuates sulfur dioxide from debilitate gasses. Wet scrubbers utilize water which is showered into the debilitate gas for the same reason (Sethi, 2020).

Figure 8: Classification of marine scrubbers



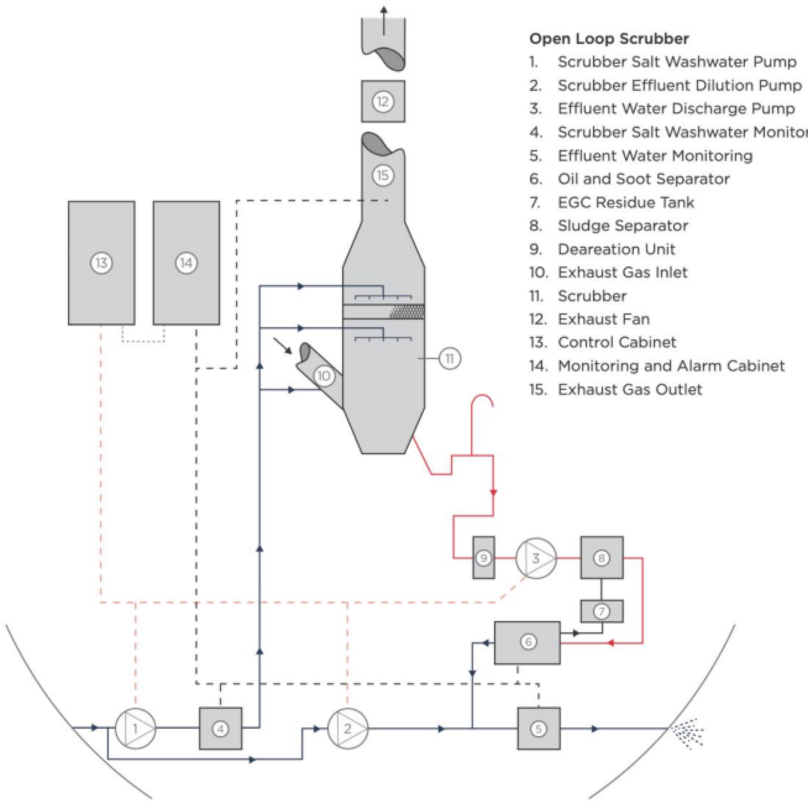
Source: Sethi (2020)

Exhaust filters can be used in different ways. While the closed-loop scrubber retains emitted sulfur for safe disposal to the receiving vehicle, the open-loop scrubber releases pollutants back to the sea after converting sulfur dioxide into sulfuric acid. There are also hybrid type filters, which can be switched between open and closed loops depending on actual situations, such as port regulations that may or may not prohibit discharge.

3.2.1 Open-Loop Scrubber

The open loop scrubber uses seawater and its characteristic alkalinity for cleaning the deplete. The debilitate gas enters the scrubber and is showered with seawater. The Sulphur oxide of the debilitate gas responds with the water and shapes sulfuric corrosive. The framework does not require any caustic pop (Sethi, 2020). A while later the water is driven through a channel framework, where it is weakened to raise the pH to the standard pH of the encompassing seawater recently released. The sum of weakening water depends on the zone where the vessel is working (Winnes, Fridell, & Moldanová, 2020). The build-up of the filtration preparation is collected in slime tanks and can be arranged at port giving squander administration gadgets. This scrubber framework can be utilized in most parts of the seas where alkalinity levels are adequate (Tran, 2017).

Figure 9: Open-loop Scrubber

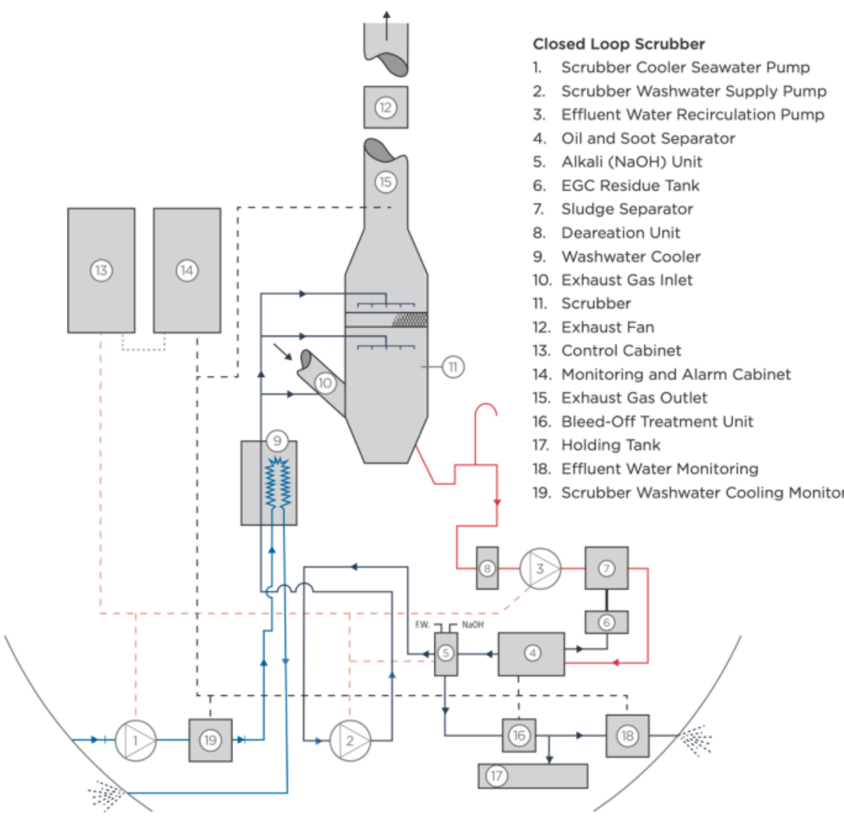


Source: ABS (2018).

3.2.2 Close-Loop Scrubber

A few nations have, as of now prohibited open-loop frameworks releasing wash water in their ports. Ship operators are being prompted to switch to close-loop operation. With this interesting after treatment framework, a straightforward coordinates arrangement guarantees both compliance in those districts and a cleaner environment (Winnes, Fridell, & Moldanová, 2020). This method collects gulf water from the scrubber wash water collection tank. The solution can handle any wash water in one step and makes dry slime with up to 85% dry substance and clean emanating water in agreement with portrayals given in MEPC 259 (Wiberg & Fredriksson, 2018). The framework is simple to function and needs no troublesome chemical injections. The structure is additionally planned for simple maintenance. The frame can be outlined as a slipped arrangement or as a measured framework. In a closed loop-type framework, the messy wash water leaving the scrubber goes to a handle or circulating tank (Tran, 2017). A reduced amount of wash water from the foot of the method tank, where the residuals are collected, is extricated employing a low suction. It goes to a hydro violent wind or separator, comparative to an open-loop framework, where the residuals are evacuated or for a few systems the extricated water can go to a drain- off treatment unit (Tran, 2017).

Figure 10: Close-loop scrubber



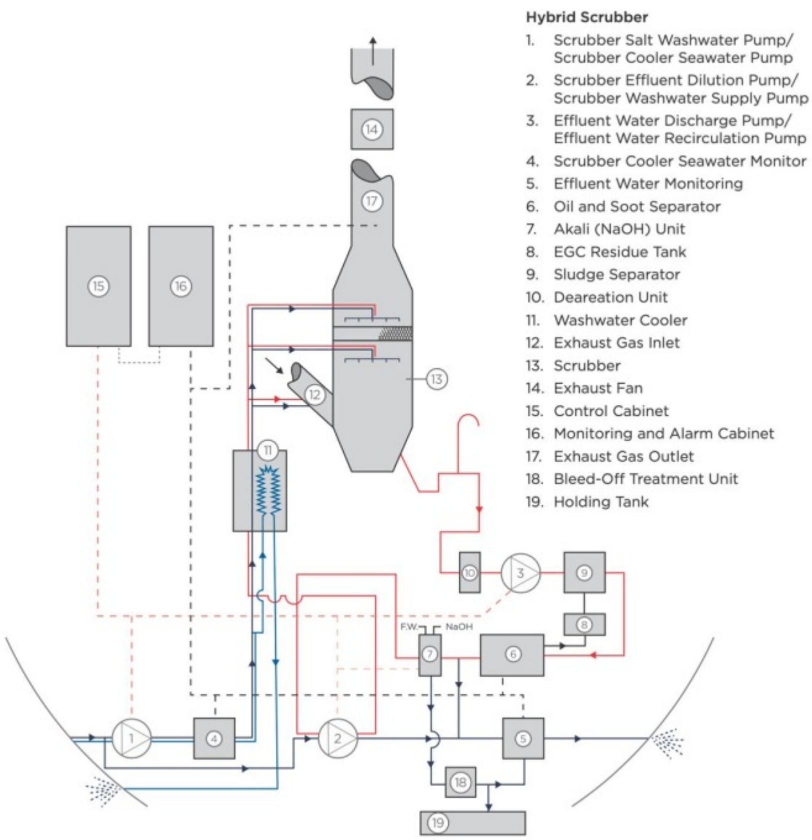
Source: ABS (2018)

3.2.3 Hybrid Scrubber System

The hybrid scrubber allows using operation on both open loops and closed-loop arrangements. These frameworks run on open-loop mode in the ocean and closed circle mode in ECA zones and ports, and their utility can be exchanged with ease (Wiberg & Fredriksson, 2018). The hybrid scrubber combines the moo running costs of the open-loop with the adaptability given by the closed-loop. Hybrid gives extra versatility, as the open-loop mode can be utilized too low alkalinity with the expansion of NaOH without the required for exchanging to closed circle mode (Panasiuk, Lebedevas, & Česnauskis, 2014). As the structure, can run on lower costing fills for more extended periods of time and around the world, they can overcome their high starting costs in arranging to financially meet with the universal directions (Sethi, 2020).

There are points of interest to the open-loop sort, such as the evasion of acquiring and dealing with caustic soda, and the avoidance of having to prepare wash water (Wiberg & Fredriksson, 2018). The closed-loop structure has the focal points so that the scrubber works with the same efficiency independently of where the vessel is working, and there is small or no water release, making it best suited for coastal, harbour and inland waters. In order to utilize the points of interest of both frameworks, a few producers have proposed hybrid cleaning frameworks (Tran, 2017).

Figure 11: Hybrid scrubber



Source: ABS (2018).

Tankers using hybrid are suitable for operating long and short voyages in international shipping. Moreover, utilizing a hybrid system allows vessels to spend more time in ECAs zone and in the harbor than the open-loop system. Tankers do not have cargo rearward of the deckhouse, so there is frequently space to grow the motor debilitate framework casing backwards or to one side to introduce the scrubber (ABS, 2018). On the off chance that a dispatch mainly works in the open ocean and will enter wash water release in limited waters for restricted periods, a crossbreed framework may be considered. On the other hand, the dispatch may be introduced with an open loop for working in regions where the release of wash water is not restricted and after that switch to sulfur-compliant fuel for working in wash water release confined ranges (ABS, 2018).

❖ *Comparison between 3 types of scrubber*

1. *Open-loop scrubber*

OPEX and CAPEX generally low

Uses seawater for cleaning; does not as a rule include capacity or taking care of dangerous chemicals (caustic soda)

Comparatively straightforward framework; less equipment/system compared to closed-loop

Huge wash water request

Not reasonable for moo alkalinity water

Limitation of wash water release in specific coastal/port ranges

Vessels not allowed to regions with wash water release confinement.

Vessels working most of the time within the ocean/open sea.

2. *Close loop scrubber*

Free of operation area which has low level of alkalinity in water, release limited coastal

Effluent has put away on board for the length that the tank volumes will allow system of wash water is very complex.

CAPEX is generally higher.

Vessel needs more space.

Extra equipment /system for water treatment

Operation length constrained by effluent tank size

Extraordinary care for taking care of and capacity of NaOH arrangement, an unsafe substance.

Moderately higher OPEX due to utilizing of NaOH.

Vessels exchanging continually in zones with release confinement or location with low alkalinity

3. Hybrid scrubber

Waste water may be put away on board for the term that the tank volumes will allow

Critical adaptability for working in all locales notwithstanding of seawater alkalinity or temperature

CAPEX is very high

Vessel needs more space

The system is very complicated.

Taking care of and capacity of NaOH, and build-up transfer for closed mode operation.

3.2.4 SWOT analysis

Table 5: SWOT Analyses of Hybrid Scrubber

Strength	**Weakness**
• Ship owners figured it out that the utilize of scrubbers might permit them to proceed using existing fuel oils instead of to switch to costlier ultra-low sulfur powers, specifically refined distillate items with a sulfur substance of less than 0.1% (David Osler, 2019). • It has exceptionally few moving parts; the plan is basic and simple to introduce on board. • Separated from de-fouling and operational checks, the framework requires exceptionally less maintenance	• The exhaust filtration system that has been fitted on global shipping ships has all of the same characteristics of discharging waste to the sea instead of storing waste water in tanks for reprocessing on land facilities. • Cooling of the deplete gas could be an issue confronted by damp scrubber systems. • The operation of the framework depends upon the alkalinity of water access and isn't reasonable to be utilized in all conditions. • A really vast volume of ocean water is required to get adequate

• This framework does not lack the capacity for squander materials • Reasonable for long and brief voyages around the world • Ships with half breed scouring frameworks can spend more time in ECA zones and on harbor than those with open loop systems. • Using lower costing HFO all of the time.	cleaning, and hence the framework expends exceptionally high power. • In ECA zones and ports, more top costing fuel should be consumed. • The framework has a long time to installing and expensive. • Scrubbers are subsequently a escape clause which makes authorization of the sulphur greatly complex, troublesome to uphold and likely to encourage non-compliance (Anastassios Adamopoulos, 2018)
Opportunities • The vessel's age will moreover be a pivotal figure, as more youthful vessels will have more time to recuperate the venture in a scrubber. • Newbuilding will too have an advantage, as they will not as it had a longer exchanging life to recoup the taken a toll of the scrubber, but moreover, the taken a toll of fitting a scrubber to a newbuilding will be less than an existing vessel.	**Threats** • Ships using scrubber may lead to an increased risk of undesirable consequences on the marine environment. • The cost for VLSFO presently utilized by a few 70% of the universal worldwide armada has dove by 278% in Singapore since the starting of 2020, concurring to appraisals compiled by cost announcing organization Argus Media. The spread is presently a few \$60 per ton over tall sulfur

• Choosing the correct scrubber provider guarantees that all fundamental specialized, arranging and establishment forms are expertly accounted for. Desires can be legitimately overseen when working with pros (Pacific Green Technologies Group, 2020)	fuel oil, down from levels over $300 per ton prior this year, wrecking the financial method of reasoning for introducing the scrubber • Components that ought to be considered incorporate motor measure and related deplete gas stream, the vessel's planning courses, scrubber sort (which is itself subordinate on a lattice of contemplations like ports, sea alkalinity and fetched), speed and ship space (Pacific Green Technologies Group, 2020) • Cost-cutting and the disintegration of marine fuel oil premiums would be challenged the installation of a scrubber (James Baker, 2020) • After establishment, less than six months, scrubber is faced with being replaced since of erosion issues that specialists have told Lloyd's List is nearly inconceivable to foresee and not broadly caught on by either ship owners or establishment groups

	(Nidaa Bakhsh & Richard Meade, 2019)

Source: Author (2020)

3.2.5 PESTLE analysis

- **P-POLITICAL**

Under the provisions of Annex VI of the International Convention for the Prevention of Pollution from Ships (MARPOL) of the International Maritime Organization (IMO), from January from January 1, 2020 all ships must utilize marine fuel oil with a sulfur substance not surpassing 0.5% by weight. This direction is commonly alluded to as the IMO Sulfur Edge 2020 (IMO Sulfur Cap 2020). If ship owners want to continue utilizing fuel oil with a sulfur substance higher than 0.5% after January 1, 2020, the vessel must be prepared with an exhaust gas cleaning system (EGCS, ordinarily called Scrubber).

Setting a scrubber empowers administrative compliance to utilize non-compliant tall sulfur fuel (Adamopoulos, 2018)

However, powerless administrative oversight implies non-compliance within the open ocean, whether through breakdown or malfeasance, cannot be viably controlled (Adamopoulos, 2018).

- **E-ECONOMIC**

The capital consumption for the scrubber establishment gives returns within the shape of fuel fetched investment funds, which can be a motivating force for dispatch administrators. Scrubbers permit ship-owners to dodge paying tall costs for alternative fuel. Capacity will be diminished by 4%-5% as a result of the sum of time vessels will be out of commission when scrubbers are introduced (Varsha Saraogi, 2020).

This proposes that proprietors picking for scrubber-fitted vessels in 2020 would recoup what they have fetched within the, to begin with, a year alone. For ship owners who select to retrofit a scrubber (or take the conveyance of a scrubber-fitted vessel) afterwards, the payback period will be longer.

- **S-SOCIAL**

In May 2018, DNV GL (Det Norske Veritas and Germanischer Lloyd) detailed that the number of vessels with scrubbers introduced or on arrange was 817. At the time this spoken to a 50% hop inside as it were some months (Ship & Bunker News Team, 2018)

In 2019, time out of benefit for scrubber retrofit had an apparent positive effect on the containership showcase adjust. Starting signs are for encouraging noteworthy bolster in 2020 as well, even though the later coronavirus episode in China has expanded instability over the retrofit plan, and will require following closely (Lloyd's Register, 2019). The effect on 'active' armada development when the volume of capacity beneath retrofit inevitably begins to diminish altogether will moreover be vital to the screen (Edward Turner, 2020).

Not as it where are investment funds from scrubbers being crushed, one of the bases for introducing scrubbers within the, to begin with, put — to ensure against the next fuel charge — has been undermined. Shipowners are presently paying less for IMO 2020-compliant VLSFO than they did for more contaminating HFO one year prior (International Shipping News, 2020)

Because of falling marine fuel costs, it affects directly to shipowners who have contributed intensely to have their vessels prepared with scrubbers

- **T-TECHNICAL**

From exchanging to Low Sulphur fills to introduce a deplete gas cleaning framework (EGCS) – moreover known as a scrubber, the whole shipping community is looking at all innovations and methods to realize full compliance.

Scrubbers have ended up one of the foremost commonsense ways of lessening sulfur debilitate for carriers and holder lines, and are utilized to actually 'scrub' toxins out of emissions. Scrubbers can be used in numerous ways. Whereas closed-loop scrubbers hold the sulfur emanations for more secure transfer at the harbor, open-loop scrubbers release toxins back within the ocean after turning the sulfur (Varsha Saraogi, 2020).

Hybrid scrubbers which switch between open and closed-loop depending on circumstances such as nearby rules which may or may not forbid the release of water.

Ship-owners favor open-looped frameworks over closed since ship owners are exceptionally simple to introduce, require less upkeep and do not require capacity for squander materials – as water is straightforwardly pumped back into the ocean

- **L-LEGAL**

In expansion, concurring to the Clean Shipping Alliance (CSA) 2020, a few 49 specialists counting a few in Japan and more than 20 different ports in Asia, Europe, Australia and the Americas demonstrated they had no deliberate of prohibiting the utilize of open-loop scrubbers in their waters.

Similarly, a report discharged by Japan's Ministry of Land, Infrastructure, Transport and Tourism (MLIT) concludes that the operation of open-loop scrubbers with tall sulfur fuel oil is not only safe, it is additionally best to burning moo sulfur fuel alone.

China has prohibited the utilization of open-loop sifting gear in outflows control ranges counting inland waters and most of its coastline. Other nations that deny or confine open-loop channels are Norway Germany, Malaysia, Latvia, India, Belgium, Lithuania, Ireland, United Arab Emirates and parts of the United States (Varsha Saraogi, 2020).

Singapore is sorting the squander from the operation of the discuss purifier as toxic industrial waste (TIW), concurring to the community's natural wellbeing.

- **E-ENVIRONMENT**

In the shipping industry, there is a furious argument about whether open-loop discuss filtration is an environmentally friendly option.

According to Varsha Saraogi, scrubbers have devastating effects on wildlife in British waters and around the world. IMO has demonstrated that it has endorsed the use of open-loop deplete channels, considering them to be "comparable" hardware, characterized as any hardware introduced for ships or handle, elective fuel oil, or compliance strategy utilized as an elective. Concerning this issue, IMO has issued strict rules for flushing wash water from depleting cleaning frameworks. “The washing water of the exhaust air filtration system must meet strict criteria so that the flushing water must have a pH of not less than 6.5” (IMO,2020).

According to IMO, a working group of experts in the field of marine environmental protection science (GESAMP) was established to assess the evidence related to the environmental impact of discharging wastewater from the system. It is expected that the 7th session of the IMO Sub-Committee on Pollution Prevention and Response (PPR7) in February 2020 will discuss this content.

In spite of IMO’s authorization, earthy people cannot believe the utilization of open-loop debilitate filters (Saraogi, 2020).

For each ton of fuel burnt, the vessel uses an open-loop deplete channel that produces approximately 45 tons of acidic washing water, containing carcinogens such as fragrant polycyclic hydrocarbon (PAH). Overwhelming metals can influence sea chemistry and marine life, agreeing to the International Committee on Clean Transportation (ICCT), a non-profit organization that gives logical examination.

ICCT moreover gauges that voyage ships that utilize tall sulfur overwhelming fuel oil (HSHFO), and open-loop debilitate channels will release 180 million tons from the side of the vessel to wash sullied discuss filtration frameworks.

As a result, a few regions and ports have presented prohibitive directions for ships working in their waters, requiring the utilization of closed-loop deplete channels or high levels of marine fuel oil.

Chapter 4 – Data and methodology

4.1 Comparison between Quantitative and Qualitative to analyze investment project.

In logical inquire about, quantitative and subjective strategies play a large part within the investigate about the point, these two strategies will offer assistance analysts collect information precisely and quickly; however, two ways—usually the inverse of how and how it works. For qualitative investigate, information collection is essentially in words and an approach that looks for to portray and analyze the characteristics of groups of individuals from the anthropologist's perspective. As for quantitative inquire about, basically collecting information by numbers and understanding connections in hypothesis and investigation from interpretation. Both quantitative and qualitative methods consider the thesis.

4.1.1 Quantitative method

Quantitative investigate utilize within the shape of inductive, make a hypothesis, subjective inquire about strategies also use interpretative views, don't demonstrate there's as it was clarification and constructivist assumption in investigating, implies that analysts depend on speculations to construct their claim investigate way suitable to the condition (Ezzy, 2013). The information collection methods of subjective inquire about are very assorted and frequently don't have a particular structure like quantitative inquire (Patton, 1980). A few strategies can be specified as Centre gather, individual meet and perception. Tests of this strategy are ordinarily little and more carefully chosen. Subjective investigate more often than not approaches the inquire about subjects most normally, in arrange to guarantee the behaviors, suppositions and sees that the inquire about issues make will be most objective and accurate (Patton, 1990).

Specifically, in these three studies, the author chose SWOT and PESTLE analysis to approach the description and compared the two investment projects to identify the strengths and weaknesses of challenging opportunities from the two projects. At the same time, assessing whether the two-project investment is appropriate for the environment, economic conditions, technical status, politics, laws of each country. From there, the decision was taken to choose the most appropriate investment plan.

- SWOT analysis

The SWOT examination could be a valuable instrument utilized to get its Strengths, Weaknesses, Opportunities and Threats in a venture. Through SWOT investigation, the creator will see the objectives as well as interior and exterior components of the organization that can undoubtedly or contrarily influence venture ventures (Gürel & Tat, 2017). Based on the SWOT analysis, ship owners can assess each of the strengths and weaknesses of both switching to LSFO and utilizing scrubber options. Moreover, ship owners or operators can also rely on the analysis to measure the level of challenge and potential of the two options (Piercy & Giles, 1989). Therefore, it is easy to make a decision in choosing an alternative to HFO to comply with the sulfur threshold of 2020. In each project, there are advantages and disadvantages of its own, and vessel operators need to have an overview and detailed analysis of each type to be able to conclude reasonable alternatives. Comparing the conversion to a new material with a sulfur content of less than 0.5% and using the scrubber system not only stops at economic conditions, investment costs, installing scrubber or buying new materials but also with regard to the potential profits, it is suitable for long-term exploitation in the future. Therefore, the SWOT analysis is an impossible method to give owners of operators a more relevant view of the four aspects of an option.

- PESTLE analysis

In addition to using the SWOT tool to survey quantitative methods, the author also uses the PESTLE analysis to clarify aspects of each project type as well as analyzing and evaluating the suitability of applying alternative methods for HFO.

Political factors: Politics has a significant impact on the operation and application of new methods instead of HFO to comply with the 2020 sulfur threshold.

Economic factors: Analyze and survey the money related circumstance of each shipowner's venture sort in both the short and long term.

Social factors: Social variables influence ship owners on numerous diverse levels, and ought to be carefully considered. All social components of a nation will altogether impact the characteristics of utilization in that nation when applying elective strategies for HFO.

Technological factors: Technology can be utilized, and typically impacted by government bolster. Mechanical signs of progress can offer assistance to create benefit for each sort of elective to comply with the sulfur rules set for early 2020.

Legal factors: Any administrative alteration that happens in a nation can influence the commerce operations of the commerce. By 2020, the sulfur concentration limited to less than 0.5% issued by IMO has affected freight rates. Many ship owners and ship operators have to think between choosing financially suitable and suitable for each area that the ship will operate in the future.

Environment factors: Environmental factors such as weather, geography and climate It will also significantly affect the fuel changes and needs of ship owners.

Pestle analysis helps owners or operators consider different factors that may affect freight rates. It promotes strategic thinking to understand strategic planning better and make choices tailored to the ship owner's situation. Identifying opportunities and taking steps according to it can give ship owners more outside opportunities. Therefore, operators must perform a Pestle analysis of the external environment. This analysis model will help ship owners to recognize market trends. This way ship owners will become more proactive in their business.

Quantitative analysis has some of the following advantages:

- The issue is seen from the point of view of an insider: Subjective inquiry makes a difference to clarify the variables of conduct and states of mind of the inquiry about subjects (Kumar, 2007).
- Because subjective inquiry about employment unstructured investigation strategies, adaptability is exceptionally high.
- Help find valuable data quickly.
- The time to conduct a subjective investigation venture is more often than not shorter and costs less than quantitative research.

Quantitative investigation does not clarify human wonders (behavioral studies). Subjective calculation of surveyors: Analysts may miss profitable points of interest of the study on the off chance that they are as well centered on testing the presumptions set forth (Tashakkori, Teddlie, & Teddlie, 1998). Differences in how questions are caught on happen when the interviewees did not get the questions postured by the researchers' but caught on in an unexpected way and reacted concurring to their elucidations. For quantitative inquiry, most interviewees are incapable of interceding, clarifying or clarifying questions to respondents. Contextual mistakes may influence the substance of the study. Quantitative inquiry about accepting that human behavior and states of mind do not alter agreeing to the setting. In any case, the object's answers may shift depending on distinctive contexts. Quantitative investigation uses more complex subjective research methods, so it will take more time to plan the inquiry about the process.

4.1.2 Qualitative method

The qualitative investigation strategy is the collection and investigation of data based on information from advertising. The reason for quantitative inquiry is to draw showcase conclusions through the utilization of factual strategies to handle information (Tashakkori, Teddlie, & Teddlie, 1998). Strategies for collecting qualitative information are regularly more organized than subjective information collection, which incorporates different shapes of studies such as online studies, paper studies, portable overviews, cross-surveys or mail. Qualitative inquiry permits the creator to clarify by the measurable investigation. As a result, insights are based on numerical standards (Cotten, 1999). Qualitative strategies are considered to be logical and sensible. Hence quantitative inquiry is appropriate to test the suspicions made. However, quantitative investigation employs more complex subjective inquiry about strategies, so it will take longer to plan the inquiry about the process.

- <u>Net Value Present</u>

In this paper, the author used NPV calculation method to assess the feasibility of 2 investment project to compliance Sulfur cap 2020. Net present value, which implies the current value of all future extend cash flows is marked down to the present:

$$NPV = \sum_{t=0}^{n} \frac{CF_t}{(1+k)^t} - CF_0$$

CF_t: Net cash flow at time t (Cash flow)

CF_0: Initial capital expenditure of an investment / project

k: Discount rate

n: Total duration of project implementation

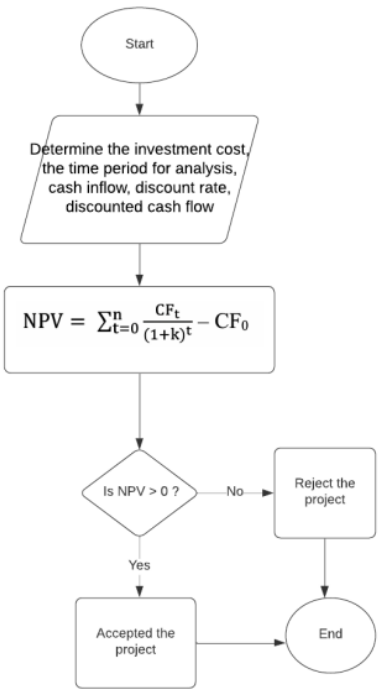
t: Time to calculate cash flow

NPV= PV inflow – Cost = Net gain in wealth

In the event that the NPV is more prominent than 0, at that point the extend is beneficial since the discount rate is as of now the opportunity cost of the venture, so on the off chance that the opportunity cost has been deducted (Žižlavský, 2014). The investment is beneficial; at that point, the investment has financial returns. Hence, when assessing a venture by NPV, it is essential to consider the value of the discount rate (more often than not rise to the intrigued price of the leading speculation opportunity that the investor can set in case not contributing within the extend being assessed) and see on the off chance that the NPV is favorable or not. A positive NPV implies the speculation is productive since the esteem of cash flow after devaluation is higher than the first venture (Lim, Park, Lee, & Park, 2006). On the off chance that there are two independent ventures, the one with the bigger NPV will acknowledge the investment and dispose of the remaining one.

The term financial comprises operational cost, capital cost and life-cycle cost. The point of environment includes the effect on Sox emanations diminishment, the impact on NO_x emanations lessening, the effect on GHG outflows lessening and the effect on particulate matter (PM) emanations diminishment (Bui, Ölçer, Kitada, & Ballini, 2017)

Figure 12: NPV flowchart analysis



Source: Author (2020)

The NPV in 2 investment projects is calculated for a period of 10 years, a long time, compared to an anticipated 25-year lifetime of the ship. Hybrid scrubber is chosen for the dissertation. According to the report of Ritchie, de Jonge, Hugi, & Cooper (2005), the CAPEX for retrofit of hybrid scrubber is 168 €/kW whereas its OPEX is 0.5 €/MWh for engine of average estimate (having control from 6000 kW to 15000 kW). In this paper, the author does not make assumptions for the conversion from HFO to LNG because VITACO's oil tankers are second ships older than ten years and, therefore, not suitable for switching to an alternative fuel like LNG. Moreover, CAPEX's conversion rate from HFO to LNG is much higher than the choice of LSFO or hybrid scrubber. CAPEX of LSFO is the most reduced capital cost compared to that the installation of hybrid scrubber (Bui, Ölçer, Kitada, & Ballini, 2017). Therefore, the author only made assumptions for two new investment options to comply with the sulfur threshold of 2020. Not at all like LNG and hybrid scrubber, the change of most engines to utilize VLSFO brings about nearly no cost or in other words, it may be insignificant (Ren & Lützen, 2015; Ritchie, de Jonge, Hugi, & Cooper, 2005). The additional OPEX of the engine running on VLSFO is almost 13 €/MWh (Ritchie, de Jonge, Hugi, & Cooper, 2005). According to Bui, Ölçer, Kitada, & Ballini (2017), LSFO essentially 30%–50% costlier than the ordinary fuel. The MGO cost is anticipated to extend within the brief term in short-sea shipping in ECAs. It is assessed to rise by approximately 87% credited to the cost of refining and changing over to LSFO. The OPEX of HFO with hybrid scrubber is approximately between 320 € and 530 € per tone Sox. It may be account for 1% to 3% of CAPEX per year (Bui, Ölçer, Kitada, & Ballini, 2017)

Table 6: CAPEX and OPEX of 2 investment project

1 Euro (€)	1.12 US dollar ($)
Scrubber CAPEX (retrofit)	168 €/kW 188.2 $/kW
Scrubber OPEX	0.5 €/MWh 0.00056 $/kWh
VSLFO CAPEX	0.0
Extra VLSFO OPEX (engine maintenance)	13 €/MWh 0.01456 $/kWh
Increase in FC due to scrubber fitting	1%

Source: Ritchie, de Jonge, Hugi, & Cooper (2005)

The price of fuel is referenced on the website https://shipandbunker.com/ and are averaged over the last year 2019 to limit the objective factors due to the Covid-19 pandemic and the oil price war between Russia and the OPEC members. Although, in April 2020, the world oil price dropped a record but still could not be a decisive factor for ship owners to switch to LSFO fuel instead of hybrid scrubber because this phenomenon is just timing problem.

Table 7: Fuel cost at Singapore (average for 1 year from June 2019 to June 2020)

Name of fuel	Price Unit
VLSFO	481 $/ton
IFO 380	333 $/ton
MGO	511.5 $/ton

Source: website https://shipandbunker.com/

Ship owners need to estimate how much money their investment will give them during the time it makes their money. This amount (also known as the "cash inflow") can be specific, known, or estimated.

The appropriate discount rate is the "k" value in the above formula. Discount rate is referred base on the rate of Joint Stock Commercial Bank for Foreign Trade of Vietnam which is a commercial bank in Vietnam. The discount rate for 12 months is 6.8%

In general, for the time being, the available funds of the ship owners or ship operators will be more valuable in the future. The reason is that they can invest the money they have in the present and profit from time to time. To calculate the NPV, the ship owner needs to know the interest rate of the investment account or an opportunity with the same level of risk as the investment being analyzed.

To calculates the value of cash inflows for each period ship owners analyze versus the amount they earn from replacement investments at the same time. This is called "discounting" the cash flow and is calculated using the simple formula:

$$\text{Value of cash inflow} = \frac{CF_t}{(1+k)^t}$$

Finally, to calculate the NPV of the project, purchased property, or investment you are analyzing, you need to add up all the discounted cash flows and subtract the initial investment.

$$NPV = \sum_{t=0}^{n} \frac{CF_t}{(1+k)^t} - \mathrm{CF}_0$$

In general, if an NPV value is positive or if there are two independent projects, the one with the higher NPV will be more profitable than spending the money on other alternative investments.

Chapter 5 – Findings and Conclusion

5.1 Tanker fleet of VITACO

As an enterprise, directly under the Vietnam National Petroleum Group – Petrolimex and operating in the field of the petroleum transport business, Vietnam Tanker Joint Stock Company (VITACO) functions to transfer petroleum from foreign vessels into wholesale depots, transporting petrol by river and sea for regional petroleum companies, provincial general materials companies.

The company is under the direct management and direction of the Vietnam National Petroleum Group – Petrolimex in all aspects. Also, it fulfils its obligations to the Ho Chi Minh City People's Committee.

VITACO Petroleum Transportation Joint Stock Company has the task of transporting petroleum to units inside and outside the industry, building and organizing the implementation of the plan of Vietnam National Petroleum Group – Petrolimex.

The company also manages and effectively uses labor, vehicles, supplies, capital and plans to invest in material and technical to serve the transportation work and implement the training, train and build the contingent of cadres and employees according to the Group's planning, plans and decentralization.

Currently, the company's fleet consists of Petrolimex 09, Petrolimex 11, Petrolimex 12, and Petrolimex 14, operating under the form of charter. Nha Be 03, Nha Be 06, Nha Be 08, Nhà Be 09, Nha Be 10 and Petrolimex 20 are operated in the form of the voyage.

Because the charter ship is due on time, the fuel cost is usually borne by the charterer, so the VITACO company only calculates the data of the vessels operating in the form of the voyage. The figures on revenue and investment costs and ship operating costs are referenced in the company's annual financial report 2019.

Table 8: Main Particular of tanker fleets of VITACO company

Vessel name	Petrolimex 20	Nha Be 03	Nha Be 06	Nha Be 08	Nha Be 09	Nha Be 10
Type	Oil tanker	Oil tanker	Oil tanker	Oil tanker	Oil tanker	Oil tanker
Year built	2005	1979	2002	2003	2004	2005
Life time	25	25	25	25	25	25
Age	15	41	18	17	16	15
DWT	19925,47	4388	6788	6679	6534,2	7958
M/E power	6150	2353.6	3120	3120	3120	3400
IMO number	IMO9352585	IMO7821489	IMO9263045	IMO9291200	IMO9305972	IMO9355381

Source: VR (2020)

There are six variables in this calculation which are forecasted to have an impressive impact on the investigation of NPV. Capital costs are not considered factors as these costs are unsurprising and have an exceptional level of certainty at the time this simulation is performed earlier to the choice.

5.1.2 Petrolimex 20

The average revenue for the 5 latest Petrolimex 20 is **6,273,748 $.** Fuel consumption and other cost (for 5 year) of Petrolimex 20 (from 2015 to 2019) is shown in Table 10. Table 8 shows the calculation of the average of CAPEX and OPEX for five years of operation. The NPV calculation of 2 investment projects shows the 10-year cash flow of Petrolimex 20 shown in Table 9

Table 9: Fuel consumption and other cost in average (for 5 year)

Crew Cost Total	514,270	$/year
Store Cost Total	89,547	$/year
Repair and maintenance	122,774	$/year
Insurance Total	128,038	$/year
General cost Total (Administration cost)	345,163	$/year
Periodic Maintenance cost (Dry dock)	225,282	$/year
Days running at sea	293.68	days
Days in port	20	days
IFO 380 consumed	4,814	ton/year
MGO consumed	240	ton/year

Source: Author (2020)

Table 10: The calculation in average of CAPEX and OPEX (from 2015 to 2019)

The IMO Sox compliance options	Investment 1		Investment 2	
	VLS fuel oil		Scrubber	
	CAPEX ($)	*OPEX ($)*	*CAPEX ($)*	*OPEX ($)*
Initial installation	0.0		1,157,184.0	
Fuel cost (include pilot fuel, if applied)		2,438,294.0		1,741,852.6
Extra Maintenance cost of Engines		631,134.8		
Scrubber maintenance cost				24,274.4
Crew cost		514,270.2		514,270.2
Store cost		89,547.1		89,547.1
Repair and maintenance		122,773.9		122,773.9
Insurance Total		128,037.9		128,037.9
General cost Total (Administration cost)		345,162.8		345,162.8
Periodic Maintenance cost (Dry dock)		225,282.3		225,282.3
Total	**0.0**	**4,494,503.0**	**1,157,184.0**	**3,191,201.3**

Source: Author (2020)

Table 11: Cash flow ($) of the 2 investments and NPVs

Year	Investment 1		Investment 2	
	VLS fuel oil		Scrubber	
	Cash flow	Yearly NPV	Cash flow	Yearly NPV
0	0.0	0.0	-1,157,184.0	-1,157,184.0
1	1,779,245.0	1,647,449.1	3,082,546.7	1,697,025.9
2	1,779,245.0	3,172,864.8	3,082,546.7	4,339,812.9
3	1,779,245.0	4,585,286.9	3,082,546.7	6,786,837.8
4	1,779,245.0	5,893,085.0	3,082,546.7	9,052,601.7
5	1,779,245.0	7,104,009.3	3,082,546.7	11,150,531.2
6	1,779,245.0	8,225,235.4	3,082,546.7	13,093,058.5
7	1,779,245.0	9,263,407.8	3,082,546.7	14,891,694.9
8	1,779,245.0	10,224,678.5	3,082,546.7	16,557,099.0
9	1,779,245.0	11,114,743.9	3,082,546.7	18,099,139.8
10	1,779,245.0	11,938,878.6	3,082,546.7	19,526,955.3
NPV	**11,938,878.6**		**19,526,955.3**	

Source: Author (2020)

As Table 9 shows, the NPV of investment 1 means that the option to switch to LSFO after ten years is worth **$ 11,938,878.6** while the NPV of investment 2 means that the option of using a Hybrid scrubber reaches **$ 19,526,955.3** after ten years. From the above results, it can be easily seen that the NPV value of both investments is greater than zero, so the two projects are feasible and acceptable. The NPV value of investment 1 is less than the NPV value of Investment 2 (**11,938,878.6 less than 19,526,955.3**). Because these are two independent projects, the investment of NPV of the investment with the higher value will be preferred because it will create higher cash flow in the future so for Petrolimex 20, they will switch to using Hybrid scrubber which is much more economically viable than switching to LSFO fuel.

5.1.3 Nha Be 03

The average revenue for 5 latest of Nha Be 03 is **1,974,065 $.** Fuel consumption and other cost (for 5 year) of Nha Be 03 (from 2015 to 2019) is shown as Table 13. Table 11 shows the calculation of the average of CAPEX and OPEX for five years of operation. The NPV calculation of 2 investment projects shows the 10-year cash flow of Nha Be 03 are shown in Table 12

Table 12 : Fuel consumption and other cost in average (for 5 year)

Crew Cost Total	268,027	$/year
Store Cost Total	89,424	$/year
Repair and maintenance	59,750	$/year
Insurance Total	33,926	$/year
General cost Total (Administration cost)	115,697	$/year
Periodic Maintenance cost (Dry dock)	147,546	$/year
Days running at sea	348.50	days
Days in port	63.80	days
IFO 380 consumed	377	ton/year
MGO consumed	19	ton/year

Source: Author (2020)

Table 13: The calculation in average of CAPEX and OPEX (from 2015 to 2019)

The IMO Sox compliance options	Investment 1		Investment 2	
	VLS fuel oil		Scrubber	
	CAPEX ($)	*OPEX ($)*	*CAPEX ($)*	*OPEX ($)*
Initial installation	0.0		442,853.4	
Fuel cost (include pilot fuel, if applied)		191,104.1		136,527.4
Extra Maintenance cost of Engines		286,621.0		
Scrubber maintenance cost				11,023.9
Crew cost		268,027.1		268,027.1
Store cost		89,424.0		89,424.0
Repair and maintenance		59,750.1		59,750.1
Insurance Total		33,926.0		33,926.0
General cost Total (Administration cost)		115,696.5		115,696.5
Periodic Maintenance cost (Dry dock)		147,546.1		147,546.1
Total	**0.0**	**1,192,095.1**	**442,853.4**	**861,921.2**

Source: Author (2020)

Table 14: Cash flow ($) of the 2 investments and NPVs

Year	Investment 1		Investment 2	
	VLS fuel oil		Scrubber	
	Cash flow	**Yearly NPV**	**Cash flow**	**Yearly NPV**
0	0.0	0.0	-442,853.4	-442,853.4
1	781,969.6	724,045.9	1,112,143.5	586,909.1
2	781,969.6	1,394,458.7	1,112,143.5	1,540,392.8
3	781,969.6	2,015,211.4	1,112,143.5	2,423,248.2
4	781,969.6	2,589,982.4	1,112,143.5	3,240,706.8
5	781,969.6	3,122,177.7	1,112,143.5	3,997,613.0
6	781,969.6	3,614,951.2	1,112,143.5	4,698,452.0
7	781,969.6	4,071,222.9	1,112,143.5	5,347,377.0
8	781,969.6	4,493,696.7	1,112,143.5	5,948,233.5
9	781,969.6	4,884,876.2	1,112,143.5	6,504,582.2
10	781,969.6	5,247,079.4	1,112,143.5	7,019,719.8
NPV	**5,247,079.4**		**7,019,719.8**	

Source: Author (2020)

As Table 12 shows, the NPV of investment 1 means that the option to switch to LSFO after ten years is worth **$ 5,247,079.4** while the NPV of investment 2 means that the option of using a Hybrid scrubber reaches **$ 7,019,719.8** after ten years. From the above results, it can be easily seen that the NPV value of both investments is greater than zero, so the two projects are feasible and acceptable. The NPV value of investment 1 is less than the NPV value of Investment 2 (**5,247,079.4 less than 7,019,719.8**). Because these are two independent projects, the investment of NPV of the investment with the higher value will be preferred because it will create higher cash flow in the future so for Nha Be 03, they will switch to using Hybrid scrubber which is much more economically viable than switching to LSFO fuel.

5.1.4 Nha Be 06

The average revenue for 5 latest of Nha Be 06 is **3,373,330 $.** Fuel consumption and other cost (for 5 year) of Nha Be 06 (from 2015 to 2019) is shown as Table 16 shows the calculation of the average of CAPEX and OPEX for five years of operation. The NPV calculation of 2 investment projects shows the 10-year cash flow of Nha Be 06 are shown in Table 15

Table 15: Fuel consumption and other cost in average (for 5 year)

Crew Cost Total	344,054	$/year
Store Cost Total	78,120	$/year
Repair and maintenance	57,573	$/year
Insurance Total	74,930	$/year
General cost Total (Administration cost)	188,367	$/year
Periodic Maintenance cost (Dry dock)	160,195	$/year
Days running at sea	356.50	days
Days in port	68.40	days
IFO 380 consumed	2,653	ton/year
MGO consumed	133	ton/year

Source: Author (2020)

Table 16: The calculation in average of CAPEX and OPEX (from 2015 to 2019)

The IMO Sox compliance options	Investment 1		Investment 2	
	VLS fuel oil		Scrubber	
	CAPEX ($)	*OPEX ($)*	*CAPEX ($)*	*OPEX ($)*
Initial installation	0.0		587,059.2	
Fuel cost (include pilot fuel, if applied)		1,344,101.7		960,247.7
Extra Maintenance cost of Engines		388,675.1		
Scrubber maintenance cost				14,949.0
Crew cost		344,053.8		344,053.8
Store cost		78,120.0		78,120.0
Repair and maintenance		57,572.6		57,572.6
Insurance Total		74,930.0		74,930.0
General cost Total (Administration cost)		188,367.3		188,367.3
Periodic Maintenance cost (Dry dock)		160,194.8		160,194.8
Total	**0.0**	**2,636,015.3**	**587,059.2**	**1,878,435.2**

Source: Author (2020)

Table 17: Cash flow ($) of the 2 investments and NPVs

Year	Investment 1		Investment 2	
	VLS fuel oil		Scrubber	
	Cash flow	**Yearly NPV**	**Cash flow**	**Yearly NPV**
0	0.0	0.0	-587,059.2	-587,059.2
1	737,314.9	682,699.0	1,494,895.0	797,102.9
2	737,314.9	1,314,827.7	1,494,895.0	2,078,734.4
3	737,314.9	1,900,132.1	1,494,895.0	3,265,430.3
4	737,314.9	2,442,080.6	1,494,895.0	4,364,222.8
5	737,314.9	2,943,884.8	1,494,895.0	5,381,623.2
6	737,314.9	3,408,518.3	1,494,895.0	6,323,660.7
7	737,314.9	3,838,734.4	1,494,895.0	7,195,917.6
8	737,314.9	4,237,082.8	1,494,895.0	8,003,562.8
9	737,314.9	4,605,923.8	1,494,895.0	8,751,382.5
10	737,314.9	4,947,443.3	1,494,895.0	9,443,808.2
NPV	**4,947,443.3**		**9,443,808.2**	

Source: Author (2020)

As Table 15 shows, the NPV of investment 1 means that the option to switch to LSFO after ten years is worth **$ 4,947,443.3** while the NPV of investment 2 means that the option of using a Hybrid scrubber reaches **$ 9,443,808.2** after ten years. From the above results, it can be easily seen that the NPV value of both investments is greater than zero, so the two projects are feasible and acceptable. The NPV value of investment 1 is less than the NPV value of Investment 2 (**4,947,443.3 less than 9,443,808.2**). Because these are two independent projects, the investment of NPV of the investment with the higher value will be preferred because it will create higher cash flow in the future so for Nha Be 06, they will switch to using Hybrid scrubber which is much more economically viable than switching to LSFO fuel.

5.1.5 Nha Be 08

The average revenue for 5 latest of Nha Be 08 is **3,156,494 $.** Fuel consumption and other cost (for 5 year) of Nha Be 08 (from 2015 to 2019) is shown as Table 19. Table 17 shows the calculation of the average of CAPEX and OPEX for five years of operation. The NPV calculation of 2 investment projects shows the 10-year cash flow of Nha Be 08 are shown in Table 18

Table 18: Fuel consumption and other cost in average (for 5 year)

Crew Cost Total	321,651	$/year
Store Cost Total	69,731	$/year
Repair and maintenance	56,269	$/year
Insurance Total	75,170	$/year
General cost Total (Administration cost)	177,012	$/year
Periodic Maintenance cost (Dry dock)	119,761	$/year
Days running at sea	334.10	days
Days in port	62.60	days
IFO 380 consumed	2,459	ton/year
MGO consumed	123	ton/year

Source: Author (2020)

Table 19: The calculation in average of CAPEX and OPEX (from 2015 to 2019)

The IMO Sox compliance options	Investment 1 VLS fuel oil		Investment 2 Scrubber	
	CAPEX ($)	*OPEX ($)*	*CAPEX ($)*	*OPEX ($)*
Initial installation	0.0		587,059.2	
Fuel cost (include pilot fuel, if applied)		1,245,468.0		889,781.5
Extra Maintenance cost of Engines		364,253.5		
Scrubber maintenance cost				14,009.7
Crew cost		321,650.7		321,650.7
Store cost		69,730.8		69,730.8
Repair and maintenance		56,269.2		56,269.2
Insurance Total		75,169.9		75,169.9
General cost Total (Administration cost)		177,012.4		177,012.4
Periodic Maintenance cost (Dry dock)		119,760.6		119,760.6
Total	**0.0**	**2,429,315.1**	**587,059.2**	**1,723,384.9**

Source: Author (2020)

Table 20: Cash flow ($) of the 2 investments and NPVs

Year	Investment 1 VLS fuel oil		Investment 2 Scrubber	
	Cash flow	**Yearly NPV**	**Cash flow**	**Yearly NPV**
0	0.0	0.0	-587,059.2	-587,059.2
1	727,178.7	673,313.6	1,433,108.9	739,893.5
2	727,178.7	1,296,752.2	1,433,108.9	1,968,553.4
3	727,178.7	1,874,010.1	1,433,108.9	3,106,201.4
4	727,178.7	2,408,508.2	1,433,108.9	4,159,579.3
5	727,178.7	2,903,413.8	1,433,108.9	5,134,929.1
6	727,178.7	3,361,659.7	1,433,108.9	6,038,030.8
7	727,178.7	3,785,961.5	1,433,108.9	6,874,236.1
8	727,178.7	4,178,833.5	1,433,108.9	7,648,500.3
9	727,178.7	4,542,604.0	1,433,108.9	8,365,411.5
10	727,178.7	4,879,428.4	1,433,108.9	9,029,218.2
NPV	**4,879,428.4**		**9,029,218.2**	

Source: Author (2020)

As Table 18 shows, the NPV of investment 1 means that the option to switch to LSFO after ten years is worth **$ 4,879,428.4** while the NPV of investment 2 means that the option of using a Hybrid scrubber reaches **$ 9,029,218.2** after ten years. From the above results, it can be easily seen that the NPV value of both investments is greater than zero, so the two projects are feasible and acceptable. The NPV value of investment 1 is less than the NPV value of Investment 2 (**4,879,428.4 less than 9,029,218.2**). Because these are two independent projects, the investment of NPV of the investment with the higher value will be preferred because it will create higher cash flow in the future so for Nha Be 08, they will switch to using Hybrid scrubber much more economically viable than switching to LSFO fuel.

5.1.6 Nha Be 09

The average revenue for 3 latest of Nha Be 09 is **3,070,803 $.** Nha Be 09 has just been launched in early 2017, the data will be calculated based on an average from 2017 to 2019. Fuel consumption and other cost (for 3 years) of Nha Be 09 (from 2017 to 2019) is shown as Table 22. Table 20 shows the calculation of the average of CAPEX and OPEX for three years of operation. The NPV calculation of 2 investment projects shows the 10-year cash flow of Nha Be 09 are shown in Table 21

Table 21: Fuel consumption and other cost in average (for 3 years)

Crew Cost Total	291,714	$/year
Store Cost Total	68,060	$/year
Repair and maintenance	38,685	$/year
Insurance Total	70,939	$/year
General cost Total (Administration cost)	165,412	$/year
Periodic Maintenance cost (Dry dock)	151,884	$/year
Days running at sea	278.00	days
Days in port	52.00	days
IFO 380 consumed	2,549	ton/year
MGO consumed	127	ton/year

Source: Author (2020)

Table 22: The calculation in average of CAPEX and OPEX (from 2017 to 2019)

The IMO Sox compliance options	Investment 1		Investment 2	
	VLS fuel oil		Scrubber	
	CAPEX ($)	*OPEX ($)*	*CAPEX ($)*	*OPEX ($)*
Initial installation	0.0		587,059.2	
Fuel cost (include pilot fuel, if applied)		1,291,339.8		922,553.4
Extra Maintenance cost of Engines		303,090.3		
Scrubber maintenance cost				11,657.3
Crew cost		291,714.4		291,714.4
Store cost		68,060.0		68,060.0
Repair and maintenance		38,685.3		38,685.3
Insurance Total		70,938.7		70,938.7
General cost Total (Administration cost)		165,412.5		165,412.5
Periodic Maintenance cost (Dry dock)		151,884.1		151,884.1
Total	**0.0**	**2,381,125.0**	**587,059.2**	**1,720,905.6**

Source: Author (2020)

Table 23: Cash flow ($) of the 2 investments and NPVs

Year	Investment 1		Investment 2	
	VLS fuel oil		Scrubber	
	Cash flow	**Yearly NPV**	**Cash flow**	**Yearly NPV**
0	0.0	0.0	-587,059.2	-587,059.2
1	689,678.1	638,590.9	1,349,897.5	662,845.9
2	689,678.1	1,229,878.7	1,349,897.5	1,820,165.4
3	689,678.1	1,777,367.4	1,349,897.5	2,891,757.5
4	689,678.1	2,284,301.5	1,349,897.5	3,883,972.5
5	689,678.1	2,753,684.8	1,349,897.5	4,802,690.0
6	689,678.1	3,188,299.0	1,349,897.5	5,653,354.4
7	689,678.1	3,590,719.6	1,349,897.5	6,441,006.6
8	689,678.1	3,963,331.2	1,349,897.5	7,170,314.2
9	689,678.1	4,308,342.0	1,349,897.5	7,845,599.0
10	689,678.1	4,627,796.4	1,349,897.5	8,470,862.7
NPV	**4,627,796.4**		**8,470,862.7**	

Source: Author (2020)

As Table 21 shows, the NPV of investment 1 means that the option to switch to LSFO after ten years is worth **$ 4,627,796.4** while the NPV of investment 2 means that the option of using a Hybrid scrubber reaches **$ 8,470,862.7** after ten years. From the above results, it can be easily seen that the NPV value of both investments is greater than zero, so the two projects are feasible and acceptable. The NPV value of investment 1 is less than the NPV value of Investment 2 (**4,627,796.4 less than 8,470,862.7**). Because these are two independent projects, the investment of NPV of the investment with the higher value will be preferred because it will create higher cash flow in the future so for Nha Be 09, they will switch to using Hybrid scrubber which is much more economically viable than switching to LSFO fuel.

5.1.7 Nha Be 10

The average revenue for one year of Nha Be 10 is **3,070,872 $.** Nha Be 09 has just been launched in early 2019, the data will be calculated based on 2019. Fuel consumption and other cost of Nha Be 09 in 2019 is shown as Table 25. Table 23 shows the calculation of the average of CAPEX and OPEX for 2019 of operation. The NPV calculation of 2 investment projects shows the 10-year cash flow of Nha Be 09 are shown in Table 24.

Table 24: Fuel consumption and other cost in average

Crew Cost Total	264,863	$/year
Store Cost Total	58,096	$/year
Repair and maintenance	89,343	$/year
Insurance Total	70,318	$/year
General cost Total (Administration cost)	148,895	$/year
Periodic Maintenance cost (Dry dock)	77,981	$/year
Days running at sea	252	days
Days in port	41	days
IFO 380 consumed	2,822	ton/year
MGO consumed	141	ton/year

Source: Author (2020)

Table 25: The calculation in average of CAPEX and OPEX in 2019

The IMO Sox compliance options	Investment 1		Investment 2	
	VLS fuel oil		Scrubber	
	CAPEX ($)	*OPEX ($)*	*CAPEX ($)*	*OPEX ($)*
Initial installation	0.0		639,744.0	
Fuel cost (include pilot fuel, if applied)		1,429,593.1		1,021,322.8
Extra Maintenance cost of Engines		299,400.2		
Scrubber maintenance cost				11,515.4
Crew cost		264,862.7		264,862.7
Store cost		58,096.4		58,096.4
Repair and maintenance		89,343.0		89,343.0
Insurance Total		70,317.7		70,317.7
General cost Total (Administration cost)		148,895.1		148,895.1
Periodic Maintenance cost (Dry dock)		77,980.8		77,980.8
Total	**0.0**	**2,438,488.9**	**639,744.0**	**1,742,333.8**

Source: Author (2020)

Table 26: Cash flow ($) of the 2 investments and NPVs

Year	Investment 1		Investment 2	
	VLS fuel oil		Scrubber	
	Cash flow	**Yearly NPV**	**Cash flow**	**Yearly NPV**
0	0.0	0.0	-639,744.0	-639,744.0
1	632,382.9	592,118.8	1,328,538.0	604,205.4
2	632,382.9	1,146,537.2	1,328,538.0	1,768,952.1
3	632,382.9	1,665,655.5	1,328,538.0	2,859,538.9
4	632,382.9	2,151,721.3	1,328,538.0	3,880,687.5
5	632,382.9	2,606,839.1	1,328,538.0	4,836,819.2
6	632,382.9	3,032,979.4	1,328,538.0	5,732,073.6
7	632,382.9	3,431,987.2	1,328,538.0	6,570,326.8
8	632,382.9	3,805,589.9	1,328,538.0	7,355,208.0
9	632,382.9	4,155,405.3	1,328,538.0	8,090,115.6
10	632,382.9	4,482,947.7	1,328,538.0	8,778,231.3
NPV	**4,482,947.7**		**8,778,231.3**	

Source: Author (2020)

As Table 24 shows, the NPV of investment 1 means that the option to switch to LSFO after ten years is worth **$ 4,482,947.7** while the NPV of investment 2 means that the option of using a Hybrid scrubber reaches **$ 8,778,231.3** after ten years. From the above results, it can be easily seen that the NPV value of both investments is greater than zero, so the two projects are feasible and acceptable. The NPV value of investment 1 is less than the NPV value of Investment 2 (**4,482,947.7 less than 8,778,231.3**). Because these are two independent projects, the investment of NPV of the investment with the higher value will be preferred because it will create higher cash flow in the future so for Nha Be 10, they will switch to using Hybrid scrubber which is much more economically viable than switching to LSFO fuel.

5.2 Discussion and recommendations

Based on the results of the SWOT and PESTLE analysis, two investment projects have their advantages and disadvantages. However, as a shipowner, VITACO should be concerned and consider which projects can generate the best profit in the future or in other words, which projects have substantial financial advantages rather than technology or other factors. Because in addition to being a shipping company, VITACO is also the owner of the six ships operating in the charter model, VITACO is most interested in the profit and the impact of the conversion to an alternative option for HFO to IMO 2020 in compliance with freight rates. Therefore, investment projects with potential or financial strength will be given priority to be chosen. Although CAPEX of LSFO is insignificant, its annual maintenance and maintenance costs are higher than the use of HFO in combination with the Hybrid scrubber system (Nagesh, Gongopadhyay, Joseph, & Banerjee, 2020). The use of a hybrid scrubber system allows VITACO to operate long-term and even in ECAs where sulfur emissions below 0.1% is controlled. VITACO can exploit in the ECAs area and can still continue using HFO without having to switch to ULSFO or MGO, which is much more expensive than HFO. It could be a long-term serving opportunity. Indeed, if the fuel costs dropped, the differential between HFO and MGO is consistently around 250$ per tons. Shipowners can spare between 2-3 M $ of fuel costs per annum, not taking care of the scrubber working expenses. Scrubbers are appropriate for each dispatch sort (CONCAWE Refinery Technology Support Group, 2015) Besides, if ship owners switch to hybrid scrubbers, suitable for ships over 15 years old, because ships over 15 years old are considered the time when the vessel starts to age, and will incur some additional costs and more than 20 years old, it is difficult to operate because old ships incur insurance premiums—old and limited acceptance of some port warehouses for safety. If VITACO considers to utilize scrubbers, it is suitable for vessels under ten years old.

Table 27: NPV of 2 investments of each vessel

Vessel	NPV	
	Switching to VSLFO	Utilizing Hybrid Scrubber
Petrolimex 20	11,938,878.60	19,526,955.30
Nha Be 03	5,247,079.40	7,019,719.80
Nha Be 06	4,947,443.30	9,443,808.20
Nha Be 08	4,879,428.40	9,029,218.20
Nha Be 09	4,627,796.40	8,470,862.70
Nha Be 10	4,482,947.70	8,778,231.30

Source: Author (2020)

According to tables 23, it can be easily seen that the NPV of utilizing hybrid scrubber is always more significant than the NPV of switching to VLSFO in every vessel. Since these are two independent investment projects, VITACO should choose a plan with a more significant NPV result to achieve higher profits in the future because it will create more substantial cash flow in the future. From the above results, it can be seen that VITACO should prefer to utilize hybrid Scrubber rather than switching to low-sulfur fuel even when the oil war between Russia and OPEC members will cause prices crude oil heads are falling at historical records. But the problem is short term, and it is predicted that in the next few months, oil prices will return to normal levels. Moreover, it can be seen that the NPV value of investment project two always reaches a value twice higher than the NPV value of investment project 1. That shows that in the future (specifically in over ten years) the transition to a hybrid scrubber to comply with a sulfur threshold of less than 0.5% generated twice as much cash flow than the transition to using a low sulfur fuel, LSFO. As a vessel owner owning six vessels operating on a voyage charter, VITACO should switch to using the hybrid scrubber system for all six vessels to comply with the new sulfur cap in 2020 and also gain benefits higher profits over the next ten years.

To apply the new 01/01/2020 rule, if VITACO chooses to switch to LSFO, it will impact freight as follows:

1. The fuel (bunker) accounts for about 25-35% of the cost structure (depending on the type of carrier, about 30-35% of oil tankers). Because when the bunker price increases, the cost will increase, so the freight rate will increase accordingly. Currently, the price difference between bunker using FO380 and LSFO is about 70-80%. Besides, due to the increase in freight rates, the bunker price will increase further because it has freight.

2. Several other factors also contribute to cost increase (at the time of changing the material) such as equipping more equipment to suit using new fuel, flushing the fuel tank, disposing of excess old fuel, etc.)

3. The initial fuel supply will be unstable because LSFO is not available everywhere to supply ships.

4. According to the regulation that applies LSFO to both international and domestic routes, all vessels must comply with

5. The BAF and LSS surcharge is based on the bunker cost, so it is a variable cost. Since this cost is included in the price, the charterer should certainly bear it (it seems that the container ship already has applied).

6. Because the difference between FO380/180 and LSFO bunker prices is too large, high freight rates will cause shocking increases, affecting many operations so that the shipping lines can have a suitable rate increase schedule. (VITACO should have a long-term plan. For example, it is not possible to increase charges immediately, but increase by 3-5% until the costs are fully covered and profitable).

7. For the domestic market, because the LSFO is used, the train fare increase will affect the domestic petroleum price (because petroleum is imported from abroad), so the economy will surely take measures to stabilize the gasoline price subsidy. Still, there is a fund to stabilize gasoline prices (increase with a roadmap, not increase shock) and many other measures.

Through calculations, analysis and assessment of strengths and weaknesses, VITACO should consider and put into a plan to implement a conversion to a hybrid scrubber to comply with the sulfur cap set by IMO in 2020, first of all, because of the cash flow it brings in the future (namely in the next ten years). It can be seen that the switch to a scrubber for all VITACO tankers is almost double the cash flow that VSLFO brings to the company over the next ten years. On the other hand, the use of scrubbers can allow owners to make long-term shipments. This is very suitable for ship owners who always operate long-term voyages like VITACO.

5.3 Conclusion

The implementation of the global sulfur cap continues to create countless discussions about the availability of fuel with low sulfur content in the future as well as the possibility of price changes of this fuel (Srivastava, 2000). Predicting future fuel prices is a challenging task. The conversion to more advanced fuels will most likely result in significantly higher fuel costs for the shipping industry.

Scope for future and limitations

The cost of different fuels is traditionally closely related to oil prices. However, such correlations should not be used for future predictions. The increasing blending of fuels will increase distillate fuel demand, then change the historical relationship and will likely push up fuel prices (Nagesh, Gongopadhyay, Joseph, & Banerjee, 2020). At the same time, the reduction for HSFO could cause the price of this fuel to go down. Therefore, in the future, a growing gap between the two competing fuel solutions will be seen with HSFO (combined exhaust gas cleaning device) priced at the bottom and MGO representing the fuels at the upper level. Most ship operations in the world in general and in Vietnam, in particular, intend to switch to using MGO or MDO fuel when the oil war is between Russia and OPEC members. Hence, the price of MGO increases is zero inevitable in the short term. As the production of blended fuels with a low Sulphur content of 0.5% gradually increased, the price of distillate products is eventually levelling off. However, if significant price differences between traditional HSFO and compliant fuels persist over time, then alternative measures, such as exhaust cleaners, would be an appropriate solution.

The rising fuel costs are expected to lead many stakeholders in the shipping industry to believe that an inevitable reduction in the speed of ships will be seen to cut operating costs. The focus on energy efficiency measures will also be strengthened for the same reason. Fuel-efficient vessels will be more competitive, while vessels fitted with exhaust cleaning equipment may have significant competitive advantages. It is expected that initially, ships with exhaust purification equipment will be able to have high chartering rates (Zhu, Li, Lin, Shi, & Yang, 2020). However, if most ships in the same segment are equipped with exhaust cleaning equipment, the rents will be lowered. Vessels without exhaust cleaning equipment may be forced to reduce rents to unsustainable levels, eventually being pushed out of the market. Therefore, ship owners need to monitor the competition in their segment to ensure that they are not left behind.

Future trends

There is a lot of mention about fuel change, fuel switching in connection with the 2020 date. And that is very important. The maritime industry is moving to a different fuel paradigm, but the real difficult fuel change that shipowners face is moving toward 2050 and trying to deal with greenhouses gases. Zero carbon fuels or carbon-neutral fuel will be critical and require new products that do not exist yet. That is going to be the real significant fuel change. There are also lots of fuels being discussed these days, including hydrogen and ammonia, LPG. The fuels can work in the existing infrastructure both on land and on ships. To get that, there is, in reality, one real solution and that is synthetic fuels- the power to fuel. It is possible to do it, and it would work.

Figure 13: Solution of tanker to comply with sulphur limitation in future.

TANKER

	Tanker 1	Tanker 2	Tanker 3
Age	3	13	To be built
Operating profile	High speed (15 knots)	Low speed (11 knots)	High speed (15 knots)
ECA exposure	Medium	Low	High
TC / spot (...who pays for fuel?)	TC (long term)	Spot	TC (long term)
North America trade?	NO	NO	Yes
Solution 1	**Hybrid fuel** 0.5% outside ECA 0.1% in ECA	**Hybrid fuel** 0.5% outside ECA 0.1% in ECA	**Hybrid fuel** 0.5% outside ECA 0.1% in ECA **+ EGR/SCR (Tier III)**
Solution 2	**HFO + Scrubber** 0.5% outside ECA Scrubber 0.1% in ECA	**HFO + Scrubber** 0.5% outside ECA Scrubber 0.1% in ECA	**HFO + Scrubber** 0.5% outside ECA Scrubber 0.1% in ECA + EGR/SCR (Tier III)
Solution 3			**LNG** + EGR/SCR (Tier III)*

Source: DNV-GL (2020)

Indeed, if providers and yards adapt, there will be a couple of thousand scrubber establishments by 2020, requiring the rest of the armada to depend on compliant fuel. The number of ships using LNG as fuel is expanding, and increased infrastructure projects are arranged or proposed along the most shipping paths, in line with this energetic improvement. At the same time, LNG is commercially appealing and accessible worldwide in amounts able to meet the fuel request of shipping within the coming decades. LNG as fuel is particularly anticipated to extend for vessels as often as possible, working in the North American and North European waters with existing or up and coming NOx prerequisites. An increment in compliant fuel costs relative to LNG will empower administrators to contribute to LNG. Elective powers, such as methanol and biofuels, are anticipated as they could serve a minor share of the advertisement. They will be an elective in a few nearby regions, where the supply fits exchanging designs for vessels.

References

Abadie, L. M., Goicoechea, N., & Galarraga, I. (2017). *Adapting the shipping sector to stricter emissions regulations: Fuel switching or installing a scrubber?* doi:https://doi.org/10.1016/j.trd.2017.09.017

ABS. (2018). Abs advisory on exhaust gas scrubber systems. Retrieved from https://ww2.eagle.org/content/dam/eagle/advisories-and-debriefs/exhaust-gas-scrubber-systems-advisory.pdf

ABS. (2019). Marine fuel oil advisory.

Alexander, C. (2009). *Market risk analysis, value at risk models* John Wiley & Sons.

Alfa Laval. (2019). Marine fuels in the low-sulphur era.

Alizadeh, A., & Nomikos, N. (2009a). *Shipping derivatives and risk management* Springer.

Alizadeh, A., & Nomikos, N. (2009b). *Shipping derivatives and risk management* Springer.

American Society for Testing and Materials. (2010). Standard specification for fuel oils. Paper presented at the

Anastassios Adamopoulos. (2018, 30 Oct). Euronav warns against scrubbers. Retrieved from https://lloydslist.maritimeintelligence.informa.com/LL1124868/Euronav-warns-against-scrubbers

Antturi, J., Hänninen, O., Jalkanen, J., Johansson, L., Prank, M., Sofiev, M., & Ollikainen, M. (2016). Costs and benefits of low-sulphur fuel standard for baltic sea shipping. *Journal of Environmental Management, 184*, 431-440. doi:10.1016/j.jenvman.2016.09.064

Argus Media. (2019). The argus white paper: The outlook for marine fuel.

Arndt, R. L., Carmichael, G. R., Streets, D. G., & Bhatti, N. (1997a). Sulfur dioxide emissions and sectorial contributions to sulfur deposition in asia. *Atmospheric Environment, 31*(10), 1553-1572.

Arndt, R. L., Carmichael, G. R., Streets, D. G., & Bhatti, N. (1997b). Sulfur dioxide emissions and sectorial contributions to sulfur deposition in asia. *Atmospheric Environment, 31*(10), 1553-1572.

Baden, S. P., & Pihl, L. (1984). Abundance, biomass and production of mobile epibenthic fauna in zostera marina (L.) meadows, western sweden. *Ophelia, 23*(1), 65-90. doi:10.1080/00785236.1984.10426605

Balcombe, P., Brierley, J., Lewis, C., Skatvedt, L., Speirs, J., Hawkes, A., & Staffell, I. (2019). *How to decarbonise international shipping: Options for fuels, technologies and policies* Elsevier.

Bergqvist, R., & Cullinane, K. (2013). SECA regulations, modal shift and transport system effects. *TA Logistics and Transport Consultants (Ed.), Gothenburg,* Buhaug, Ø, Corbett, J. J., Endresen, Ø, Eyring, V., Faber, J., Hanayama, S., . . . Markowska, A. Z. (2009). Second imo ghg study 2009. *International Maritime Organization (IMO) London, UK, 20*

Bui, K. Q., Ölçer, A. I., Kitada, M., & Ballini, F. (2017). Selecting technological alternatives for regulatory compliance towards emissions reduction from shipping: An integrated fuzzy multi-criteria decision-making approach under vague environment. *Proceedings of the Institution of Mechanical Engineers, Part M: Journal of Engineering for the Maritime Environment,* , 1475090220917815.

Capaldo, K., Corbett, J. J., Kasibhatla, P., Fischbeck, P., & Pandis, S. N. (1999a). Effects of ship emissions on sulphur cycling and radiative climate forcing over the ocean. *Nature, 400*(6746), 743-746.

Capaldo, K., Corbett, J. J., Kasibhatla, P., Fischbeck, P., & Pandis, S. N. (1999b). Effects of ship emissions on sulphur cycling and radiative climate forcing over the ocean. *Nature, 400*(6746), 743-746.

Cofala, J., Amann, M., Gyarfas, F., Schoepp, W., Boudri, J. C., Hordijk, L., . . . Gupta, S. (2004). *Cost-effective control of SO2 emissions in asia* doi://doi.org/10.1016/j.jenvman.2004.04.009

Cofala, J., Amann, M., Gyarfas, F., Schoepp, W., Boudri, J. C., Hordijk, L., . . . Panwar, T. S. (2004). Cost-effective control of SO2 emissions in asia. *Journal of Environmental Management, 72*(3), 149-161.

CONCAWE Refinery Technology Support Group. (2015). Scrubbers systems: Technology overview, benefits and market trends. Retrieved from https://safety4sea.com/scrubbers-systems-technology-overview-benefits-and-market-trends/?__cf_chl_jschl_tk__=54192fc48c92de3ce4d913268183c62181b4f9da-1597134096-0-AahoT94bIEHUYbnlnzGFDWcBRFqljL8FLjCKsGYy__w2sOgmAPozXLSjWsqvyinh0ouBOiJr4riqM0Np0vSdWUt5dS3nSaqo5CVTRtHfupSAHQ7RExxpsVh5CD6C5AWNPvVjsBlYByBuDt7T_DzgbKemSyLYvdH7rTvfb0q2VISXPgpVt9WQcF0bq6CIYTaj8kcMvEpDxzyfv8MdOoTEQ1EoMrT_Fl5Ri2LG011PyagLKllG8YxQ1dFdNEjxtyVre-pp8t2LzNYmj3MjdW6ZbCm5pWVTzhlufVrDz2xA_UyoLPyh4mAkNtIRJGo5VneIs3hpkgjhfq3yxmgDKMVjp6_WslkZ_eYp_2HFpNVjTQnx

Content Marketing. (2020, 31 Mar). Crises may push down VLSFO and HSFO prices even further. Retrieved from https://lloydslist.maritimeintelligence.informa.com/LL1131755/Crises-may-push-down-VLSFO-and-HSFO-prices-even-further

Corbett, J. J., & Fischbeck, P. (1997). Emissions from ships. *Science*, *278*(5339), 823-824.

Corbett, J. J., Wang, H., & Winebrake, J. J. (2009a). The effectiveness and costs of speed reductions on emissions from international shipping. *Transportation Research Part D: Transport and Environment*, *14*(8), 593-598.

Corbett, J. J., Wang, H., & Winebrake, J. J. (2009b). The effectiveness and costs of speed reductions on emissions from international shipping. *Transportation Research Part D: Transport and Environment, 14*(8), 593-598.

Corbett, J. J., & Winebrake, J. J. (2008). Emissions tradeoffs among alternative marine fuels: Total fuel cycle analysis of residual oil, marine gas oil, and marine diesel oil. *Journal of the Air & Waste Management Association, 58*(4), 538-542.

Coronavirus is decimating IMO 2020 ship-scrubber savings. (2020, Mar 10,). *Benzinga.Com*

Cotten, S. R. (1999). Mixed methodology: Combining qualitative and quantitative approaches. *Contemporary Sociology, 28*(6), 752.

Cullen, W. P. (1997). Marine fuelsâ€"Worldwide sulphur levels. *Statistical Report Produced for the Norwegian Maritime Directory,*

Cullinane, K., & Bergqvist, R. (2014a). No title. *Emission Control Areas and their Impact on Maritime Transport,*

Cullinane, K., & Bergqvist, R. (2014b). No title. *Emission Control Areas and their Impact on Maritime Transport,*

Da Silva, P., & Le Gall, R. (2003). No title. *Method for Obtaining Oil Products with Low Sulphur Content by Desulfurization of Extracts,*

David Osler. (2019, 04 Nov). Scrubbers are tried, tested and still getting better. Retrieved from https://lloydslist.maritimeintelligence.informa.com/LL1129820/Scrubbers-are-tried-tested-and-still-getting-better

DNV, G. L., SAFER, S., & GREENER, D. (2018). Global sulphur cap 2020. *Compliance Options and Implications for Shipping–focus on Scrubbers, Extended and Updated In,*

Duffy, J. E. (2003). Biodiversity loss, trophic skew and ecosystem functioning. *Ecology Letters, 6*(8), 680-687. doi:10.1046/j.1461-0248.2003.00494.x

Edward Turner. (2020). *Boxship scrubber retrofits: Assessing the impact*. (). Retrieved from https://sin.clarksons.net/News/Article/149531

Elmgren, R. (1989). Man's impact on the ecosystem of the baltic sea: Energy flows today and at the turn of the century. *Ambio,* , 326-332.

Eyring, V., Stevenson, D. S., Lauer, A., Dentener, F. J., Butler, T., Collins, W. J., . . . Isaksen, I. S. (2007). Multi-model simulations of the impact of international shipping on atmospheric chemistry and climate in 2000 and 2030.

Ezzy, D. (2013). *Qualitative analysis* Routledge.

Fenton, P. (2017). The role of port cities and transnational municipal networks in efforts to reduce greenhouse gas emissions on land and at sea from shipping–an assessment of the world ports climate initiative. *Marine Policy, 75*, 271-277.

Folke, C., Kautsky, N., Berg, H., Jansson, Å, & Troell, M. (1998). The ecological footprint concept for sustainable seafood production: A review. *Ecological Applications, 8*(sp1), S63-S71.

Garpe, K. (2008). *Ecosystem services provided by the baltic sea and skagerrak*. Stockholm: Swedish Environmental Protection Agency. Retrieved from http://libris.kb.se/resource/bib/11289804

Geography of the baltic sea area. (2011).

Guihen, D., White, M., & Lundälv, T. (2012). Temperature shocks and ecological implications at a cold-water coral reef. *Marine Biodiversity Records, 5*(July 2012) doi:10.1017/S1755267212000413

Gürel, E., & Tat, M. (2017). SWOT analysis: A theoretical review. *Journal of International Social Research, 10*(51)

Han, C. (2010). *Strategies to reduce air pollution in shipping industry* doi://doi.org/10.1016/S2092-5212(10)80009-4

Harvey, C. J., Cox, S. P., Essington, T. E., Hansson, S., & Kitchell, J. F. (2003a). An ecosystem model of food web and fisheries interactions in the baltic sea. *ICES Journal of Marine Science, 60*(5), 939-950.

Harvey, C. J., Cox, S. P., Essington, T. E., Hansson, S., & Kitchell, J. F. (2003b). An ecosystem model of food web and fisheries interactions in the baltic sea. *ICES Journal of Marine Science, 60*(5), 939-950.

HELCOM. (2018a). State of the baltic Sea–Second HELCOM holistic assessment 2011-2016. Paper presented at the *Baltic Sea Environment Proceedings,* 155.

HELCOM. (2018b). State of the baltic Sea–Second HELCOM holistic assessment 2011-2016. Paper presented at the *Baltic Sea Environment Proceedings,* 155.

Hine, R. S., & Beardsley, T. (2008). *Aœ dictionary of biology* (6. ed. ed.). Oxford [u.a.]: Oxford Univ. Press. Retrieved from http://bvbr.bib-bvb.de:8991/F?func=service&doc_library=BVB01&local_base=BVB01&doc_number=016456449&sequence=000002&line_number=0001&func_code=DB_RECORDS&service_type=MEDIA

Ignacio Alcaide, J., Rodríguez-Díaz, E., & Piniella, F. (2017). European policies on ship recycling: A stakeholder survey. *Marine Policy, 81*, 262-272. doi:10.1016/j.marpol.2017.03.037

IJERA. (2018). Fuel preferences for marine diesel engine: The advantages and disadvantages.

IMO. (2018). *Guidance on the development of a ship implementation plan for the consistent implementation of the 0.50% sulphur limit under marpol annex vi*. (). International Maritime Organization: International Maritime Organization. Retrieved from file:///Users/haiau/Downloads/MEPC.1-Circ.878%20-%20Guidance%20On%20The%20Development%20Of%20A%20Ship%20Impl ementation%20Plan%20For%20The%20Consistent%20Implementatio...%20(Secretariat).pdf

in International Shipping News. (2020, Mar 10,). Coronavirus is decimating IMO 2020 ship-scrubber savings. *Benzinga.Com*

International Maritime Organization. (2013). *MARPOL annex VI and NTC 2008: With guidelines for implementation* International Maritime Organization.

IPIECA: Joint industry guidance on the supply and use of 0.50%-sulphur marine fuel. (2019, Aug 20,). *Contify Energy News* Retrieved from https://www.emis.com/php/search/doc?pc=IN&dcid=658469730&primo=1

ISO 8217: 2012. (2012). Petroleum Products–Fuels (class F)–Specifications of marine fuels.

ITF/, & OECD. (2019). *Logistics development strategies and performance measurement*. ().

Jambeck, J. R., Geyer, R., Wilcox, C., Siegler, T. R., Perryman, M., Andrady, A., . . . Law, K. L. (2015). Plastic waste inputs from land into the ocean. *Science, 347*(6223), 768-771.

James Baker. (2020, 18 Mar). Scrubber installations hit by delays and lower spread. Retrieved from https://lloydslist.maritimeintelligence.informa.com/LL1131560/Scrubber-installations-hit-by-delays-and-lower-spread

Jasper Faber, T. H. (2016). Assessment of fuel oil availability.

Jonsson, L., Nilsson, P., Floruta, F., & Lundälv, T. (2004). Distributional patterns of macro- and megafauna associated with a reef of the cold-water coral lophelia pertusa on the swedish west coast. *Marine Ecology Progress Series, 284*, 163-171. doi:10.3354/meps284163

Kaminski, J. (2003a). Technologies and costs of SO2-emissions reduction for the energy sector. *Applied Energy, 75*(3-4), 165-172.

Kaminski, J. (2003b). Technologies and costs of SO2-emissions reduction for the energy sector. *Applied Energy, 75*(3-4), 165-172.

Kavussanos, M. G., & Visvikis, I. D. (2006). Shipping freight derivatives: A survey of recent evidence. *Maritime Policy & Management, 33*(3), 233-255.

Kim, A., & Seo, Y. (2019). The reduction of SOx emissions in the shipping industry: The case of korean companies. *Marine Policy, 100*, 98-106. doi:10.1016/j.marpol.2018.11.024

Kumar, M. (2007). Mixed methodology research design in educational technology. *Alberta Journal of Educational Research, 53*(1)

Larson, D., Varangis, P., & Yabuki, N. (1998). *Commodity risk management and development* The World Bank.

Larsson, M., & Granstedt, A. (2010). Sustainable governance of the agriculture and the baltic Sea—Agricultural reforms, food production and curbed eutrophication. *Ecological Economics, 69*(10), 1943-1951.

Lauringson, V., & Kotta, J. (2016). Mussels of a marginal population affect the patterns of ambient macrofauna: A case study from the baltic sea. *Marine Environmental Research, 116*, 10-17. doi:10.1016/j.marenvres.2016.02.010

Lim, S., Park, D., Lee, D. S., & Park, J. M. (2006). Economic evaluation of a water network system through the net present value method based on cost and benefit estimations. *Industrial & Engineering Chemistry Research, 45*(22), 7710-7718.

Limbourg, S., Giang, H. T. Q., & Cools, M. (2016). *Logistics service quality: The case of da nang city* Elsevier.

Lindstad, H. E., Rehn, C. F., & Eskeland, G. S. (2017). Sulphur abatement globally in maritime shipping. *Transportation Research Part D: Transport and Environment, 57*, 303-313.

Lindstad, H. E., & Eskeland, G. S. (2016a). *Environmental regulations in shipping: Policies leaning towards globalization of scrubbers deserve scrutiny* doi://doi.org/10.1016/j.trd.2016.05.004

Lindstad, H. E., & Eskeland, G. S. (2016b). *Environmental regulations in shipping: Policies leaning towards globalization of scrubbers deserve scrutiny* doi://doi.org/10.1016/j.trd.2016.05.004

Lloyd's Register. (2019). *Sulphur 2020: What's your plan?* ().

Mander, S. (2017). Slow steaming and a new dawn for wind propulsion: A multi-level analysis of two low carbon shipping transitions. *Marine Policy, 75*, 210-216.

Marine science data centers (2017). Retrieved from https://search.credoreference.com/content/entry/fofmarine/marine_science_data_centers/0

Markowska, A., & Żylicz, T. (1999). *Costing an international public good: The case of the baltic sea* doi://doi.org/10.1016/S0921-8009(98)00138-4

Mats Walday Tone, Kroglund Norwegian, Institute for Water Research, (NIVA). (2017). The baltic sea - the largest brackish sea in the world.

McKinnon, A. C. (2007). Decoupling of road freight transport and economic growth trends in the UK: An exploratory analysis. *Transport Reviews, 27*(1), 37-64.

Michelle Wiese Bockmann. (2020). *Oil price war adds to tanker market volatility*. (). Retrieved from https://lloydslist.maritimeintelligence.informa.com/LL1131430/Oil-price-war-adds-to-tanker-market-volatility

Ministry of Industry and Trade. (2019a). *Documentation of logistic performance indicator of vietnam*. ().

Ministry of Industry and Trade. (2019b). *Vietnam logistic report 2019*. ().

Mittnik, A., Wang, C., Pfrengle, S., Daubaras, M., Zariņa, G., Hallgren, F., . . . Tõrv, M. (2018). The genetic prehistory of the baltic sea region. *Nature Communications, 9*(1), 442.

Nagesh, B., Gongopadhyay, M. S., Joseph, M. A., & Banerjee, M. T. (2020). Study on the use of limestone on scrubber system and desulfurization of high and low sulphur fuel oils in ships. *Journal of Offshore Structure and Technology, 7*(1), 16-24.

Nidaa Bakhsh, & Richard Meade. (2019, 12 Sep). Scrubber corrosion repairs required less than six months after installation. Retrieved from https://lloydslist.maritimeintelligence.informa.com/LL1129158/Scrubber-corrosion-repairs-required-less-than-six-months-after-installation

Notteboom, T. (2011). The impact of low sulphur fuel requirements in shipping on the competitiveness of roro shipping in northern europe. *WMU Journal of Maritime Affairs, 10*(1), 63-95.

Notteboom, T., Delhaye, E., & Vanherle, K. (2010). Analysis of the consequences of low sulphur fuel requirements. *ITMMA–Universiteit Antwerpen Transport&Mobility,*

Oceana.Shipping pollution. Retrieved from https://eu.oceana.org/en/shipping-pollution-1

Oeder, S., Kanashova, T., Sippula, O., Sapcariu, S. C., Streibel, T., Arteaga-Salas, J. M., . . . Schlager, C. (2015). Particulate matter from both heavy fuel oil and diesel fuel shipping emissions show strong biological effects on human lung cells at realistic and comparable in vitro exposure conditions. *PLoS One, 10*(6)

Ojaveer, H., Jaanus, A., Mackenzie, B. R., Martin, G., Olenin, S., Radziejewska, T., . . . Zaiko, A. (2010). Status of biodiversity in the baltic sea. *PloS One, 5*(9), e12467. doi:10.1371/journal.pone.0012467

Österblom, H., Hansson, S., Larsson, U., Hjerne, O., Wulff, F., Elmgren, R., & Folke, C. (2007). Human-induced trophic cascades and ecological regime shifts in the baltic sea. *Ecosystems, 10*(6), 877-889.

Pacific Green Technologies Group. (2020). Why will so many ships not have scrubbers on time for IMO 2020? Retrieved from https://www.pacificgreentechnologies.com/articles/why-will-so-many-ships-not-have-scrubbers-time-imo-2020/

Panasiuk, I., Lebedevas, S., & Česnauskis, M. (2014). Selection of exhaust scrubber: Concept for optimal solution. *Environmental Research, Engineering and Management, 70*(4), 40-45.

Parker, C. J. (1987). Herald of free enterprise. *Seaways,*

Patton, M. Q. (1980). Qualitative evaluation methods.

Patton, M. Q. (1990). *Qualitative evaluation and research methods* SAGE Publications, inc.

Perera, R. (2017). *The PESTLE analysis* Nerdynaut.

Peter Sand. (2019). *Bimco launches interactive graphs showing bunker fuel spreads*. ().

Piercy, N., & Giles, W. (1989). Making SWOT analysis work. *Marketing Intelligence & Planning,*

PIHL, L. (2002). Structure and diversity of fish assemblages on rocky and soft bottom shores on the swedish west coast. *Journal of Fish Biology, 61*, 148-166. doi:10.1006/jfbi.2002.2074

Pihl, L., Baden, S., Kautsky, N., Rönnbäck, P., Söderqvist, T., Max.Troell, & Wennhage, H. (2006). Shift in fish assemblage structure due to loss of seagrass zostera marina habitats in sweden. *Estuarine, Coastal and Shelf Science, 67*(1), 123-132. doi:10.1016/j.ecss.2005.10.016

Plomaritou, E., & Nikolaides, E. (2016). Commercial risks arising from chartering vessels. *Journal of Shipping and Ocean Engineering, 6*, 261-268.

Rastogi, N., & Trivedi, M. K. (2016). PESTLE technique–a tool to identify external risks in construction projects. *International Research Journal of Engineering and Technology (IRJET), 3*(1), 384-388.

Roh, S., Thai, V. V., & Wong, Y. D. (2016). *Towards sustainable ASEAN port development: Challenges and opportunities for vietnamese ports* doi:https://doi.org/10.1016/j.ajsl.2016.05.004

Rydén, L., Migula, P., & Andersson, M. (2003). *Environmental science: Understanding, protecting and managing the environment in the baltic sea region* Baltic University Press.

SAFETY4SEA. (2019). *New report analyzes environmental and economic aspects of scrubbers*. (). Retrieved from https://safety4sea.com/new-report-analyzes-environmental-and-economic-aspects-of-scrubbers/?__cf_chl_jschl_tk__=a82f364624e9ac372e4463d0368dc55fdc0cfc06-1594195195-0-AUmmV4075Eg7Dl8lDXdHEO5IEh2-3ADiBVb76w_4CAVy77YeOGZSBb-ir_X_OuoBrs_3l3nka7eXz-9M7Q1DCufk-MtTtwbeSdLcoabu3fCkDL18EpTrMwVMBRobGbbqixZEiLqRpPrVeCbG9wTtSdnDkctF5W5IFc8GmFRaxAjwp_mj1XcbXzeVdGyKIW4IkC-MynARLVW0PALGNL0tvaH1Awmv_VHAfjocFCC7EL8yNkk3ybUM0Kj8WlaJT3rCLEljIe9AUHRk1dTZmncUphP5-1NE11GEV01LfBqdj3qAcnCBnpArpZuv5yWfcpFKK2vxB-wWNYspERmu-zGAAfc3slxSpS4cLaRZ0OZ6pfSQ

Samitas, A., & Tsakalos, I. (2010). Hedging effectiveness in shipping industry during financial crises. *International Journal of Financial Markets and Derivatives, 1*(2), 196-212.

Sargun Sethi. (2020). A guide to scrubber system on ship. Retrieved from https://www.marineinsight.com/tech/scrubber-system-on-ship/

Ship & Bunker News Team. (2018, June 11,). IMO 2020: Dramatic rise in scrubber interest. Retrieved from https://shipandbunker.com/news/world/137769-imo-2020-dramatic-rise-in-scrubber-interest

Shrestha, R. M., Bhattacharya, S. C., & Malla, S. (1996a). *Energy use and sulphur dioxide emissions in asia* doi://doi.org/10.1006/jema.1996.0027

Shrestha, R. M., Bhattacharya, S. C., & Malla, S. (1996b). *Energy use and sulphur dioxide emissions in asia* doi://doi.org/10.1006/jema.1996.0027

Snoeijs-Leijonmalm, P., Schubert, H., & Radziejewska, T. (2017). *Biological oceanography of the baltic sea* Springer Science & Business Media.

Solakivi, T., Laari, S., Kiiski, T., Töyli, J., & Ojala, L. (2019). How shipowners have adapted to sulphur regulations – evidence from finnish seaborne trade. *Case Studies on Transport Policy, 7*(2), 338-345. doi:10.1016/j.cstp.2019.03.010

Sparholt, H. (1994). Fish species interactions in the baltic sea. *Dana, 10*, 131-162.

Srivastava, R. K. (2000). *Controlling SO2 emissions--a review of technologies* United States Environmental Protection Agency, Office of Research and ….

Streets, D. G., Carmichael, G. R., & Arndt, R. L. (1997a). *Sulfur dioxide emissions and sulfur deposition from international shipping in asian waters* doi://doi.org/10.1016/S1352-2310(96)00204-X

Streets, D. G., Carmichael, G. R., & Arndt, R. L. (1997b). *Sulfur dioxide emissions and sulfur deposition from international shipping in asian waters* doi://doi.org/10.1016/S1352-2310(96)00204-X

Streets, D. G., Carmichael, G. R., & Arndt, R. L. (1997c). *Sulfur dioxide emissions and sulfur deposition from international shipping in asian waters* doi://doi.org/10.1016/S1352-2310(96)00204-X

Susanne Baden, Martin Gullström, Bengt Lundén, Leif Pihl, & Rutger Rosenberg. (2003). Vanishing seagrass (zostera marina, L.) in swedish coastal waters. *Ambio, 32*(5), 374-377. doi:10.1579/0044-7447-32.5.374

Szydarowski, W. (2005). *Geography of flows in the south baltic sea area and their implications for regional growth*. Karlskrona: Baltic Gateway. Retrieved from http://libris.kb.se/resource/bib/9995569

Tashakkori, A., Teddlie, C., & Teddlie, C. B. (1998). *Mixed methodology: Combining qualitative and quantitative approaches* Sage.

The Danish Ecological Council. (2018). *Cleaner shipping*. ().

Theo Notteboom. (2010). The impact of low sulphur fuel requirements in shipping on the competitiveness of roro shipping in northern europe.

Thomas Cho. (2020). *Singapore sells mostly low sulfur marine fuels in january*. (). Retrieved from http://info.opisnet.com/bunker-fuel-news

Topali, D., & Psaraftis, H. N. (2019). The enforcement of the global sulfur cap in maritime transport. *Maritime Business Review,*

Tran, T. A. (2017). Research of the scrubber systems to clean marine diesel engine exhaust gases on ships. *Journal of Marine Science: Research & Development, 7*(6)

Valentin, E. K. (2001). SWOT analysis from a resource-based view. *Journal of Marketing Theory and Practice, 9*(2), 54-69.

Varsha Saraogi. (2020, 8 JANUARY). Debunking: The problem of ships using open-loop scrubbers. Retrieved from https://www.ship-technology.com/features/open-loop-scubbers/

Vermeire, M. B. (2012). Everything you need to know about marine fuels. *Published by Chevron Global Marine Products,*

Vierth, I., Karlsson, R., & Mellin, A. (2015a). Effects of more stringent sulphur requirements for sea transports. *Transportation Research Procedia, 8*, 125-135.

Vierth, I., Karlsson, R., & Mellin, A. (2015b). *Effects of more stringent sulphur requirements for sea transports* doi://doi.org/10.1016/j.trpro.2015.06.048

Voipio, A. (1981). *The baltic sea* Elsevier.

Walker, T. R., Adebambo, O., Del Aguila Feijoo, Monica C., Elhaimer, E., Hossain, T., Edwards, S. J., . . . Zomorodi, S. (2019). In Sheppard C. (Ed.), *Chapter 27 -*

environmental effects of marine transportation Academic Press. doi://doi.org/10.1016/B978-0-12-805052-1.00030-9

Wiberg, J., & Fredriksson, G. (2018). Complying with the 2020 global sulphur limit.

Winnes, H., Fridell, E., & Moldanová, J. (2020). Effects of marine exhaust gas scrubbers on gas and particle emissions. *Journal of Marine Science and Engineering, 8*(4), 299.

Yanhong Zhao, Yang Xu, Lijiao Zhou, Xingmin Zhao, Yaning Wang. (2018). Analysis of the solution to the 0.5% of global sulfur limits of ships by 2020.

Zetterdahl, M., Moldanova, J., Pei, X., Pathak, R. K., & Demirdjian, B. (2016). Impact of the 0.1% fuel sulfur content limit in SECA on particle and gaseous emissions from marine vessels. *Atmospheric Environment, 145*, 338-345.

Zhu, M., Li, K. X., Lin, K., Shi, W., & Yang, J. (2020). How can shipowners comply with the 2020 global sulphur limit economically? *Transportation Research Part D: Transport and Environment, 79*, 102234.

Žižlavský, O. (2014). Net present value approach: Method for economic assessment of innovation projects. *Procedia-Social and Behavioral Sciences, 156*(26), 506-512.