



UNIVERSITAT  
POLITÈCNICA  
DE VALÈNCIA



ESCUELA TÉCNICA  
SUPERIOR INGENIEROS  
INDUSTRIALES VALENCIA

**TRABAJO FIN DE MATER EN DIRECCIÓN Y GESTIÓN DE  
PROYECTOS**

**STAKEHOLDER ANALYSIS AND  
DECISION-MAKING OF SHIPOWNERS  
FACING THE COMING IMPLEMENTATION  
OF IMO SULPHUR 2020 POLICY**

AUTHORESS: YIRONG LI

SUPERVISOR: PABLO ARAGONÉS BELTRÁN

**Academic year: 2018-19**

# CONTENTS

1	INTRODUCTION.....	9
2	OBJECTIVE.....	11
3	LITERATURE REVIEW.....	12
3.1	Stakeholder analysis.....	12
3.2	Method AHP.....	16
4	METHODOLOGY.....	19
5	CASE STUDY.....	22
5.1	INTRODUCTION OF THE CASE STUDY.....	22
5.1.1	SHIPPING TRANSPORTATION MARKET.....	23
5.1.2	GLOBAL BUNKER MARKET.....	25
5.1.3	POLICY CONTEXTS.....	26
5.1.4	PROJECT DESCRIPTION.....	28
5.2	STAKEHOLDER ANALYSIS.....	30
5.2.1	STAKEHOLDER IDENTIFICATION.....	30
5.2.2	STAKEHOLDER PRIORITIZATION.....	30
5.3	SELECTION OF THE EXPERTS.....	40
5.4	STRUCTURE OF THE PROBLEM.....	41
5.4.1	CRITERIA OF THE DECISION MAKING.....	41
5.4.2	ALTERNATIVES OF THE STUDY.....	43
5.4.3	ALTERNATIVES DISCARDED.....	48
5.5	PROCESS OF THE DECISION MAKING.....	49
5.5.1	METHOD AHP.....	50

5.6	SENSITIVITY ANALYSIS .....	58
5.7	RESULT ANALYSIS – DISCUSSION .....	63
6	CONCLUSIONS .....	64
7	BIBLIOGRAPHY .....	66
8	Annex. Judgement of experts .....	67

## **FIGURES**

Figure 1	Power/ Interest grid .....	20
Figure 2	AHP general structure .....	20
Figure 3	Age distribution of world merchant fleet by vessel type, 2018 .....	24
Figure 4	Map of Emission Control Areas .....	27
Figure 5	Power/Interest grid of stakeholders .....	31
Figure 6	Refinery flow sheet for residual fuel oil desulphurization .....	33
Figure 7	ISO 8217 2017 fuel standard for marine residual fuels.....	38
Figure 8	Decomposition of the problem into a hierarchy .....	41
Figure 9	Exhaust gas cleaning system basic components .....	44
Figure 10	Open loop exhaust gas cleaning system.....	45
Figure 11	Close loop exhaust gas cleaning system .....	46
Figure 12	Hybrid exhaust gas cleaning system open loop operation.....	47
Figure 13	Hybrid exhaust gas cleaning system close loop operation .....	47
Figure 14	Decomposition of the problem in program SuperDecision.....	49
Figure 15	Matrices of decision of Expert A.....	51
Figure 16	Matrices of decision of Expert B .....	51
Figure 17	Matrices of decision of Expert C .....	52
Figure 18	Matrices of decision of the group.....	52
Figure 19	Matrices of alternatives of Expert A .....	54
Figure 20	Matrices of alternatives of Expert B .....	55
Figure 21	Matrices of alternatives of Expert C .....	55
Figure 22	Matrices of alternatives of group .....	55
Figure 23	Priorities of alternatives of Expert A.....	56

Figure 24	Priorities of alternatives of Expert B.....	56
Figure 25	Priorities of alternatives of Expert C.....	56
Figure 26	Priorities of alternatives of group.....	57
Figure 27	Sensitivity analysis of primer level criteria .....	60
Figure 28	Sensitivity analysis of second level sub-criteria C31 and C41.....	62

## TABLES

Table 1	Weight allocation comparison.....	53
Table 2	Evaluation of alternatives.....	54
Table 3	Alternative priority comparison .....	57

## **ACKNOWLEDGEMENT**

I would first like to thank my thesis advisor Dr. Pablo Aragonés-Beltrán of the Departamento de Proyectos de Ingeniería at Universitat Politècnica de València. The door to Prof. Aragonés-Beltrán office was always open whenever I ran into a trouble spot or had a question about my research or writing. He consistently allowed this paper to be my own work, but steered me in the right the direction whenever he thought I needed it.

I would also like to thank the experts who were involved in the validation survey for this research project. Without their passionate participation and input, the validation survey could not have been successfully conducted.

Finally, I must express my very profound gratitude to my parents, my friends and my classmates of the master study for providing me with unfailing support and continuous encouragement throughout my years of study and through the process of researching and writing this thesis. This accomplishment would not have been possible without them. Thank you.

Yirong Li

## RESUMEN

El principal tipo de hidrocarburos usado como combustible en los buques es el fueloil pesado, derivado del residuo de la destilación del petróleo crudo. El petróleo crudo contiene azufre que, tras la combustión en el motor, es liberado en la atmósfera junto con el resto de emisiones del buque. Basándose en la política actual, a los buques se les permite consumir un búnker con un contenido de azufre por debajo de 3.5% m/m en todo el mundo siguiendo la norma ISO 8217: 2012, excepto en el Área de Control de Emisiones de América del Norte (AEC). Con el fin de reducir las emisiones de SOx de los barcos para que puedan mejorar la calidad del aire y proteger el medio ambiente, el 27 de octubre de 2016, la OMI decidió que el límite de azufre conforme al Anexo VI de MARPOL entraría en vigor el 1 de enero de 2020, lo que limita el contenido de azufre en El fuel oil usado a bordo se reducirá a 0,50% m/m. Con la influencia del mercado búnker debido a la próxima implementación, el propietario de los barcos debe tener su propio proyecto para realizar el análisis de las partes interesadas con el objetivo principal de ejecutar el proceso de toma de decisiones para sus barcos dentro de alternativas definidas y seguir el próximo procedimiento de transformación para asegurarse de que cumplan con la nueva política. El estudio de caso muestra en detalle cómo se realizó el análisis de las partes interesadas y cómo el proceso de toma de decisiones ayudó al propietario de los barcos a encontrar su mejor opción en tales circunstancias.

**Palabras Clave:** análisis de las partes interesadas, toma de decisión, AHP, petróleo marítimo, OMI Azufre 2020



## ABSTRACT

The main type of bunker oil for vessels is heavy oil. Basis the current policy, vessels are allowed to consume bunker with the Sulphur content below 3.5% m/m all over the world basis ISO 8217:2012 except of 4 North American Emission Control Area (ECA). Now with the new regulation that ask to reduce SO<sub>x</sub> emissions from ships so that can improve air quality and protect the environment, on October 27, 2016, IMO decided that the Sulphur Limit under MARPOL Annex VI would enter into force from January 1, 2020, which limits Sulphur content in fuel oil used on board to be reduced to 0.50% m/m. Under the influence to the bunker market due to the coming implementation, shipowner need to have their own project to do the stakeholder analysis with the main goal to run the decision-making process for their fleets within defined alternatives and follow the coming procedure in transformation to make sure they would be compliant regarding the new policy. The case study shows in details of how the stakeholder analysis was done and how the decision-making process helped shipowner to find their best option under such circumstance.

**Keywords:** Stakeholder analysis, decision-making, AHP, Marine bunker fuel, IMO sulphur 2020

# **1 INTRODUCTION**

Over 80 percent of world merchandise trade by volume and over 70 percent by value is carried by sea and handled by seaports worldwide. Maritime transportation is the most important and economic way of transportation in global trading with significant scale, which depends on millions of vessels sailing across oceans every day.

The main type of bunker oil for vessels is heavy oil. Basis the current policy, vessels are allowed to consume bunker with the Sulphur content below 3.5% m/m all over the world basis ISO 8217:2012 except of 4 North American Emission Control Area (ECA), which require ships to use bunker with Sulphur content below 0.10% m/m on and after 1 January 2015.

Although air pollution does not have direct cause and effect associated with vessels, it causes a cumulative effect on air quality problems. So considering above situation, IMO (International Maritime Organization) developed MARPOL (International Convention for the Prevention of Pollution from Ships) regulations, which is the main international convention covering prevention of pollution of the marine environment by ships from operational and accidental causes, to limit main air pollutants contained in ship exhaust gas, including Sulphur oxides (SO<sub>x</sub>) and nitrous oxides (NO<sub>x</sub>), and prohibits deliberate emissions of ozone depleting substances (ODS).

In order to reduce SO<sub>x</sub> emissions from ships so that can improve air quality and protect the environment, on October 27, 2016, IMO decided that the Sulphur Limit under MARPOL Annex VI would enter into force from January 1, 2020, which limits Sulphur content in fuel oil used on board to be reduced to 0.50% m/m. The implementation of the new policy will significantly reduce the amount of Sulphur oxides emanating from ships and should have major health and environmental benefits for the world, particularly for populations living close to ports and coasts.

With the releasing of the new regulation in details, global shipowners have to develop their own project to decide how they would act to meet the requirement. The project will include following stages: 1. Investigation of the bunker market and ship industry; 2. Decision-making with the consideration of company strategy; 3. Evaluation and contraction in ship transforming; 4. Transforming and maintenance; 5. Close of the project. So, this work would focus on the early stage of the project, that is the stakeholder analysis as part of the investigation and decision-making.

Due to the background of the project, the stakeholders would be made by parties from maritime transportation market and bunker industry from upstream to downstream, including shipowners, charterers, refinery and physical supplier, shipyard, national authorities and international organizations.

According to the recommendation and guideline provided by IMO, shipowners are mainly facing two options to make sure to be compliant of the new regulation. One is to install exhaust gas cleaning systems on board, which also is known as “scrubbers”. These scrubbers are designed to remove Sulphur oxides from the ship’s engine and boiler exhaust gases. The other option is waiting to use the new grade of cargo provided by physical supplier, which meet the requirement directly.

The study would use the methodology of stakeholder analysis to support the decision-making process on the role of shipowner by applying methodology of power/interest grid to identify and analysis those stakeholders and use AHP to find out which is the best option to be compliant with the coming regulation related with Sulphur content.

The work is structured as follows:

- Chapter 2 presents the objective of this work with general objective and sub-objective focusing on the stakeholder analysis and decision-making process of the shipowner under the project management environment facing the coming implementation of IMO sulphur 2020 regulation.
- Chapter 3 focuses on the literature review on both field of stakeholder analysis and decision-making process by analyze the previous works has been done and find the link between those works and the study would be done in this one.
- Chapter 4 develops the methodology would be used in case study of this work.
- Chapter 5 presents the adoption of stakeholder analysis by using the power/interest grid and decision-making approach with method AHP in selected case with details.
- Chapter 6 contains the main conclusion.

## **2 OBJECTIVE**

With the coming implementation in policy change known as the IMO Sulphur 2020, the limit for sulphur in fuel oil used on board has been set as 0.50% m/m from 1 January 2020, it becomes a common question in shipping industry especially in bunker market that how should shipowner act in this period to make sure all their vessel would be compliant facing the upgraded requirement from IMO.

In this work, under the environment of project management of shipowner company as promoter, the main focus would be concentrated on the early stage of the project, which is the decision-making part.

The overall objective of the present project is to make sure all its own vessels under would be compliant under the new regulation of sulphur limit since 1 January 2020.

In order to meet the overall project, there are following specific objectives:

- A. Study regarding to the change in policy and define the project
  - Well understanding on the new regulation related with the project
  - Establishment of project structure
  - Identify the stakeholders related in the project
  
- B. Make the decision for shipowner
  - Determination of the goal on the decision-making problem
  - Identification of criteria and sub-criteria
  - Identification of possible alternatives
  - Using the methodology applicable to get the better option

## **3 LITERATURE REVIEW**

In this part, papers related with stakeholder analysis and the Analytic Hierarchy Process would be reviewed and by using the ideas and conclusions mentioned to help the analysis and study in this work.

### **3.1 STAKEHOLDER ANALYSIS**

In this part, three papers focus on stakeholder analysis would be reviewed. They are working on the stakeholder analysis in construction projects from different point of view.

In most of the projects, the identification, analysis and engagement of stakeholders are the essential foundation for project management.

As the definition from PMBOK, stakeholder has been defined as “Every project will have stakeholders who are impacted by or can impact the project in a positive or negative way. While some stakeholders may have a limited ability to influence the project, others may have significant influence on the project and its expected outcomes. The ability of the project manager to correctly identify and manage these stakeholders in an appropriate manner can mean the difference between success and failure.” (Project Management Institute, Inc., 2013)

The project stakeholder management includes four major parts that is identify stakeholders, plan stakeholder management, manage stakeholder engagement and control stakeholder engagement. There are several models of stakeholder analysis has been mentioned in the book, and the power/interest grid is the most widely use one, that is to categorize stakeholders by defining their level of power and interest regarding to the outcome of the project.

On the paper of Stefan Olander and Anne Landin (Stefan Olander, 2005), authors put their attention on the stakeholder influence in construction projects. Due to the complexity of a construction project, multiple stakeholders with different interests were involved in different stage of the project. Affects brought by stakeholders would be in both positive and negative way during the implementation of the project. The study was structured by two case studies and use the power/interest matrix to analysis different influence of stakeholders showed in different stages of the project.

The first project is a housing project in Sweden consisting of 60 apartment, major stakeholders of this project includes the real estate developer, the Municipality, residents in the vicinity, the

national government, interest groups for the preservation of the cultural and historical image of the city and interest groups for senior citizens. By analyzing power/interest matrix in different stage of the project of phase one and two, the result shows that the position of stakeholders in the matrix is keeping changing due to their different interests got affected in different stage of the project. The conflicts among stakeholders caused time delay as the main consequence of the project. From the opinion of author, if the project management team took the neighboring residents into consideration at first, there might be chance to get a better performance of the project finally, as when looking back to those stages mentioned in the analysis, neighboring residents are those who got affected a lot by the construction project but didn't get enough explanation and information.

The second project is a railroad project in Sweden. It is a construction of a two-way railroad track through the town center. There are seven major stakeholders got identified in the project, including The National Railroad Administration, the Municipality, the railroad companies, the residents in the vicinity of the expanded railway, the National Government, the National Board of Housing and the Swedish Rescue Services. Authors looked at the process how they were managed during the stage of the feasibility and conceptual, the formal planning and the stage of appeals. By using the power/ interest matrix, the change of position of different stakeholders were shown clearly on figures. Due to the conflicting public opinion expressed by the residents in the vicinity, bad influence was brought to the project in society. The project was delayed around seven years as the main consequence.

In addition, in both of the case studies, the construction projects are under the influence of media, which cannot be defined as a stakeholder but an enormous effect of media had been shown in both projects. The interest conflict among stakeholders is not just a problem within the project, the stakeholder like residents would try to express their opinion by using the power of media and appeal for support from the society. It will be difficult to estimate the influence of the media in such projects and to control the potential risk accordingly. From the view of project management, the fundamental way to keep it under control is to act better in stakeholder management so that such situation could be avoid then.

As the conclusion got by authors, after looking on cases how stakeholders were managed during the project. it is essential to understand that the stakeholders influence in the project is not static. Their different concerns in different stage need to be paid attention to so that effective communication could be developed accordingly before making any decision and decrease the risk of conflict.

On the paper of Stefan Olander (Olander, 2007), the study is about the stakeholder impact analysis in construction project management. In this work, the definition of stakeholder has been looked, from the initial version of Freeman in 1984 to the one of Mitchell in 1997. The definition that adopted by PMI is basis on the idea of Freeman, that "project stakeholders are

individuals and organizations that are actively involved in the project or whose interests may be affected as a result of project execution or project completion.”

The attributes of stakeholders are analyzed in following paragraphs. And basis on their attributes, during the process of identification, analysis and engagement of stakeholders in a project, the main method is using the impact/probability matrix. As a further step of the matrix, the vested interest-impact index (Vill) developed by Bourne and Walker in 2005 is also been used as an indicator in this study.

There are three cases has been studied in this work to do a stakeholder analysis for construction project. The first one is a housing project for senior citizens consisting of 60 apartments, the main conflict caused by one of stakeholders, residents in the vicinity, that the construction would bring negative effect in the living condition of surrounding houses. The second is a civil engineering project consisting of the expansion of a single-track railway into twin track through densely populated areas, the conflict among stakeholders caused an around six-year non-value-adding time waste due to the no approval of municipality on the project. The third is another housing project consisting of about 1200 apartments. Unlike the other two projects, due to the strong political support from local government, the negative impact from local residents had been limited so that the project did not delay as much as the other two projects mentioned below.

By looking at the result of stakeholder analysis of above three projects, the author got the conclusion that stakeholder impact index can be a planning and an evaluation toll in stakeholder management and project management. The impact and influence of stakeholder are keep changing in different stage of the project, by using this indicator the management group can have a better prediction and set better plan when facing conflict raised by stakeholders.

On the paper of Stefan Olander and Anne Landin (Landin, 2008), the work is a comparative study of factors affecting the external stakeholder management process. In general, those external stakeholders have more chance to hold their interests against the developer of the project, which will lead to the conflict within the implementation of the project.

In this work, authors did a case study to compare the stakeholder management process in two development projects in Sweden: the City Tunnel project in Malmo and the expansion of the west coast line through the city of Lund. In the first project, a traditional quality measurement has been used in it. All stakeholder groups are included in a quality measurement system and the customer satisfaction measure system so that there was a team developed to be responsible for the communication with stakeholder and respond to any of their concerns in this project. But the other project, they used a totally different approach in stakeholder management. Not like the way in City Tunnel project, the project management team just keep the stakeholder management and communication with them in the minimum level, in most of time they just informed stakeholders about the decisions had been made. The lack of communication finally

caused the conflict with local residents and delayed the project in the end. There are also other differences between these two projects showed in this work, including in project organization, media relation etc.

As the conclusion of this work, it is found that the conflicts between external stakeholders and project managers is caused by different way of viewing of the problem so that the stakeholder analysis should trying to find out the possible compromise could be taken without affect the objective of the project. As the interests of different stakeholder are under a dynamic environment, it is always needed to keep smooth communication with major stakeholder group and avoid the conflict might be raised.

The identification, analysis and engagement of stakeholder is the foundation of the project management. As mentioned in above papers, the projects of construction are really complicated that involves multiple stakeholders both internal and external. In these projects, those stakeholders have different interests and sometimes those interests are opposing with each other, which might cause conflict in any stage of the project.

Not like construction industry with rich experience in project management, in bunker industry it is more usual to put the such decision-making problem within project environment into business negotiation area so that their mainly attention would be put on the situation of themselves instead of doing the complete analysis to include all parties who might bring both positive and negative affects to the project.

Comparing with the normal practice of the industry, the adoption of stakeholder analysis in such project is trying to show the advantage of using such method in analyzing and helping to be more prepared for the following decision-making process by clearer understanding of the interests of different stakeholders involved in this project.

The power/ interest grid mentioned in PMBOK is well used in many papers, which has been proved as efficient and useful way to clarify the position of different stakeholder. And in this work, it has been considered as the best tool to analyze those stakeholders.

By doing a complete stakeholder analysis to evaluate and estimate their interests showed in different stage of the project, that can help the developer to prepare in advance on the possible trade-off to compromise and on the communication plan to have a smooth exchanging of idea so that the potential conflict can be mostly avoid accordingly.

Considering the situation and environment of the problem to be studied on this work, the problem is totally different from the section of construction. The problem from bunker industry is also quite complicated with a lot of stakeholders involved. But for this specific one, from the view of stakeholder analysis, it is much simpler to analyze comparing with the cases mentioned in previous papers.



The problem would be studied on this work is a project with main goal to decide the best option under the environment of implementation of a new regulation so that there is no much conflict could be raised as the interests of different stakeholders are not conflicting. All the stakeholders got identified in the study are all in the same direction with developer in this project, is to let vessels be compliant under the new regulation no matter what kind of action to be taken finally and which of those stakeholders would be engaged into the project. Those interests a comparingly to be static during the entire project life without much change.

When looking at those stakeholder groups of this project, most of them are the external stakeholders, like national authorities, refinery, shipyard etc. Each stakeholder has their own attitude or preference towards those alternatives due to their interests and power showed during the analysis of stakeholders. At the stand of developer of the project, to have a good prediction in stakeholders' preference and keep a smooth communication within the stakeholder community would support the performance of the project to maximize the benefit of the shipowner during the total process.

## 3.2 METHOD AHP

In previous studies of decision-making area, there are several methods to structure a decision problem. Among all these methods, Analytic Hierarchy Process is one of the very effective approach to establish a hierarchic decomposition of the problem in order to support the decision-making process.

Thomas L. Saaty (Saaty, How to make a decision: The Analytic Hierarchy Process, 1990) gave an complete introduction to the Analytic Hierarchy Process, that is developed based on the knowledge of mathematics, philosophy and psychology. As the finding that is also mentioned in this paper by the psychologist George Miller shows out that in general, people could only deal with information involving simultaneously only a few facts, seven plus or minus two. But in real world, decision making is affected by countless issues and attributes, that makes the decision-making process to be extremely complicated. With the using of AHP, that shows a clear overall view of the problem with intrinsic relationship in the situation and also helps decision makers to determine the ranking of importance among those issues or attributes by comparing homogeneous elements accurately. When looking on how to use AHP to structure a decision problem generally, it defines those most important parts when constructing hierarchies that are the problem itself, the environment, the issues or attributes leading to solution and the stakeholders related.

AHP is using the hierarchic structure to deconstruct the decision-making problem into multiple levels, the top level is the overall goal of the problem, then is the level of criteria and sub-criteria

if needed, and the bottom level is the alternatives. When the hierarchic structure has been well defined by the decision maker, it moves to the step that is to determine the relative importance of different attributes or criteria with respect to the goal. By this process, we can get the pairwise comparison matrix regarding to criteria. Basis on the number of the matrix, after the normalization, the weight allocation within criteria can be get. And with further calculation, the consistency index and consistency ratio can also get as well. Then the result of pairwise comparison between alternatives can also lead to the matrix of alternatives regarding to each criterion. By doing the calculation of normalization, the priority of alternatives will be clear as well. After combined all these results together, the decision maker would be able to get a clear idea on the best option of the problem.

In the paper, author showed us two examples referring to two types of measurement, the relative one with choosing the best house to buy and the absolute one with employee evaluation.

On the other paper of Thomas L. Saaty (Saaty, Rank from comparisons and from ratings in the analytic hierarchy/network processes, 2004), further than the conceptual introduction of Analytic Hierarchy Process the author tried to explain the rank from comparisons and from ratings in the AHP/ANP. The use of rating in AHP is the using of absolute judgement when doing comparison among alternatives.

In the common practice of bunker industry, most of the decision-making problems are more likely to be decided by business negotiation and balance. It is a meaningful action to adopt the multi-criteria decision-making method into such problem in this industry.

As showed in the part of stakeholder analysis, the problem that will be study in this work is quite complicated with total over ten stakeholders involved. And a lot of criteria from different dimension of the problem can found as important to be assessed during the decision-making process. Each one of the decision maker team will have different emphasis and focus which will make the decision-making to be more complicated.

As mentioned in those papers, the reason why decides to adopt method AHP in this problem is that by using the deconstruct approach, the hierarchic structure can be established typically into four levels, they are overall goal, criteria, sub-criteria and alternatives. It can show the problem to everyone in the decision-making team in a much clearer and simpler way.

The decision-making problem is so complicated in realistic world that will be affect by enormous facts in environment surroundings. It is important to find a clear and easy-understanding way to help the decision-maker to get the better solution by a method simple to be adopted and well supported in theoretical side. Considering all these above, method AHP can be found as the best option for this case.

The biggest advantage of adoption of the method AHP, is that the method let those criteria or sub-criteria intangible to get the possibility by using the pairwise comparison supported by

mathematical calculation and finally get the weight allocation among criteria and sub-criteria in detailed numbers. This kind of approach can help decision maker to be much clearer about their idea during the pairwise comparison.

In the process of the comparison between alternatives, since there are only two alternatives in this decision-making problem, there is no use to adopt ranking into this process. The relative judgement is better in this one. The absolute judgement can be used in other problem with more alternatives and hard to do the pairwise comparison directly.

The use of method AHP in this study will be a good starting for decision- making project in this industry, which is able to support more decision maker in multi-criteria decision-making problem of this sector.

## 4 METHODOLOGY

A case study is conducted in this work, basis on the project of a Chinese medium-small shipowner company. The main goal of this project is to decide the best option of the shipowner to ensure that their fleet would be compliant under the new regulation in bunker fuel sulphur content which published by IMO and would enter into force on 1 January 2020. The main reason for selecting this project is because by general practice in bunker industry, such decision-making problem normally would be left in business balance and negotiation without using any methodology to get a conclusion. By doing this study, it has been chosen to show how the decision-making process would be done under the project environment when adopting those tools and methods from project management.

The main source of information in this case study was interviews with various stakeholders in the project, including project owners, refinery, physical supplier, shipyard etc. The interview was conducted as semi-open interview. The main topic, question and structure of the interview has been prepared before starting. In addition to the interviews, official reports and guideline relating with the problem published by international organization have also been examined in order to get the official opinion and suggestion on structure of the interview.

In stakeholder analysis field, there are multiple method can be used to analyze. Considering the character of the problem, the power/interest grid would be adopted here to determine the level of power and interest of those stakeholders identified in this problem. The structure of the matrix is shown as below figure:

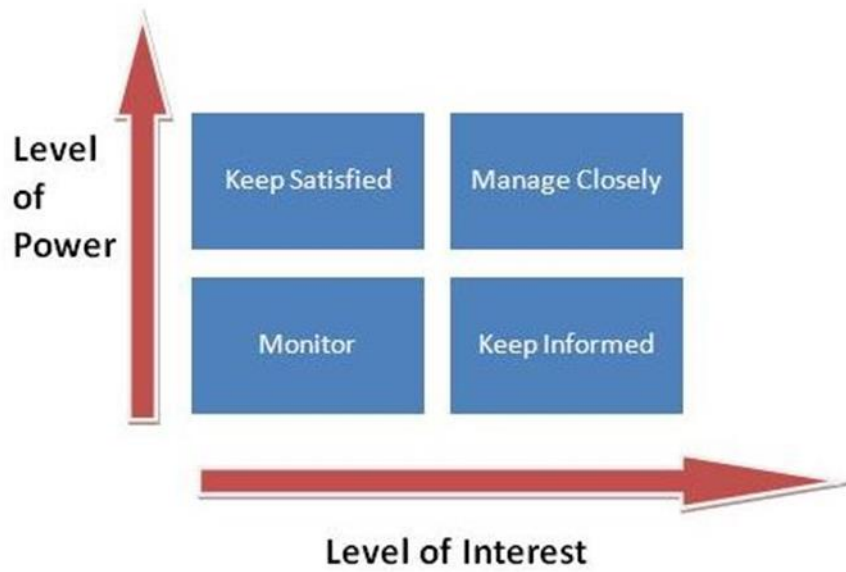


Figure 1 Power/ Interest grid

In decision-making part, within all methods existing, the method Analytic Hierarchy Process would be used in this case study. The method AHP is working in the way of deconstruction, that basis on the comments and information gathered from those stakeholders through interview, the decision-making problem would be transformed into the hierarchic structure showed on below Figure 2 with basically three levels, including overall objective, criteria and alternatives. By following the methodology of AHP to get the best alternative decided finally.

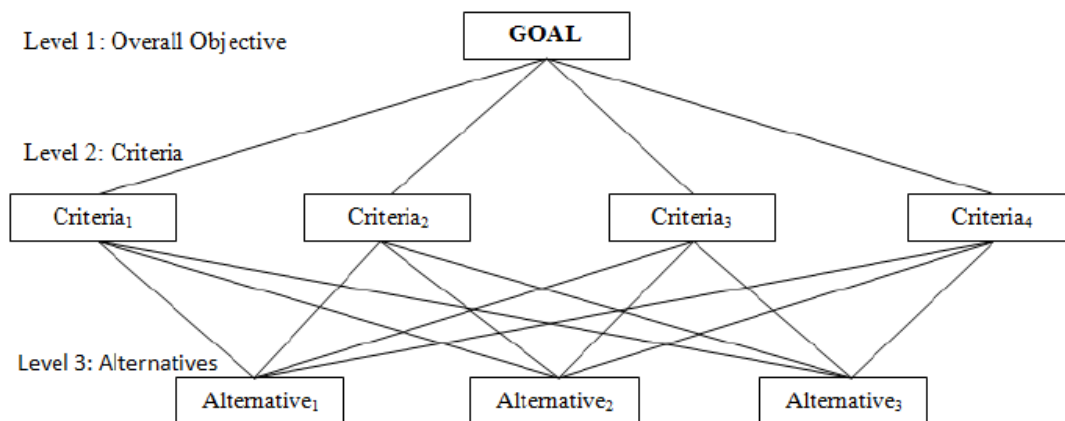


Figure 2 AHP general structure

The process of method AHP will be supported by the program Superdecision in weight allocation calculation, priority calculation and sensitivity analysis of the problem.

## **5 CASE STUDY**

### **5.1 INTRODUCTION OF THE CASE STUDY**

Under the significant influence of globalization in past several decades, people and communities are more and more connected with each other. At the same time, the trend of interaction and integration among people, companies and governments are continuing shaping the world not only affecting on everyone's daily life but also in the global economy development.

Globalization brings infinite chances. In economic side, globalization shows as the exchange of goods and services within all the world. In many countries and territories, it comes with the rapid growth in economy and the strong push of development in quick speed. During this process, the scale of trading volume keeps increasing rapidly and the global supply chain and distribution system has been established successfully. Under this impact, the cooperation between countries and companies are much closer than ever before. With the development of international organization who is for the open trade in world market, such as World Trade Organization, and more and more bilateral or multilateral trading agreements are signed, the demand of transportation of goods and services is keep going up.

Nowadays, there are four main transportation method in market. It includes air transportation, rail transportation, road transportation and ocean transportation. With the huge advantage in costs and time, over 80 per cent of world merchandise trade by volume and over 70 per cent by value is carried by sea and handled by seaports worldwide. With these numbers, it is clear that ocean transportation plays a very important role in world economy development.

The global shipping market is made by three parts, international shipping, domestic navigation and fishing. In this work, we will focus on the international shipping part. In this sector, there are several types of vessels including Vehicle, Ro-Ro, Refrigerated bulk, Other liquids tankers, Oil tanker, Liquefied gas tanker, General cargo, Ferry-RoPax, Ferry-pax only, Cruise, Container, Chemical tanker and Bulk carrier. All the operation of these international ships will be affected by the implementation of the new regulation that for ships operating outside of ECA, the limit for sulphur in fuel oil used on board has been set as 0.50% m/m (mass by mass) from 1 January 2020.

### 5.1.1 SHIPPING TRANSPORTATION MARKET

Basis on the numbers from United Nations Conference on Trade and Development (UNCTAD) published on Review of Maritime Transportation 2018 (United Nations Conference on Trade and Development, 2018), with the support from world economic recovery and the improvement in global goods trading, the total volume of world seaborne trade was estimated at 10.7 billion tons with the expanding rate at 4 per cent, that is the fastest growth in five years. In 2017, containerized trade increased by 6.4 per cent, meanwhile dry bulk commodities trade increased by 4.0 per cent. Crude oil shipments rose by 2.4 per cent and refined petroleum products and gas increased by an estimated 3.9 per cent.

Global economic expansion is the main driver of world shipping demand. Seaborne trading volume is an indicator to show the growth in global investment, manufacturing activity and goods trade.

Together with the influence of globalization and the establishment of world supply chain distribution network, the demand of transportation in raw materials, components and final goods is also increasing. It also been showed in the growth of shipping volume as the international merchandise trade volume increased by 4.7 per cent in 2017.

From vessel side, till 1 January 2018, the world commercial fleet consisted of 94,171 vessels, with a combined tonnage of 1.92 billion dwt, including following vessel types:

- Dry bulk carriers
- Oil tankers
- Container ships
- General cargo ships
- Others

Dry bulk carriers that carry iron ore, coal, grain and similar cargo has the largest share of the world fleet in dead-weight tonnage and the largest share of total cargo-carrying capacity. They are followed by oil tankers that carry crude oil and its products. Container ships carry over half of total seaborne trade in value due to her characteristic of high speed and efficiency. General cargo ships are under the long-term trend of decreasing due to the competition with container ships. Others includes Gas carriers, Chemical tankers, Offshore vessels, Ferries and passengers ships etc.

Normally vessels are able to serve around 25 to 30 years depends on different type. In following Figure 3 , the average age of current vessels under serving is around 20 years, except for dry bulk carriers and container ships, that are much younger than others. It can be considered as



the result of increasing volume in commodities trades, improving technique in modern shipbuilding industry and rising need of larger vessels in market.

Economic grouping and vessel type		Years					Average age		Percentage change
		0-4	5-9	10-14	15-19	20+	2018	2017	2017-2018
<b>World</b>									
Oil tankers	Percentage of total ships	14.97	21.89	17.04	8.46	37.64	19.06	18.73	0.32
	Percentage of dead-weight tonnage	21.70	33.86	24.60	14.30	5.55	9.99	9.90	0.09
	Average vessel size (dwt)	78 543	84 016	78 643	93 525	8 303			
Dry bulk carriers	Percentage of total ships	27.83	41.32	12.90	8.72	9.24	9.10	8.77	0.33
	Percentage of dead-weight tonnage	29.99	43.04	12.93	7.22	6.82	8.28	7.93	0.34
	Average vessel size (dwt)	79 281	76 618	73 750	60 907	54 304			
General cargo ships	Percentage of total ships	6.09	16.26	11.88	7.03	58.75	25.82	25.10	0.72
	Percentage of dead-weight tonnage	11.59	26.27	14.50	9.84	37.80	18.66	18.17	0.49
	Average vessel size (dwt)	8 060	6 641	5 400	6 392	2 656			
Container ships	Percentage of total ships	17.40	26.67	26.81	14.74	14.37	11.94	11.53	0.41
	Percentage of dead-weight tonnage	29.55	30.98	23.71	10.32	5.45	9.04	8.71	0.32
	Average vessel size (dwt)	83 122	56 847	43 284	34 246	18 568			
Other	Percentage of total ships	13.07	19.42	11.62	8.48	47.41	22.86	22.32	0.54
	Percentage of dead-weight tonnage	20.70	24.04	16.10	10.78	28.39	15.45	15.34	0.11
	Average vessel size (dwt)	9 253	7 507	8 440	7 741	4 156			
All ships	Percentage of total ships	13.75	22.01	13.25	8.54	42.46	20.83	20.34	0.50
	Percentage of dead-weight tonnage	25.74	35.98	18.16	10.20	9.92	10.09	9.85	0.24
	Average vessel size (dwt)	43 360	38 186	32 634	29 049	6 150			

Figure 3 Age distribution of world merchant fleet by vessel type, 2018

SOURCE: UNCTAD SECRETARIAT CALCULATION, BASED ON DATA FROM CLARKSONS RESEARCH

The top five ship-owning countries covers 49.6 per cent of the world fleet in dead-weight tonnage, that are Greece, Japan, China, Germany and Singapore. Shipowners from Greece has the biggest market share in oil tankers, as well as dry bulk carriers, which is followed by Japan and China. In container ships market, shipowners from Germany hold the largest market share.

### 5.1.2 GLOBAL BUNKER MARKET

To give the overall picture of the entire bunker market, it is important to be clear in some basic concept of the bunker industry as the first step.

Following the definition given by the Third IMO Greenhouse Gas Study 2014 (International Maritime Organization, 2015), International shipping means shipping between ports of different countries, as opposed to domestic shipping. International shipping excludes military and fishing vessels. By this definition, the same ship may frequently be engaged in both international and domestic shipping operations. This is consistent with the IPCC 2006 Guidelines (Second IMO GHG Study 2009). And International marine bunker fuel is “[...] fuel quantities delivered to ships of all flags that are engaged in international navigation. The international navigation may take place at sea, on inland lakes and waterways, and in coastal waters. Consumption by ships engaged in domestic navigation is excluded. The domestic/ international split is determined on the basis of port of departure and port of arrival, and not by the flag or nationality of the ship. Consumption by fishing vessels and by military forces is also excluded and included in residential, services and agriculture” (IEA website: <http://www.iea.org/aboutus/glossary/i/>).

As the definition by the International Convention for the Prevention of Pollution from Ships (MARPOL), Fuel oil means any fuel delivered to and intended for combustion purposes for propulsion or operation on board a ship, including distillate and residual fuels. In current bunker market, marine fuel can be distinguished as following:

- Petroleum fuels with a Sulphur content of 0.10% m/m or less.
- Petroleum fuels with a Sulphur content of more than 0.10% m/m but equal to or less than 0.50% m/m.
- Petroleum fuels with a Sulphur content of more than 0.50% m/m but equal to or less than 3.50% m/m.
- Liquefied Natural Gas, LNG
- Methanol
- Biofuels
- Liquid Propane Gas, LPG
- Dimethyl Ether, DME

Among all these above, LNG, Methanol, Biofuels, LPG and DME can also be called as alternative fuels. Even LNG is the one has the biggest market share within them, generally used simply on LNG carriers, still cannot compare with the market share of petroleum fuels. The use of them plays a negligible role in the entire market.

Following the mostly adopted fuel standard in market, ISO 8217 2010, published by International Organization for Standardization (ISO), marine fuel can be divided into marine distillate fuels and marine residual fuels. The blends of distillates and residuals frequently used in practice are described as marine diesel oil (MDO) or intermediate fuel oils (IFO).

In marine distillate fuels, DMA is mostly used in market that is pure distillate petroleum product, also normally called as Marine Gasoil. It is used in smaller medium to high speed auxiliary units or auxiliary engines of a ship. They can be further grouped following different limit of sulphur content, such as MGO, LSMGO (with low Sulphur content less than 1.0%), ULSMGO (with low Sulphur content less than 0.1%).

In marine residual fuels, RMG and RMK are mostly used. During the distillation process of crude oil, the remaining residue that does not pass into gas phase is referred as residual fuel or heavy fuel oil. They can be further categorized by viscosity to be known as RMG 380 or RMK 500 etc. They can also be categorized by Sulphur content, such as FO, LSFO (with low Sulphur content less than 1.0%), ULSFO (with low Sulphur content less than 0.1%).

### 5.1.3 POLICY CONTEXTS

As the first international body devoted exclusively to maritime matters, International Maritime Organization (IMO) was adopted in 1948. Firstly, it was just established due to the consideration of maritime safety issue. Then during the development of this organization, more important issues attracted attention such as the threat of marine pollution from ships, especially those caused by oil tankers. As can be found in the slogan of IMO, the main objectives of this organization are safe, secure and efficient shipping on ocean oceans.

Under the organization structure of IMO, there is a specific committee – The Marine Environment Protection Committee (MEPC), that was set in November 1973. MEPC is responsible for the co-ordination within IMO to deal with issues that related with prevention and control of pollution to the environment from ships.

#### *5.1.3.1 MARPOL - THE INTERNATIONAL CONVENTION FOR THE PREVENTION OF POLLUTION FROM SHIPS*

The most important document in prevention of pollution in shipping industry is MARPOL- The International Convention for the Prevention of Pollution from Ships. It focuses on the prevention of pollution to the marine environment by ships from both operational or accidental side.

The MARPOL Convention was adopted on 2 November 1973 at IMO. Also, there are several protocols related got passed by IMO in the following years. In 1997, a Protocol was adopted to

amend the Convention and a new Annex VI, which focuses on the Prevention of Air Pollution from Ships, was added which entered into force on 19 May 2005.

The Convention includes regulations with the goal at preventing and minimizing pollution from ships, no matter it is caused by accident or is from routine operations. The latest version now includes six technical Annexes, which generally covered all areas in prevention of pollution.

Annex I Regulations for the Prevention of Pollution by Oil

Annex II Regulations for the Control of Pollution by Noxious Liquid Substances in Bulk

Annex III Prevention of Pollution by Harmful Substances Carried by Sea in Packaged Form

Annex IV Prevention of Pollution by Sewage from Ships

Annex V Prevention of Pollution by Garbage from Ships

Annex VI Prevention of Air Pollution from Ships

In Annex VI, those requirements to regulate the air pollution is introduced, which includes the emission of ozone-depleting substances, Nitrogen Oxides (NO<sub>x</sub>), Sulphur Oxides (SO<sub>x</sub>), Volatile Organic Compounds (VOCs) and shipboard incineration. It also establishes requirements for reception facilities for wastes from exhaust gas cleaning systems, incinerators, fuel oil quality, for off-shore platforms and drilling rigs and for the establishment of SO<sub>x</sub> Emission Control Areas (SECAs). Within this chapter, the Regulation 14 is the one for Sulphur Oxides (SO<sub>x</sub>) and Particulate Matter.



Figure 4 Map of Emission Control Areas

SOURCE: [HTTPS://WWW.SHIPOWNERSCLUB.COM/LOUISE-HALL-SULPHUR-REQUIREMENTS-IMO-EMISSION-CONTROL-AREAS/](https://www.shipownersclub.com/LOUISE-HALL-SULPHUR-REQUIREMENTS-IMO-EMISSION-CONTROL-AREAS/)

The regulation defined Sulphur Emission Control Areas, presented in Figure 4, that includes following areas:

The Baltic Sea area

The North Sea area

The North American area

The Unites States Caribbean Sea area

As the general regulation part, since the adoption in 1997, MARPOL Annex VI set a 4.50% m/m as the limit of sulphur content of marine fuel. Then in 2008, with release of MEPC 58, the limit of Sulphur content has been reduced to 3.5% m/m from 2012 and to 0.50% m/m from 2020 onwards (within ECA area other limits will be applied).

For mentioned ECA areas above, the original limit of sulphur content of marine fuel was set as 1.50% m/m. Then the limit was adjusted to be max 1.00% m/m since Q3 of 2010 and max 0.10% m/m from 2015 onwards.

According to the latest information released by IMO, the document MEPC 70 sent in October 2016, for ships operating outside of ECA, the limit for sulphur in fuel oil used on board has been set as 0.50% m/m from 1 January 2020. It is based on the revised Annex VI of MARPOL adopted in October 2008 and entered into force on 1 July 2010.

Since the new regulation is known in market, there are always voice hope to delay the implementation, but it has been confirmed by IMO to be impossible. As the date is set in MARPOL treaty, if anyone want to reset the date of implementation it can only be changed by an amendment of MARPOL Annex VI and also get it adopted by MEPC. And this process needs at least six months before adoption and then enter into force at least sixteen months after adoption. Even continuous voice in market from shipowners hope to delay the implementation, it is too late now to amend the date and do any revise of the date to enter into force before 1 January 2020.

#### 5.1.4 PROJECT DESCRIPTION

With coming of the new regulation into implementation, it is necessary for shipowner to well understand the requirement of IMO and set a strategy for all his fleet to make sure the smooth and safe operation of this company after 1 January 2020. It is essential for shipowner to set its own company strategy and finish his action accordingly before the new regulation entering into force that to make sure all fleets would be compliant to the limit which set by IMO.

The project is of a medium-small size shipowner company mainly focus on dry bulk carriers and general cargo ships, which need to set their company short term plan and put it into action for those vessels under operation to make sure they would be compliant in bunker consuming under the new regulation.

Within this project, shipowner need to do the research and investigation about the bunker market and future policy trend, also evaluate the company own situation. The main goal of the project is to decide the best option they should take within the project by going through the decision-making process so that they can go on in the following stages in contraction and transformation. Through all these efforts during the project, shipowner would be sure that their fleets are compliant to the new regulation and the project will be able to profitable finally.

The project includes following stages and activities:

**A. Investigation of bunker market and evaluation of the company situation**

- Study of the new regulation
- Assessment of supply and demand prediction in bunker market
- Evaluation of company own fleets

**B. Decision making**

- Identification, analysis and engagement of stakeholder
- Decision-making process

**C. Evaluation of supplier and contraction**

- Selection and evaluation of supplier
- Contraction

**D. Transforming and maintenance**

- Transforming
- Technical check and acceptance of vessel

**E. Close of the project**

- Put vessel into shipping market
- Close

This work will focus on the decision-making stage of the project, including the stakeholder identification, analysis and engagement, together with the decision-making process by using the approach of Analytic Hierarchy Process.

## 5.2 STAKEHOLDER ANALYSIS

When the project has been well-defined, it is important to identify those stakeholders who are related with the project during the entire project life circle. Well identification of the stakeholders can help the promoter to have better management in following stage of the project and to plan a more effective plan in risk management accordingly.

### 5.2.1 STAKEHOLDER IDENTIFICATION

Considering the objective and the environment surrounding of the project, there are following stakeholders related with the project:

- A. Shipowner
- B. Charterer
- C. Refinery
- D. Physical supplier
- E. Maritime Safety Authority
- F. Customs
- G. Shipyard
- H. EGCSs maker
- I. International Maritime Organization
- J. International Organization of Standardization
- K. Environmental group

### 5.2.2 STAKEHOLDER PRIORITIZATION

After the identification of the stakeholder, the method Power/ Interest grid will be used to analyze them accordingly so that can help the following step of decision-making. As shown in following figure, those stakeholders have been put into the according position in it.

There are four grids in Power/ Interest analysis, Manage closely, Keep informed, Keep Satisfied and Monitor.

- Manage closely indicates to the stakeholder with high power and highly interests, that the promoter needs to make the greatest efforts to satisfy them.

- Keep informed is the category for those with low power but high interests so that they need adequately inform from the promoter to ensure that no big issue would be raised. Stakeholder in this category would be able to provide more details of the project.
- Keep satisfied includes those with high power but low interest. Promoter should keep them satisfied with sufficient efforts and information but not too much.
- Monitor is for those with both low power and low interests so that no need to give too much information.

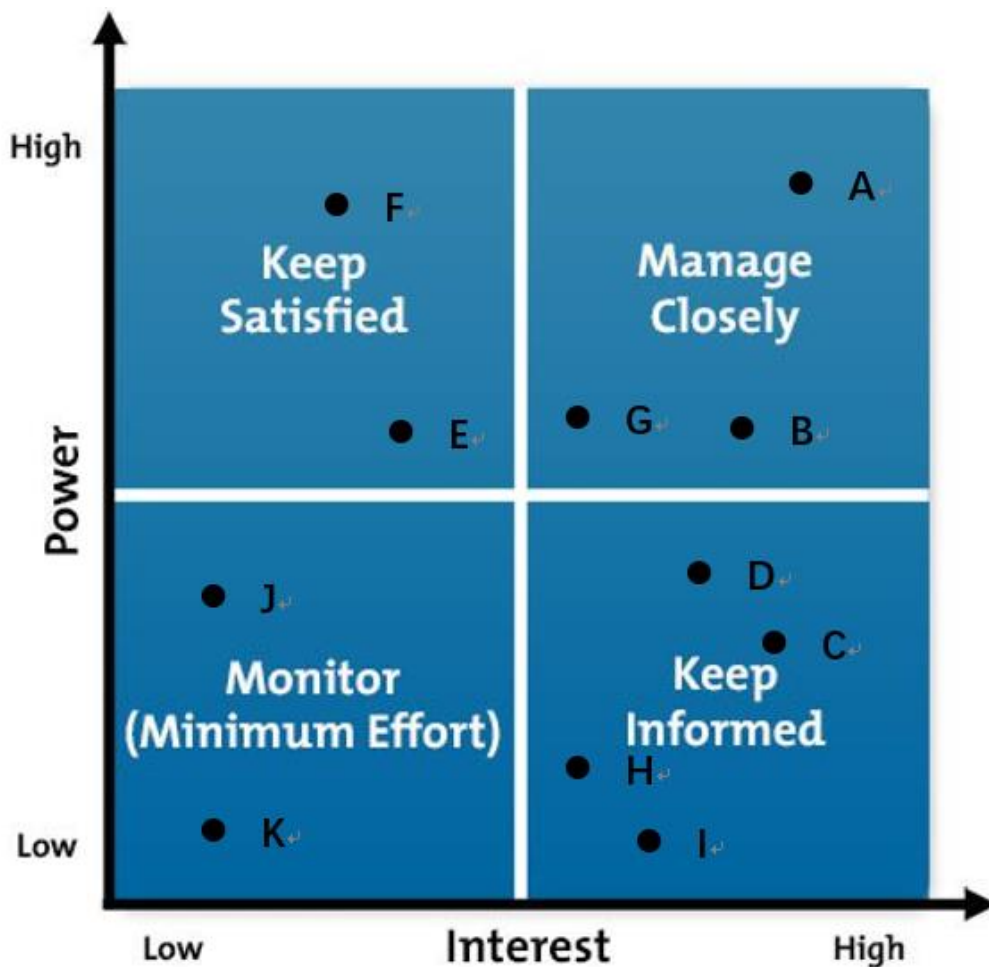


Figure 5 Power/Interest grid of stakeholders

#### A. Shipowner – Manage Closely

By talking with shipowner through the interview, and sharing their opinion regarding this project, they are the one who has both high power and high interest in this project. As the promoter of the project, the objective of the project is to select the best option for the company and archive the best performance of the project.



They explained that the project is part of the short-term strategy of the company, which related with quite number of investments recently and also would influence the financial performance of the company in following years. As it is a medium-small size shipowner company mainly focus on dry bulk carriers and general cargo ship, the action taken during the project will affect their rentability of the company in the coming years. So, they are highly interest-related in the project.

At the same time, they have the definite power in whatever decision and action to be taken during the entire project life circle, no matter on the early stage of decision-making or the coming process of contraction and transformation.

### **B. Charterer – Manage Closely**

All the fleets of shipowner, if they are not left on own operation then would be put into chartering market so that charterer will be responsible for the operation issue including bunker arrangement accordingly to the statement of charter party.

After communicating with the staff of shipowner in chartering department, over half of their vessels are in the chartering market so that the attitude from charterer, regarding to this case, has a lot influence related with decision and action of decision maker. From this side of view, charterer as a stakeholder in this project has high interest related of the case, since they will be responsible as the future bunker bill payer depends on the charter party agreement.

In chartering market, not most of charterers have showed their general opinion like Hudson Shipping Lines that they would refuse to charter any vessel with EGCSs installed after the implementation of the IMO Sulphur 2020 regulation. But the preference of charterer between different options can be treated as their power to influence the business environment of the project.

So, with the concern of all above facts, charterer has been put at the category of Manage Closely in the grid. Even they are also in this category, but comparing the power with shipowner, charterer has been put in lower position at the figure.

### **C. Refinery – Keep Informed**

The predicted supply from refinery is a very essential part in the research and investigation of the project, as it is the foundational information that to support the running of the project. Basis on the news already in market, some of big global refinery company including BP, ExxonMobil, Sinopec and others have announced that they will provide compliant product to bunker fuel market in order to meet the demand of the market regarding to the new regulation that would be enter into force soon.

According to the information and prediction released by IMO, the global refinery would be able to supply sufficient compliant low-sulphur fuel oil after the implementation of the new regulation in theory.

Through the comments get from staff of refinery, to provide compliant product in market would need them to add another procedure during their process which is called as desulfurization, which is related to the investment of equipment in refinery side. The general process could be found in following flowsheet:

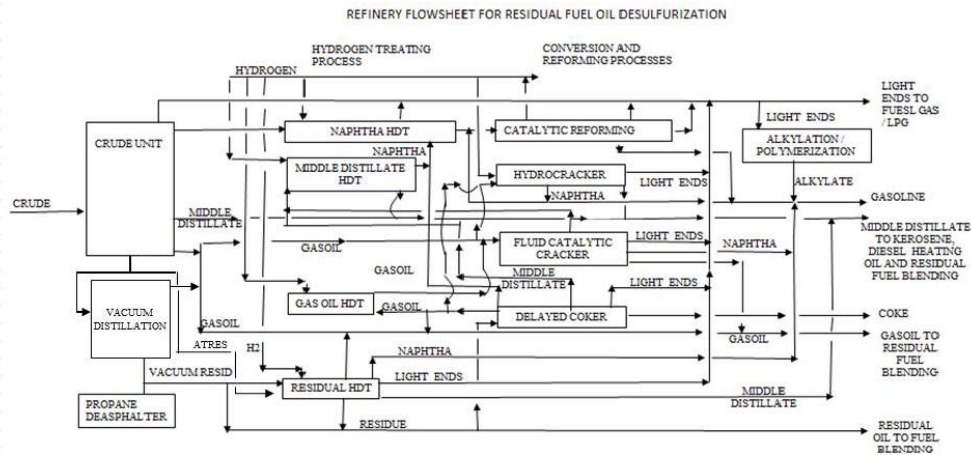


Figure 6 Refinery flow sheet for residual fuel oil desulfurization

From the other side, even refineries can provide sufficient supply on the compliant product, it still hard for them to estimate the scale of this new market. From the feedback of the shipping market, most refinery will take the strategy to provide both ordinary fuel oil and the compliant low-sulphur fuel oil. After the implementation of the new regulation, refinery will adjust their production plan with the changes shown in demanding market accordingly. For example, in China market, Sinopec has announced that they are well prepared in refinery side in desulfurization procedure to produce compliant fuel oil. By looking at the information on market, on long-term strategy, refinery might select to provide compliant fuel oil as the major part in production and just leave the minimum ability in ordinary fuel oil production to meet the requirement form vessels with EGCSs installed. At the same time, it is also known in market that there is no exact plan on continuous quantity to be produced for the market as the compliant fuel oil is not the most profitable product to the refinery, which means that from the economic consideration, as per the consideration get from refinery side through communication, they would prefer to fabricate product with higher value instead of focusing on the fuel oil market.

By the information from market and those comments get from refinery directly, it can be found that in this project, the refinery is the one that has high interest but with low power so they are left in the field of Keep informed.

#### **D. Physical supplier – Keep Informed**

Physical supplier is the bridge between refinery and end customer in bunker market, that they buy the product from refinery and sell to vessel who would be responsible for the entire middle procedure in between, including the cargo storage, paper work related, distribution network arrangement, bunker barge arrangement and so on.

Under influence of the strategy of refinery side, physical supplier mentioned during communication that they also need to establish their supplying network for both ordinary and compliant fuel oil to meet the need of vessels have different strategy that use EGCSs or use compliant fuel oil directly. In this circumstance, from the economic side, they will increase the extra demand in storage capacity and barge availability accordingly, which would lead to increase in their company cost area.

By looking at the situation in China, physical supplier explained that due to the limited quantity of compliant fuel oil is provided by refinery, usually the berth they use to load the cargo is only accessible for medium range barge, which increase the transportation cost for physical supplier in purchasing from refinery. Usually the medium range barge is only 35,000-55,000 DWT that is much smaller than the Aframax with 80,000-120,000 DWT, which is usually used in transportation of ordinary fuel oil now. All of them would be another additional part in company cost and affect the cash-flow of the physical supplier.

In the business side, physical supplier commented that on the current stage it is difficult to estimate the price gap between ordinary and low-sulphur fuel oil. The market has totally different prediction from different point of view. There is some voice in market that price difference would be higher than estimated due to the insufficient supply at the beginning of 2020 and when could the price gap been narrowed would be hard to get a conclusion according to the information and feedback from market now. With the concern of all these facts, all parties are waiting for the exact situation after the implementation cautiously so that to decide their further action in general and individual company level.

Physical supplier is the actual counterparty with shipowner or charterer in bunker purchasing that makes they have stronger power than refinery. Both of them are in the category of Keep informed but the physical supplier is in the higher position than refinery in the grid.

#### **E. Maritime Safety Authority – Keep Satisfied**

As part of the national authority, basis on the guideline issued by IMO, Maritime Safety Authority is the actual entity who has the power to check and control vessels on how they act by checking the document on board to record their daily operation and using other technology.

There are already some authorities like Maritime and Port Authority of Singapore has announces ban on vessel with the use of open loop scrubber to discharge scrubber wash water in port. The authorities have the power to establish local regulation on the limitation of operation considering the local policy concern. The protection of the maritime environment and anti-pollution is one of the main goals for all local authorities.

With the coming of implementation of the IMO sulphur 2020 regulation, local authorities need to establish their local practice working procedure accordingly to clear how vessels would be examined when calling the port under their control. As per the communication with Chinese Maritime Safety Authority, they will soon release their local regulation related with open loop EGCSs installed vessel in calling Chinese ports.

The attitude shown by local authorities of the ports in major shipping routes of vessels will affect the preference of shipowner in choosing their action during this project. It is always necessary to make sure the operation is safe and legal under the local regulation.

With above mentioned for authorities, it is put into the category of Keep satisfied considering the high power and low interest shown in this project.

#### **F. Customs – Keep Satisfied**

As mentioned in previous definition of the project, this project is focusing on the fleets that are under serving on international routes and also could be called as international shipping vessels. Considering of this, the bunker fuel oil for this kind of vessels is different with domestic vessels. The bunker of them is tax-free products and always need to be under the governance of customs both in quality and in quantity.

Due to the responsibility of customs, it is also involved in the list of stakeholders on the respect to this project. No matter the vessel under serving has chosen either alternative as their final decision, once they are under the control of local customs, all the documents on board related with bonded bunker that would be pumped into vessel fuel tank would be checked by customs to make sure all procedure and operation is fully legal under the local regulation.

As another national authority, customs are also put into the category of Keep satisfied like Maritime Safety Authority we have looks earlier. But comparing with Maritime Safety Authority, customs are considered to have almost same level of power but with lower interest in this project. It is because that from the view of customs they just keep following the current working

procedure in the control of bonded products for international shipping vessels as always, no additional adjustment is required with the changing of policy.

#### **G. Shipyard – Manage Closely**

Basis on normal procedure of vessel operation, expect of considering additional accident, usually ships would enter into shipyard for repairing and ordinary check every two to five years. Now with the implementation of new regulation, it requires shipowner to make extra plan for vessels to go shipyard, no matter for the installation of EGCSs or for the tank cleaning procedure before starting to use the compliant low-sulphur fuel oil to reduce the negative impact brought to engine systems.

Basis on the information got through the communication with shipyard, they are all busy and highly occupied in drydock for installation or tank cleaning need from shipyard.

As stakeholder, shipyard has been put in the category of Manage closely because it is the counterparty of shipowner to do the installation or other action according to the instruction from owner. High power and high interest have been shown during the operation. At the same time, comparing with other two, shipowner and charterer, also are in this field, shipyard shows lower level of power and interest in the project, which makes his position is lower than the other two.

#### **H. EGCSs maker – Keep Informed**

As the producer of the EGCSs, it is closely related with one of the alternatives, the installation of EGCSs to be make the vessel meet the requirement under new regulation. In the project, EGCSs maker acts as the supplier, who would provide required equipment and be responsible for the further maintenance of the EGCSs according to the instruction from owner.

In addition, from the channel of EGCSs maker, shipowner as the promoter could get latest news on the market not only about the preference of other shipowners in the same situation, but also about if any change in technical development or local regulation release related with the systems.

With the role of EGCSs maker in this project, it is put in the field of Keep informed with low power but high interest shown. Comparing with other stakeholders, refinery and physical supplier, in this category, due to his lower power and interest regarding to the influence in future operation related with promoter, EGCSs maker has been considered to put in position lower than the other two.

### **I. International Maritime Organization – Keep Informed**

International Maritime Organization (IMO) is the organization under United Nations as the body devoted exclusively to maritime matters. Under IMO, there is the Marine Environment Protection Committee (MEPC), that is responsible for coordinating the Organization's activities in the prevention and control of pollution of the environment from ships.

After the releasement of IMO sulphur 2020 regulation, MEPC keeps publishing official reports and guidelines to clear the action need to be taken by all parties regarding the change, including the assessment of fuel oil availability, guideline for exhaust gas cleaning systems, guidance on the development of a ship implementation plan for the consistent implementation of the 0.50% sulphur limit under MARPOL ANNEX VI and so on.

IMO and MEPC are keeping close attention to whatever information from all parties involved related with the implementation of the new regulation. Like it is mentioned in IMO slogan: safe, secure and efficient shipping on clean oceans, they will continuously move on in the direction in marine environmental protection and control of pollution caused by vessels activities all over the world.

As one of the major stakeholders of the project, it is put on the field of Keep informed to mark his high interest and low power. Comparing with others also in this category, his interest and power shown in this project is lower with them so it is in the lowest position within this field.

### **J. International Organization of Standardization – Monitor**

The International Organization of Standardization is the international organization who develop and publish international standards in a lot of things, such as ISO 21500 is well known as the international standard developed to provide guidance, principals and good practice in project management. As the same in bunker area, ISO 8217 is the international standard developed to define the technical specs that all bunker products need to meet. The latest version with details can be found as following:

**REQUIREMENTS FOR MARINE RESIDUAL FUELS**

Characteristic	Unit	Limit	Category ISO-F-										Test method reference	
			RMA	RMB	RMD	RME	RMG				RMK			
			10	30	80	180	180,0	380,0	500,0	700,0	380,0	500,0		700,0
Kinematic viscosity at 50 °C	mm <sup>2</sup> /s <sup>a</sup>	Max	10,00	30,00	80,00	180,0	180,0	380,0	500,0	700,0	380,0	500,0	700,0	ISO 3104
Density at 15 °C	kg/m <sup>3</sup>	Max	920,0	960,0	975,0	991,0	991,0				1010,0		ISO 3675 or ISO 12185; see 6.1	
CCAI	–	Max	850	860	860	860	870				870		see 6.2	
Sulfur <sup>b</sup>	mass %	Max	Statutory requirements										ISO 8754 or ISO 14596 or ASTM D4294; see 6.3	
Flash point	°C	Min	60,0	60,0	60,0	60,0	60,0				60,0		ISO 2719; see 6.4	
Hydrogen sulfide	mg/kg	Max	2,00	2,00	2,00	2,00	2,00				2,00		IP 570; see 6.5	
Acid number <sup>c</sup>	mg KOH/g	Max	2,5	2,5	2,5	2,5	2,5				2,5		ASTM D664; see 6.6	
Total sediment – Aged	mass %	Max	0,10	0,10	0,10	0,10	0,10				0,10		ISO 10307-2; see 6.9	
Carbon residue – Micro method	mass %	Max	2,50	10,00	14,00	15,00	18,00				20,00		ISO 10370	
Pour point (upper) <sup>d</sup>	winter	°C	Max	0	0	30	30	30				30		ISO 3016
	summer	°C	Max	6	6	30	30	30				30		
Water	volume %	Max	0,30	0,50	0,50	0,50	0,50				0,50		ISO 3733	
Ash	mass %	Max	0,040	0,070	0,070	0,070	0,100				0,150		ISO 6245	
Vanadium	mg/kg	Max	50	150	150	150	350				450		IP 501, IP 470 or ISO 14597; see 6.14	
Sodium	mg/kg	Max	50	100	100	50	100				100		IP 501, IP 470; see 6.15	
Aluminium plus silicon	mg/kg	Max	25	40	40	50	60				60		IP 501, IP 470 or ISO 10478; see 6.16	
Used lubricating oil (ULO): – Calcium and zinc; or – Calcium and phosphorus	mg/kg	–	Calcium > 30 and zinc > 15 or Calcium > 30 and phosphorus > 15										IP 501 or IP 470, IP 500; see 6.17	

- a 1 mm<sup>2</sup>/s = 1 cSt.
- b The purchaser shall define the maximum sulfur content in accordance with relevant statutory limitations. See Introduction.
- c See Annex E.
- d Purchasers should confirm that this pour point is suitable for the ship's intended area of operation.

Figure 7 ISO 8217 2017 fuel standard for marine residual fuels

On the line of sulphur, the limit has been marked as Statutory requirements, which means that max 0.50% m/m from 1 January 2020. As the technical concerns has been mentioned by IMO, with the process of desulfurization in refinery, the flash point and the viscosity characteristics might change and so far, has no confirmed report on the influence could be brought to the performance of engine systems.

Even with the mature product like ordinary fuel oil, there are still have quality claim by the vessels side that even the products meet all the specs need to be test according to ISO 8217, the using of bunker fuel still arise bad performance in engine systems and caused massive loss economically. Like in 2018, multiple quality claim of 4-Cumylphenol has been reported, which leaded bad function of engine systems, and it is not even on the specs list of ISO 8217.

With the wider use of compliant low-sulphur fuel oil due to the coming implementation of new regulation, ISO is expected to develop and publish new version of bunker quality standard to provide technical support to all parties related.

Due to the reason all above, International Organization of Standardization has been put in field of Monitor regarding to his comparingly low interest and low power showed in the project. From the view of promoter, the strategy is to keep eye on the updating and comments from them on the technical issue.

**K. Environmental group – Monitor**

The environmental group usually as Non-governmental organization gathers the people who care about the environmental protection and anti-pollution issue both in local and globally. From the view of shipping industry, limiting SOx emissions from ships will improve air quality and protects the environment.

With the trend of tighter limit in emissions from ships, environmental group would keeping push all parties to act more in environmental related issue, including asking for tighter regulation in emissions from vessels not only SOx but also NOx. In additional, considering the working principal of EGCSs, environmental group would ask for stricter regulation in control of the waster water discharging during port calling to protect the costal water quality.

It has been put into the category of Monitor as it has both low power and low interest in this project, with even lower power than the International Organization of Standardization so that it in the lower position in the figure.



### 5.3 SELECTION OF THE EXPERTS

Once the problem has been defined, the group of experts to make the decision is also confirmed. The group includes three experts and they are experienced operator of the shipowner company with focus on different business area.

Expert A has rich experience in shipowner operation and he also worked on physical supplier company so that he has deep understanding on how to cooperate with local marine authorities and port authorities.

Expert B is selected due to his previous working experience in chartering area so that he has much clearer idea about what will be influence to be brought into chartering market and give his suggestion from this side of view.

Expert C works as the purchaser for bunker in the shipowner company, who is familiar with global bunker market in general and also is well-noted about the shipping routes of their company fleets under operation, the local regulation of the calling ports and also the predicted supply ability of fuel oil.

The communication with those three experts was realized by a short video conference at first to gather their personal idea from different side of view about the problem. And the results of questionnaire were collected by email to support the further calculation under the AHP approach. Those results of the questionnaire could be found in Annex accordingly.

## 5.4 STRUCTURE OF THE PROBLEM

After communication with those stakeholders of this project, by taking their opinion regarding to the problem, following structure, criteria and sub-criteria of the problem have been defined accordingly as shown in below:

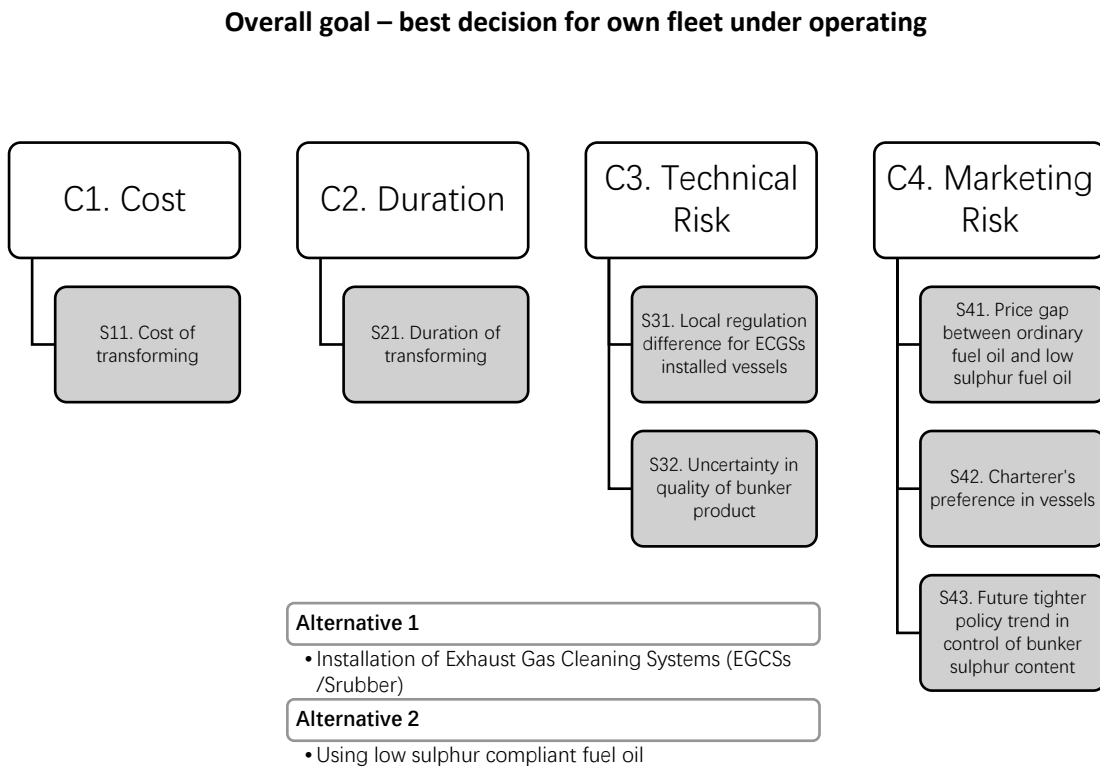


Figure 8 Decomposition of the problem into a hierarchy

### 5.4.1 CRITERIA OF THE DECISION MAKING

Those criteria and sub-criteria are been defined as following group:

- **Cost**

S11. Cost of transforming

- **Duration**

S21. Duration of transforming

- **Technical risk**

S31. Local regulation difference for ECGSs installed vessels

S32. Uncertainty in quality of bunker product

- **Marketing risk**

S41. Price gap between ordinary fuel oil and low sulphur fuel oil

S42. Charterer's preference in vessels

S43. Future tighter policy trend in control of bunker sulphur content

To identify criteria and sub-criteria of the problem, that require the understanding as thoroughly as possible for the problem itself and also the environment surrounding of it. With the consideration of attributes that contribute to the solution, on the first level those criteria are grouped into four that includes the financial cost, time cost, technical risk and marketing risk.

- S11 - Cost of transforming

The economic cost for installation of EGCSs system or tank cleaning process.

- S21 - Duration of transforming

The Time cost for installation of EGCSs system or tank cleaning process.

- S31 - Local regulation difference for EGCSs installed vessels

For example some of the ports like Singapore, the Maritime and Port Authority of Singapore has announces ban on vessel with the use of open loop scrubber to discharge scrubber wash water in port, which means even those vessels with scrubber system is compliant when burning regular bunker fuel according to the regulation, they still need change to use compliant low-sulphur fuel oil when calling Singapore.

- S32 - Uncertainty in quality of bunker product

On the side of regular bunker fuel, there are well developed quality standard to follow, that is the ISO 8217. But when looks to the compliant low-sulphur fuel oil, due to the extra process of desulphurization to reducing the sulphur content in fuel oil, it will bring the change of quality in flash point (for storage safety) and viscosity (to easy move through pumps and piping of vessel). So far, there is no international standard for this product. From the opinion of market, both physical supplier and vessel side will follow the existing standard plus the updated sulphur content limit. But it may also bring negative impact to ship machinery systems which is still unclear.

- S41 - Price gap between ordinary fuel oil and low sulphur fuel oil

According to the research and investigation of IMO, they did all the calculation about the impact of the new policy basis the price gap around USD 128/MT of fuel oil. On the other side, from the latest news in market, it will have big chance that especially on the beginning days after the implementation of the new regulation, there won not be sufficient compliant low-sulphur fuel

oil supply in the whole market, which might widen the price gap than expected and no one can predict when would the situation become better.

- S42 - Charterer's preference in vessels

As known from the market, there already has been big charterer company like Hudson Shipping Lines announced that they would stop chartering vessel with EGCSs after the IMO sulphur 2020 entering into force. At the same time, there are also other charterers who support the use of EGCSs considering the increasing fuel cost with the rising of crude price.

- S43 - Future tighter policy trend in control of bunker sulphur content

From the concern of anti-pollution and maritime environmental protection, the policy of sulphur content control would be tighter and tighter in coming future and it is under discussion in IMO as we all known. In this field, the installation of EGCSs and the use of compliant low-sulphur fuel oil would act differently.

The reason why no opportunity has been taken into consideration in criteria is that the implementation of the new regulation is already confirmed by IMO is compulsory and would not have any delay. On the respect to this regulation, according to the responding voice from shipping market it is confirmed that positive influence would be brought into environment protection field and it would also push the technology development of ship engine design to be more efficiency and environmental-friendly. But the action that should be taken by shipowner in short term, which is the problem being studied now, is obligatory for them to act compliantly in bunker consuming. From the view of shipowner, whatever action they would take according to the decision made in this project it would lead to have an investment on equipment once at this time or continuous higher cost for compliant bunker in future, which shows nothing in opportunity for the company itself no matter in financial side or business side so far.

#### 5.4.2 ALTERNATIVES OF THE STUDY

According to the recommended action from the guideline issued by IMO and the opinion from experts, there are following three alternatives of the problem.

- A. Installation of the Exhaust Gas Cleaning Systems (EGCSs / Scrubber) and continuous using of ordinary fuel oil
- B. Directly using compliant low-sulphur fuel oil

The Alternative A is together with the keep using of ordinary fuel oil to install the Exhaust Gas Cleaning Systems (EGCSs / Scrubber) into the vessel by using the water to wash the exhaust gas

to confirm that vessel operation is compliant to the IMO regulation. The basic working principal of the system can be found in following Figure 9. The scrubber wash water would be storage in separate tank on board and be discharged when vessel calling to a discharging port under the instruction of port authority accordingly.

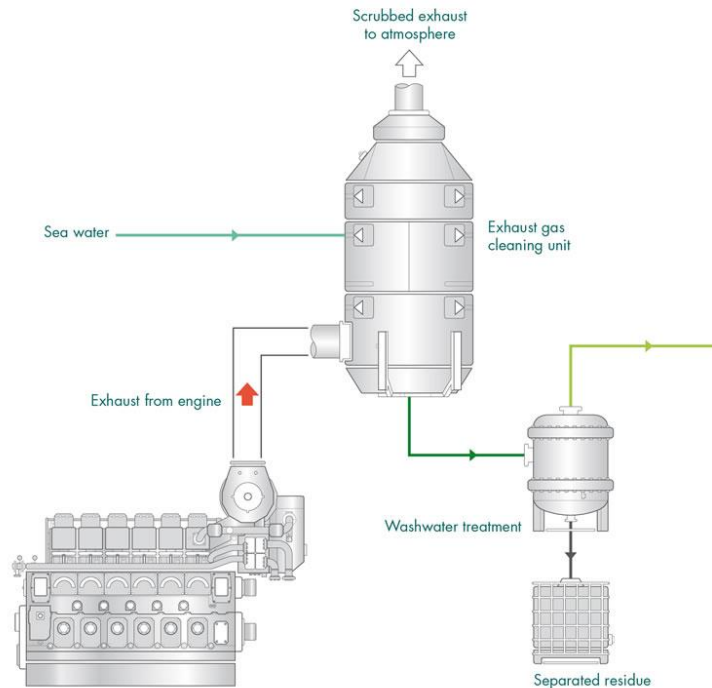


Figure 9 Exhaust gas cleaning system basic components

SOURCE: EXHAUST GAS CLEANING SYSTEM ASSOCIATION

There are three types of EGCS: open loop, closed loop and hybrid. Generally, all these three types scrubber are working following the same principle showed above. The installation of EGCSs requires vessel to set a plan of entering into shipyard, but vessel would not need to do extra tank cleaning process. The different working process for those three can be found in following figures.

Open loop EGCSs is the cheapest option that wash water is taken from the sea, used for scrubbing, treated and discharged back to sea, with the natural chemical composition of the seawater being used to neutralize the results of SO<sub>2</sub> removal. The working principal can be found in Figure 10.

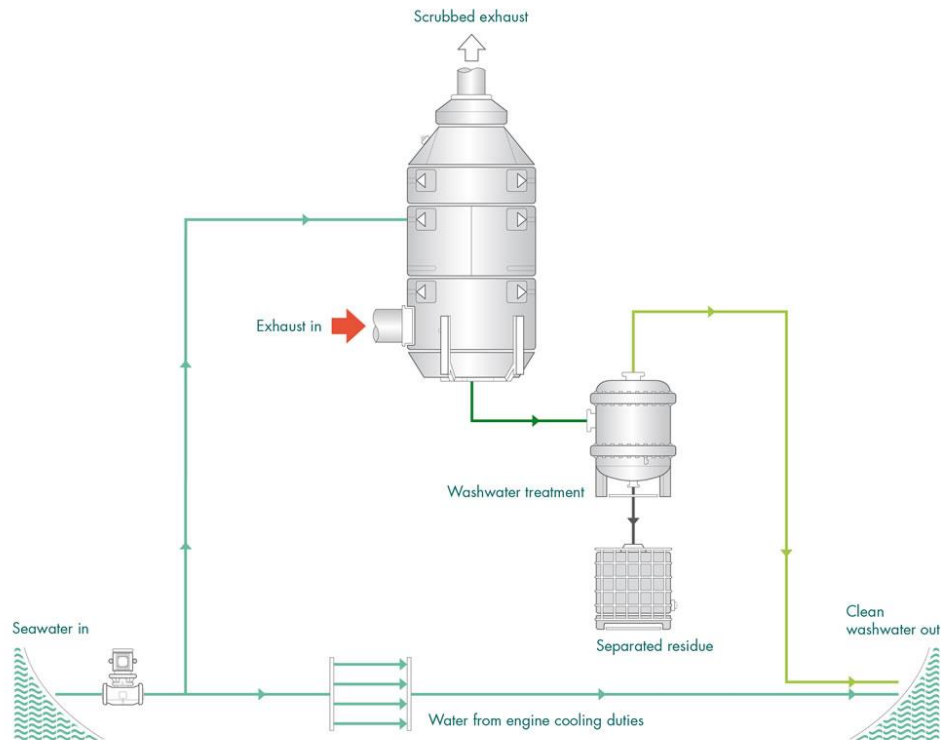


Figure 10 Open loop exhaust gas cleaning system

SOURCE: EXHAUST GAS CLEANING SYSTEM ASSOCIATION

Close loop EGCSs is that to use freshwater treated with an alkaline chemical such as caustic soda is used for neutralization and scrubbing so that it would be more expensive as it requires additional pumps, tanks of sludge et cetera. It is showed in Figure 11.

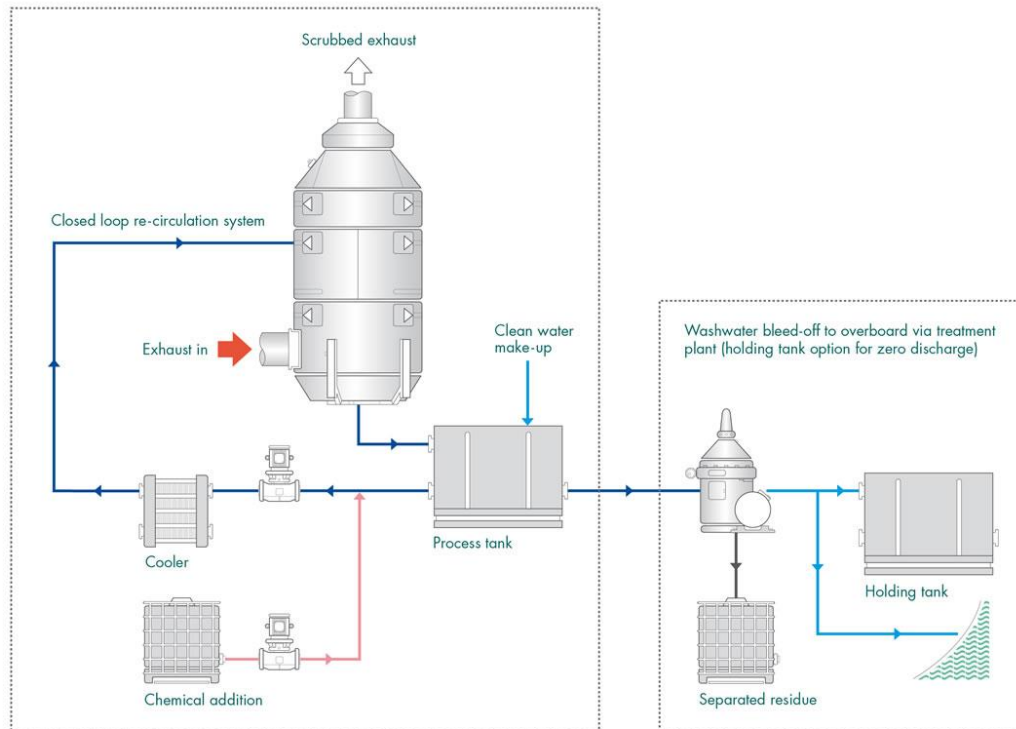


Figure 11 Close loop exhaust gas cleaning system

SOURCE: EXHAUST GAS CLEANING SYSTEM ASSOCIATION

Hybrid EGCSs is the system can work both in open and close loop mode, which means it requires two sets of pumps and piping. The system under two different modo of operation can be found in Figure 12 and Figure 13.

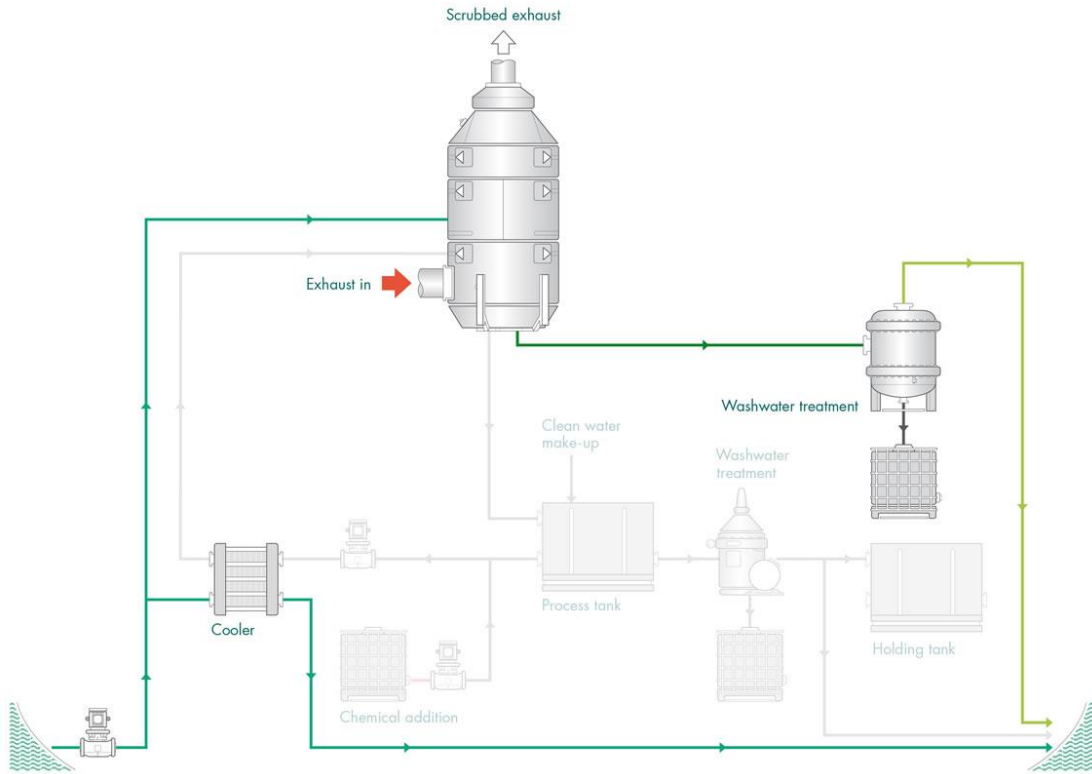


Figure 12 Hybrid exhaust gas cleaning system open loop operation

SOURCE: EXHAUST GAS CLEANING SYSTEM ASSOCIATION

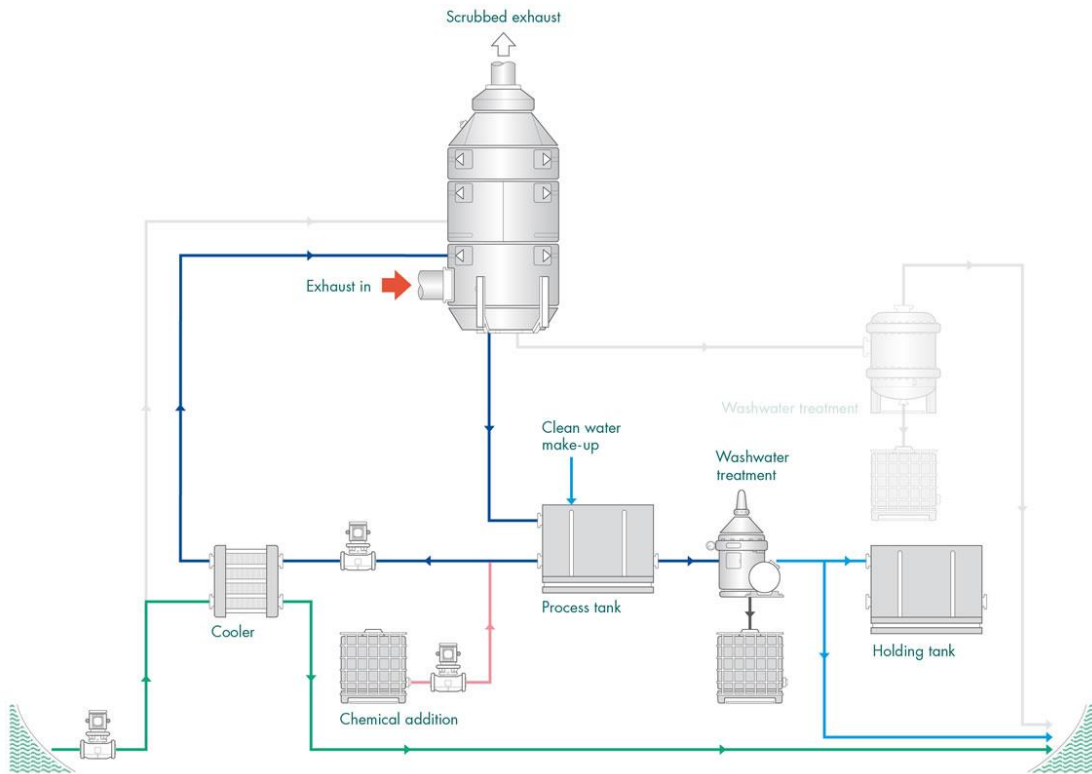


Figure 13 Hybrid exhaust gas cleaning system close loop operation



*SOURCE: EXHAUST GAS CLEANING SYSTEM ASSOCIATION*

For the Alternative B, on the respect of directly using the compliant low-sulphur fuel oil, it requires vessel to be prepared especially in technical part. It is necessary for vessel to go through the process of tank cleaning according to the suggestion from IMO before changing to use the compliant fuel oil. Vessel need to be sure on its technical capability to handle different types of fuel due to the concern of higher or lower viscosity fuels. And also, it will be essential that during the beginning period after the implementation, ship crew is able to handle sulphur non-compliant fuels even in the situation of non-availability of sulphur compliant fuels. Once vessel starts to consume the compliant fuel oil, it requires vessel crew to closely verify machinery performance on compliant fuel oil.

#### 5.4.3 ALTERNATIVES DISCARDED

There is also another option which is mentioned in the guideline of IMO, but it is thought not comparable as alternative in this work.

##### ■ Using Liquid Natural Gas, LNG

As mentioned above in background of the problem, there are also several alternative marine fuels in market. Among all these, Liquid Natural Gas could be an option for regulatory compliance as it currently has the largest market share.

Under the influence of implementation of IMO sulphur 2020 regulation and policy trend of tighter control in sulphur content in bunker fuel, it will push the technical development of wider use of LNG as a marine fuel. More can more company might consider to invest into LNG consuming vessels. But considering the process of vessel building, it can only be taken as a part of the long-term company strategy. For those fleets already under operation, it is not possible to reform the entire engine system to make it ready for using LNG instead.

On the other hand, without a well-organized supply network of LNG cover most of ports along the major shipping routes, it would be hard for shipowners to change to use LNG as bunker fuel. Nowadays, generally speaking the supply of LNG from the view of global market is unstable. The existing LNG bunkering infrastructure is focused mainly in the Baltic and North Sea. In all European regions, there are projects that focusing on the building of LNG infrastructure and the increase of LNG supply. In North American, there are some projects under operation and additional project under discussion. But most of the infrastructure are in ECA area, and from the global view, even other regions have the plan to offer LNG bunkering in the coming year it would not be possible to be treated as an option of shipowner now.

## 5.5 PROCESS OF THE DECISION MAKING

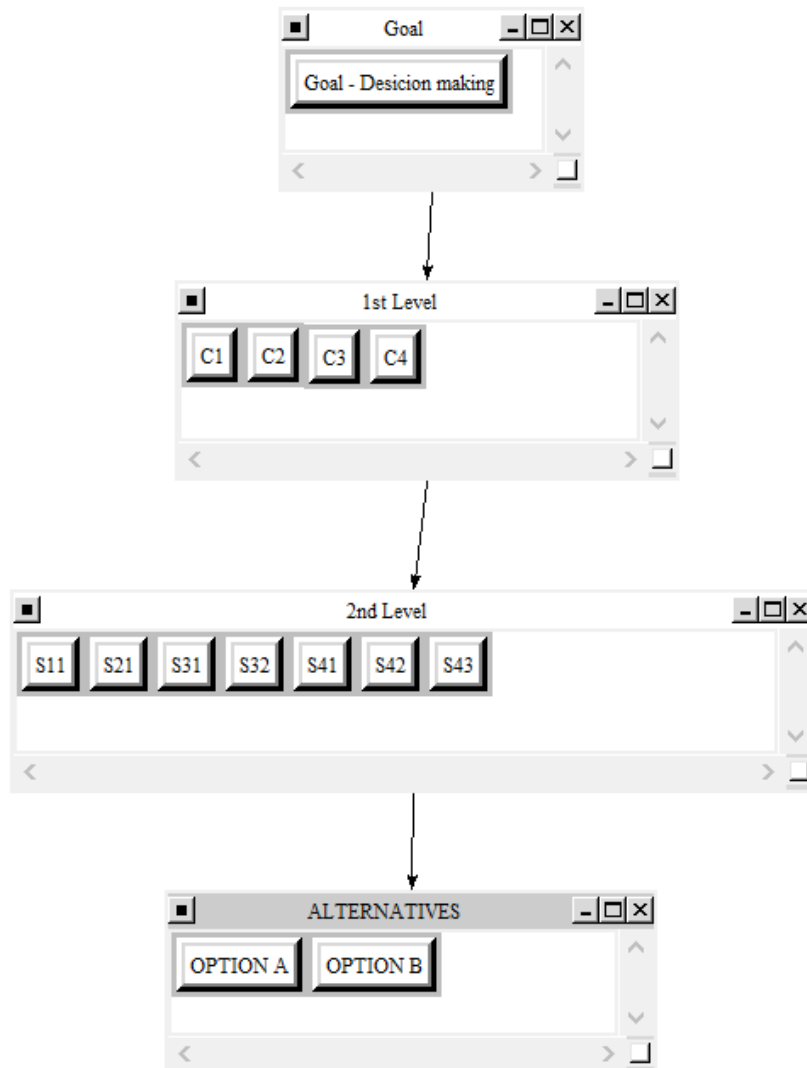


Figure 14 Decomposition of the problem in program SuperDecision

In this case, the approach Analytic Hierarchy Process will be used to do the decision-making process. In following paragraph, the process of decision-making basis on the results of experts would be showed in details and also point out the most preferred alternative.

### 5.5.1 METHOD AHP

The method AHP is to do the comparisons between pairs of elements to establish matrices from them. With the mathematical calculation of these matrices, the priorities among those elements of the same level would be shown and also with the respect to the superior level.

When the priorities of those elements of each level have been defined, it would lead to the establishment of the global priorities with the respect to the overall objective.

Those alternatives would be lined basis on the weight have obtained in descending order, that the highest value indicates the most preferred alternative

#### 5.5.1.1 DESCRIPTION OF THE DECISION MAKER

The project is of a medium-small size shipowner company that need to set their company short term plan and put it into action for those vessels under operation to make sure they would be compliant in bunker consuming under the new regulation. After the complete stakeholder analysis has been done previously, considering the analysis conclusion, within the entire project member group, the decision maker is the group of three experts that from the shipowner company who with the clear idea of the entire project objective and structure. They have rich experience in operation of the vessels and also with deep knowledge in different field related with different stakeholders' area in this project.

The individual result of experts will be combined and after the calculation the group decision is going to represent the idea of all.

#### 5.5.1.2 WEIGHT ALLOCATION

Matrix of Expert A							
	C1	C2	C3	C4	Name		Normalized by Cluster
C1	1	1/5	1/6	1/5	C1		0.04990
C2	5	1	1/5	1/3	C2		0.12956
C3	6	5	1	5	C3		0.59979
C4	5	3	1/5	1	C4		0.22075
					S11		0.04990
	S31	S32			S21		0.12956
S31	1	1/4			S31		0.11996
S32	4	1			S32		0.47983
					S41		0.14514
	S41	S42	S43		S42		0.05856
S41	1	3	7		S43		0.01704
S42	1/3	1	4				
S43	1/7	1/4	1				

Figure 15 Matrices of decision of Expert A

From the result of Expert A, on the first level of criteria the most important one is C3 – Technical risk. And among all sub-criteria, the one with most importance is S32 - Uncertainty in quality of bunker product.

Considering his previous working experience in physical supplier company, Expert A shows more attention in technical part when doing comparison between paired elements, as the quality of bunker fuel is closely related with the performance of the engine system. It is essential to have a good control of technical risk to make sure that vessels could be under best technical situation after the reformation to serve in shipping transportation.

Matrix of Expert B							
	C1	C2	C3	C4	Name		Normalized by Cluster
C1	1	1/3	1/5	1	C1		0.10396
C2	3	1	1/5	1/5	C2		0.12823
C3	5	5	1	3	C3		0.52063
C4	1	5	1/3	1	C4		0.24717
					S11		0.10396
	S31	S32			S21		0.12823
S31	1	3			S31		0.39047
S32	1/3	1			S32		0.13016
					S41		0.17079
	S41	S42	S43		S42		0.06158
S41	1	4	8		S43		0.01480
S42	1/4	1	6				
S43	1/8	1/6	1				

Figure 16 Matrices of decision of Expert B

Expert B also agree on the decision that C3 – Technical risk is the most important one among the first level of criteria, but the weight of C3 is slightly lower than Expert A. Instead of that, the weight of C4 – Marketing risk is higher than the one of Expert A. At the same time, among all sub-criteria, C31 - Local regulation difference for ECGSs installed vessels has been put as the one with most importance.

With the consideration from the view of chartering market, the local regulation difference would be a limitation of vessel with different action in this problem. It would weaken the ability of both vessels and company in competition of chartering market. And also it might limit the selection of transportation route even company decides to leave the vessel under their own operation.

STAKEHOLDER ANALYSIS AND DECISION-MAKING OF SHIPOWNERS FACING THE COMING  
IMPLEMENTATION OF IMO SULPHUR 2020 POLICY

Matrix of Expert C							
	C1	C2	C3	C4	Name		Normalized by Cluster
C1	1	1/2	1/5	1/4	C1		0.06816
C2	2	1	1/5	1/4	C2		0.09514
C3	5	5	1	1/5	C3		0.27008
C4	4	4	5	1	C4		0.56662
					S11		0.06816
	S31	S32			S21		0.09514
S31	1	7			S31		0.23632
S32	1/7	1			S32		0.03376
					S41		0.33808
	S41	S42	S43		S42		0.18673
S41	1	2	7		S43		0.04182
S42	1/2	1	5				
S43	1/7	1/5	1				

Figure 17 Matrices of decision of Expert C

Expert C put C4 – Marketing risk as the one has the most importance on the primer level of criteria, and C3 – Technical risk is on the next position. Among all the sub-criteria. The S41 - Price gap between ordinary fuel oil and low sulphur fuel oil is the most important one, and C31 - Local regulation difference for ECGSs installed vessels is the second one.

On the position of bunker purchaser, Expert C is more sensitive on the price fluctuation of the bunker price. From this view, the uncertain prediction of price gap between two products attract more attention of him. And also, from his opinion, the reason to put the local regulation difference on the second place is because that will greatly affect future bunker purchase strategy of the company.

Matrix of Group							
	C1	C2	C3	C4	Name		Normalized by Cluster
C1	1	0.3218	0.1882	0.3684	C1		0.06310
C2	3.1072	1	0.2000	0.2554	C2		0.12097
C3	5.3133	5.0000	1	1.4422	C3		0.46282
C4	2.7144	3.9149	0.6934	1	C4		0.35312
					S11		0.06310
	S31	S32			S21		0.12097
S31	1	1.7380			S31		0.29378
S32	0.5754	1			S32		0.16904
					S41		0.22898
	S41	S42	S43		S42		0.09907
S41	1	2.8845	7.3186		S43		0.02507
S42	0.3467	1	4.9324				
S43	0.1366	0.2027	1				

Figure 18 Matrices of decision of the group

By combination of the individual result of each expert, in the opinion of group C3 – Technical risk and C4 – Marketing risk are the first and second most important criteria in the primer level. But the distance between these two in weight has been narrowed.

By looking to the sub-criteria, S31 - Local regulation difference for ECGSs installed vessels and S41 - Price gap between ordinary fuel oil and low sulphur fuel oil are two with most weight. And the distance has been narrowed between them as well.

	EXPERT A	EXPERT B	EXPERT C	GROUP
C1	0.04990	0.10396	0.06816	0.06310
C2	0.12956	0.12823	0.09514	0.12097
C3	0.59979	0.52063	0.27008	0.46282
C4	0.22075	0.24717	0.56662	0.35312
S11	0.04990	0.10396	0.06816	0.06310
S21	0.12956	0.12823	0.09514	0.12097
S31	0.11996	0.39047	0.23632	0.29378
S32	0.47983	0.13016	0.03376	0.16904
S41	0.14514	0.17079	0.33808	0.22898
S42	0.05856	0.06158	0.18673	0.09907
S43	0.01704	0.01480	0.04182	0.02507

*Table 1 Weight allocation comparison*

By looking all results of weight allocation of individual expert and the group, the final allocation of group is the number of balances among experts in criteria and sub-criteria.

In criteria level, two experts showed their highest preference in C3 and the rest one with highest on C4. In the group result the C3 is considered as more important than C4 but the difference is smaller in number.

In Sub-criteria level, three experts showed their highest preference in three different sub-criteria, that is S31, S32 and S41. In group result, the one with highest preference is S31 and coming with S41 and S32.

**5.5.1.3 EVALUATION OF ALTERNATIVES**

With the respect to the criteria C1 – Cost and C2 - Duration, the recommended predicted number from IMO will be used for comparison between two alternatives. Detailed number could be found in following table.

	Cost (million \$)	Duration (days)	Local regulation difference	Uncertainty in quality	Price gap	Charterer's preference	Future policy trend
Alternativa A	2.8	80					
Alternativa B	0.5	7					

*Table 2 Evaluation of alternatives*

For remained sub-criteria, the preference of each expert and the preference of group after comparison in pair can be found in following figures:

Matrix of expert A						
S31	A	B		S41	A	B
A	1	1/4		A	1	3
B	4	1		B	1/3	1
S32	A	B		S42	A	B
A	1	4		A	1	3
B	1/4	1		B	1/3	1
				S43	A	B
				A	1	1/2
				B	2	1

*Figure 19 Matrices of alternatives of Expert A*

Matrix of expert B						
S31	A	B		S41	A	B
A	1	1/5		A	1	1/5
B	5	1		B	5	1
S32	A	B		S42	A	B
A	1	1/3		A	1	1/6
B	3	1		B	6	1
				S43	A	B
				A	1	1/8
				B	8	1

Figure 20 Matrices of alternatives of Expert B

Matrix of expert C						
S31	A	B		S41	A	B
A	1	1/8		A	1	1/5
B	8	1		B	5	1
S32	A	B		S42	A	B
A	1	1/5		A	1	1/5
B	5	1		B	5	1
				S43	A	B
				A	1	1/5
				B	5	1

Figure 21 Matrices of alternatives of Expert C

Matrix of Group						
S31	A	B		S41	A	B
A	1	0.1842		A	1	0.4932
B	5.42884	1		B	2.0274	1
S32	A	B		S42	A	B
A	1	0.6437		A	1	0.4642
B	1.55362	1		B	2.15443	1
				S43	A	B
				A	1	0.2321
				B	4.30887	1

Figure 22 Matrices of alternatives of group



5.5.1.4 RESULT: PRIORITIES OF ALTERNATIVES

With all the results could be got from the matrices above, the priorities of alternatives are shown as following both as individual opinion and group decision:

	S11	S21	S31	S32	S41	S42	S43
Weights	0.049898	0.129564	0.119958	0.479834	0.145142	0.058563	0.017040
A	0.151515	0.080460	0.200000	0.800000	0.750000	0.250000	0.666667
B	0.848485	0.919540	0.800000	0.200000	0.250000	0.750000	0.333333
<b>A</b>	0.560701			OPTION A			0.56070
<b>B</b>	0.439298			OPTION B			0.43930

Figure 23 Priorities of alternatives of Expert A

Expert A is the only one who has the result that Alternative A is better than Alternative B with small different in final number. He didn't show much preference between the two options. From the numbers of the above table, the sub-criteria S32 the one has most priorities among them all and in this one Alternative A has much higher score than Alternative B. And also, the same situation showed in S41, the sub-criteria on the second important position.

	S11	S21	S31	S32	S41	S42	S43
Weights	0.103964	0.128236	0.390473	0.130158	0.170787	0.061579	0.014802
A	0.151515	0.080460	0.155548	0.250000	0.166667	0.142857	0.111111
B	0.848485	0.919540	0.844452	0.750000	0.833333	0.857143	0.888889
<b>A</b>	0.158253			OPTION A			0.15825
<b>B</b>	0.841747			OPTION B			0.84175

Figure 24 Priorities of alternatives of Expert B

	S11	S21	S31	S32	S41	S42	S43
Weights	0.068161	0.095136	0.236321	0.033760	0.338077	0.186726	0.041818
A	0.151515	0.080460	0.111111	0.166667	0.166667	0.166667	0.166667
B	0.848485	0.919540	0.888889	0.833333	0.833333	0.833333	0.833333
<b>A</b>	0.144304			OPTION A			0.14430
<b>B</b>	0.855696			OPTION B			0.85570

Figure 25 Priorities of alternatives of Expert C

Expert B and Expert C have the similar result that Alternative B is better than Alternative A with a large leading in numbers. It is a totally different result comparing with the one of Expert A. Among all sub-criteria, Alternative B has been treated as better than Alternative A in scores.

	S11	S21	S31	S32	S41	S42	S43
Weights	0.063099	0.120968	0.293781	0.169034	0.228976	0.099073	0.025068
A	0.151515	0.080460	0.155548	0.391616	0.330297	0.317033	0.188378
B	0.848485	0.919540	0.844452	0.608384	0.669703	0.682967	0.811622
<b>A</b>	0.242949				OPTION A		0.24295
<b>B</b>	0.757050				OPTION B		0.75705

Figure 26 Priorities of alternatives of group

	EXPERT A	EXPERT B	EXPERT C	GROUP
<b>A</b>	0.560701	0.158253	0.144304	0.242949
<b>B</b>	0.439298	0.841747	0.855696	0.757050

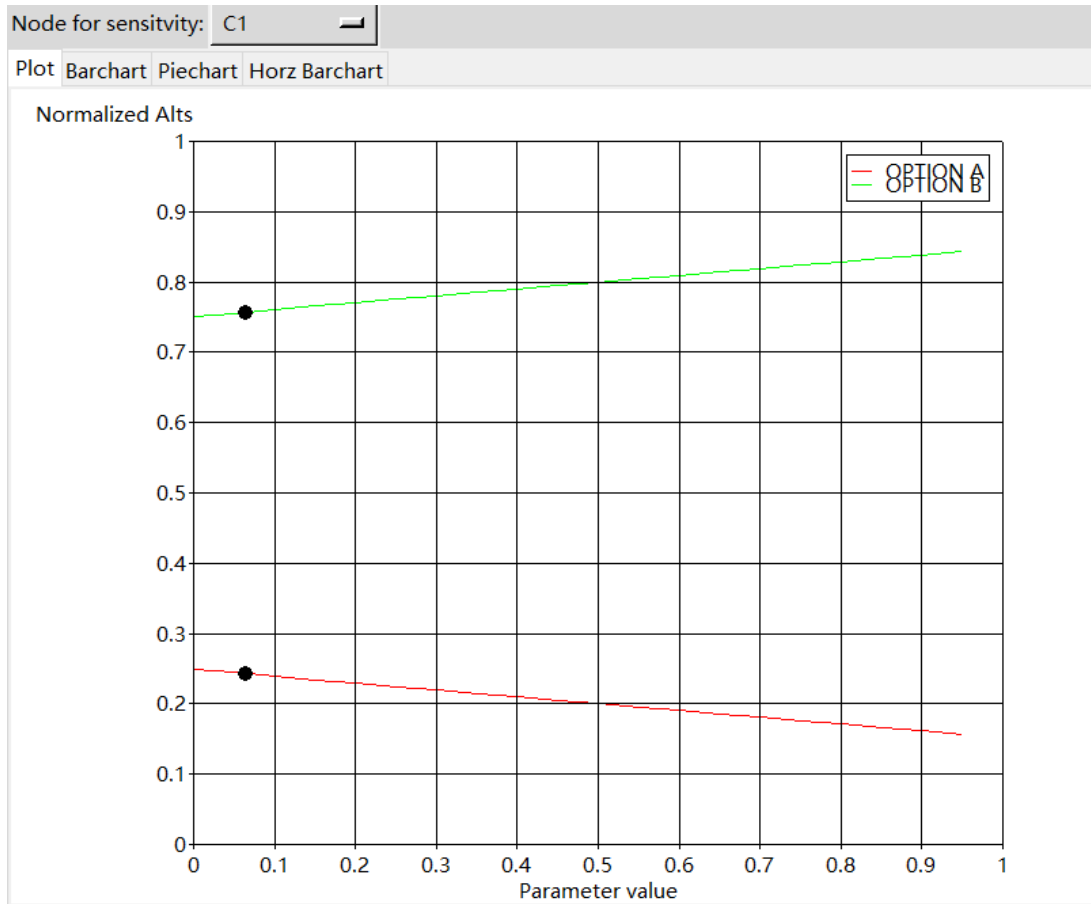
Table 3 Alternative priority comparison

By looking at the comparison of results of experts and group, showed in Table 3, the one of group can be found as a balance among three experts. In Expert A, he is the only one who decide Alternative A is little bit better than the other. But as the final result of group under internal balance, finally Alternative B is still better than Alternative A in numbers, but the distance of difference has been narrowed finally.

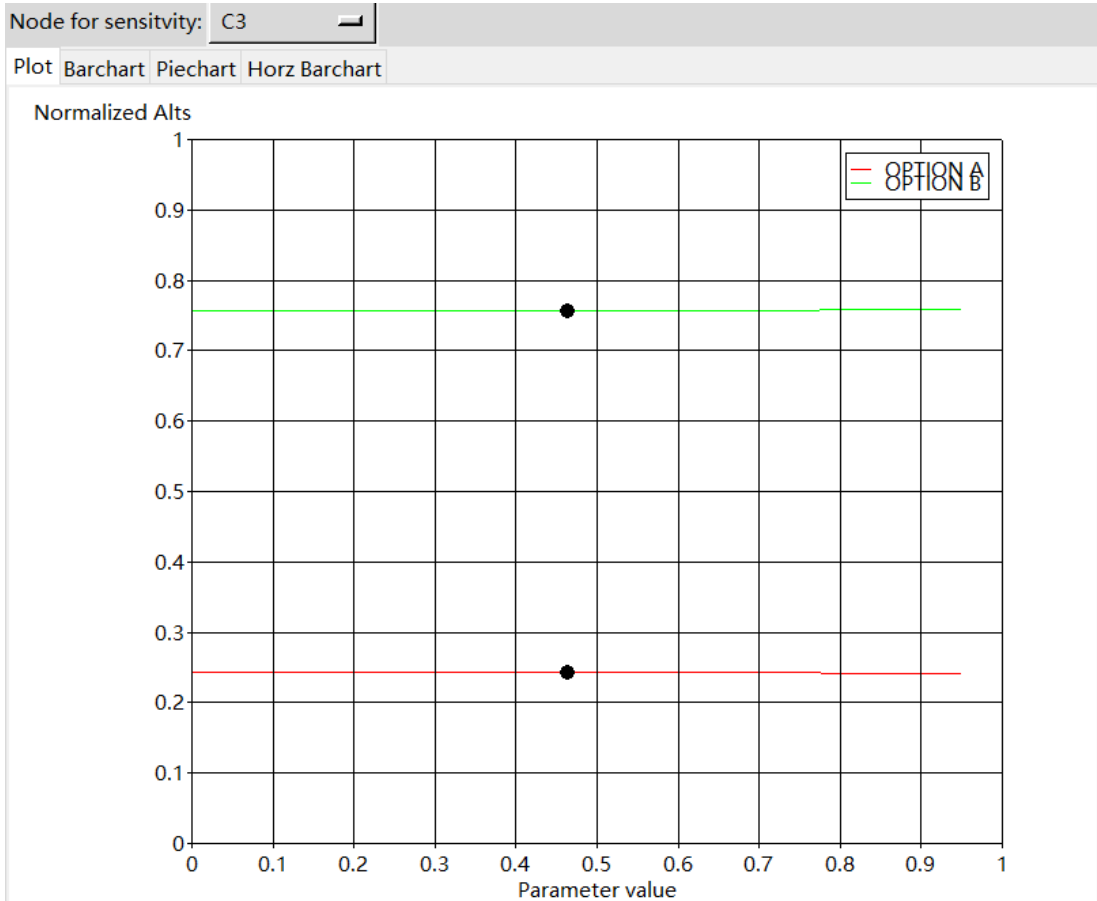
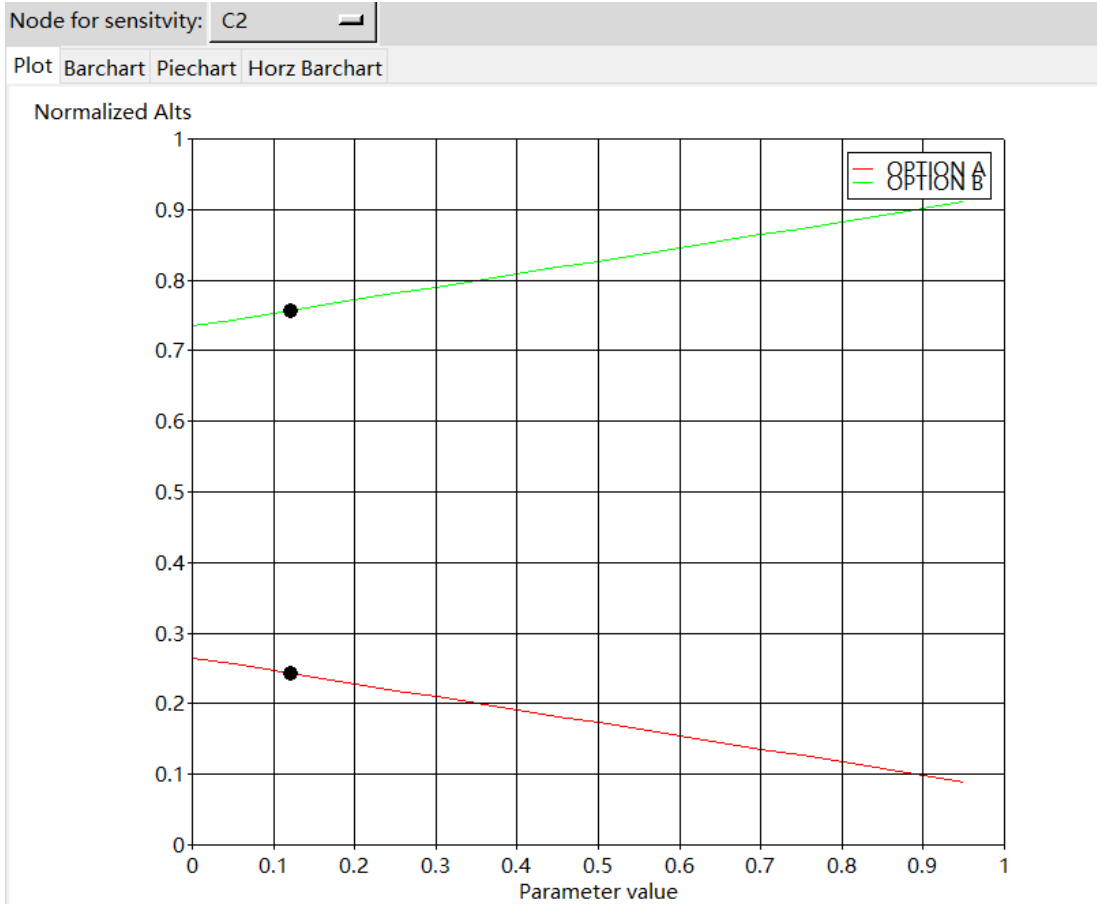
Basis on the mathematic result shown by program SuperDecision with the approach AHP, Alternative B to use the compliant low sulphur fuel oil will be the better option for the shipowner company.

## 5.6 SENSITIVITY ANALYSIS

With the following figures captured from the program SuperDecision basis on the result of group, the analysis of sensitivity can be checked for those principal criteria: cost, duration, technical risk and marketing risk. And also, among all the sub-criteria, the top two in ranking will be looked as well, S31 and S41: local regulation difference for ECGSs installed vessels and price gap between ordinary fuel oil and low sulphur fuel oil.



STAKEHOLDER ANALYSIS AND DECISION-MAKING OF SHIPOWNERS FACING THE COMING IMPLEMENTATION OF IMO SULPHUR 2020 POLICY



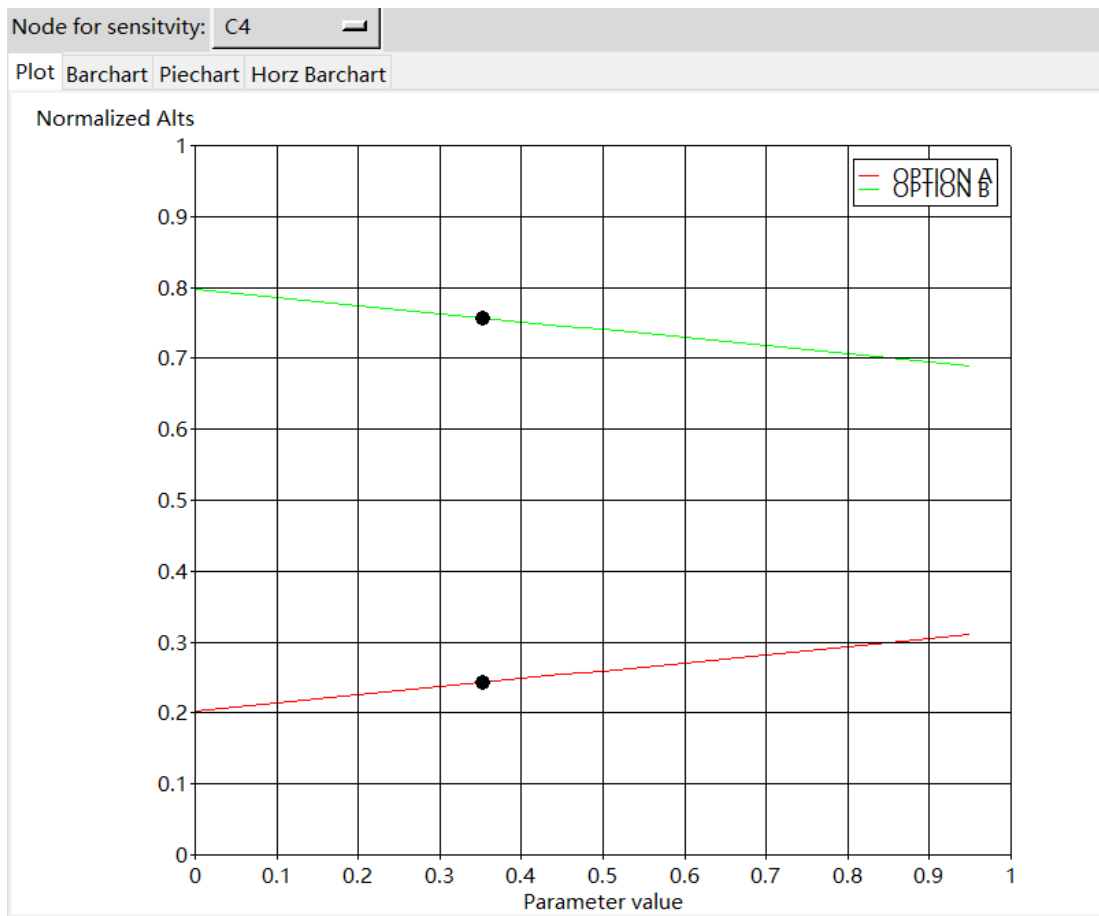
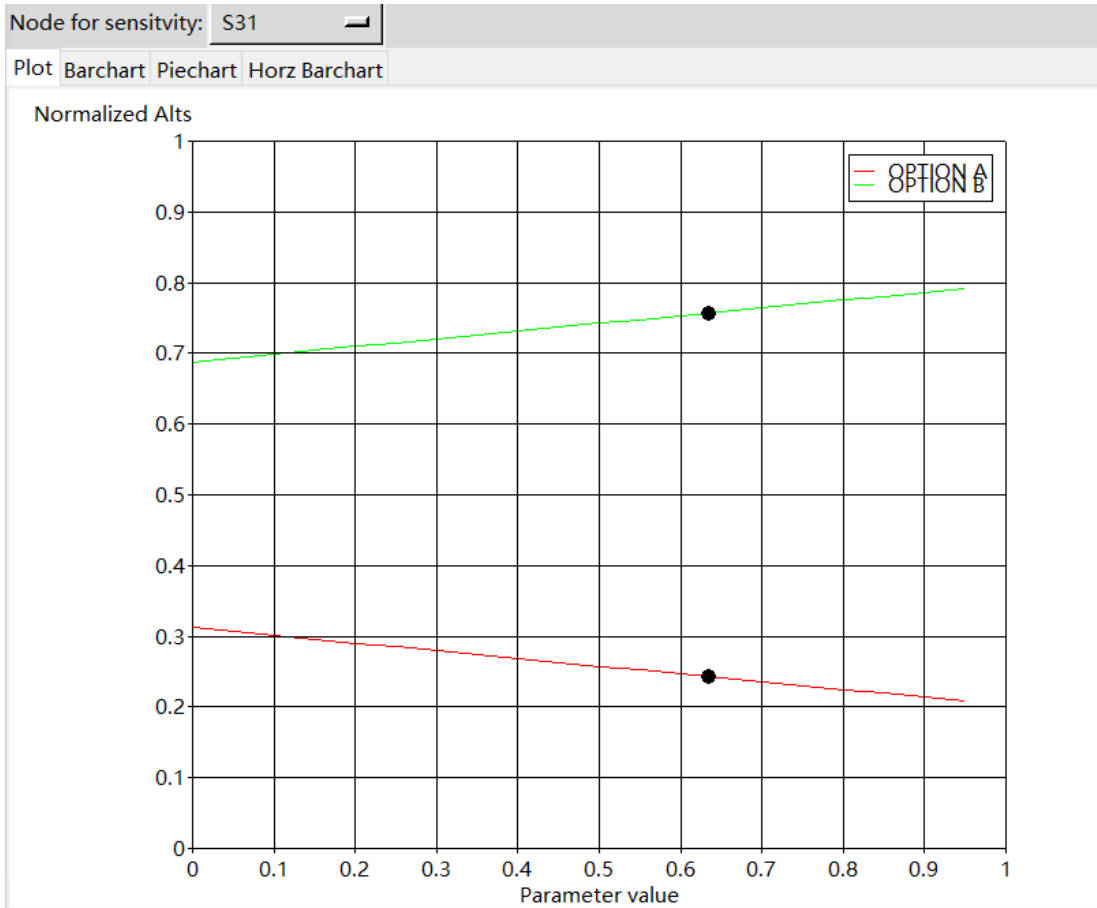


Figure 27 Sensitivity analysis of primer level criteria

According to the prediction showed in above Figure 27, on the side of C1 and C2, Alternative A is the one who need more investment in equipment and need more time in transformation, so if the priority of these two going up, the advantage of Alternative A would also increase accordingly.

On C3, there is no significant change in result if the priority becomes with more weight allocation. On C4, if the priority keeps increasing, the difference between two alternatives would be narrowed, but Alternative B would be still better than the other.



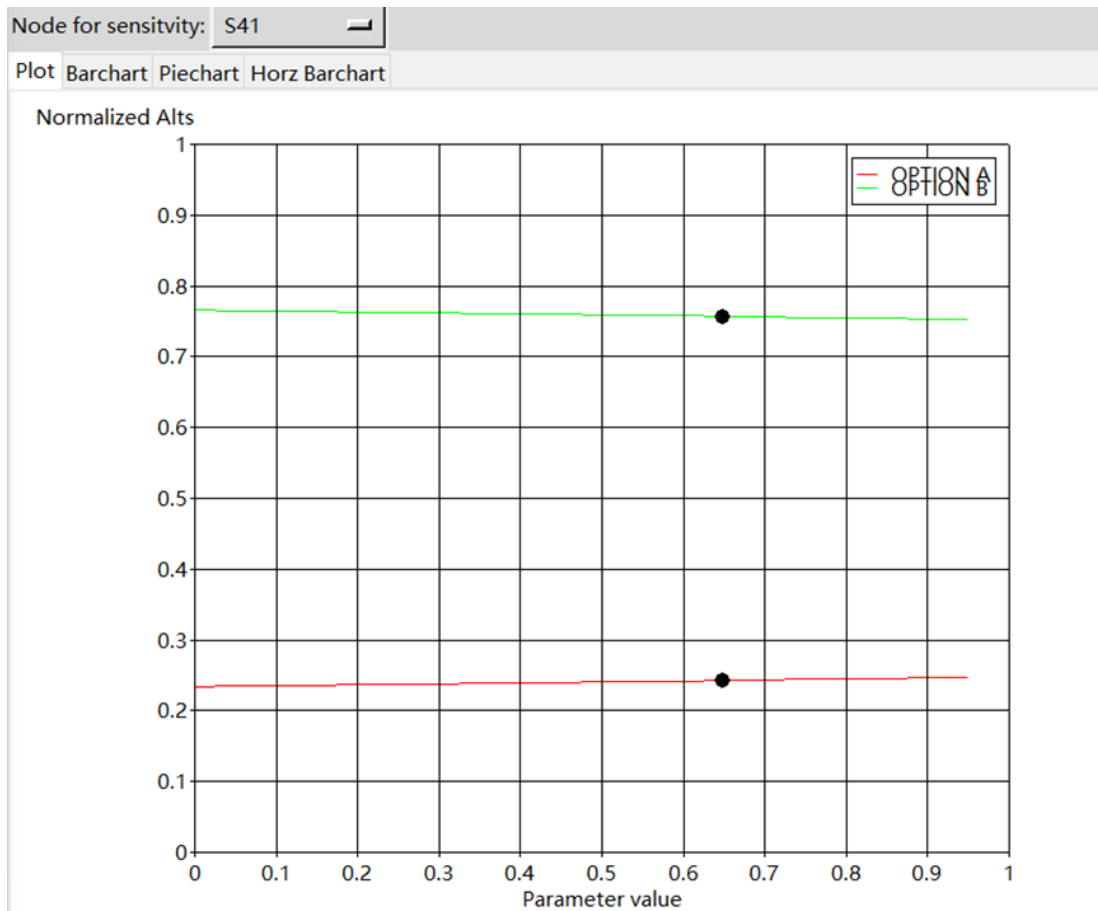


Figure 28 Sensitivity analysis of second level sub-criteria C31 and C41

By looking at Figure 28, the weight of sub-criteria S31 if going down then the distance between two alternatives will be less, but on the opposite direction, if it is going up, then the Alternative B will be much better than the other.

When looking at the figure of S41, the distance between Alternative A and B and comparably stable. With the change of weight to be higher or lower, it shows just slightly change in priority of alternatives.

## 5.7 RESULT ANALYSIS – DISCUSSION

By working following the entire decision-making process by using the approach AHP, the results showed in figures of previous part 1.5.1.4 support the final decision of the group that the Alternative B is the better option for the shipowner company and the following stages of the project should go ahead on this decision.

Even the result of individual expert lead to different opinion on decision-making process, by the method of group decision the decision maker group finally get a more balanced result supported by the mathematic calculation. Through this process, the concern of different expert has been fully taken into consideration during the decision-making procedure both in weight allocation and in alternative priority.

Both the project and the decision-making are complicated in this study as a lot of stakeholders have been involved in the project life circle. It is difficult to always keep them satisfied in the entire project. But with the study in this work, different role and interest of each stakeholder has been identified, which not only supported the decision-making process as the earlier stage of the project but also would help shipowner to be well-acted in the following stages of the project as a promoter and reach the best performance for the project itself and for the company as well.



## **6 CONCLUSIONS**

Shipping is a traditional industry that has close relationship with world trading and transportation market. Considering the massive scale of maritime merchant scale and combining with the increasing attention been paid to global environmental problem and anti-pollution problem, the trend of tighter control in Sox and NOx emission from ships to realize the sustainable development is quite clear in recent decades.

Under global surrounding like above, it requires the entire industry to react from the entire industry from upstream to downstream. The implementation of the IMO sulphur 2020 is not an end, but as a starting to point out the direction of the industry. The long-term technical development is expected in not only better refinery production, but also wider use of LNG vessel engine system, more efficient in performance of vessel fuel oil engine system and so on. More alternative fuel products are been waiting to keep the good acting in vessels serving operation but less harmful to the maritime environment and air quality.

It brings a chance to different parties in this industry to think about what they should do or what they can do in limiting the emission from ships. Expect for those long-term investment and company plan need to be thought about including investment in newbuilding vessels with LNG consumed engine system, or strategy plan on newbuilding vessel with EGCSs system installed etc., most of the shipowners are facing the problem on how to make a decision for their vessels underserving now.

To perform a better management of this problem, it is necessary to put it under the environment of project, as its fully fit with the definition of a project that is temporary and unique. The main goal of this project is to make a decision on what is the best option for shipowner under such situation. As there are so many parties get involved in this thing, both public authorities and private companies, they all have their positive or negative impact to the project. Considering this, major stakeholders need to be well identified and by doing the analysis of them to support the further procedure in decision-making.

As each stakeholder has their own position in the power/ interest grid, which can also be considered as their various preference and different opinion towards those possible alternatives are shown in the market. There are enormous information spreading in the market with latest report on technical side, official guideline issued by international organization, prediction report or assessment from professional consultant and attitude from private companies are full of the

market. The facts need to be considered when doing the decision making is also keep increasing, which makes the problem to be more and more complicated for all.

Different shipowner would use different strategy to get the solution, that depends on the background of information of the company, such as big liner company might prefer more on the option of installation of the EGCSs as the big liner vessels generally is under operating in quite stable shipping route with a massive consumption of bunker every day, in addition the freight of liners are keep in low level due to the economic situation globally. The decision of big liner company will influence the market prediction on this problem, but their preference can give no reference to other shipowner company, as they are facing totally different situation.

Like the company we are looking in the case study, they are a medium-small shipowner company with bulk carriers and general cargo vessel, and almost half of their vessels are under chartering or would be put into chartering market so that the decision are likely to be definitely different with those liner companies with the consideration in different criteria.

In order to simplify the decision-making process in the project, the method AHP has been defined as the best tool in such problem. By using the hierarchy structure to deconstruct the problem, can give a clear picture to support the decision maker. Instead of combining all facts together and getting more and more confused in the decision-making process, by following the method AHP to do those steps of weight allocation, prioritization of alternative regarding to different criteria and sub-criteria, it helps decision maker to quantify those intangible facts in the problem.

Instead of keeping the decision-making process in business negotiation area, the adoption of method AHP in this case provides another possible way in find solution more objective that when facing the final option get by the method AHP, the decision maker can find support in number from pairwise comparison, which is more realistic than arguing on blurred concepts.

As an attempt to adopt methodology of operational research area into practical business section, the result is on the same direction that shows in the feedback from market and shows the reason why such outcome could be get. It can lead to a wider apply of such method in similar problem in the future of this industry, not only in decision making but also in cases like shipping route selection or new vessel building project management etc.

## **7 BIBLIOGRAPHY**

- International Maritime Organization. (2015). *Third IMO GHG Study 2014*. London, UK: International Maritime Organization.
- Landin, S. O. (2008, 6 16). A comparative study of factors affecting the external stakeholder management process. *Construction Management and Economics*, pp. 553-561.
- Olander, S. (2007, 3 26). Stakeholder impact analysis in construction project management. *Construction Management and Economics*, pp. 277-287.
- Project Management Institute, Inc. (2013). *A Guide to the Project Management Body of Knowledge (PMBOK® Guide) – Fifth Edition*. Atlanta, U.S.A.: Project Management Institute, Inc.
- Saaty, T. L. (2004, 4 22). Rank from comparisons and from ratings in the analytic hierarchy/network processes. *European Journal of Operational Research*, pp. 557-570.
- SaatyL.Thomas. (1990). How to make a decision: The Analytic Hierarchy Process. *European Journal of Operational Research*, 页 9-26.
- Stefan Olander, A. L. (2005, 1 11). Evaluation of stakeholder influence in the implementation of construction projects. *International Journal of Project Management*, pp. 321-328.
- United Nations Conference on Trade and Development. (2018). *Review of Maritime Transport 2018*. Geneva, Switerland: UNCTAD secretariat.

## 8 ANNEX. JUDGEMENT OF EXPERTS

### A. Expert A

1. Of the two criteria being compared, which is considered more important by the shipowner with respect to the overall goal, the cost or the duration? And how important than the other?

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

2. Of the two criteria being compared, which is considered more important by the shipowner with respect to the overall goal, the cost or the technical risk? And how important than the other?

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

3. Of the two criteria being compared, which is considered more important by the shipowner with respect to the overall goal, the cost or the marketing risk? And how important than the other?

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

4. Of the two criteria being compared, which is considered more important by the shipowner with respect to the overall goal, the duration or the technical risk? And how important than the other?

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

5. Of the two criteria being compared, which is considered more important by the shipowner with respect to the overall goal, the duration or the marketing risk? And how important than the other?

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

6. Of the two criteria being compared, which is considered more important by the shipowner with respect to the overall goal, the technical risk or the marketing risk? And how important than the other?

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

7. Of the two sub-criteria being compared, which is considered more important by the shipowner with respect to the technical risk, the local regulation difference for EGCS installed vessels or the uncertainty in quality of bunker product? And how important than the other?

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

8. Of the two sub-criteria being compared, which is considered more important by the shipowner with respect to the marketing risk, the price gap between ordinary fuel oil and low sulphur fuel oil or the charterer's preference in vessels? And how important than the other?

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

9. Of the two sub-criteria being compared, which is considered more important by the shipowner with respect to the marketing risk, the price gap between ordinary fuel oil and low sulphur fuel oil or the future tighter policy trend in control of bunker sulphur content? And how important than the other?

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

10. Of the two sub-criteria being compared, which is considered more important by the shipowner with respect to the marketing risk, the charterer's preference in vessels or the future tighter policy trend in control of bunker sulphur content? And how important than the other?

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

11. When the considering the technical risk with the respect to the local regulation difference for EGCS installed vessels, which option is more preferred by shipowner, the installation of EGCS or the use of low sulphur compliant fuel oil? And how much is preferred than the other?

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

12. When the considering the technical risk with the respect to the uncertainty in quality of bunker product, which option is more preferred by shipowner, the installation of EGCS or the use of low sulphur compliant fuel oil? And how much is preferred than the other?

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

13. When the considering the marketing risk with the respect to the price gap between ordinary fuel oil and low sulphur fuel oil, which option is more preferred by shipowner, the installation of EGCS or the use of low sulphur compliant fuel oil? And how much is preferred than the other?

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

14. When the considering the marketing risk with the respect to the charterer's preference in vessels, which option is more preferred by shipowner, the installation of EGCS or the use of low sulphur compliant fuel oil? And how much is preferred than the other?

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

15. When the considering the marketing risk with the respect to the future tighter policy trend in control of bunker sulphur content, which option is more preferred by shipowner, the installation of EGCS or the use of low sulphur compliant fuel oil? And how much is preferred than the other?

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

**B. Expert B**

1. Of the two criteria being compared, which is considered more important by the shipowner with respect to the overall goal, the cost or the duration? And how important than the other?

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

2. Of the two criteria being compared, which is considered more important by the shipowner with respect to the overall goal, the cost or the technical risk? And how important than the other?

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

3. Of the two criteria being compared, which is considered more important by the shipowner with respect to the overall goal, the cost or the marketing risk? And how important than the other?

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

4. Of the two criteria being compared, which is considered more important by the shipowner with respect to the overall goal, the duration or the technical risk? And how important than the other?

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

5. Of the two criteria being compared, which is considered more important by the shipowner with respect to the overall goal, the duration or the marketing risk? And how important than the other?

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

6. Of the two criteria being compared, which is considered more important by the shipowner with respect to the overall goal, the technical risk or the marketing risk? And how important than the other?

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

7. Of the two sub-criteria being compared, which is considered more important by the shipowner with respect to the technical risk, the local regulation difference for EGCS installed vessels or the uncertainty in quality of bunker product? And how important than the other?

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

8. Of the two sub-criteria being compared, which is considered more important by the shipowner with respect to the marketing risk, the price gap between ordinary fuel oil and low sulphur fuel oil or the charterer's preference in vessels? And how important than the other?

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

9. Of the two sub-criteria being compared, which is considered more important by the shipowner with respect to the marketing risk, the price gap between ordinary fuel oil and low sulphur fuel oil or the future tighter policy trend in control of bunker sulphur content? And how important than the other?

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---



10. Of the two sub-criteria being compared, which is considered more important by the shipowner with respect to the marketing risk, the charterer's preference in vessels or the future tighter policy trend in control of bunker sulphur content? And how important than the other?

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

11. When the considering the technical risk with the respect to the local regulation difference for EGCS installed vessels, which option is more preferred by shipowner, the installation of EGCS or the use of low sulphur compliant fuel oil? And how much is preferred than the other?

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

12. When the considering the technical risk with the respect to the uncertainty in quality of bunker product, which option is more preferred by shipowner, the installation of EGCS or the use of low sulphur compliant fuel oil? And how much is preferred than the other?

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

13. When the considering the marketing risk with the respect to the price gap between ordinary fuel oil and low sulphur fuel oil, which option is more preferred by shipowner, the installation of EGCS or the use of low sulphur compliant fuel oil? And how much is preferred than the other?

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

14. When the considering the marketing risk with the respect to the charterer's preference in vessels, which option is more preferred by shipowner, the installation of EGCS or the use of low sulphur compliant fuel oil? And how much is preferred than the other?

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

15. When the considering the marketing risk with the respect to the future tighter policy trend in control of bunker sulphur content, which option is more preferred by shipowner, the installation of EGCS or the use of low sulphur compliant fuel oil? And how much is preferred than the other?

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

**C. Expert c**

1. Of the two criteria being compared, which is considered more important by the shipowner with respect to the overall goal, the cost or the duration? And how important than the other?

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

2. Of the two criteria being compared, which is considered more important by the shipowner with respect to the overall goal, the cost or the technical risk? And how important than the other?

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

3. Of the two criteria being compared, which is considered more important by the shipowner with respect to the overall goal, the cost or the marketing risk? And how important than the other?

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

4. Of the two criteria being compared, which is considered more important by the shipowner with respect to the overall goal, the duration or the technical risk? And how important than the other?

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

5. Of the two criteria being compared, which is considered more important by the shipowner with respect to the overall goal, the duration or the marketing risk? And how important than the other?

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

6. Of the two criteria being compared, which is considered more important by the shipowner with respect to the overall goal, the technical risk or the marketing risk? And how important than the other?

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

7. Of the two sub-criteria being compared, which is considered more important by the shipowner with respect to the technical risk, the local regulation difference for EGCS installed vessels or the uncertainty in quality of bunker product? And how important than the other?

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

8. Of the two sub-criteria being compared, which is considered more important by the shipowner with respect to the marketing risk, the price gap between ordinary fuel oil and low sulphur fuel oil or the charterer's preference in vessels? And how important than the other?

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

9. Of the two sub-criteria being compared, which is considered more important by the shipowner with respect to the marketing risk, the price gap between ordinary fuel oil and low sulphur fuel oil or the future tighter policy trend in control of bunker sulphur content? And how important than the other?

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

10. Of the two sub-criteria being compared, which is considered more important by the shipowner with respect to the marketing risk, the charterer's preference in vessels or the future tighter policy trend in control of bunker sulphur content? And how important than the other?

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

11. When the considering the technical risk with the respect to the local regulation difference for EGCS installed vessels, which option is more preferred by shipowner, the installation of EGCS or the use of low sulphur compliant fuel oil? And how much is preferred than the other?

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

12. When the considering the technical risk with the respect to the uncertainty in quality of bunker product, which option is more preferred by shipowner, the installation of EGCS or the use of low sulphur compliant fuel oil? And how much is preferred than the other?

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

13. When the considering the marketing risk with the respect to the price gap between ordinary fuel oil and low sulphur fuel oil, which option is more preferred by shipowner, the installation of EGCS or the use of low sulphur compliant fuel oil? And how much is preferred than the other?

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

14. When the considering the marketing risk with the respect to the charterer's preference in vessels, which option is more preferred by shipowner, the installation of EGCS or the use of low sulphur compliant fuel oil? And how much is preferred than the other?

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

15. When the considering the marketing risk with the respect to the future tighter policy trend in control of bunker sulphur content, which option is more preferred by shipowner, the installation of EGCS or the use of low sulphur compliant fuel oil? And how much is preferred than the other?

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---