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Challenges/issues of implementing MARPOL Annex VI in Papua New Guinea: an assessment from the regulator's point of view with recommendations for national implementation.

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CHALLENGES/ISSUES OF IMPLEMENTING MARPOL ANNEX VI IN PAPUA NEW GUINEA

An assessment from the regulator's point of view with recommendations for national implementation

By

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Declaration

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

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

(Signature):
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Supervisor's affiliation**.....**

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Abstract

Title of Dissertation: **CHALLENGES/ISSUES OF IMPLEMENTING MARPOL ANNEX VI IN PAPUA NEW GUINEA. An assessment from the regulators point of view with recommendations for national implementation.**

Degree: **Master of Science**

KEYWORDS: Maritime regulator, Energy, Climate change, Sulphur, Pollution, Ship

The shipping industry's share of the emission of pollutants into the atmosphere and the effect it has to human health and the environment is increasingly becoming important. With the trend predicted to have a significant impact if the industry continues on the business as usual scenario, the IMO is pushing for the member states to ratify and adopt MARPOL Annex VI by making some of the requirements mandatory for all members which will address the increasing global climate problem.

In preparation to this effort of ratifying MARPOL Annex VI in a small island developing state like Papua New Guinea, this study was undertaken with the aim of identifying the challenges in its implementation and recommend appropriate measures for effective implementation. In order to address this, a questionnaire survey was conducted targeting key stakeholders understanding of MARPOL Annex VI and how they viewed the importance of this instrument. Together with the survey, a PESTLE analysis complemented by a SWOT analysis of the maritime administration agency was undertaken to identify preparedness level and point out challenges.

The findings revealed that there was still a need to understand better the requirements of MARPOL Annex VI by the stakeholders that were to implement the instrument and that these levels of understanding could hinder effective implementation of the instrument. In light of the findings, there were recommendations made so that the challenges identified will be addressed when the instrument is adopted and implemented in the country.

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List of Abbreviations

N_2	Nitrogen
O_2	Oxygen
CO_2	Carbon dioxide
NOx	Nitrogen oxide
SOx	Sulphur oxide
CO	Carbon monoxide
HC	Hydrocarbon
PM	Particulate matter
IPCCAR5	Intergovernmental Panel on Climate Change Fifth Assessment Report
GHG	Greenhouse gas
CH_4	Methane
LNG	Liquefied Natural Gas
IMO	International Maritime Organisation
NDC	Nationally Determine Contribution
CBDR	Common but differentiated responsibility
NMFT	No more favourable treatments
MARPOL	The International Convention for the Prevention of Pollution form Ships
EGCS	Exhaust Gas Cleaning Systems
SIDS	Small Island Developing States
PIC	Pacific Island Countries
SO_2	Sulphur dioxide
VOC	Volatile Organic Compounds
UV	ultra violet
WHO	World Health Organisation
PAH	polycyclic aromatic hydrocarbon

UNFCCC	United Nations Framework Convention on Climate Change
LOSC	United Nations Convention on the Law of the Sea
ODS	Ozone depleting substance
ECA	Emission Control Area
EEDI	Energy Efficiency Design Index
SEEMP	Ships energy efficiency Management Plan
GT	Gross Tonnage
IEEC	International Energy Efficiency Certificate
DCS	Data Collection System
RO	Recognised Organisation
IAPP	International Air Pollution Prevention
IPCC	Inter-governmental Panel on Climate Change
IOM	International Organisation of Migration
HSFO	High Sulphur Fuel Oil

1. Introduction

1.1 Study Context

Air pollution has in recent years become one of the most significant environmental issues in the world attracting global interest. According to Campara et.al, (2018), the major sources of air pollution over the last three decades were thought to be from land based sources like large industrial plants and road vehicles and received more attention resulting in it being regulated and reduced. However, ships were considered too mobile, too far from the coast and was thought to be insignificant until research into air pollution from ships was undertaken confirming the necessity to develop international regulations to limit these harmful emissions. The main problem is identified by Witknowski (2020) as the combustion products emitted from the marine diesel oil comprising of exhaust gas like nitrogen (N_2), Oxygen (O_2), carbondioxide (CO_2) and water vapour and pollutants including nitrogen oxides (NOx), sulphur oxides (SOx), carbon monoxide (CO), hydrocarbons (HC) and particulate matter (PM).

One of the main concerns nowadays is the issue of climate change induced by greenhouse gas (GHG) concentrations in the atmosphere and its impact on people and the environment that presents the life support systems. The main drivers to the increase of the concentration of these air pollutants can be attributed to global economic and population growth. As pointed out in the Intergovernmental Panel on Climate Change Fifth Assessment Report (IPCCAR5), the climate system has warmed up resulting in atmosphere and ocean becoming warmer and the amounts of snow and ice disappearing with sea level rising. Anthropogenic GHG emission is the main cause giving rise to increased atmospheric concentration of the GHG components that includes carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (NOx). This has seriously contributed to the impact on natural and human systems across the globe where terrestrial freshwater and marine species has shifted biogeographical regions,

their seasonal and migration patterns affected, crops having yields dropping and oceans acidification increasing. Further, extreme weather and climate events like the change of temperature to either cold or warm extremities, increasing extremely high sea levels and number of heavy precipitation level have all become rampant (IPCC, 2014). These issues have therefore increased global awareness and the need to globally address them.

Looking at shipping industry and its contribution to climate change issues, shipping industry contributes just over 2% of the total emissions which is comparable to Germany's total emissions and will significantly increase if the industry continue to operate on the business as usual scenario (Doelle & Chircop, 2019). The impact of total shipping emissions contributing to air pollution affecting the quality of air and leading to observed changes in the global climate regime and the environment is now distinctively clear with future projections made. The third International Maritime Organisation (IMO) GHG Study 2014 had already predicted future scenarios showing significant increase of CO_2 emission followed by NOx but at a lower rate as a result of tier II and III engines but CH_4 is projected to increase rapidly when liquefied natural gas (LNG) is added to the ship bunker mix. The overall particulate matter (PM) and SOx has been foreseen to continue to decline with set reduction of SOx targets to be implemented by January 2020 (IMO, 2014). While the fourth IMO GHG Study 2020 maintains that CO_2 remains the dominant source of shipping's climate impact consistent with the third IMO GHG Study 2014, the GHG emission of total shipping that included international, domestic and fishing had increased from 977 million tonnes in 2012 to 1,076 million tonnes in 2018 (IMO, 2020a). This showed an increasing GHG emission trend by the shipping sector thus calling for serious efforts to decarbonize shipping and reduce other GHG which to this time still poses a big challenges for effective implementation.

In Papua New Guinea, many will argue that the issue of air pollution is not considered serious but climate change issues that are resultant of the air pollution issue is

becoming increasingly important. Issues like sea level rise that has resulted in the world's first climate change refugees in the Cateret Islands, declining coastal and marine resources, disturbed and unpredictable hydrological regimes and loss of critical habitat and biological diversity obviously calls for more climate actions and thus points towards the need of addressing air pollution. According to the second Papua New Guinea's Enhanced Nationally Determined Contribution (NDC) 2020 submission to the Paris Convention, it was stated that the country saw a net increase of the GHG from 2002 to 2015 which supports the need for action (PNG Climate Change and Development Authority, 2020). With the country being ranked as the tenth vulnerable country in the world to the risk of climate change, this status calls for more attention which justifies its contribution towards a collective and global effort as shown by its participation in the Paris Agreement.

While noticing the vulnerability of the regions of the country including its coastal communities to climate change issues, it has placed a strong emphasis on working towards implementing the requirements through its NDC's. Additionally PNG is also an International Maritime Organisation (IMO) member state and thus has an obligation in adopting the IMO conventions for implementation in the country. As part of this commitment, it takes the adoption and implementation of MARPOL Annex VI as an important step forward in addressing the air pollution and energy efficiency components of its vessels registered under its flag and also as a port state function. This will also compliment the NDC's that are required under the Paris Agreement for the common good of addressing reduction of GHG. Given that the Paris Agreement requirements are more flexible under the common but differentiated responsibility (CBDR) notion, the implementation of MARPOL Annex VI when adopted and becomes mandatory will incorporate the notion of 'no more favourable treatment' (NMFT) which will then see a lot of challenges arising for the different stakeholders. Therefore, there is a strong need for the challenges associated with its implementation and enforcement to be identified and best possible alternatives and options are proposed to address effective implementation of this convention in the country.

1.2Statement of Problem

Papua New Guinea is an archipelagic state that depends on coastal trade ship movements that move goods around the country from the main ports that are visited by international vessels. This includes the many small outer lying ports and inland water ways that are inaccessible by road. Given the increasing mineral and petroleum resources boom in the country, trade by shipping is highly likely to increase to move the internationally obtained plant and equipment as well as goods and services. Furthermore, people movement between maritime provinces will increase placing more demand for more vessels.

Knowing that Papua New Guinea is a party to the MARPOL Convention and has to ratify the implementation of MARPOL Annex VI, the question of its readiness to easily and effectively roll out its implementation to its flag vessels while carrying out its port state obligations pertaining to implementation of MARPOL Annex VI raises concern. Given the many requirements and their implementation deadline lapsing like the IMO Strategy targets, Papua New Guinea is yet to formally ratify the convention and have it incorporated into the national legislation as it has done for other MARPOL Annexes. The Marine Pollution (Ships and Installation) Act 2013 is the national legislation that covers the MARPOL Annexes but does not include Annex VI, and there is an eminent need to incorporate MARPOL Annex VI before its full implementation is recognised.

With the stringent measures of the implementation of this annex like the IMO 2020 requirements where ships are required to use fuels with a sulphur content of 0.50% m/m or lower or have an approved equivalent means of compliance such as the exhaust gas cleaning system (EGCS) commonly known as the scrubbers or the use of non-fuel oil alternatives such as switching to liquefied natural gas (LNG), vessels in Papua New Guinea have a high tendency of not being able to swiftly incorporate these

requirements once PNG ratifies the annex and regulates for implementation. Knowing that on the one hand the adoption and implementation of this annex will contribute to the widely accepted benefit of reducing greenhouse gas and addressing human health issues, on the other hand there is a very high likelihood that the stringent measures of this annex will not be easily accepted because of the unfamiliarity of the requirements amongst the industries. Therefore there is a clear need to address the issue of implementation and this will then require a clear strategic pathway after challenges and issues are identified and this study looks at addressing this uncertainty.

When revisiting studies already undertaken for maritime sectors in PNG especially related to IMO Conventions and shipping, there has been studies undertaken to improve maritime sector in PNG overall but identification of issues related to implementation of MARPOL Annex VI in Papua New Guinea with recommendation for improved implementation has not been undertaken. Examples of maritime studies include study by Rupen (1987) undertaken for the shipping industry in PNG back in the 1980s with emphasis to coastal shipping, a recent study by Gwaday (2019) who undertook a study and looked at identifying issues impacting search and rescue of small vessels operating in PNG waters and a study by Hauseng (2020) who looked at the main causes of inadequate maritime safety taking into considerations the three main obligations of accident investigation, surveys and audits of the maritime administration. As such, this study undertaken will look at improving the implementation of MARPOL Annex VI and directly contribute to improvement of shipping and the maritime sector in the country.

In summary, this study specifically looks at providing a direction to the maritime administration agency (PNG National Maritime Safety Authority) in the country by identifying issues and challenges that can be faced in implementing the MARPOL Annex VI convention in the country and thus make recommendations for a strategic pathway development to effectively implement the requirements including IMO 2020 beyond its date of entry into force. This will require a synergistic effort by all

stakeholders from the administration, port authority and facility operators, the shipping industry, the fuel suppliers and those other interrelated government agencies in the country. In doing so, the study will not only contribute to providing directions for addressing air pollution and climate change issues from shipping sector by implementing MARPOL Annex VI requirements but it will also serve as a reference to other Pacific Island nations and other developing nations, especially the small island developing state states (SIDS) to prepare for implementing the requirements of this convention.

1.3 Aim of the study and the Objectives

The aim of the study is to identify the challenges of implementing MARPOL Annex VI in Papua New Guinea and determine and recommend appropriate actions to allow for an effective implementation and enforcement of MARPOL Annex VI.

In order to address the aim of the study, the following objectives are used and they are to;

i) Determine the significance of implementing MARPOL Annex VI in Papua New Guinea and its implications to addressing the issues of air pollution and improve energy efficiency to address climate change.

ii) Assess and evaluate the level of preparedness in implementing MARPOL Annex VI in Papua New Guinea.

iii) Identify the main/major challenges that can be encountered when implementing MARPOL Annex VI by the key stakeholders that includes the administration agency, the port regulator and operators, the ship owners, shipping companies and the fuel suppliers.

iv) Recommend appropriate measures for implementation by the stakeholders identified.

1.4 Research questions

i) How do the key stakeholders view the implementation of the MARPOL Annex VI in terms of its significance to improving air pollution and energy efficiency for combating climate change?

ii) What is the level of preparedness of the key stakeholders in implementing MARPOL Annex VI in Papua New Guinea?

iii) What are the major challenges faced by these key stakeholders in effectively implementing MARPOL Annex VI?

iv) What are the appropriate measures available to be recommended for implementation and how can they be used to address the challenges?

1.5 Significance of study

The study provides some insights on the issues and challenges associated with implementing MARPOL Annex VI Convention in Papua New Guinea. It provides some baseline information and data on which recommendations are made, that can be helpful when addressing issues and challenges of implementing MARPOL Annex VI in other Pacific Island Countries (PIC) as well as small island developing states (SIDS).

Overall, the study addresses the primary objective of the IMO's air pollution emission control and reduction effort developed as a roadmap through the IMO GHG Reduction Strategy and its vision re-affirming the commitment to reducing GHG emission from shipping. Therefore this study looks at ways to improve PNG's country effort when implementing MARPOL Annex VI Convention. In doing so, the study also contributes to fulfilling the country and Pacific region's commitment to the Paris Climate Change convention through its NDC.

1.6 Research Method

Data collection for this research involved both primary and secondary sources. For primary source, a questionnaire survey was used targeting the groups of interest which includes;

- The PNG National Maritime Safety Authority as the maritime administration agency acting in the interest as flag, port and coastal state,
- The PNG Ports Corporation Limited which is the port regulator and operator,
- The ship owners and the shipping companies which will be directly affected by the implementation of MARPOL Annex VI and IMO 2020, and;
- The marine fuel suppliers who will be directly impacted by the implementation of MARPOL Annex VI and IMO 2020

Secondary sources through literature review was done and included common internet search engines like google, google scholar and World Maritime University online library. This included peer reviewed journals, scientific publications and other websites. Further, country reports, policy papers and strategy information is used for PESTLE analysis exercise to identify those issues that needs to be addressed for the shipping industry that includes the main stakeholders mentioned. The analysis was used to identify risks and influential factors that has been complemented by a SWOT analysis to put into perspective the strengths, weaknesses, opportunities and threats of the main stakeholders in implementing MARPOL Annex VI.

1.7 Structure of thesis

In *Chapter 2: Literature Review*, the topics that underpin this study are examined. Firstly the relationship of air pollution and climate change is examined to create a basic understanding of the role MARPOL Annex VI plays in addressing air pollution prevention and energy efficiency while combating the global climate change phenomenon. This is followed by the description of the emergence of MARPOL Annex VI through the IMO as a measure to reduce air pollution from shipping while

also acting as the mitigation measure to address climate change issues. The ensuing section then looks at the challenges that can be faced by a member state who is party to the convention in implementing and enforcing the convention. Finally, strategies adopted in other countries are looked at that is available and can be easily incorporated to address the issue.

In *Chapter 3: Methodology*, the methodology involved in the activities undertaken is described. There were three different types of activities undertaken in this survey and that includes PESTLE analysis, SWOT Analysis and a semi-structured questionnaire survey. This section presents the procedures followed in the obtaining the data in the three different types of activities.

In *Chapter 4: Results*, the result of the activities involved are described with their statement of results.

In *Chapter 5: Discussion*, the results of each activity are drawn together and the implications of the results are discussed in line with the way key stakeholders viewed the implementation of MARPOL Annex VI in PNG in terms of its significance to improving air pollution and combating climate change, the level of preparedness of the various sectors considering political and legal, socio-economic, technological and environmental levels. Further the discussion covers the strengths, weaknesses, opportunities and threats of the key stakeholder organisations and also highlights the possible challenges that can be faced by way of implementation and enforcement. This then leads on to discussing the possible management options that can be implemented by the stakeholders.

In *Chapter 6: Conclusion and Recommendation with some future research option*, the strategies that can be used to enhance effective implementation of MARPOL Annex VI in PNG are summarised and recommendations are made to improve the overall implementation and enforcement with a highlight of some future research options.

2. Literature Review

2.1 Understanding air pollution

2.1.1 Defining air pollution

Air pollution can be defined as the presence of substance in the air that can have harmful effects on humans, animals, vegetation or material (Schraufnagel et.al, 2019). According to Manisalidis et.al (2020), air pollution is defined by first outlining the multiple interactions that human have with their physical surroundings that influences the environment. With the understanding that the environment is comprised of the biotic (living organisms and micro-organisms) and the abiotic (hydrosphere, lithosphere and atmosphere), pollution is defined as the introduction into the environment substances that are harmful to humans and other micro-organisms. These harmful substances are referred to as pollutants and come in the form of solid, liquid and gas produced in a higher than usual concentration that reduce the quality of the environment. In the case of air pollution, it is the atmosphere that receives these pollutants which in turn affects the human beings, animals, plants and the ecosystem services.

Air pollution comes from various sources like industry and transport and can have different characteristics depending on composition, source and condition under which they are produced. Some of the common gas produced are comprised of sulphur oxides (mainly sulphur dioxide [SO_2]), nitrogen oxides (mainly nitrogen oxide and nitrogen dioxide), reactive hydrocarbons (normally referred to as volatile organic compounds (VOCs) and carbon monoxide. These gases are called primary pollutants because they are directly released into the atmosphere. Others like the gaseous and particle pollutants that are derived from the primary pollutants are called secondary pollutants (Schraufnagel et.al, 2019). Figure 1 presents some of the common air pollutants that is emitted into the atmosphere every day.

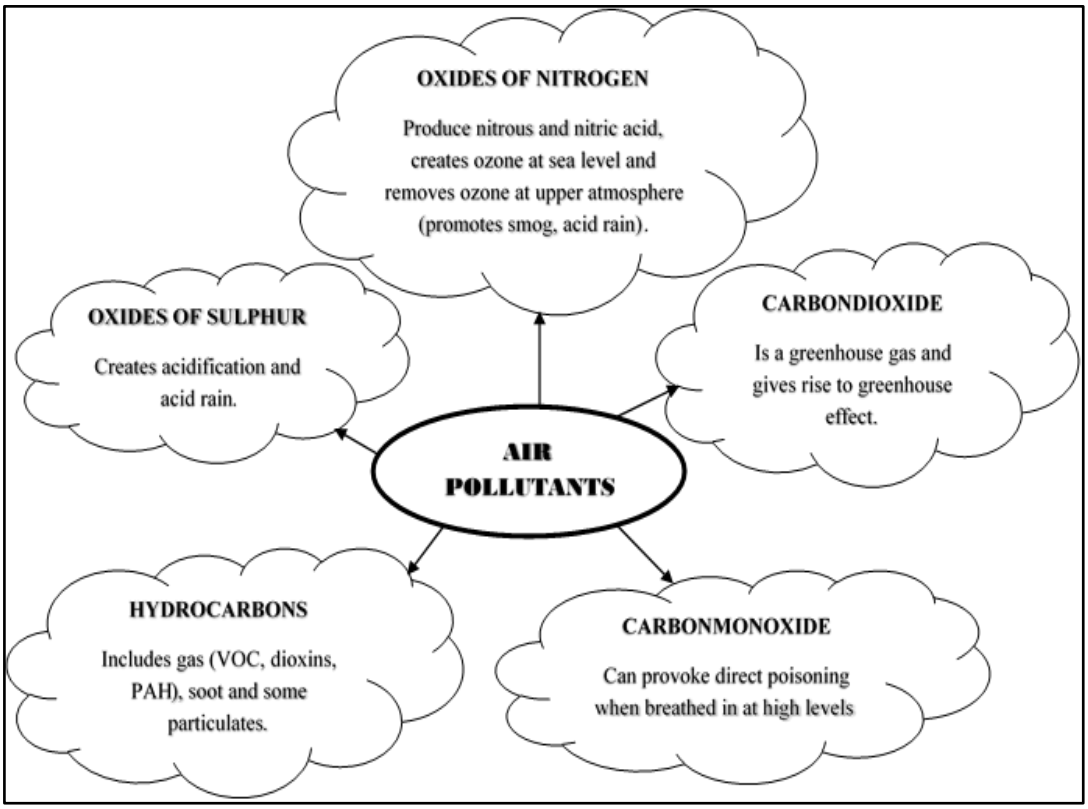

Figure 1. Examples of the common air pollutants. Compiled by author.

2.1.2 The cause and effect of air pollution

The issue of air pollution has attracted more attention in the last century giving rise to more studies being undertaken relating to its impact on both human and the ecosystem health. While the effect on the human system has been direct, the effect on the ecosystem health has been associated to climate change that again affects the health of humans and ecosystem with close to trillion tonnes of air pollutants and climate pollutants have already been added to the atmosphere. As seen from the air particles sampled from the air, it showed that air consisted of sulphates and nitrates from fossil fuel, black carbon from diesel combustion and biomass burning and mineral dust, and sea salt particles from natural sources. These particles showed that they can travel far and wide by atmospheric winds and can trap sunlight in blue and ultra-violet (UV)

wavelengths. Some of the major climate pollutants identified are gasses like carbon dioxide, methane, nitrous oxide, halocarbons and refrigerants that absorb and emit infra-red (heat) radiation and thus warm the planet (Ramanathan 2020).

According to Manisalidis et.al (2020), the World Health Organisation (WHO) mentions six major air pollutants and they are particle pollution, ground level ozone, carbon monoxide, sulphur oxides, nitrogen oxides and lead. These pollutants are said to be more related to human health and environment impacts through issues like acid rain, global warming, greenhouse effect and climate changes. Similar airborne pollutants are mentioned by Herdzik (2021) as a product of combustion of hydrocarbon fuels in ships that makes up the emission from the transport sector. The common pollutants identified are oxides of nitrogen, oxides of sulphur, carbon dioxide, carbon monoxide and hydrocarbons in the form of gas, soot and some particles.

Table 1. The common pollutants that are emitted from ships showing their effects to human health and the environment. Compiled by author.

Pollutant	**Effects to human health and environment**
Oxides of Nitrogen (NOx)	• These gases combine with water and oxygen in the atmosphere to produce nitrous and nitric acid which are highly corrosive. • Nitrogen dioxide (a reddish brown highly toxic gas) causes lung damage • At sea level, these gases reach with organic compounds to produce low level ozone (O_3) which is a significant pollutant and a cause of smog. • In the upper atmosphere the same gas (NO_2) react to remove ozone. • The gasses travel great distance from source of production and create smog, acid rain and so on.

Pollutant	Effects to human health and environment
Oxides of sulphur (SOx)	• Affects human health through irritation, bronchitis, lung issues, skin redness, damage to eye and cardiovascular issues. • Associated to environmental issues like acidification of soil and acid rain.
Particulate Matter (PM)	• The polycyclic aromatic hydrocarbons (PAH) present in residual fuel oil are highly carcinogenic • The unburnt particles represented in the soot that consist heavy metals and organic materials are carcinogenic and can be drawn deeper into the bronchial passage and are known to induce asthma, bronchitis and heart failure.
Carbon monoxide (CO)	• Produced by incomplete combustion of fossil fuel which can be lethal to human in high concentration through poisoning. • It contributes with the greenhouse gases that are connected to global warming and climate change.
Carbon dioxide (CO_2)	• This is a major greenhouse gas that gives rise to global warming and climate change.
Volatile Organic Compounds (VOCs)	• At sea level, these compounds reach with oxides of nitrogen to produce low level ozone (O_3), a significant polluter and creator of smog. • VOCs such as toluene are found to associate with cancer in humans
Polycyclic Aromatic Hydrocarbons (PAHs)	• Found in coal and tar sediment and are generated through incomplete combustion, incineration and engines.

Pollutant	Effects to human health and environment
	• Recognised for its toxic, mutagenic and carcinogenic properties and is an important risk factor for cancer.

From the attention that air pollution has attracted, many studies have been conducted and the effects of air pollution has been identified. The two main areas are the effects of air pollution on health of human and the impact of air pollution on the environment. Manisalidis et.al (2019) presents the effects of health as both short term and long term of which both exhibit some form of diseases symptoms. While the short term effects are temporary, they have the tendency to lead into difficulties. The long term effects can be chronic and very harmful in that, they affect the neurological, reproductive and the respiratory systems and causes cancer. The environmental impacts caused by air pollution is also gaining more attention. The important effects on the environments are acid rain, haze, global climate change and others.

Realising the health effects and environmental impacts of air pollution, many international institutions have recognised the need to address the issue of air pollution as they do not only give rise to economic impacts but also affects the societal functions when human and livelihoods are affected. The international agreements for climate change by the United Nations Framework Convention on Climate Change (UNFCCC), the World Health Organisation (WHO) and the International Maritime Organisation (IMO) are some of the many organisations that are vigorously working towards addressing this issues of air pollution and its effect on human health and the impact on the environment.

Therefore, as Mansiladis et.al (2019) suggests, a global prevention policy is needed to curb and combat anthropogenic air pollution with the application of sustainable development practices while taking into considerations information coming from research. In support of such calls, the IMO through its implementation of the

MARPOL Annex VI Convention in addressing the prevention of air pollution from ships through its member states show a determined effort in addressing such from the shipping sector which constitutes the overall transport sector and it is work ongoing.

2.2 The emergence of MARPOL Annex VI

Air pollution from maritime transport has been seen to have an international character where urgent necessity for international regulations to limit harmful emissions became increasingly important. Several international conventions of general character relating to air pollution did take into account air pollution issues, one of the most profound one is the United Nations Convention on Law of the Sea (LOSC) adopted and signed in 1982. Being an international framework that calls for protection and preservation of marine environment including addressing of pollution damage amongst others, the call for dealing with pollution of sea and air has been mentioned specifically in Article 212 [7]. Through this convention, the parties to LOSC were authorised to adopt national regulations for the prevention, reduction and control of marine pollution from air or indirectly through air while also considering international recognised norms, standards and recommended practices (Campara et.al 2018).

Doelle & Chircop (2018) present a clear outline of how the issue of air pollution emissions associated with international shipping was tossed under the United Nations Framework Convention on Climate Change, 1992 (UNFCCC). Options of allocating emissions to individual state parties were considered but none of the options has been selected and thus remains open. The 1997 Kyoto Protocol did continue to maintain the discussions on emission by international shipping but did not allocate emissions of shipping to international parties and instead called for developed countries to work together through the IMO. However, the Paris Agreement in 2015 failed to uphold the Kyoto Protocol commitment but it also did not dismiss and restrict the commitment to be pursued by IMO through its member states. This sets a scene where it negates the

conflict of interest of a member state of both organisation working towards two different commitment and thus keeps the options of commitment still open.

The increasing awareness of air pollution from ships causing a cumulative effect together with other sources of air pollution saw the need for shipping industry to regulate emissions from the ships. This saw the inclusion of the MARPOL Annex VI in the MARPOL Convention with the 1997 Protocol amendments for the first time to regulate harmful compounds emitted from ships (Campara et.al 2018). The main aims were focused at limiting main air pollutants emitted from ship exhaust gas like sulphur oxide (SOx), nitrous oxide (NOx) and also prohibit deliberate emission of ozone depleting substances (ODS). Further the annex focused on regulating shipboard incineration and emission of volatile organic compounds (VOC) from tankers. This saw the development of regulations within the MARPOL Annex VI.

In fact, MARPOL Annex VI entered into force on 19 May 2005. However, this annex was then revised again noting the technological improvements as well as the implementation experience that resulted in the revised MARPOL Annex VI and associated NOx Technical 2008 guidelines being adopted in October 2008. The revised version entered into force on 01 July, 2010. The revised version included main changes that included progressive reduction in the emission of SOx, NOx and particulate matter while also introducing emission control area (ECA) for further reduction of emission of these pollutants within these special areas (IMO 2019). Further to this, the changes for energy efficiency measures aimed at reducing GHG emissions primarily CO2 saw the adoption of the new Chapter 4 regulations on energy efficiency that came into force on 01 January 2013 (Campara et.al 2018).

Under the revised MARPOL Annex VI, the revisions involving SOx saw global sulphur limit reduced from 3.5% m/m to 0.5% m/m effective from 1 January 2020 whereas the ECAs had their SOx and particulate matters reduced to 0.1% m/m starting 1 January 2015.The revisions on progressive reductions in emission from marine

diesel engines installed on ships involved the tier level emissions. Tier I emission limits involve marine diesel engines installed on a ship constructed on or after 1 January 2000 and prior to 1 January 2011. Additionally, marine diesel engines installed on a ship constructed on or after January 1990 but prior to January 2000 are required to comply with their tier I emission limits if an approved method has been certified by the administration. The Tier II emission limits are for marine diesel engines that is installed on a ship constructed on or after 1 January 2011 with more stringent requirements. Tier III emission limits are for engines installed on a ship constructed on or after 1 January 2016 and operating in the ECAs and this is summary requirements are shown in Table 2.

Table 2. MARPOL Annex VI Tier levels and their nitrogen oxide limit level (Campara et.al 2018).

Tier	**Ship's construction date (on or after)**	**Total weighted NOx emission limit value (g/kWh)** ***n = engine's rated speed/crankshaft revolutions per minute (rpm)***		
		n < 130	**n = 130 - 1999**	**n ≥ 2000**
I	1 January 2000	17.0	$45 \bullet n^{(-0.2)}$	9.8
II	1 January 2011	14.4	$44 \bullet n^{(-0.23)}$	7.7
III	1 January 2016* 1 January 2021**	3.4	$9 \bullet n^{(-0.2)}$	2.0

*ships operating in the North America or the US Caribbean ECA. **ships operating in the Baltic Sea or the North Sea ECA.

The inclusion of recognising the ECAs in this annex has been another significant step forward in further preventing pollution from ships. To attain the ECA recognition, a specific sea area including port areas submit to the International Maritime Organisation (IMO) a proposal following guidelines outlined in appendix III of MARPOL Annex VI requesting the designation of the area to an ECA. Currently there are four areas recognised as ECAs shown in Table 3. In these areas specific standards

are controlled as required in regulation 13 on emission control of NOx through Tier III emission standards and regulations 14 on control on SOx limits of 0.1% m/m.

Table 3. MARPOL Annex VI ECAs showing the dates of adoption, entry into force and effect date of SOx and NOx (Campara et.al, 2018).

Emmission Control Areas (ECAs)	**Controlled compounds**	**Adoppted by IMO**	**Entry into force**	**Effective from**
Baltic Sea area	SOx	26 Sept 1997	19 May 2005	19 May 2006
	NOx	7 Jul 2017	1 Jan 2019	1 Jan 2021
North Sea area	SOx	22 Jul 2005	22 Nov 2006	22 Nov 2007
	NOx	7 Jul 2017	1 Jan 2019	1 Jan 2021
North American Sea area	SOx; PM	26 Mar 2010	1 Aug 2011	1 Aug 2012
	NOx	26 Mar 2010	1 Aug 2011	1 Jan 2016
US Caribbean Sea area	SOx; PM	26 Jul 2011	1 Jan 2013	1 Jan 2014
	NOx	26 Jul 2011	1 Jan 2013	1 Jan 2016

In terms of the regulations on energy efficiency for ships, there are two main requirements with the main technical measure of compliance referred to as the Energy Efficiency Design Index (EEDI) supported by the second requirement referred to as the Ship Energy Efficiency Management Plan (SEEMP). These requirements apply to all international trading vessels of 400GT and more. The EEDI is a performance based mechanism for a new ship or one that has undergone a major conversion. This is minimum energy efficiency calculated using the IMO developed formula and this minimum energy efficiency is weighted through Required EEDI and Attained EEDI where Attained EEDI should be equal to or less than the Required EEDI. The SEEMP is required for the purpose of establishing operational mechanisms in terms of fuel efficiency, thereby improving ships energy efficiency performance. Unlike EEDI, the SEEMP is not subject to approval by flag administration but is required on board a vessel before issuance of the first International Energy Efficiency Certificate (IEEC).

Additional to the two energy efficiency regulation requirements is the recent mandatory requirement of collection and reporting of ship fuel oil. Being termed as the recent significant milestone in the GHG reduction in ships, the requirement calls for all ships of 5000GT and more to collect fuel oil consumption data for the types they use. Other data requirements covering the energy efficiency of ships like distance travelled, service hour at sea and cargo capacity are required under this new regulation 22A of MARPOL Annex VI. This regulation was adopted on the 28 October 2016 and came into force in 01 March 2018 with the first reporting period targeted at 01 January 2019 with the underlying objective of providing global centralised data base that will enable more accurate analysis for informed decision making.

2.3 Implementation and enforcement of MARPOL Annex VI

The MARPOL Annex VI is made up of four chapters and the appendices. The first chapter gives a general overview by introducing some of the conventions terms used and provides some useful definitions. The exceptions and exemptions of the application of this Annex is also presented in this chapter. The second chapter talks about the surveys, certification and means of control when implementing this annex. The chapter describes the survey requirements, certification system and control principles. The chapter also outlines the port state control issues and violation detection as well as enforcement. The third chapter points out the key requirements for control of emissions from ships. The chapter outlines the measures and requirements to address air pollutants that includes ozone depleting substances, nitrogen oxides, sulphur oxides with particulate matter and volatile organic compounds. Included with this is the shipboard incineration, reception facilities and the bunker management that includes fuel oil availability and quality. The fourth chapter outlines the energy efficiency for ships with the main intent to regulate some operational and design aspects of the ship. Additionally, the mandatory data collection system (DCS) and the

need to promote technical co-operation and transfer of technology is also covered in this chapter.

In order for a state to effectively implement and enforce an instrument, in this case is the MARPOL Annex VI, state has to become a party to the instrument. Once the IMO instruments are concluded between members, they are international instruments and these instruments are normally there for states to transpose into national law to prevent international treaty obligations and liability in international law after having ratified it (Muriithu 2019). Also the instruments then becomes legally binding and mandatory for the member state to implement and enforce and be able to prosecute in the event that requirements are not being obliged to.

For the purpose of establishment of compliance in this Annex, all ships of 400GT and above as well as floating drilling rigs and other platforms are subject to surveys in compliance with the requirements as specified in Chapter 3 on air pollution prevention measures. Specific to this section, an initial survey is required before the ship is put into service followed by renewal surveys that are specified by the administration not exceeding five years. Further, the ship will also be subject to an intermediate survey within three months before or after the second anniversary date of the certificate or within three months before or after the third anniversary date of the certificate which is will also take the place of the annual survey as pointed out in paragraph 4 of regulation 5. The surveys are to be carried out by the officers of the administration or by Recognised Organisation (RO) normally referred to as Class Societies. The ships to which chapter 4 on energy efficiency measures of the Annex applies, an initial survey is required to be carried out before a new ship is put into service. This is to verify the ships attained EEDI and to ascertain that it is captured in the SEEMP and this is kept on board the vessel.

When a vessel shows compliance to the surveys undertaken, certificates are endorsed and issued to show that the vessel is compliant to the MARPOL Annex VI

requirements. An International Air Pollution Prevention (IAPP) certificate is issued to show compliance of the vessel to both the air pollution prevention requirements and the energy efficiency requirements outlined in Chapter 3 and Chapter 4 respectively of the Annex. This particular certificate also considers the availability of both the International Energy Efficiency (IEE) certificate and the Ship Energy Efficiency Management Plan (SEEMP). The IEE certificate is provided at the initial stages of the ships life cycle and is valid for the vessels lifespan as long as no major conversion of the ship is undertaken.

The mandatory data collection system for fuel consumptions of ships has been a recent inclusion in the MARPOL Annex VI and requires ships of 5000GT and above to collect and report data on their fuel consumption. That includes the data for each type of fuel they use together with the data regarding the energy efficiency of ships such as distance travelled, service hours at sea and cargo capacity for cargo ships. This annual aggregate data will then be provided to the flag state or the Recognised Organisation who will then verify through methodology included in the SEEMP and issue a statement of compliance to the ship. The flag states are then required to subsequently submit this data to IMO to keep an anonymous ship fuel oil consumption database and produce an annual report (Arora A, 2017).

As part of a port state control on operational requirements, a ship when in a port or offshore terminal under the jurisdiction of another party is subject to inspection by authorised officers of that party. In such cases where a party has clear grounds for believing that master or crew are not familiar with essential shipboard procedures relating to prevention of air pollution from ships, the party shall take steps to ensure that eh ship shall not sail until situation has been brought to order according to the requirements of the various guidelines and the annex.

3. Methodology

3.1 Analysis of the significance of implementing MARPOL Annex VI

3.1.1 Research approach

In undertaking this research, an inductive approach was taken as selection of the case and method of analysis is empirical where observations are initiated and generalised theories are used for conclusions. Specific questions were asked for specific observations and these observations are used to identify the how people view the different aspects of MARPOL Annex VI depending on broad generalizations.

3.1.2 Research strategy

The two main approaches are quantitative research and qualitative research but a third approach is normally used which is a mixed method research whereby the third research approach mentioned incorporates the use of both quantitative and qualitative research. For this research, the qualitative research design was chosen and this is explained in the next section.

3.1.3 Research design and method

For this particular research, a case study design was considered and the research strategy used was the qualitative research strategy. Cresswell (2014) mentions a case study as a study whereby researcher develops an in-depth analysis of a case, often a program, event or activity, process or one or more individual which is similar to the summary provided by Bryman (2012). Bryman further goes on to say that a case study is a detailed and single analysis of a single case and associates the case study with a location such as community or organisation. As such, in this research, a case study was undertaken looking at the process of implementing MARPOL Annex VI with the

intent of identifying the challenges that will hinder effective implementation in Papua New Guinea.

3.1.4 Data collection methods and tools

Data collection for this research involved both primary and secondary sources. For primary source, a questionnaire survey was used targeting the groups of interest which included;

- The PNG National Maritime Safety Authority as the maritime administration agency acting in there interest as flag, port and coastal state,
- The port regulators of the country which is the PNG Ports Corporation Limited,
- The ship owners and the shipping companies which will be directly affected by the implementation of MARPOL Annex VI and IMO 2020, and;
- The marine fuel suppliers who will be directly impacted by the implementation of MARPOL Annex VI and IMO 2020

The questionnaire was subjective as it targeted respondents understanding of MARPOL Annex VI. It should be noted that subjective questions are different to objective questions. That is, the objective questions are based in facts and can determine right or wrong or true or false. In this case, the questions are set as rating questions with explanations sought on why they indicated their rating. The analysis will be done using qualitative analysis using themes and coding. Other information like vessel registration details will be directly requested from the PNG National Maritime Safety Authority which is the maritime administration agency.

Secondary sources through literature review was also undertaken and included common internet search engines like google, google scholar and World Maritime University online library. Other information like published country reports was also consulted.

3.1.5 Sample selection

In this study, a non-probability sample form was used. This was more less a quasi-random sampling which was not mathematically represented and the ability of reaching the sampling population was limited. In this instance, the purposive sample type was used where the subject selected was representative of the groups mentioned. Hence, the sample members were selected based on their knowledge and expertise on the subject matter, for this specific research it is their involvement in the use and implementation of MARPOL Annex VI regulations which is described in Lune H & Berg B (2017) as subjects having certain or similar attitude. In this case senior personnel will be targeted given their direct influence in being responsible for decision making in this case for MARPOL Annex VI implementation in their various agencies. Addition to the questionnaires researcher sent out, since the targets was section managers and organisational heads, a snowball sampling technique was also incorporated where those approached survey subjects will be requested to use their network with the stakeholders to pass on the questionnaires to those they thought should be involved in the main stakeholder groups already mentioned.

In this research the following subjects were being targeted and they are;

- Executive Manager – Maritime Operations (National Maritime Safety Authority)
- Executive Manager – Maritime Administration (National Maritime Safety Authority)
- Manager – Marine Environment Protection (National Maritime Safety Authority)
- Manager – Ship Surveys & Inspection (National Maritime Safety Authority)
- Manager – Maritime Standards and Compliance (National Maritime Safety Authority)
- Consort Shipping Services Rep
- Curtain Brothers Shipping Rep

- Pacific Towing Rep
- PPL Rep
- PNG Ports Rep
- AES Rep
- Port Moresby Yatch Club Rep
- Puma Energy Refinery Rep
- Niugini Oil Rep
- Island Petroleum Rep
- Total Rep
- Frabelle Rep
- South Sea Lines Rep
- R&A Marines Rep

3.1.6 Research process

The questionnaire was tested out with WMU students with each student requested to look at the questionnaire as a representative of the various stakeholders mentioned to see the time taken for response and also capture any issues that could arise and then the researcher sent out a formal request letter in the administration agency's maritime operations and administration division head and managers as well as mangers and divisional head of the port regulator and shipping companies and marine fuel oil suppliers. Following their response to the emails, the questionnaires were forwarded for them to fill and resend back to the researcher. The initial request letter briefly explained the nature and scope of study including the topic under investigation and also, the questionnaire was administered after consent was sought.

3.1.7 Data analysis

When analysing the data, coding system was used to identify the common trends for the responses. Themes were deduced from the commonalities supported by literature reviews.

3.2 Analysis of the level of understanding and preparedness in implementing MARPOL Annex VI

This part of the survey was also undertaken as part of the questionnaire that was used in 3.1 and was administered together following the methods applied in 3.1. However, the questions differed from the previous where understanding of certain concepts were sought whereas the previous sought for their level of significance.

3.3 Analysis of the major challenges that can be encountered implementing MARPOL Annex VI

As is the case for undertaking PESTLE, the scope of the research was identified as the implementation of MARPOL Annex VI in Papua New Guinea. Information was then collected from literature, news, articles, personal communication and personal experience and was used to populate a table. For this survey the analysis exercise was undertaken to identify those issues that needed to be addressed for the shipping industry that included the main stakeholders mentioned. The analysis was used to identify risks and influential factors that was complemented by a SWOT analysis to put into perspective the strengths, weaknesses, opportunities and threats of the main stakeholders in implementing MARPOL Annex VI and paved way for proposing recommendation to implement.

4. Results

This chapter presents the results of the study.

4.1 Analysis of the significance of implementing MARPOL Annex VI

The results are presented in the following order.

- Participants of the survey,
- Determining significance of implementing MARPOL Annex VI
- Assessing and evaluating the level of understanding and preparedness in implementing MARPOL Annex VI

4.1.1 Survey participants

Table 3 presents the survey participants that responded to the questionnaire that was sent out. The participants were from those target stakeholder groups and those that occupied senior management roles but it should be noted that the views presented are as individuals and does not represent any of their organisations.

Table 4. Survey participants and the respondent code used. Compiled by author.

RESPONDENT CODE	DESIGNATION	ORGANISATION
001	Executive Manager – Maritime Operations	Maritime Administration
002	Ship Inspector	Maritime Administration
003	Manager – Qualification and Crew Matters	Maritime Administration
004	Chief Maritime Compliance Officer	Port Authority/Port Facility Owner

005	Marine Technical Superintendent	Shipping Industry

4.1.2 Significance of ship sourced air pollution to climate change

This section shows the results on how the participants perceived ship sourced air pollution and its contribution to climate change and whether they thought the implementation of MARPOL Annex VI is important in Papua New Guinea (PNG).

Table 5 Participants perception of ship source air pollution and climate change relationship and the significance of MARPOL Annex VI implementation. Compiled by author.

Do you agree that ship sourced air pollution is one of the main contributing factors to global climate change?		
Respondent	Response	Reason
001	Strongly agree	Shipping is responsible for 18-30% of worlds NOx and 9% of SOx pollution and therefore it is obvious that ship source air pollution is one of the main contributing factor to global climate change.
002	Agree	Most big ships use heavy fuel oil to run their main engines. Not only that, all ships exhaust gas pollute the air.
003	Neutral	The view on this is because unlike Europe, Asia and America where shipping traffic is heavy, Papua New Guinea is in the Pacific which consists of mainly developing countries. The number of ships passing through is not much and the level of pollution is proportional to that

004	Agree	The ship sourced pollution is one among many other pollutants. It must be regulated to minimize the risks it has on the environment and people
005	Agree	In agreement with above due to current researched shows that 3% of global warming contribution comes from marine industry. It is equivalent to major industrial countries such as USA and China.

Generally almost all participants except one agreed that ship sourced air pollution was one of the main contributing factors to climate change. The one participant that did not agree nor disagreed explained that ship traffic in Papua New Guinea and Pacific is not as heavy as other parts of the world. For those that agreed, one participant strongly agreed citing ships NOx and SOx emission.

4.1.3 Importance of implementing MARPOL Annex VI

Table 6 Participants view of the importance of implementation of MARPOL Annex VI in Papua New Guinea. Compiled by author.

Do you view implementation of MARPOL Annex VI as important in Papua New Guinea?		
Respondent	Response	Reason
001	Very important	There is no difference on importance of MARPOL VI in PNG compare to other countries although PNG has a very significant position in the world due to big rainforest and pristine environment and thus needs attention.
002	Important	Many big ships are visiting our ports, jetties and terminals.

003	Fairly important	Fairly important but not as a matter of urgency. This is in line with small ship traffic in PNG and also near our coastal waters.
004	Important	The air in Papua New Guinea is fresh with the pristine environment and MARPOL Annex VI must be implemented to maintain this.
005	Slightly important	Considers as slightly important as to improve awareness and preparedness as a marine industry to the global warming.

In terms of their view on the importance of implementing MARPOL Annex VI in PNG, the participants though that it was important with one indicating very strong importance and pointing out PNG's need to equally address the issue as a global partner. Two participants pointed out PNG's undisturbed natural landscape, tropical forest and the biota as a key factor that needs to be protected giving significance to the adoption and implementation of MARPOL Annex VI. This is shown in Table 6.

4.2 Analysis of the level of understanding and preparedness in implementing MARPOL Annex VI

4.2.1 Understanding MARPOL Annex VI

When PNG ratifies MARPOL Annex VI and is ready to implement the instrument, it is important to understand the instrument and the requirements. This section shows how the participants responded in line with their level of understanding of MARPOL Annex VI and it is shown in Table 7.

Table 7. Results of the survey participants understanding of MARPOL Annex VI. Compiled by the author.

Respondent	Response
Do you understand well MARPOL Annex VI with reference to each sections/chapter of the Annex?	
a. Chapter 1. General: gives as an introduction some of the basics of the convention including definitions.	
001	To a great extent
002	Somewhat
003	Somewhat
004	Somewhat
005	To a great extent
b. Chapter 2. Survey, certification and means of control: provides for the survey requirements, certification system and control principles including Port State Control issues, violation detection and enforcement	
001	To a great extent
002	Somewhat
003	Somewhat
004	Very little
005	To a great extent
c. Chapter 3. Requirement for control of emission from ships: gives details of the measures to address various air pollutants and important related issues as bunker management and incinerator.	
001	To a great extent
002	Somewhat
003	Somewhat
004	Very little
005	To a great extent

Respondent	Response
d. Chapter 4. Regulation on energy efficiency from ships: provides for the regulation of some operational and design aspects where some of these entered into force in 2013.	
001	To a great extent
002	Somewhat
003	Somewhat
004	Very little
005	To a great extent
Reasons	
001	All the above listed subjects a-d are directly related to the responsibilities as the head of Maritime Operations division
002	As a ship inspector, port state control inspection is undertaken on ships with regards to MARPOL Annex VI
003	PNG is yet to ratify but as a Chief Engineer I still understand the basic requirements.
004	Have little knowledge of MARPOL Annex VI and the provisions specified therein.
005	As per academic requirements and work requirements, MARPOL Annex VI was studied and currently practice some sections like the IAPP certification.

Chapter 1 of MARPOL Annex VI gives some of the basics of the convention including definitions. Two participants showed that they understood to a great extent this part. Three participants did indicate some understanding but not to a greater extent meaning they lacked more understanding. Chapter 2 on surveys, certification and means of control together with Chapter 3 on requirements on control of emission from ships and Chapter 4 Regulation on energy efficiency from ships all exhibited similar results as in Chapter 1. While two participants exhibited strong understanding of MARPOL Annex VI, the other two indicated understanding to some extent the different chapters

and one participant indicated very little knowledge of MARPOL Annex VI and this is shown in Table 7.

Interestingly, the two participants that showed very strong understanding of the instrument were employed in senior roles in their respective firms and indicated working directly with the implementation of the requirements. The other two participants were involved in roles that limited their involvement in dealing with the requirements of the instrument. Once the instrument is ratified and comes into force, more input in terms of implementation and enforcement will be required and there is a clear need for more awareness and education and this should be considered.

4.2.2 Understanding regulations for air pollution control and energy efficiency.

Understanding emission regulations and the requirements can allow for a informed decision making when implementing MARPOL Annex VI. As such, the participants were asked how they understood the various regulations mentioned in MARPOL Annex VI and the results are presented in Table 8.

Table 8. Results of participant understanding of MARPOL Annex VI emission regulations. Compiled by the author.

Respondent	Response
Do you understand the regulation for the following emissions well?	
a. Ozone depleting substance:	
001	To a great extent
002	Somewhat
003	Somewhat
004	Very little
005	To a great extent
b. Nitrogen Oxides:	
001	To a great extent

002	Very little
003	Somewhat
004	Very little
005	To a great extent
c. Sulphur oxides:	
001	To a great extent
002	Somewhat
003	Somewhat
004	Very little
005	To a great extent
d. Volatile organic compounds:	
001	To a great extent
002	Very little
003	Somewhat
004	Very little
005	To a great extent
e. Incineration emissions:	
001	To a great extent
002	Somewhat
003	Somewhat
004	Very little
005	To a great extent
f. Energy Efficiency (GHG Minimisation):	
001	To a great extent
002	Somewhat
003	Somewhat
004	Very little
005	To a great extent
Reasons	

001	All the above listed subjects a-d are directly related to the responsibilities as the head of Maritime Operations division
002	Do the checks/inspections to the ship to some extends with own understanding
003	Made readings on the basic requirements on the item but still not confidently sure. Still need to read and understand more.
004	Very little knowledge on this and need to upskill
005	Academic and work applications. Emissions part a, b and c practically come to play when purchase of new engines and approved spares for vessels

The results of the participants understanding of the regulations showed very similar results as in Table 7. This could be highly likely to be similar because, both refer to the requirements of the MARPOL Annex VI and there could not be much difference but the emission regulations normally contain the technical codes as well.

4.2.3 Understanding guidance for compliance for compliance of the sulphur cap limit

Given the recent entry into force of IMO 2020, the participants were asked on how they understood the guidance for compliance of the sulphur cap limit. Table 8 shows the results.

Table 9. Results of the participants understanding of IMO 2020. Compiled by the author.

Respondent	Response
	The IMO 2020 is the ship emission regulation of lower sulphur bunkering fuel of 0.50% mass/mass outside the Emission Control Areas (ECA) which has come into force after 01 January, 2020. Indicate how well you understand the guidance for compliance of the sulphur cap limit in terms of;

a. Regulations involving sulphur cap limits	
001	To a great extent
002	Somewhat
003	Very little
004	Very little
005	To a great extent
b. Selection of compliant fuels	
001	To a great extent
002	Somewhat
003	Very little
004	Very little
005	To a great extent
c. Properties of blended fuel oil	
001	To a great extent
002	Very little
003	Very little
004	Very little
005	Not at all
d. Properties of distillate fuels	
001	To a great extent
002	Somewhat
003	Very little
004	Very little
005	Not at all
e. Ship specific plans	
001	To a great extent
002	Somewhat
003	Very little
004	Very little

005	To a great extent
f. Bunkering	
001	Somewhat
002	Very little
003	Very little
004	Very little
005	To a great extent
g. Fuel oil non availability	
001	To a great extent
002	Somewhat
003	Very little
004	Very little
005	Not at all
h. Managing non-compliant fuel oil	
001	To a great extent
002	Very little
003	Very little
004	Very little
005	Not at all
Reasons	
001	Engaged in conducting consultations for stakeholders and maritime industry on above listed subjects from a-h to clarify new requirements before they came into force and therefore have no problem to understand them
002	Checks are carried out on ships records during inspection.
003	Had not have a chance of reading this new regulation and thus knowledge is very little.
004	Has very little knowledge in this field.

005	Academic and practical application when ordering bunker for vessel as to comply with MARPOL Annex VI.

Table 9 shows the participants understanding of IMO 2020 on sulphur cap restrictions. The participants were asked on how well they understood regulations involving sulphur cap limits and two participants indicated very strong understanding. One indicated understanding to some extent while the other two participants indicated very little understanding. In terms of the selection of sulphur cap compliant levels, a similar trend is exhibited as is shown in regulations involving sulphur cap limits. This may have been because both questions related to current sulphur cap limits for fuels to be used in vessels and the participants responded interchangeably.

The participants understanding on properties on blended fuel oil showed only one participant mentioning strong understanding while the other three indicated very little understanding and one participant indicated no understanding at all. This may have been because the participants were not directly involved in fuel production and distribution and also the properties seem to be too technical to understand which has bearing on their response. Similar results are also shown with the level of understanding on the properties of distillate fuel.

In terms of the ship specific plans, two participants indicated strong understanding, while one indicated moderate understanding and the final two indicated very little understanding. In terms of bunkering one participant indicated very strong understanding, while three participants indicated very little understanding and one indicated moderate understanding.

In terms of fuel oil non-availability and management of non-compliant fuel oil, a similar set of results were exhibited by participants. Only one participant indicated understanding to a great extent while others indicated very little to no understanding. This trend is highly likely because the participants are not directly involved in the fuel

industry and their knowledge of issues with fuel could be reflected in this case. One participant indicated in the comments the involvement with IMO 2020 requirements and indicated strong understanding while the other participant that showed strong understanding of IMO 2020 mentioned some training and the current role in ordering bunker for vessels. Therefore it is likely to say that some past trainings and work exposure related to MARPOL Annex VI does improve one's understanding of the instrument.

The participants were presented with some challenges in implementing IMO 2020 and were asked to indicate what their views were on how important they thought these challenges were. The results are presented in Table 10.

4.2.4 Challenges in implementing the MARPOL Annex VI in terms of the IMO 2020 and their importance

Table 10 Results of participants understanding of the challenges in implementing IMO 2020. Compiled by the author.

Respondent	Response
Indicate your view on how important you think the challenges are in implementing the IMO 2020	
a. Fuel availability and quality	
001	Very important
002	Very important
003	Important
004	Important
005	Very important
b. Operational aspects such as tank cleaning and weak changeover	
001	Very important
002	Important
003	Important

004	Important
005	Very important
c. Infrastructure maturity of alternate fuels	
001	Important
002	Important
003	Important
004	Important
005	Very important
d. Fuel price in the market	
001	Important
002	Very important
003	Important
004	Important
005	Very important
e. Lack of experience in enforcement	
001	Very important
002	Important
003	Very important
004	Important
005	Very important
Reasons	
001	All listed above have direct impact on adequate implementation of MARPOL VI IMO 2020 as well as efficiency to the shipping companies to provide reliable service and to ensure protection of the environment.
002	Quality of fuel will minimize air pollution. Alternate fuel like LNG can emit cleaner air. People tend to use low quality fuel because of the fuel price in the market.

003	Challenge of getting sulphur content to within limit. To address this other issues like safety for operation of machinery needs to be addressed. Lack of experience and knowledge are important areas to address. Inspectors need to enforce PSC once MARPOL Annex VI is ratified.
004	The implementation of IMO 2020 is important in reducing air pollution from ocean-going vessels.
005	There is a lack of data gathering in Papua New Guinea. Not much competiveness in the fuel market to bring quality and competitive price. Infrastructure is inadequate.

The participants were asked on how important the challenge of the fuel availability and the quality was in implementing the IMO 2020 and all participants indicated this as important. All other challenge listed also received similar indication from the participants stating all as important challenges to take into considerations when implementing IMO 2020. There is a high likelihood that the participants understood the mandatory requirements of IMO 2020 implementation. This is evident in the reasons provided by the participants shown in Table 10 when they were asked to explain why they had their answer like that.

4.3 Analysis of the major challenges that can be encountered in implementation of MARPOL Annex VI.

The analysis of the major challenges that can be encountered were done using a SWOT analysis of the regulator organisation, in this case, the Papua New Guinea National Maritime Safety Authority and then an overall PESTLE analysis was done to highlight those opportunities and threats. This analysis was specifically targeting the implementation of MARPOL Annex VI.

4.3.1 SWOT Analysis for implementing MARPOL Annex VI by regulating organisation

Table 11 SWOT analysis of the PNG NMSA for implementing the MARPOL Annex VI. Compiled by the author.

SWOT ANALYSIS FOR THE PNG NATIONAL MARITME SAFETY AUTHORITY OF PAPUA NEW GUINEA FOR IMPLEMENTING MARPOL ANNEX VI
STRENGTHS • The PNG National Maritime Safety Authority is the government funded statutory agency that is created and in operation by an Act of Parliament (NMSA Act 2003) and mandated to regulate maritime transport. • Has a well-defined and functioning Board of Management that provides visionary directions to the organisation and creates the link to the responsible ministry which is the Ministry of Transport, • The organisation has a well-defined organisational chart that covers the basic functions of; ✓ Maritime operations that is involved in the implementation of mainly SOLAS and MARPOL through its ships surveys and inspections section, the Marine Environment Protection section and the Aids to Navigation section. ✓ The Maritime administration team covers STCW by the Qualification and Crew Matters division while the hydrography team is responsible for mapping with the Standards and Compliance team looking at IMSAS audit issues with the III Code and also handles the process of convention ratification and adoption. ✓ The Corporate services is the support services sector with Human Resource and Finance team. ✓ The Executive Division is the Chief Executive Office and its support team.

- Has a corporate plan that is supported by the annual work plans and annual budget allocations.
- Have designated officers that are required as per the qualification requirements to perform tasks according to the job description. For instance, ship surveyors and inspectors are trained maritime officers.

WEAKNESSES

- Officers lack in depth knowledge and understanding of MARPOL Annex VI requirements as many requirements have recently come into force.
- There is lack of up to date information of the changes from IMO and officers not seriously taking note of the updates and progress in IMO and its committees.
- Officers complacent in progressing their allocated tasks with little emphasis on annual reviews on performance.
- Work priorities not aligned to aims and not goal focused.
- Some sections are under-staffed.
- Dialogue between agencies like NMSA and Climate Change and Development Authority or even NMSA to port operators ship owners/companies and fuel suppliers
- In adequate representation in the IMO with little emphasis placed for attendance of IMO meets.

OPPORTUNITIES

- Current government priority is to promote opportunities for development through the recently developed National Oceans Policy and the transport sector improvement programs.
- PNG being an IMO member state can ratify instrument (MARPOL Annex VI) and implement the recent mandatory requirements like the IMO 2020
- Government priority is also on climate change issues looking at both mitigation and adaptation issues.

THREATS

• Change of government in the coming elections in June 2022 where government priorities can shift affecting implementation of MARPOL Annex VI. • MARPOL Annex VI not ratified and adopted as national legislation disadvantaging companies and other stakeholders in preparing and working towards those mandatory requirements like the compliant sulphur fuel oil supply for ship board use. • Implementation of instrument (MARPOL Annex VI) will be costly through conversion of vessel, maintenance and operation, fuel cost and hiring of extra man power. • Implementation of MARPOL Annex VI and charge of fuel can affect marine main and auxiliary engines of vessels putting life at risk (safety risk). • Human health at risk • Air quality deteriorate and climate change impacts increase.

4.3.2 PESTLE analysis for the implementation of MARPOL Annex VI

The PESTLE analysis involved the external environment opportunities and threats. In fact, it is the extension of the SWOT Analysis undertaken in Table 11.

Table 12 PESTLE Analysis of the implementation of MARPOL Annex VI. Compiled by the author.

Sector	**External Environment (Opportunities/Threat**
Political	• International Commitments through Kyoto Protocol and Paris Agreement on ship sourced air pollution and keep temperature rise below 2 degrees Celsius. • IMO Commitment through the IMO Strategy to address zero carbon emission by end of century.

	• In PNG, Government approval is required to sign the instruments to ratify MARPOL Annex VI and the government is committed through the National Oceans Policy and National Transport sector Plan. • Government to adopt MARPOL Annex VI as a national legislation to implement IMO mandatory requirements for MARPOL Annex VI. • Oceans policy implementation • National transport sector plan • Change of government in the upcoming National Elections in 2022 can affect the progress of ratification of the instrument (MARPOL Annex VI)
Economical	• There are cost factors involved in MARPOL Annex VI and that can involve; ✓ Initial economic cost if there is a need for conversion of vessel ✓ Maintenance and operation cost ✓ Fuel cost ✓ Hiring of extra man power
Social	• Ship safety where change of fuel oil can have effect on marine main and auxiliary engines putting life at risk. • Impact on human health can be improved.
Technological	• Have required equipment available • Have technical skills and expertise to operate equipment.

Legal	• Ratify MARPOL Annex VI and be party to it to implement. • Have a national legislation to give effect to implementing the instrument.
Environment	• Improved air quality • Reduce climate change impacts

5. Discussions

5.1 Analysis of the significance of implementing MARPOL Annex VI

5.1.1 Significance of ship sourced air pollution to climate change

The survey results did show that four out of the five respondents agreed that the ship sourced air pollution is one of the main contributing factors to global climate change. This phenomenon has been realised by many including notable international organisations like the UNFCCC, the IPCC, the WHO and the IMO. The Sixth Assessment Report of IPCC clearly points out that human induced climate change is already affecting the weather with evidences observed for heatwaves, heavy precipitation, droughts and tropical cyclones as a result of increased GHG production with higher concentration found in the air (IPCC, 2021). The Fourth GHG Study by IMO points out that the share of shipping emissions in global anthropogenic emissions has increased from 2.76% in 2012 to 2.89 % in 2018. That is, the GHG emissions that includes CO_2, CH_4 and N_2O (nitrous oxide) have increased from 977 million tonnes in 2012 to 1,076 million tonnes indicating a 9.6% increase (IMO, 2020).

In Papua New Guinea, ship sourced air pollution is not thought to be a problem as the vessel traffic is less and air pollution emission level is directly related to the number of vessel traffic in the country. This was a reason highlighted by one of the respondent who indicated neutral thoughts on the subject of ship sourced air pollution being a problem in the country. While Papua New Guinea's footprint in ship sourced air pollution and its impact to climate change is not clearly defined amongst other nations in the globe, a report on the climate change profile by the World Bank in 2011 indicated a mean temperature increase by 1 °C since 1970, the sea temperature in the Pacific to have increased between 0.6 to 1°C, the number of category 4 and 5 storms having doubled and the number of hot days and nights to have significantly increased (World Bank, 2011). This suggests that, the impact of air pollution to climate change

is real and one stand out issue associated with climate change issue of rising sea level and inundation is the relocation of the Cartaret Islanders who are the first climate refugees in the world to be relocated to the main Bougainville Island of the Autonomous Region of Bougainville in Papua New Guinea (IOM, 2014).

Therefore, from the above discussions, there is very little doubt that the impact of air pollution and climate change is real. This issue does not have any territorial boundaries which then calls for a collective and global effort in which Papua New Guinea is of no exception in seriously considering mitigation and adaptation measures in addressing the issue. This warrants Papua New Guinea to increase efforts in addressing the issue and one important way can be to actively participate by adopting and implementing MARPOL Annex VI in the country.

5.1.2 Importance of implementing MARPOL Annex VI

There has been many studies undertaken to determine the impact of air pollution with studies pointing to the impacts relating to both environmental and health issues that affects human beings, animals, plants and the ecosystem services. Shipping industry and its operations have now been realised as one of the sectors that contributes to the emission of air pollutants. This has been evident in the successive GHG studies sanctioned by the IMO with the latest being the Fourth GHG Study 2020 with all studies showing a significant increase in the air pollution incidences on a business as usual scenario (IMO, 2020b). As the international body that regulates shipping, the IMO has taken air pollution from shipping seriously and has been working alongside with other organisations like the UNFCCC and WHO to address this issue through MARPOL Annex VI to reduce air pollution that is being emitted from ships.

Greater emphasis is now placed by the IMO through its member states to adopt and implement the MARPOL Annex VI requirements that includes both emission control measures from air pollution emitted from ships while considering energy efficiency

measures in shipping. The recent significant step forward was the adoption and implementation of the GHG strategy that created a roadmap with short term, medium terms and long term strategies. With the intention to achieve the mitigation of the volume of total annual GHG from international shipping by 50% compared to 2008 by the year 2050, the measures are constantly reviewed. Having the current target of a 40% reduction in carbon intensity by 2030 and pursuing efforts towards a 70% reduction by 2050 comparing the levels to 2008, the member states are required to work towards this target (Joung et.al, 2020).

Papua New Guinea, being an IMO member state, has a responsibility as part of the global community to contribute to these ambitious targets. With many requirements now becoming mandatory for IMO member states, PNG is of no exception as it will be sending ships out to other international ports as well as receiving ships in its ports and waters. Knowing that the current IMO norm of 'no more favourable treatment' rule being widely emphasised in IMO member states where vessels of a state which is not a party to the convention is treated the same as the vessel that flies the flag of a convention member state, PNG needs to ratify and adopt in its national legislation the MARPOL Annex VI Convention so that it also becomes MARPOL Annex VI compliant. This will in fact help the industry and also significantly contribute to the IMO ambitious targets. Taking into considerations the proposed long term IMO strategies like member states development of action plans to reduce emission from shipping and encourage port development and activities to facilitate reduction of GHG emission from shipping amongst others, PNG will be ready in embracing such changes once MARPOL Annex VI is ratified and adopted. As such, there is an immediate need for PNG to ratify and adopt the MARPOL Annex VI into its national legislation.

5.2 Level of understanding and preparedness in implementing MARPOL Annex VI

5.2.1 Understanding MARPOL Annex VI

Understanding MARPOL Annex VI is important for informed decision making during implementation and enforcement of the instrument requirements. The main stakeholders that will be directly involved in implementing the requirements are the administration agency, the ship owners, the shipping companies, the port facility owners, the port operators and the fuel oil production, distribution and supplying companies. Having different set of roles and responsibilities and their nature of operations, the firms can have varying understanding of the different sets of MARPOL Annex VI requirements. For instance, the fuel refinery, distributors and suppliers may find fuel sulphur cap component more appropriate and important to them while the ship owners and ship company with the administration agency will find all of the requirements in MARPOL Annex VI as equally important. Such situations can dictate the level of understanding, shaped by their roles and responsibilities which also can dictate the way decisions are prioritised and made.

Once PNG ratifies and adopts the instrument for implementation, the various stakeholders will be required to start implementing those relevant requirements. The administration agency, as the flag state and port state control agency will be tasked to implement and enforce those requirements that comes under this instrument. While flag state responsibility in the case of their flag vessel needs to comply with certain requirements, this responsibility is placed to a Recognised Organisation (RO). However port state control falls on the port state control inspectors who are required to exhibit a high level of understanding of the Convention requirements and that is a critical part that needs to be looked at mainly through education and awareness.

In the survey undertaken, one of the respondent was involved in port state control and his indication of the understanding of MARPOL Annex VI was moderate. This can

give some basic understanding of the level of awareness a person has. Such understanding can be playing a critical role when carrying out inspections and such level of understanding can hinder effective implementation and enforcement. Given the technical requirement of this particular annex, it is important that officers involved in implementing this instrument are being provided training to understand the various components within the instrument. This can include aspects in understanding requirements in air pollution emission control including bunker management and incineration as well as understanding regulations on energy efficiency from ships. While the design aspects could be delegated to ROs, having a basic understanding can provide better judgement on decision making.

Therefore as a responsible maritime agency, the National Maritime Safety Authority of Papua New Guinea needs to consider sourcing and providing education and awareness training for all stakeholders in the country to improve implementation when the instrument is ratified and adopted as national legislation.

5.2.2 Understanding regulations for air pollution control and energy efficiency

As discussed in 5.2.1, understanding of the various requirements in the instrument improves the level of understanding of the requirements that becomes a precursor to improved implementation. While MARPOL Annex VI gives the requirements at a broader level in its four chapters covered, the detailed technical regulations that covers the different emission like SOx, NOx, ODS, VOC, incineration emission and energy efficiency provides detailed requirements that needs to be consulted when equipment is designed like the scrubbers for SOx or engine design for NOx.

Because of the technicality of these Codes that requires technical know-how and resource inputs, the flag states normally engage ROs who are responsible for the design aspect taking into considerations the relevant code guidance. The required specifications are consulted from the guidelines and are provided for the vessels that

are covered under the MARPOL Annex VI. An important point to note is that, the RO in this instance can represent the flag state where compliance is demonstrated to the administration of the vessels flag state and not the classification society. Nevertheless, the classification society can act as a RO on behalf of the flag state which means that those equipment designed and produced under some classification societies are done where the class societies act as the ROs on behalf of the flag state. The above statement is important especially during port state inspection where there can be misconstrued interpretation of the class society acting on behalf of the flag state. In this instrument, enforcement issues are communicated to the flag state administration to enforce using their RO if there be any actions required to be closed out.

Therefore, in short it can be said that understanding of the regulations and specific technical codes for air pollution control and energy efficiency may require specialist knowledge but does not negate the need for general understanding as generic understanding is still required to aid one in their decision making process during implementation and enforcement.

5.2.3 Understanding guidance for compliance of the sulphur cap limit.

The new limit on the sulphur content in the fuel oil used on board ships came into force by 01 January, 2020 which required sulphur fuel of 0.50%m/m (mass by mass) outside emission control areas and 0.10% m/m inside ECAs. Many see this reduction as a new health and environment benefit to people, especially those that live close to ports and coasts. With the understanding that SOx is harmful to human health and environment, the reduction in SOx is an important step forward. This is because SOx has been seen as causing respiratory, cardiovascular and lung diseases while it also causes environment issues like the acid rain creation affecting crops and forests and contributes to the acidification of the oceans (IMO, 2019).

With low sulphur fuel use on board vessels becoming mandatory, the various stakeholders need to understand the guidance for the compliance of sulphur cap. Various option are available to reduce the sulphur cap and that can be done by blending higher and lower sulphur content to reach the required sulphur content or by using different fuel with low or zero sulphur like liquefied natural gas (LNG) or even using scrubber to trap SOx and particulate matter. By allowing various options available that can be used, it leaves choices for ships and ship owners to choose to suite their need. For fuels that are not sulphur cap compliant, the use of scrubber can be the available option but the scrubber has to be approved by the flag state as an alternate means of meeting sulphur limit requirements.

One important thing to note in this instance is that, this requirement applies to fuel oil used on board a vessel and not like other requirements where restrictions are done by vessel size. The sulphur cap requirement is mandatory and therefore, all vessel will be required to use fuel that is sulphur cap compliant. Therefore, it is imperative that those stakeholders that are refining and supplying fuel oil for ship board use should understand the properties of blended fuel oil, and distillate fuel oil, ship specific plans, fuel oil non-availability and managing non-compliant fuel oil. The guidebook on Compliance with the 2020 Global Sulphur Cap gives a detailed guide to ships that will comply. Further, the book 'Joint Industry Guidance on the Supply and Use of 0.50% Sulphur Marine Fuel' provides detailed understating in handling sulphur compliant fuel. Such references should be consulted and used when dealing with the understanding of sulphur compliant fuel and implementation of its requirements.

5.2.4 Challenges in implementing IMO 2020 and its importance.

The IMO 2020 is the mandatory sulphur cap requirement of ship fuel oil to be used on board. This has some challenges associated with it that can hinder swift implementation. This includes challenges like fuel oil availability and quality, the

operational aspect such as tank cleaning and weak changeover, infrastructure maturity of alternate fuels, fuel price in the market and lack of experience and enforcement.

The fuel oil availability in the required quality is a challenge that will arise. With the idea of blending fuel to bring it to the new range of 0.50%m/m sulphur limit compliance, there is a high likelihood that composition can differ from supplier to supplier and port to port. This can lead to compatibility and mechanical problems. This risk of not standardizing such fuel to ISO 8217:2017 standards will give rise to contaminated fuels or an added substance or chemical waste that can affect ship engines in several ways like clogging pipelines and fuel filters. This can subsequently become a vessel safety issue. This is an important challenge that needs to be taken into considerations if PNG ratifies and adopts MARPOL Annex VI and implements the sulphur cap requirements.

The operational aspect of tank cleaning where ships will change over from high sulphur fuel oil (HSFO) to compliant fuel oil will require cleaning. This then will require special procedures and such procedures need to be followed. While manual cleaning during dry dock can happen, some ships use alternate option of having specific change over procedures where specific fuel has been loaded on top of existing fuel oil which gradually flushes through the fuel system until sulphur content of the fuel oil is at the compliant level.

In order to address the challenges, especially associated with changeover form high sulphur fuel to compliant fuel, an important way forward is to develop a ship implementation plan that will involve risk assessments and mitigation plans of the impact of the new fuels while fuel system modification and tank cleaning can also be included if needed. Further issues like fuel capacity and segregation capability, procurement of compliant fuel, fuel oil change over plan and documentation and reporting can all be covered in the ship implementation plan. However, it is clearly stated in the MEPC.1/Circ.878 that ship implementation plan is not mandatory but can

prepare and guide a vessel transition to complying with sulphur cap requirements (IMO, 2020c).

The issue of fuel price in the market is a challenge that still needs to be determined further. According to Barleta & Sanchez (2019), LNG may cost less than fuel mix and a marine diesel oil. Low sulphur content can be expensive than heavy fuel oil with high sulphur content. They present estimates that compliance with IMO 2020 will increase the average cost of fuel price. This can trickle down to affecting freight cost through shipping to increase which then normally is reflected in the price of goods and services.

While IMO does provide guidance on the various requirements and how they can be effectively implemented, the tool to drive forward the guidance is technical know-how and experience. Since IMO 2020 has come into force recently, experience and enforcement can be a challenge for countries like Papua New Guinea. To differentiate a particular breach from a very minor offence and a serious offence and to decide on what could be the relevant penalties can be a challenge to the respective administration agencies.

In PNG, all of these challenges are important when MARPOL Annex VI is ratified. Together with the other requirements, the IMO 2020 is different in a way. That is, the IMO 2020 relates to the fuel that a vessel requires and thus this can directly influence of the price of goods and services whereby the fuel oil price has direct bearing over increased freight cost the is reflected on goods that reach a counter in a shop. Having the understanding that the challenges are important does not address the issue of how best a strategy can be put forward to address the level of interest. With very little study done to date in Papua New Guinea on the implementation of MARPOL Annex VI, more studies need to be undertaken to establish the baseline and determine the strategy forward. IMO 2020 on sulphur cap should be given priority with the understanding

that all fuel oil used on board vessel and the various requirements of switching and others needs to be addressed.

5.3 Major challenges that can be encountered when implementing MARPOL Annex VI

The implementation of MARPOL Annex VI falls within the responsibility of the National Maritime Safety Authority which is the maritime administration agency in the country that is responsible for issues and affairs of maritime transport. As such, it takes on the responsibility of implementing the IMO instruments in the country. While many of the IMO Conventions have been ratified and adopted and implemented, MARPOL Annex VI is yet to be ratified and adopted for implementation.

Given the current status of some of the requirements in MARPOL Annex VI becoming mandatory like the IMO 2020, PNG still needs to ratify and adopt this Convention so that the requirements for implementation are seamlessly implemented as flag state, port state and coastal state. While issues associated with coastal state obligation may seem bleak, implementation as flag state will require vessels of certain sizes, in this instance 400GT vessels and to conform to its requirements through the issuance of IAPP certificate and others can be easily be done. For port state control requirements, inspections can be done as required by member state but this can all be done if PNG becomes a party to this instrument and adopts the instrument to implement in the country. The process of ratifying the instrument can be done easily. In fact, the political outlook of PNG in supporting this instrument is favourable with the government prioritising its input in the process of ratification.

Nevertheless, the main challenge area for this particular instrument is the implementation and the enforcement. Because PNG is a closed registry, it does not have many large vessels compared to other countries and the flag state requirements under this instrument is minimal. However, there is a significant number of domestic vessels which are directly involved in using fuel oil on board and that is an important

cause for concern. Knowing that IMO 2020 has already come into force since 1 January 2020, PNG has not ratified the instrument and cannot be able to implement the requirement. As such PNG is working towards ratifying and adopting the instrument and once it does, the issue of implementing IMO 2020 in the country will become a priority task to implement. In this situation, the challenges discussed in 5.2.4 will become real where fuel oil availability and quality issues will emerge. Issues with fuel price will be realised and confusion of proper implementation and enforcement will set in with lack of experience and inadequate enforcement guidelines.

With education an awareness of the subject matter being identified as an important challenge highlighted throughout the discussion, one other important component that comes to light is the lack of studies undertaken to identify specific challenges and ways to approach so that it provides a baseline information on what could be done to improve implementation and enforcement. Having a strong and well researched baseline will create a foundation on which actions for improvement can be based on. This strongly points that more study is needed together with the education and awareness programs. With one LNG extraction plant already operating in country and the others about to be developed and extracted, an important step that could be considered is the use of alternate fuel in the country, in this case LNG but again, it will require proper research for feasibility to provide the future for LNG as an alternate fuel source.

6. Conclusions and Recommendations with some future research options

In order to conclude, it is important to revisit the aim of the study. The aim of this study was to identify the challenges that could hinder effective implementation and enforcement of MARPOL Annex VI in PNG. It was seen that MARPOL Annex VI requirements become more prominent recently, especially the mandatory requirement of the use of sulphur compliant fuel. This is an important issue especially for a small island developing state and the challenge is huge. While there are IMO guidance on how to effectively implement the MARPOL Annex VI requirements, the people who are in the position of implementing the requirements can have limited knowledge and little information on the requirements and how to implement creating a mammoth task in implanting the instrument.

With IMO's target and its strategies to implement being time defined, there is very little option of delaying the ratification and adoption of the instrument at the national level. PNG being a small island developing nation will have the sulphur cap requirement implementation and enforcement a high priority target. Therefore, the two important recommendations are to firstly, involve all stakeholders in developing a MARPOL Annex VI implementation strategy that will spell out a pathway in addressing the challenges highlighted by way of aligning the actions to the IMO Strategy short term, medium term and long term strategies and secondly to develop an education and awareness plan to target the stakeholders with initial and refresher trainings conducted in line with every new resolutions if it comes on board. By planning out the actions through the strategy, it is anticipated that the implementation of the instrument will be made easier and effective.

While this study highlights the general challenges, a need is there for a study looking at PNG as a small island developing state and the challenges the implementation of IMO 2020 poses to it. Another area of research can be associated with the feasibility

of supplying LNG from LNG production facilities to domestic vessels as an alternate fuel source. Finally with a defined shipping lane traversing through PNG from the Jomard Passage in the south to the Vitiaz Strait in the north, a study can be conducted on the likelihood of developing a slow steam area in line with PNG's ocean policy. This can use a similar approach as in the ECAs.

7. References

Barleta, E. P. & Sanchez, R. J., (2019). Towards the determination of international maritime transport. FAL Bulletin 372(4), 1564-4243. https://repositorio.cepal.org/bitstream/handle/11362/45242/1/S1901101_en.pdf

Bryman, A. (2012). Social research methods. Oxford University Press

Campara, L., Hasanspahic, N & Vujicic, S. (2018). Overview of MARPOL Annex VI regulations for prevention of air pollution from marine diesel engines. SHS Web of Conference, 58, 01004. https://doi.org/10.1051/shsconf/20185801004

Cresswell, J. W. (2014). Research design: qualitative and quantitative and mixed method approach. Sage

Doelle, M & Chircop, A. (2018). Decarbonizing international shipping: An appraisal of the IMO's Initial Strategy. RECIEL, 00, 1-10. https://doi.org/10.1111/reel.12302

Gwady, M.K. (2019). A study of maritime SAR and safety of small vessels: a regional perspective with focus on Papua New Guinea. [Master's thesis, World Maritime University]. https://commons.wmu.se/all_dissertations/1165/.

Hauseng, C. R. (2020). Promoting maritime safety through findings of accident investigations, surveys and audits in the Pacific: the case of Papua New Guinea. [Master's thesis, World Maritime University]. https://commons.wmu.se/cgi/viewcontent.cgi?article=2354&context=all_dissertations.

Herdzik, J. (2021). Decarbonization of Marine Fuels – The Future of Shipping. Energies 14, 4311. https://doi.org/10.3390/en14144311

Intergovernmental Panel on Climate Change Convention. (2014). *Climate change 2014: Synthesis Report*. https://www.ipcc.ch/report/ar5/wg3/

Intergovernmental Panel on Climate Change. (2021). Climate Change 2021. The Physical Science Basis. Summary for Policy Makers. https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_SPM.pdf

International Maritime Organisation. (2014). Third IMO GHG study 2014. https://www.researchgate.net/publication/281242722_Third_IMO_GHG_Study_2014_Executive_Summary_and_Final_Report

International Maritime Organisation. (2019). Prevention of Air Pollution from Ships. https://www.imo.org/en/OurWork/Environment/Pages/Air-Pollution.aspx

International Maritime Organisation. (2020a). Fourth IMO GHG Study 2020. Executive Summary. https://wwwcdn.imo.org/localresources/en/OurWork/Environment/Documents/Fourth%20IMO%20GHG%20Study%202020%20Executive-Summary.pdf

International Maritime Organisation. (2020c). Guidance on the development of a ship implementation plan for consistent implementation of the 0.50% sulphur limit under MARPOL Annex VI. https://www.gard.no/Content/26643626/MEPC1-Circ878_Guidance%20of%20the%20development%20of%20a%20SIP.pdf

International Maritime Organisation. (2020b). Reduction of GHG emissions form ships: Fourth IMO GHG 2020 – Final Report. Note by the Secretariat. MEPC 75/7/15. https://safety4sea.com/wp-content/uploads/2020/08/MEPC-75-7-15-Fourth-IMO-GHG-Study-2020-Final-report-Secretariat.pdf

International Organisation for Migration. (2014). Assessing the evidence: Migration, Environment and Climate Change in Papua New Guinea. https://sustainabledevelopment.un.org/content/documents/2185(IOM,%202014)%20Assessing%20the%20Evidence%20Migration,%20Env,%20and%20CC%20-%20%20PNG.pd

Joung, T., Kang, S., Lee, J & Ahn, J. (2020). The IMO Initial Strategy for reducing Greenhouse Gas (GHG) emissions and its follow up actions towards 2050. Journal of International Maritime Safety, Environmental Affairs and Shipping. 4(1), 1 – 7. http://doi.org/10.1080/25725084.2019.1707938

Lune, H. & Berg, B. L (2017). Qualitative research methods for social sciences. Create Space Independent Publishing

Manisidlaidis, I., Stavropoulou, E., Stavropoulos, A. and Bezirtzoglou, E. (2020). Environmental and Health Impacts of Air Pollution: A Review. Frontiers in Public Health 8(14). https://doi:10.3389/fpubh.2020.00014

Muriithi, A. W. (2019). A case study of the implementation and enforcement of MARPOL Annex VI Sulphur regulations in Kenya. [Master thesis, World Maritime University]. https://commons.wmu.se/all_dissertations/1122

Papua New Guinea Climate Change and Development Authority. (2020). Papua New Guinea's Enhanced Nationally Determined Contribution 2020. https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Papua%20New%20Guinea%20Second/PNG%20Second%20NDC.pdf

Ramanathan, V. (2020). Climate Change, Air Pollution and Health: Common Sources, Similar Impacts and Common Solutions In W.K Al-Delamy, V. Ramanathan and M. Sanchez – Sorondo (Eds), Health of People, Health of Planet and our responsibility.

Climate change, Air Pollution and Health (pp.49 – 59). Springer https://doi.org/10.1007/978-3-030-31125-4

Rupen, C. K. (1987). *Shipping industry in Papua New Guinea*. [Masters thesis, World Maritime University]. https://commons.wmu.se/cgi/viewcontent.cgi?article=1810&context=all_dissertations.

Schraufnagel, D. E., Balmes, J. R., Cowl, C. T., Matteis, S. D., Jung, S. E., Mortimer, K., Perez-Padilla, R., Rue, M. B., Riojas – Rodriguez H., Sood, A., Thurston, G. D., To, T., Vanker, A. and Weiebbles, D. J., (2019). Air Pollution and Noncommunicable Diseases. A Review by the Forum of International Respiratory Societies' Environment Committee, Part 1 – The Damaging Effect of Air Pollution. CHEST 155(2), 409 – 416 https://doi.org/10.1016/j.chest.2018.10.042

Witkowski, K. (2020). Research of the Effectiveness of Selected Methods of Reducing Toxic Exhaust Emissions. Journal of Marine Science and Engineering, 8, 452. doi: 10.3390/jmse 8060452

World Bank. (2011). Vulnerability, Risk Reduction and Adaptation to Climate Change. https://climateknowledgeportal.worldbank.org/sites/default/files/2018-10/wb_gfdrr_climate_change_country_profile_for_PNG.pdf

Appendices

Consent letter and questionnaire

CONSENT LETTER

World Maritime University
P O Box 500, 20124
Malmo, Sweden

Dear Sir/Madam,

This note serves to kindly request your consent to participate in my research study titled "An assessment of the challenges/issues of implementing MARPOL Annex VI in Papua New Guinea from a regulators point of view with recommendations for national implementation". The main purpose of this study is to identify the challenges that will be faced by the regulators and the industry when implementing MARPOL Annex VI in the country with special reference to IMO 2020 on Global Sulphur Cap and thus identify measures to address the challenges.

Therefore you are kindly invited to assist in completing the survey questionnaire. Your intention to participate can be withdrawn at any time as this participation is voluntary. Your identity will not be disclosed and will be kept confidential with information provided to be used anonymously.

Your participation in this survey will be beneficial to the implementation and enforcement of MARPOL Annex VI, especially the implementation of IMO 2020 on sulphur cap in the country.

Should you require further information regarding this questionnaire or the research project, you can contact me by email on w1802536@wmu.se or +46734888987.

By completing and submitting this survey, you express your consent in participating in this survey.

Your considerations and participation in this survey is highly appreciated.

Sammy Kalepo
World Maritime University

Consent Form for
Anonymous Surveys

Research Topic	An assessment of the challenges/issues of implementing MARPOL Annex VI in Papua New Guinea from a regulators point of view with recommendations for national implementation.
Student's Name and Department	Sammy Kalepo Maritime Safety and Environment Administration
Supervisors Name and Department	Professor Aykut Olcer Academic Head Maritime Energy Management
Researchers Contact Information	Email: w1802536@wmu.se Phone: +47734888987

Dear Participant,

This Research is undertaken as a requirement for Master of Science Degree. The topic for this research is "An assessment of the challenges/issues of implementing MARPOL Annex VI in Papua New Guinea from a regulators point of view with recommendations for national implementation". This topic is being chosen because it is identified as a topic that poses a lot of challenges to many developing states and is seen that it will have implications to the shipping and the fuel supplying industries in Papua New Guinea and other South Pacific island countries. In undertaking this research, it can shed some light in identifying the challenges that can be faced by both the regulator and the industries involved and thus remedial actions can be identified to address the challenges for effective implementation. This survey is undertaken

as a case study for Papua New Guinea only. I can be contacted via email or the phone number presented above if you need any assistance with regards to the questionnaire. To further help you understand better the following is presented;

Purpose of this study.

The study is undertaken to identify challenges that will hinder smooth implementation of the MARPOL Annex VI, especially the IMO 2020 Sulphur Cap component. In fact, the regulation has internationally come into force with the global sulphur cap of 0.5% m/m for use in vessels and the challenges Papua New Guinea faces in terms of its implementation has not been identified and this research looks at addressing this issue and provide for some recommendations that can be adopted for use.

Requirement from you.

If you decide to participate in this project, you will complete a survey Questionnaire and return it through email. Copies can also be sent using other means like watsapp.

Length of Questionnaire.

The survey should take around ten (10) minutes.

Risk of Participation.

There is NO risk in participating and you may choose to participate or decline if you decide to do so.

Benefits of Participation

The result of this study will be used to be incorporate into the plan of action for implementing MARPOL Annex VI, especially 0.5% sulphur cap for ship owners, and fuel suppliers. A copy of the project result can be made available to the participants upon request. This can also be beneficial for use in other South Pacific states.

Confidentiality

Every information will be kept confidential and is only for the purpose of this research and NO third party is authorized in any way to have access to the information.

Guarantee of Anonymity.

Your participation is 100% anonymous.

Compensation for Participation.

There is NO compensation/payment of any sort for participation.

Deletion of Data.

The data will be deleted from my laptop upon completion of my MSc studies, degree scheduled to be awarded 31 October 2021.

Contact for information concerning this study.

Email and phone contact is stated above.

You are free to refuse to participate in this research project or to withdraw your consent and discontinue participation in the project at any time without penalty or loss of benefits to which you are otherwise entitled. Your participation will not affect your relationship with the institution(s) involved in this project.

My return of this survey implies my consent to participate in this research and I have been allowed a second copy of this form to keep for my records. If you are not satisfied with the manner in which this study is being conducted, you may report (anonymously if you so choose) to my contacts.

COUNTRY: Papua New Guinea	**YEARS OF SERVICE:**
SEX: Male [ ] Female [ ]	**CURRENT POSITION:**

SURVEY QUESTIONNAIRE

A. PERSONAL INFORMATION

Name: _____
Designation: _____
Organisation:_____
Sector: (select the most appropriate sector that you represent and tick the circle)

Maritime Administration ○
Port Authority ○
Port Facility Owner ○
Ship Owner ○
Shipping industry ○
Ship fuel supplier industry ○
Other (Government) ○
Other (Private Entities) ○

B. SURVEY QUESTIONS

1. **Do you agree that ship sourced air pollution is one of the main contributing factors to global climate change?**

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Please state your reason why you indicate the above view?
_____
_____
_____
_____

2. **Do you view implementation of MARPOL Annex VI as important in Papua New Guinea?**

Not Important	Slightly Important	Fairly Important	Important	Very Important
1	2	3	4	5

Please state your reason why you indicate the above views?
_____
_____
_____
_____

3. **Do you understand well MARPOL Annex VI with reference to each sections/chapter of the Annex?**

   a) **Chapter 1. General: gives as an introduction some of the basics of the convention including definitions.**

Not at all	Very little	Somewhat	To a great extent
1	2	3	4

   b) **Chapter 2. Survey, certification and means of control: provides for the survey requirements, certification system and control principles including Port State Control issues, violation detection and enforcement**

Not at all	Very little	Somewhat	To a great extent
1	2	3	4

   c) **Chapter 3. Requirement for control of emission from ships: gives details of the measures to address various air pollutants and important related issues as bunker management and incinerator.**

Not at all	Very little	Somewhat	To a great extent
1	2	3	4

   d) **Chapter 4. Regulation on energy efficiency from ships: provides for the regulation of some operational and design aspects where some of these entered into force in 2013.**

Not at all	Very little	Somewhat	To a great extent
1	2	3	4

Please state your reason why you indicate the above views?
_____
_____

_____
_____

4. **Do you understand the regulation for the following emissions well?**

a) Ozone depleting substance:

Not at all	Very little	Somewhat	To a great extent
1	2	3	4

b) Nitrogen Oxides:

Not at all	Very little	Somewhat	To a great extent
1	2	3	4

c) Sulphur oxides:

Not at all	Very little	Somewhat	To a great extent
1	2	3	4

d) Volatile organic compounds:

Not at all	Very little	Somewhat	To a great extent
1	2	3	4

e) Incineration emissions:

Not at all	Very little	Somewhat	To a great extent
1	2	3	4

f) Energy Efficiency:

Not at all	Very little	Somewhat	To a great extent
1	2	3	4

Please state your reason why you indicate the above views?
_____
_____
_____
_____

5. **The IMO 2020 is the ship emission regulation of lower sulphur bunkering fuel of 0.50% mass/mass outside the Emission Control Areas (ECA) which has come into force after 01 January, 2020. Indicate how well you understand the guidance for compliance of the sulphur cap limit in terms of;**

a) Regulations involving sulphur cap limits

Not at all	Very little	Somewhat	To a great extent
1	2	3	4

b) Selection of compliant fuels

Not at all	Very little	Somewhat	To a great extent
1	2	3	4

c) Properties of blended fuel oil

Not at all	Very little	Somewhat	To a great extent
1	2	3	4

d) Properties of distillate fuels

Not at all	Very little	Somewhat	To a great extent
1	2	3	4

e) Ship specific plans

Not at all	Very little	Somewhat	To a great extent
1	2	3	4

f) Bunkering

Not at all	Very little	Somewhat	To a great extent
1	2	3	4

g) Fuel oil non availability

Not at all	Very little	Somewhat	To a great extent
1	2	3	4

h) Managing non-compliant fuel oil

Not at all	Very little	Somewhat	To a great extent
1	2	3	4

Please state your reasons why you indicate the above views?
_____
_____
_____
_____

6. **Indicate your view on how important you think the challenges are in implementing the IMO 2020**

a) Fuel availability and quality

Not Important	Slightly Important	Fairly Important	Important	Very Important
1	2	3	4	5

b) Operational aspects such as tank cleaning and weak changeover

Not Important	Slightly Important	Fairly Important	Important	Very Important
1	2	3	4	5

c) Infrastructure maturity of alternate fuels

Not Important	Slightly Important	Fairly Important	Important	Very Important
1	2	3	4	5

d) Fuel price in the market

Not Important	Slightly Important	Fairly Important	Important	Very Important
1	2	3	4	5

e) Lack of experience in enforcement

Not Important	Slightly Important	Fairly Important	Important	Very Important
1	2	3	4	5

Please state your reasons why you indicate the above views?

_____

_____

_____

_____