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Climate Change Control Systems and Technology Series

Edited by

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Preface

I would like to thank Prof Dr. Ahmed Salman, Prof. of Economic Entomology and Head of Plant Protection Department, Faculty of Agriculture, Sohag University, Prof. Dr. Mohamed A. A. Abdel-Rahman, Plant Protection Research Institute, Agricultural Research Center, Prof. Dr. Ahmed Amin Sayied Plant Protection Research Institute, Agricultural Research Center, and Mr. Moustafa Mohamed Sabry PhD student, Faculty of Agriculture, Sohag University for revising and preparing this ebook.

-Dr. Sulaiman Olanrewaju Oladokun

About Author

Dr.O.O.Sulaiman is Associate Professor of Ocean Engineering, and coordinator for Maritime Technology International program, University Malaysia Terengganu. His specialization is in Safety and Environmental risk and reliability for maritime and ocean systems, maritime and ocean energy and environment, sustainable maritime system design. He is chartered engineer with diverse academic and professional background. He has taught and mentor courses and research projects on contemporary issues in maritime and ocean engineering field. He has authored and co-authored a total of about more than 120 publications which include proceeding papers, journal papers, technical report and chapters in book, monograph, seminar papers and other types of academic publications. He has authored more than 60 peer review journals and 6 books. He has patented research work on marine green technology. He is chattered engineer registered under UK Engineering Council. He is the member of royal Institute of Naval Architecture (RINA) and Institute of Marine Engineering, Science and Technology (IMarEST), PIANC, IEEE, ASME.

Acknowledgement

A book that cover wide range of salient information on contemporary sustainable marine maritime technology and systems in coastal and ocean environment owe much appreciation to various individuals, equipment manufacturers and organizations. I am grateful for those who helped in different ways during the preparation of the book.

Introduction

The book will represent a master piece that provides information and guidance on future direction of marine technology and sustainability requirement. The book focuses on various contemporary issues that make its contents richer, more informative and beneficial to the wide number of readers in industry and academic sphere. This book provides the most recent information about proactive approach to sustainable development technology for readers about requirements of sustainable marine system. The book will be useful as followed:

- Reference material for academician, students, researcher, universities library, research institution as well as classroom subject.
- Networking, literature citation
- Useful information for maritime industry and organization Industry and regulatory institution.

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Control: Climate Change Control System and Technology

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Towards Sustainable Green Ship Technology

Abstract

Man live in two worlds, the biosphere and the techno sphere world over the years, time needs, growth, speed, and knowledge and competition have created demand that necessitated man to build complex institution. Ship design is not left out in this process. Inland water, are under treat from untreated waste that can feed bacteria and algae, which in turn exhaust the oxygen. The ocean cover 70 percent of the globe, many think that everything that run into it is infinite, the ocean is providing the source of freshening winds and current that are far more vulnerable to polluting activities that have run off into them too many poisons, that the ocean may cease to serve more purpose if care is not taking to prevent pollution. This issue of environment becomes so sensitive in recently and most are linked to infrastructure development work. Most especially in maritime industry polluting activities from oil bilge to ballast pumping that has turned into poison has advert effect on water resources. Some have choked too much estuarine water where fish spawn. In a nutshell, the two worlds we live are currently are out of balance and in potential conflict. Man is in the middle, and since the treat are mostly water related, ship is in the middle too. Historical records of number of calamity that has resulted to heavy lost and pollution call for environmentally sound ship. This has lead to a number of regulations today that will subsequently affect policies change and procedures interaction with the system. The current situation has affected the design of new ships and modification of existing ships. This paper review and discuss green technology emanating from regulations and highlight new system design being driven by marine pollution prevention and, protection and control regulation.

Keywords: Combustion; Climate Change; Control; Design; Emissions; Environment; Efficiency; Emission; Global Warming; GHG; Impact; Inventory; Johor Port; Mitigation; Machineries; Power; Power Plant; Sustainability; Ship; Safety; Sustainability; Vessel

Introduction

Human civilization from Stone Age to industrial, computer and information to multimedia innovative technological era, work has been mostly about building and forgetting the inherited biosphere environment world. Today human sensitivity is aggressively defining age as an age of sensitivity, safety and environment. Human developmental works for years during era transition have been built with oblivion or lack of consciousness to the environment. The term “environmental issues” usually implies one of two interpretations:

1) Wind, waves, tides, sediment characteristics and or other environmental factors involved in development work.

2) Environmental protection in the sense of reducing the negative impact on water, air, soil quality, infrastructure, health and coastal habitat.

In the first sense of the term, all concern need to agree that methods for predicting and reporting environmental conditions have greatly improved especially in the dimension of scientific analysis. This can provide directions to connect necessary dots. In shipping and associated industries, ship protection and marine pollution are respectively interlink in term of safety and environment, conventionally ship safety is being deal with as its occurrence result to environmental problem.

Pollution from maritime industry seems to be small, currently at approximate 3%, especially considering emission. Today considering volume of ships in the world ocean, pollution from shipping can be considered to be exponentially rising. Culmination of oversight regarding emission has lead to point form pollution that contribute to impact of ozone layer depletion, incessant flooding, global warming and more unknown calamity whose source is hard to determined seem to be on the way if caution is not exercise in the current ways of doing things. Shipping is not left behind in this, in fact, maritime world seem to be the most to get hit by next big environmental revolt. Pollutions is about accident and accident is about pollution, because, the later is the cause of the former. This paper address environmental impacts to ship design with respect to human, safety, ship, reliability, channel, maneuverability factors and marine environment. This section also emphasizes on the need to incorporate in the ship design spiral, the design process regarding the above enumerated factors, for example environmental issues were never part of the ship design spiral [1-3). Iterative risk approach according to formal safety assessment, which is has been deduced from best proactive offshore QRA is presented in Figure 1

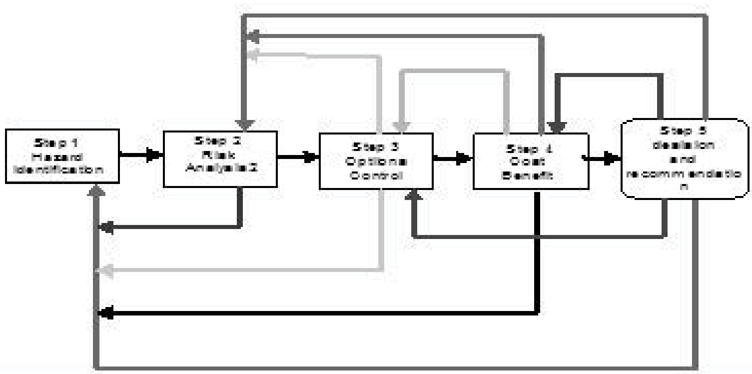


Figure 1: Risk approach.

This section presently review of collected information and used a risk based approach to analyze environmental issue, ship system, current practice and regulatory analysis to deduce prospect green technology and practice for ship. Figure 1 describes the qualitative process of examination of the issue under examination, which involve matching system requirement with regulation to deduce gap and technological requirement. The issue of green ship is addressed by analyzing evolving technology. In respect to the above, current situation is examined, policy, demand, mitigation and way to move forward green ship is addressed. Also addressed is emphasize on importance of simulation and scientific system based risk analysis, especially for ship complex and dynamic system design and channel accommodation of large ship and sip movement in port as well as the introduction of marine environment awareness in maritime curriculum. Need to incorporate as much of cybernetic technology in navigational and maritime operations for sustainable and efficient performance is stressed. Actionable marine environment mitigation measure, recommendation for strategies to achieve safe, cost marine ship, navigation and protection of the marine environment cost effective state of art sustainable of ship design at planning stage is advised [2]. Risk based design is advised to be incorporated in decision leading adopting new green technology, the process should include:

- High goal based objectives.
- System compatibility with compliance.
- Hazard identification.
- Risk analysis.
- Risk control option.
- Reliability, system complexity and uncertainty analysis.
- Cost benefit and sustainability analysis.

Less attention is given to ship life cycle, material properties, variable and frequency matching with the environment. A situation that has lead to unbearable condition like corrosion and other unseen environmental degradation that accumulate into painful catastrophically loses. Also ship scraping and what happen to the environment after ship scraping. In ship recycling little or no attention is given to the residual material that finds their ways to pollute the sea [4,5].Other areas of concern in the ship design process are consideration for channel design criteria, ships controllability and maneuverability in dredged channels. All in all, incorporating preventive and control sensible measures in ship design can only optimize method and give us confidence on our environment.Focal areas that need revolutionary changes in ship design that is being identified in this paper are [6].

- Material selection to withstand structural, weight, economical lifecycle anticorrosion and fouling.
- Incorporating ship simulation at early stage of ship design.
- Structural scantly to withstand structural function, reliability, integrity, weight, economical lifecycle.
- Incorporation maneuvering ship simulation at early stage of design iteration.
- Incorporate new close loop environmental disposal technology system to make new ships environmental safe.
- Low pollutions and efficiency ship.

Environmental Issue and Impact areas

Environmental issue becomes blessing through opening new window of green technology opportunity for conservation, recycling, miniaturization, system integration and management of resources. It is important to start to implement clean ships initiative for ship design, this include optimal choice require to design shipboard pollution control system that will allow waste or hazard treat or process on board or allow integration of such system in existing ship. Most especially, it is necessary to incorporating such system in earlier ship design process through forming basic concept to set aside enough space on board for scalable, efficient proactive and sustainable system [7]. There is need to design system that will allow waste to be destroyed on board the ship and those that cannot be destroyed would be treated to level where discharge is harmless. Advert environmental occurrence and impact of recent days, is evolving sensitivity leading to new policies for pollution control and more seem to be coming [8]. For example, NOx emission limit compliance and SOx Sulfur Emission Control Area (SECA) In the Baltic is being implemented. If actions are not taken now, the repercussion could include similitude of:

- Inconvenience of discharge regulation
- More MARPOL special discharge areas
- Augmentation of confusion caused by waste signature (advert of floating of debris)

Considering the beneficent part of this contemporary issue, environmentally sound ship with self contained. They can be independent of shore facilities for shipboard waste management will end up reducing logistic requirement and costs. Time has seen how ineconomical and inconvenience it is for ships pumping liquid waste to pier side reception facilities, offload solid waste and excess hazardous material for disposal. Where vessels are astronomically being charge substantial costs by private contractors to dispose generated wastes. With this, green ship will nonetheless give the following beneficial business advantages to maritime industry [9].

i. They ships will be among the significant ship of tomorrow.

ii. They will be the ship with good pride and public image that will provide leadership definition to shipping companies of tomorrow.

iii. They will be safer, environmental friendly (everything around them including marine recourses will be safe).

iv. They ship will maintain good relationship with legislation and environmental agencies (hence minimizes the risk of fines and litigation).

v. It will helps in the control of operational pollution, ship movement in waterways, minimizing the risk of an environmental incident.

vi. Enables companies to demonstrate a proactive approach to environmental protection.

vii. It will helps companies to gain recognition of investment in pollution control technology

viii. It will improves operational efficiency will provides confidence that environmental risk is being managed effectively. High levels of environmental performance can create competitive advantage

In today environmentally conscious world, there is already so much pressure on ship owners to minimize the impact of their operations on the environment. More regulations are likely to be enforced; luckily, human civilization is enjoying an age of innovation and development. Advancement in transportation, information and technological has involved dynamic and complex activities that manage speed, safety, reliability, miniaturization, cost, mobility and networking in most industries efficiently. This poweress of human civilization is evidence that technology that is required to developed efficient low pollution and environmental friendly technology are available. It is matter of exercising more creativity and culture of sharing, complementation available resources within limited time and employing them to meet requirement of sustainable system equity law (cost, speed, efficiency, low pollution etc) [10].

Major Environmental Impact Areas

Environmental protection is considered a design constraint when evaluating cost, schedule, and performance of systems under development, and product improvement. The engineer need to consider the environmental impact of proposed actions, and mitigation plan required to supports unrestricted operations. This can be achieved by developing, producing, installing, and managing all shipboard equipment, systems, and procedures require reducing and managing shipboard wastes in compliance with existing and anticipated environmental worldwide restrictions. Table 4 shows Global warming potential for from marine activities. This should be done without jeopardizing the ship mission, survivability, or habitability. The major effects of ships environmental effects that must be prevented protected or control can be in the following form [11,12].

- Intentional and unintentional discharge from ship (oil, garbage, antifouling paint, transfer of indigenous species from ballast water)
- Environmental damage and pollution due to port activities
- Disturbance of marine environmental (collision and noise)
- Intentional and unintentional (emission from energy equipments, from scraping of ships at the end of their life cycle)

Compound	GWP (100 Year ITH)	Inclusion
Cox	1	Natural occurring compounds
NOx	296	
CHX	23	
HFC-134a	1,300	HFC's
HFC-227ea	3,500	
HFC-c-23a	12,000	
CF	1	Novec 1230 Fire protection fluid

Table 1: Global Worming Potential (GWP) of various compounds

Risk associated with environmental issue in ship design [13]:

Accidental Risk: marine accident that could result to oil spills which then end up degrading the environment. Group of Expert on Scientific Aspect of Marine Environmental Protection (GESAMP) reported that 300-400 thousands of oil entered the world ocean according to [14] were caused by collision with marine mammal, which then causes propeller injuries, hence more economic losses.

Operational Risks: socio economic impacts to marine ecology, habitat and coastal infrastructures are affected through operational activities that result to oil spill, emission, ballast water, garbage, dredge contamination, antifouling.

Vessel, Channel and Maneuverability Risk: in the context of ship design, the impacts areas are related to shipping trends, channel design criteria, ship maneuverability, ship controllability, and use of simulators in channel studies. Since World War II many nations built port but forget about maintaining them according to larger ships being produced by shipyards. Physical dimension and ratio of ships to channel that have impact in today's ship controllability design are:

- Increase in ship beam expansion where as channel width is not, length/beam (L/B) ratio.
- Radius of turns and turning areas-radius of turns is directly related to navigation safety and protection of the marine environment, large rudder angles are needed to navigate

small radius turns rudder size, this is hardly critically taken into consideration in ship design work;.

- Power/tonnage ratio.
- Minimum bare steerage speed and windage.

Over the last decade, each passing years has been augmented with concerned about issue of environment. The issue touch all area of human endeavors, in maritime technology this include design, construction, operation and beneficial disposal of marine articraft. The non renewable energy source that has driven past technology has ended up with increasing the resources of the planet, but depleting components of environment that support life. This has accumulated to production that demands long term sustainability of the earth. Precipitated point form pollution effect over the year is currently calling for public awareness and it translating into impacts of the following areas described below.

Commercial Forces: this include situation of company or product that operate in unenvironmental friendly way, people are prone to spurn the company's products and service. This has impact on company return on investment.

Regulations: public pressure on governmental and non-governmental organization regulating environmental impacts due to untold stories of disaster and impact. The public is very concerned about quality of life of people and the need for it is to be sustained. To meet their requirement and need of the future generation, then the environment must be protected. Conspicuous issue, expertise and new finding on multidimensional uncertainty make them to go extra length on unseen issue. Contrasting between the first two, commercial force action on can become forth problems.

Water, Air and Soil Pollution: Water volume that support the planet, scarcity of land, Global warming and health impacts.

Ship Concept Design: is very important in shipping and it account for 80 percent of failure, therefore compliance and making of optimal design at concept stage has a great impact in ship whole life cycle. The impact of environment in ship design is very difficult because of large numbers of associated uncertainties within the phases of design process. Environmental impact that needs to be taken into considerations in concept design can be classified into the following [15]:

- **Construction:** this involve pollution, this comes into picture when multidirectional thinking give wisdom on what happen during transportation, material handling and what is being released to the nearby rivers.
- **Operations:** considering limiting life cycle of ships at estimate of 20 years, issues relating to operation are equally not easy to quantify in design work. Even thus a lot of research effort has been set on move on this. But the call of the day requires allowable clearance and solution to be given to accidental, ballast waste, fouling and biodiversification.
- **Disposal:** issue of disposal that cover waste and emission and as well as what to do with the ship at the end of her life cycle.
- **Energy and environment:** The case of air pollution, global warming , ozone depletion and climate change

International Maritime Organization (IMO) Get Serious

Evidence about the volume of the water planetary percentile, how significant this is to the safeguard of the planet and conversely the volume of ships that ply every day put pressure from land based environmental organization to sea based regulatory governor [15,16].

Important IMO Conventions (http://www.imo.org/About/Conventions/ListOfConventions)

- International Convention for the Safety of Life at Sea (SOLAS), 1974, as amended
- International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto and by the Protocol of 1997 (MARPOL)
- International Convention on Standards of Training, Certification and Watch keeping for Seafarers (STCW) as amended, including the 1995 and 2010 Manila Amendments

Other conventions relating to maritime safety and security and ship/port interface:

- Convention on the International Regulations for Preventing Collisions at Sea (COLREG), 1972
- Convention on Facilitation of International Maritime Traffic (FAL), 1965
- International Convention on Load Lines (LL), 1966
- International Convention on Maritime Search and Rescue (SAR), 1979
- Convention for the Suppression of Unlawful Acts Against the Safety of Maritime Navigation (SUA), 1988, and Protocol for the Suppression of Unlawful Acts Against the Safety of Fixed Platforms located on the Continental Shelf (and the 2005 Protocols) International Convention for Safe Containers (CSC), 1972Convention on the International Maritime Satellite Organization (IMSOC), 1976. The Torremolinos International Convention for the Safety of Fishing Vessels (SFV), 1977
- International Convention on Standards of Training, Certification and Watchkeeping for Fishing Vessel Personnel (STCW-F), 1995 Special Trade Passenger Ships Agreement (STP), 1971 and Protocol on Space Requirements for Special Trade Passenger Ships, 1973

Other Conventions Relating to Prevention of Marine Pollution:

- International Convention Relating to Intervention on the High Seas in Cases of Oil Pollution Casualties (INTERVENTION), 1969Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (LC), 1972 (and the 1996 London Protocol)
- International Convention on Oil Pollution Preparedness, Response and Co-operation (OPRC), 1990Protocol on Preparedness, Response and Co-operation to pollution Incidents by Hazardous and Noxious Substances, 2000 (OPRC-HNS Protocol)
- International Convention on the Control of Harmful Anti-fouling Systems on Ships (AFS), 2001 International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004 The Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships, 2009.

Conventions Covering Liability and Compensation: International Convention on Civil Liability for Oil Pollution Damage (CLC), 1969 1992 Protocol to the International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage (FUND 1992) Convention relating to Civil Liability in the Field of Maritime Carriage of Nuclear Material (NUCLEAR),1971 Athens Convention relating to the Carriage of Passengers and their Luggage by Sea (PAL),1974 Convention on Limitation of Liability for Maritime Claims (LLMC),1976 International Convention on Liability and Compensation for Damage in Connection with the Carriage of Hazardous and Noxious Substances by Sea (HNS), 1996 (and its 2010 Protocol) International Convention on Civil Liability for Bunker Oil Pollution Damage, 2001 Nairobi International Convention on the Removal of Wrecks, 2007.

Other Subjects: International Convention on Tonnage Measurement of Ships (TONNAGE), 1969 International Convention on Salvage (SALVAGE) 1989.

Policies and Procedures Build-Up: Pollution/Emission Prevention and Control: The earlier pollution regulation by IMO work under International convention for the prevention of pollution from ships (MARPOL, 1973. It covers accidental and operational oil pollution as well as pollution by chemicals, goods in packaged form, sewage, and garbage. Its adoption was later modified to follow tacit procedure by protocol of 1978 relating thereto (MARPOL 73/78) because of urgency of implementation, MARPOL (Table 2). New annex to MARPOL have been introduced in diplomatic conference because of need of the time. Especially annex six was quickly adopted, but allowances are given for independent adoption and implementation because of environmental geographical differences. And also because lack of enough evidence of data.

Other areas where IMO focus on are process and facilitation and system base framework like the use of formal safety assessment and check list and documentation, and provision of International safety management. Annex is the latest that is attracting more scurrility like oxide of nitrogen (NOx) limit for new design, collection of air pollution data by al ports, Sulfur emission Control Area. Table 2 illustrates MARPOL73/78. New Annex to MARPOL covers the following areas: Control and management of ballast water to minimize transfer of harmful foreign species EMS, 2000). IMO MARPOL coverage is presented in Table 2.

- Global prohibition of Tributyltin (TBT) in antifouling coating-phase out in 2008.
- Control and management of emission from ship combustion machineries (Annex VI).

Other areas IMO gets serious are: Marine Environmental Protection Committee (MEPC), IMO technical committee forming subcommittee on specific issue to implement regulation towards necessary mitigation.

International Convention on oil Pollution, Response and Cooperation (OPRC), 1990: policy to combat major incidents or threats of marine pollution through port state control (PSC) to prevent mitigates or eliminates danger to the coastline from a maritime casualty. Protocol under this convention covers marine pollution by hazardous and noxious substance (HNS Protocol) s.

- The IMO proposal to regulate the use of TBT-based antifouling paints. A ban on application of TBT-based paints in 2003 and a total ban in 2008 are suggested. In anticipation of new regulations, the marine paint industry has developed alternatives to tributyltin self-polishing copolymers (TBT-SPCs).
- IMO establishment of Safety Management System (SMS) and is a part of the requirement for obtaining and maintaining ISM certification.

MARPOL	Coverage
Annex I	Oil
Annex II	Noxious liquid chemicals
Annex III	Harmful Goods (package)
Annex III	Sewage
Annex III	Garbage
Annex VI	Emission and air pollution -SOx, NOx and green house gas, emission of ozone depletion gas (ODG)

Table 2: MARPOL Coverage

As a result of this, international environmental organisations are seriously encouraging all concerned parties to galvanize their community by setting up panels, collaborating with scientists and technical bodies, to encourage the use of existing scientific bodies and research centers for global observation systems. This includes the taping of the informal sources of information related to early warning as part of the solution to deal with the problem of sharing data among countries, as well using human capacity and the rapid spread of internet as a tool for information compilation, discussions and news dissemination. Some of the land and sea based regulations that have been passed are [17-19]:

- MARPOL 78: Cover Annex I, includes Oil, Annex II-Noxious liquid chemicals, Annex III- Harmful Goods (package), Annex IV-Sewage, Annex V-Ballast water.
- Adoption of control and prevention measures in 2003 by IMO, as well as problems associated with the transfer of harmful aquatic organisms in ships' ballast water to address greenhouse gas emissions.
- IMO also passed the MARPOL Annex VI during a diplomatic conference and bypassed the usual tacit procedure. Whereby Annex VI-emission and air pollution (SOx, NOx and green house gas, emission of Ozone Depletion Gas (ODG))
- Adopt the convention in 2004 to support the International Convention on the Control of Harmful Anti-fouling Systems on Ships 2001. The diplomatic conference also addressed the implementation of the International Convention on Oil Pollution Preparedness, Response and Co-operation 1990.
- Global prohibition of TBT in antifouling coating-phase out scheduled for 2008.
- International convention on oil pollution, response and cooperation (OPRC) (1990).
- Policy to combat major accidents or threats, control to prevent, mitigates or eliminates the danger of marine pollution from the port to its coastline from a maritime casualty.
- Protocol on the carriage of Hazardous and Noxious Substances (HNS).
- Oil Spills Protocol: Protocol Concerning Specially Protected Areas and Wildlife (SPAW Protocol).
- Protocol Concerning Pollution from Land-based Sources and Activities (LBS Protocol).
- Agenda 21 debut on sustainable development.

Maritime work and regulation has always been a top down set-up, as result of IMO seriousness on environmental issue various maritime organization follow suite, some of the development that follows IMO actions are:

Classification Societies: Classification societies are aggressively building service on environment protection, notation, and various performance indicators to get all concern committed to running an environmentally sound ships.

- Lloyds: Lloyds through risk assessment holistic method deduce effects and framework for clean ship the benchmark standard.
- Dnv: DnV has equally lunched Environmental Ballast Water Management Assessment (EMBLA) database integrated project that will manage discharge of ballast water.
- European Union: Recently the European Union has embarked on multinational project call On Board Treatment of Ballast Water (MARTOB) ballast water.
- Montreal Protocol: Some 110 governments attended Parties to the Montreal Protocol, in September 1997 where several important decisions were reached, includingthe tightening of restrictions on several destructive chemicals.
- The export of hazardous waste from Organization for Economic Cooperation and

Development (OECD) countries to non-OECD countries is banned under the convention, this ban entered into force in 1998 in the EU countries.

- Trim optimization by NORDEN/Green Steam and Nordic Tankers
- Real-time analysis of bunker quality and emissions by A. P. Møller
- Automated engine monitoring by MAN and A. P. Møller

Policies and Procedures Build-up for Collision Preventions and Control Measures

Although ships may spend 90 to 98 percent of their operational lives underway at sea speed in deep water, it is during the mandatory beginning and end of every voyage when the risk of collisions and groundings are highest. Ensuring the ability to maintain complete and positive control of a ship's movement during these segments of a voyage is absolutely vital if that risk of navigation safety and protection of the marine environment is to be reduced. According to INTERTANKO's 1996 on port and putting bigger and bigger ships (and more of them) into the same old channel [20,21].

- The design recommended limit for trim by the stern for a tanker is 0.015 L in accordance with Regulation 13 of MARPOL 73/78, Annex I. This information, which is based on tests conducted in deepwater, includes a turning circle diagram as well as tables showing time and distance to stop the vessel from full and half-speed.
- IMO Resolution A601 [15], which was adopted in 1987, contains recommendations for ensuring maneuvering information is available on board the ship.
- The 1995 Seafarers Training, Certification and Watch keeping STCW Code, Section A-VIII/2 part 3-1, and article 49 require the master and pilot to exchange information regarding navigation procedures, local conditions and the ship's characteristics.
- A Marine Board study assessed the use of numerical simulation technology to train mariners and concluded that while modeling accuracy is sufficient for deep-water operations; modeling requires refinement to provide the accuracy needed for shallow and restricted water operations.

Ship Design Policy Build-Up

In 1971, IMO adopted Resolution A.209 (VII) establishing recommendations regarding posting maneuvering regulation II-1/29.3.2 of SOLAS requires rudder movement from 35 degree on either side to 35 degree to the other side within 28 seconds or less. IMO approved circular MSC/Circ.389 in 1985 establish interim guidelines for estimating the maneuverability. This include rudder size and effectiveness, ability to transit at slow forward speed, propulsion and propeller characteristics, number of available engine reversals, adequate horsepower for control, extra reserve rudder angle needed to allow for ship crabbing from wind forces or moored ship suction, visibility from bridge and bridge arrangement, hull form squat (trim and sink age) characteristics and effect of bank forces on moorings and passing ships, air draft, emergency anchoring ability, amount of tow line leads and line access [4].

Current Ship Design Practice

Existing design tools cannot, at least with any degree of reliability, be used to design a vessel and ensure that it will ensure environmental reliability and adequate maneuverability in shallow or restricted waters. Neither can it be used to satisfy demand need by clean ships. In part this is because of the extreme on-linearity of hull and propulsion characteristics under these conditions. In general, naval architects and marine engineers are educated and equipped with knowledge, skills, and design processes that permit continuous checking and balancing of constraints and design tradeoffs of vessel capabilities as the design progresses. The intended result of the design process is the best design given the basic requirements of speed, payload, and endurance to achieve sustainable system design. Ship design focus is not placed on how the channels and waterways are designed. Even more importantly, there is a general lack of understanding of the operational scenario regarding piloting of vessels in constrained waterways. Only recently has there been a real attempt to fully integrate human operational practices with vessel design. The involvement of human beings onboard vessels both extends and restricts the inherent vessel maneuvering capabilities. This also complicates the necessary methodology for assuring safe and efficient operations.

Environmental parameters	Environmental Demand	Impact areas
Ship design	Need for longer safe life cycle	New limit definition, correct material selection, Material technology, quality control of safety and environment
Construction	High worker safety standards, low energy input	Improved hull hydrodynamic,
Emission	Minimum pollution and emission, Minimum SOx, NOx and green house gas-zero discharge	Advance close loop process on board, waste recycling equipment, improve training
Scrapping	Zero harmful emission	Beneficial disposal
Operations waste	Efficient maneuverability	Improve maneuverability

Table 3: Parameters Demand and Impact

Taking waste, pollution issue and restricted waterway maneuverability as an important part of ship design spiral would be a necessary step to enabling proper tradeoffs in vessel design. The reality is that maneuverability and pollution protection is still not an important consideration in ship design of many merchant ships. The result is that design decisions that can compromise environment and collision are decided in favor of other factors. Consideration for full range of ship, channel design, environment, maneuverability, technology and human factors relationships offer opportunity to achieve high efficient and safe environmental friendly sustainable marine transportation. The new challenge of environment is also a reminder for need to squeeze in more stuff in the design spiral. Table 3 shows demand and impact parameters for technological signature.

Environmental Mitigation toward Green Technology (Pollution Prevention Protection and Control Measure)

Shipboard Waste and Emission Prevention, Protection and Control

Treatment and elimination Pollution Prevention or Pollution Control (**P²**C) this is backbone of the thrust in achieving clean ship. **Pollution Prevention** uses fewer environmentally harmful substances and generates less waste on board.

Pollution Control: involve increase treatment, processing, or destruction of wastes on board. The basic P²C principles follows elimination of the use of environmentally harmful chemicals, such as Ozone-Depleting Substance (ODSs), toxic antifouling hull coatings, and other hazardous materials, through the best approach for dealing with some potential problems. *Reducing* the amount of waste being generated on board is often better than treating it on board. For example, reducing the amount of plastics and other packaging materials taken aboard can simplify solid and plastics waste management. Similarly, reducing the volume of liquid wastes generated (such as gray water) may simplify onboard liquid-waste treatment system and operation. Figure 2 shows strategies for green ship technology. Table 4 shows environmental impact and response. Table 5 describes reduction potential from research conducted in Europe.

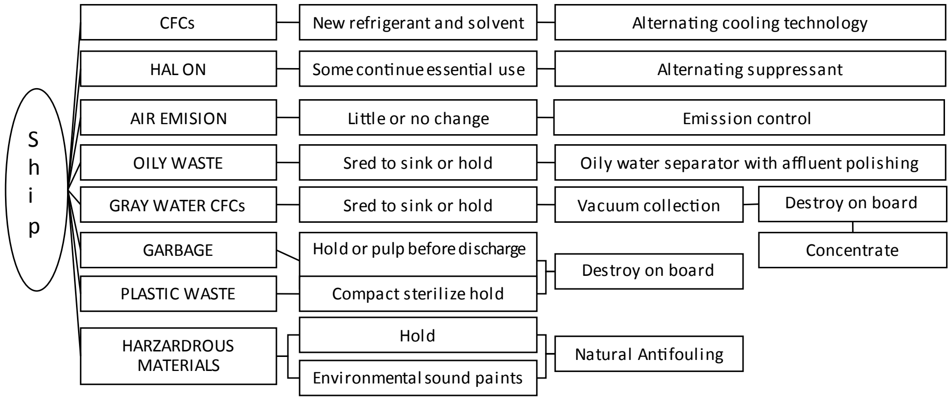


Figure 2: Strategies for Green Ship Technology.

Environmental impact	Mitigation science	Mitigation response
More energy and Power means more emission	Maximum fuel efficiency	environmental friendly retrofit and hybrid design, use of alternative energy
Antifouling	Harmless	Biocide free technology
Ballast water	Zero biological invasion or transfer of alien species	Segregated ballast tanks, improved ballast water tank design, ballast water treatment, ballast water data base
Sea mammal Interaction	Maneuverability capability	Safer ship structure design, Improve maneuvering capability, Navigation aid, misinformation, exchange, reeducation
Accident	Able officer, Ship structure, Integrity	New monitoring through port sate control
Fire	Harmless	Halon phase out
Wave wash of High speed Marine craft	Zero inundation and spray ashore	Moderation of hydrodynamic force

Table 4: Environmental Impact and Response.

For the wastes and hazardous materials that cannot be prevented, we must develop pollution-control strategies and technologies. Other technical mitigation measures are:

Antifouling

- Toxic approach uses other metals such copper and zinc, or agrochemicals e.g. triazines.
- Fouling release is confronted by the use physical properties of low surface energy coating that cause the very weak attachment of fouling organisms. E.g. silicone based coating.
- Fouling deterrence marine organism not knows for fouling like corals are use.
- Mobile hull cleaning is also being used operationally.

Ballast Water Discharge: On board treatment of chemical (chlorination), physical treatment (Ultra violet light, heat treatment), filtration and cyclonic separation, shore base treatment is sometime being used but not common.

Operational mitigation based on information of biological difference between coastal ocean water where ballasting and deballasting is done accordingly.

Air emission

- Sulfur reduction in bunker fuel

- Nitrogen reduction to choice of propulsion system (retrofit)
- On board emission control retrofitting system like, water injection, emulsion
- Operationally speed reduction and use of shore power connection can be implemented

Ship to be scrap may contain on-board consumables may hazardous wastes. Unless subjected to prior cleaning, these substances will follow the vessel to the ship breaking facility. Most ship dismantling occurs in developing countries. The Basel Convention controls the transboundary movements and disposal of hazardous wastes.Up to now dismantling sites have been chosen by ship owners on a commercial basis. This has resulted in ship dismantling activities today being mainly performed in a few developing countries (India, Bangladesh and Pakistan with increasing interest in China, Vietnam and the Philippines) where there is little or no alternative employment for the workforce and where safety, health and environment regulations applicable in most of the developed countries are not applied.

Stages	Remarks
Primary measures:	1.Use of low sulfur fuel (less than 6 g/kwh)
	2.HFO sulfur content-Need for oil company to change their equipment for low sulfur oil production-> ship-owner will face high cost, additive solution has been expensive so far
	3. Reduction of NOx, SOx, +cost saving through boiled off gas reuse.
Secondary measures:	1. Exhaust gas cleaning system or technology Sox for SECA (Emission Control Area) & Fuel change over.
	2.Nitrogen reduction through choice of propulsion system
	3.Sulfur reduction -in bunker fuel
	4.Reliquification plants for Liquified Natural Gas (LNG)/Liquified Petroleum Gas(LPG) carriers
	5.Use of Turbo generator plant –> Paticulate matter (PM)- SAC volume is the void space in the fuel valve downstream of the closing face
Operationally	1.On board Catalytic system like : Converter, water injection Emulsion
	2. speed reduction (10-20%).
	3.Use of shore power connection
	4. Dual fuel option for low sulfur restricted areas (1.5-4.5), this comes with need for additional tanks.
	5. The content of hydrocarbons in the exhaust gas from large diesel engines depends on the type of fuel, the engine adjustment and design.
Retrofitting for existing engines:	1. Use of NOx injectors.
	2.Retarding injection timing
	3. Temperature control of the charge air.
	4.Exhaust Gas Recirculation (EGR)
	5.Fuel/water emulsion
	6.Water injection
	7.Humid Air Motor (HAM) Technique- addition of wet steam to the engine 50% reduction
	8.Selective Catalytic Reduction (SCR)
For new engines	1.Engine certification
	2.Pre-certification,
	3.Technical file clarification on engine family and group,
	4.Final certification
	5.Alfa Lubricator system 6.Reduction in cylinder oil consumption-> reduction in particulate emission
	7.Electronic control engine Programmed fuel injection for exhaust valve emission reduction
	8. Use of high efficiency air flow for power take off reduce fuel and reduction of emission.

Table 5: Reduction Potentials.

The dismantling procedures used can result in hazardous conditions for the workforce and both local and global pollution of the environment. This issue concern related to ship dismantling has been raised in the UN and the potential for improvements in ship dismantling is believed to be significant.Important environmental aspects for ship at the end of their life. Methods used at present in the ship demolition industry to recover the values represented by scrap materials themselves create contamination and pollution. The discharge of gases from cutting and burn-off operations presents a threat to the environment as well as to the individuals exposed. Important environmental aspects of concern with ship breaking are:

- Cathodic protection (Al, Zn).
- Batteries (Pb, Cd, Ni and sulphuric acid).
- Coatings and paint (PCB, Cu, Zn, Cl and TBT).
- Fire fighting agents.
- Refrigerants dichlorodifluoromethane (Freon-12) and chlorodifluormethane (R22).
- Thermal insulation (asbestos, PCB).
- The hull and large steel structures (Fe).
- Electrical system (Cu, PVC, PCB, Pb, Hg).
- Hydrocarbons and cargo residues.

Ship Collision Prevention (Safety and Environmental Prevention, Protection and Control Measure)

Most accident is attributed to a flagrant controllability problem. They remain the classic impetus necessary to make improvements to safety and environmental protection. There is need to ensure adequate vessel maneuverability perhaps better matching of vessel, channel and operational practices.

- Ship maneuverability as major iterative element of design spiral: Ship maneuverability is not considered particularly important during the design process. Because owners generally do not include maneuverability requirements as part of the design specification; Firm deep- and shallow/restricted water maneuvering standards can be applied during the design process should be established.
- Modeling and simulation: Collection of data using dual frequency Differential Global Positioning System (DGPS) receivers and proper analysis needs to be supported to enable unlocking understanding of restricted water operations.

Major Finding and Best Practice Green Ship Technology

Environmental technology also becomes a serious issue of environment start of another revolution. Today environmental technology product and services are booming. The major environmental aspects related to maintaining machinery and auxiliary systems are oil (additives), coolants, gases, electrical/electronic waste, seals, insulation and scrap-metals. Table 6 and 7.

Model	Environmental performance
Kutsuro Kijima	Showed a modeling approach that permitted analysis of passing situations of vessels in waterways that would help set procedural standards for safe passing vessels in port.
IanDand	Reported on the development of models for ship squat model those have shown very good accuracy over the years.
Larry Daggett	Described the advent of dual frequency DGPS receivers and their role in gathering full-scale ship trial data. In addition to the excellent horizontal accuracy of the normal DGPS receiver, these receivers provide vertical location with an accuracy measured in centimeters.

Table 6: Development Coalition Control Services Model (22).

Product	Target	Environmental performance
200-Ton Air-Conditioning Plant Conversion Kit	Ozone safe substances:	The CG-47and DDG-51 plants have been successfully converted to the ozone-friendly refrigerant HFC-236fa where conversion kit has been established by NSWCCD.
Waste Pulpers	Solid waste: Solid	The pulper is the machine into which you dump tremendous quantities of paper, cardboard, or food waste. The waste mixes with seawater to form slurry, which is then discharged overboard. Studies show an immediate 100,000-to-1 dilution when discharged into the wake of a ship. Ships equipped with a pulper can dispose of their paper, cardboard, and food waste just about anywhere and at anytime at sea including MARPOL areas.
OWS and Bilge water Polishers	Liquid waste	These bilge cleaners the US Navy uses, it contain long-lasting emulsifying agents, which produce stable oil-in-water emulsions that shipboard OWSs cannot effectively process.
Valve gauge		Valve gauge assembly developed by NSWCCD the ring-gauge isolator to improve the reliability of sanitary waste system sewage transfer-pump suction and discharge gauges [8]. Figure 2 shows the valve gauge assembly.
Integrated liquid discharge system	**Therma Destruction**	NRL plan for concept where ultrafiltration membrane systems would concentrate bilgewater, graywater, and sewage (as previously described); the clean effluents would be discharged; and the concentrates would be evaporated/incinerated in a thermal-destruction system (See Figure 3)

Table 7: Environmental Performance Technology

The maintenance system shall provide continuous improvement of existing procedures and routines. Improvements in maintenance are mainly motivated by cost reduction and increased operational reliability and safety considerations, but often have positive environmental consequence in addition. **Table 4 and 5 show some resent environmental performance products.** A number of promising developments that exist today are shown in Table 6 and **7**. For green ship project, conventional wastes and emissions must be control according to the present strategy for treating or eliminating these wastes using the above principle [22]:

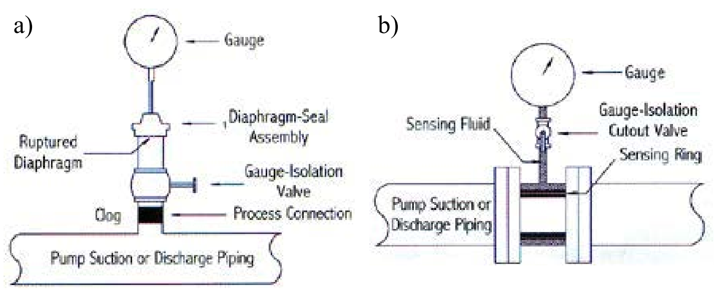


Figure 3: a) diaphragm assembly valve assemble b) Ring gauge valve isolator assembly

Green House Emission Green Technology

Recent critical environmental revolt such as the issue of the rising sea levels and floods has brought about a sense of awareness with regards to environmental degradation. There is an increased awareness that everything on this planet is interconnected. Water will flow to the rivers through the ground and eventually end up in the sea. This makes the management of the quality of water and air, the balance of their purity and the prevention of the substance running into them a crucial point in protecting the environment from further deterioration [15]. High pressure associated with air pollution due to the rapid climate change, led IMO diplomatic conferences to the new Annex VI, Chapter III which deals with the requirements for the control of emissions from ships including [15]:

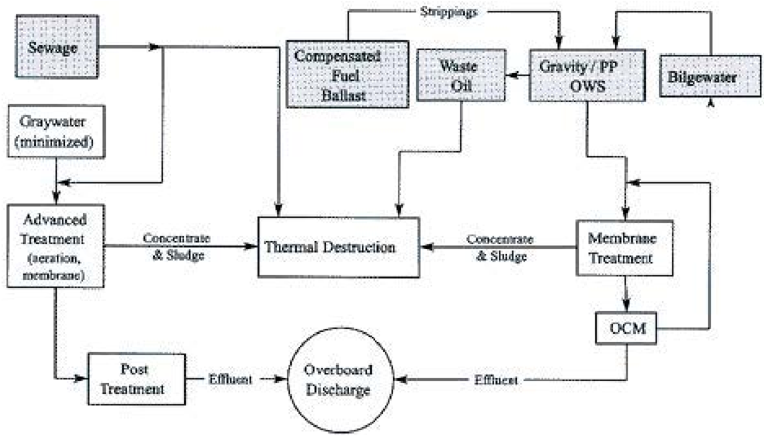


Figure 4: Integrated Liquid Discharge System Concept

- Regulation 12: Ozone depletion substances
- Regulation 13: NOx
- Regulation 14: SOx
- Regulation 15: Volatile organic compounds
- Regulation 16: Shipboard incinerator
- Regulation 17: Reception facilities
- Regulation 18: Fuel oil requirement
- Regulation 19: Requirement for platform and drilling rigs

Fossil fuel is considered as the single largest contributor to emissions. Apart from the NOx and SOx regulation which has been introduced, COx smoke emission is likely to be regulated. To facilitate the adoption to emission regulations, operators, officers, engine builders, yards and ship-owners are doubling their efforts to adopt new technologies to make this earth a better place to live in. *However of late, the issue became increasingly serious with the Marine Environment Protection Committee (MEPC) in its 60th session on 22 to 26 March, 2010* concluding that more work needs to be done before it could finalized the proposed mandatory application of technical and operational measures which was designed to regulate and reduce the emission of Greenhouse Gases (GHGs) from international shipping. IMO has been waiting for the outcome of the COP 15 before they hit the industry with the new emission regulations where unilateral options for the maritime industry were being considered.

The technical and operational measures which was adopted includes the interim guideline on the methods of calculation and the voluntary verification of the Energy Efficiency Design Index (EEDI) for new ships, which will stimulate innovation and the technical development of all the elements influencing the energy efficiency of a ship, as well as the guidance on the development of a Ship Energy Efficiency Management Plan for all ships in operation. Table 8 and 9 shows potential achievement to implementation of the technology [17,23]. The main area to meet emission reduction targets, MachineryWHR, scrubbers, EGR, etc.

- Propulsion: Propellers, rudders, trim optimization, etc.
- Operations: Route planning, performance monitoring, etc.

- Logistics: Better interaction between transport forms, evelopment/modification of existing ship types etc.

Category	Components	Sources	Current method of reduction
Emission to air	Cox	Machineries/incinerator/boiler	Operational and energy efficiency measures
	Sox		Low sulfur fuel exhaust washing
	NOx		Exhaust cleaning, engine modification, or input media
	HC		Exhaust gas recirculation
	Noise	Machineries/cargo operations	Insulation
	Particles	Machineries/incinerator/boiler	Electronics lubrication and injection
	HFC/Halon	Fire extinguisher/refrigeration system	vapor return, recovery plant
	VOC	Cargo operation	Sequential loading

Table 8: Emission and reduction measures.

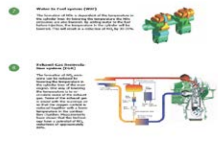
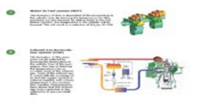
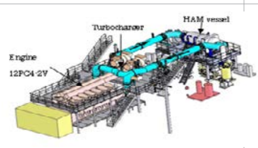
Waste heat recovery system	A. P. Møller –MAN, Aalborg Industries, Odense Lindø Shipyard		Use main engine exhaust gas heat that contains hot energy that is transformed to steam. The steam can be used for cargo and fuel heating power generation-7-14% of fuel can be saved from heat recovery system (24)
Exhaust Gas Recirculation system	MAN, A.P. Møller		NOx is formed at high temperature; therefore, its formulation can be reduced by lowering the temperature in the system. Exhaust gas can be recircultion, where some is mixed scavenge air to reduce the oxygen content, and consequencial reduction in temperature in the system. The technology has potential to reduce Nox by 80%.
Water in Fuel Emulsion (WIF)	MAN and A. P. Møller		Reduction of 30-35% NOx can be achieved byadding water to the fuel before injection
Scrubbers	Aalborg Industries and DFDS		This technology can be used to control future regulation of SOx release. The scrubber use water to wash the sulfur out of the exhaust gas. Testing of the system has shown SOx reduction of 98%, and simultaneous reduction of harmful particlelate matter are reduced by 80%.
Optimization of pump system and cooling systems	DESMI, APV, Odense Lindø, Grontmij Carl-Bro		20% electrical power generation reduction can be achieved by using optimized cooling water system. Also 90% power saving, can be achieved can be reduced through reduction in pump resistance. Pump size can also be reduced via this technology
LNG for aux. engines and gas turbines	Mols-Linen and DTU		Most diesel engine in harbor run in diesel, by using switching to LNG to run auxiliary engine under fuel arrangement, 20% of Cox35% of NOx can be achieved
Selective Catalytic Reduction	Dansk Teknologi and Danish Navy		
Turbo charging with variable nozzles	MAN and ABB		

Table 9: Machineries.

Table 10 below shows strategies to reduce air pollution from ship, and Figure 4 Shows process input of ship design spiral. In respect to operations, companies have used voyage planning, •marine Institution established Student forum that focus on Green Ship technologies, other arrangement at sea include introduction of 'Green shipping' in the working procedures onboard and implementation of constant focus on energy saving possibilities on the ships. In respect to logistics better transport planning , better tools for evaluation of the most, energy efficient transport forms and better cooperation between the transport providers are current practice that are working to reduce pollution (18).

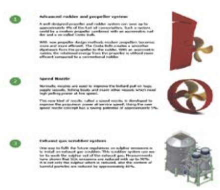
New paint systems	Hempel		Choosing right antifouling paint with low water friction is beneficial to reduce ship resistance and subsequencial saving of fuel of 3-8%, hence proportional reduction of emission.
Advance Rudder and propeller system	MAN and ABB		Modern ruder design that combine propeller with asymmetric ruder called costa bulb, efficient propeller design provide smooth slipstream from the proper to the rudder, and asymmetry rudder rotational energy is utilized more efficiently.
Speed nozzle	MAN and ABB		Nozzle are used to improve the bollard pull on tugs, supply vessel, fishing boats and other vessel which need high pulling power at low speed. Speed nozzle are modern nozzle with improve propulsion power at service speed. The technology has reduction capability up to 5%

Table 10: Propulsion

Another best practice is the case of MASRK ship an 8500 TEU container vessel, optimised with (Figure 5):

Figure 5: Maersk line.

- Waste heat recovery exhaust boilers
- Power and Steam turbine technology
- Water in Fuel technology (WIF)
- Exhaust gas recycling
- (EGR)Exhaust gas Scrubber Extra costs 30 mill USD (approx 10% of newbuilding costs)

The Goals was to have -30% reductions of CO_2emissions, Achieved result include 11-14%-90% reduction of NOx emissions-Achieved 80%-90% reduction of SOx emissions-Achieved 90%.

Figure 6 shows a magto-electric waste energy recovery system modeled numerically at UMT, while Figure 7 shows the amount of additional energy which can be produced from the system [25].

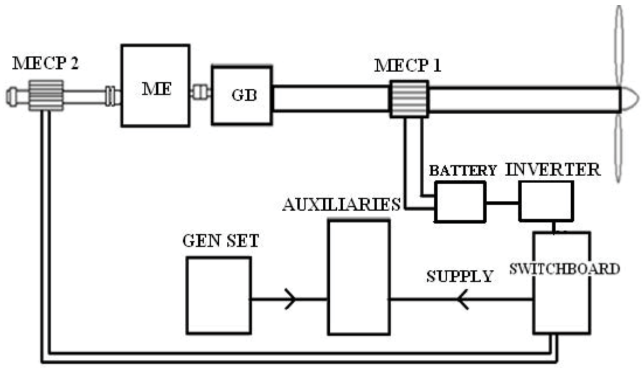


Figure 6: Magneto electric system model.

The system offers flexibility in optimizing plant operations to minimize operation costs or maximize propulsion power. The use of these sets is considerably reduced thereby providing a further potential to reduce operating costs.

a. Carbon capture b. Recovered power

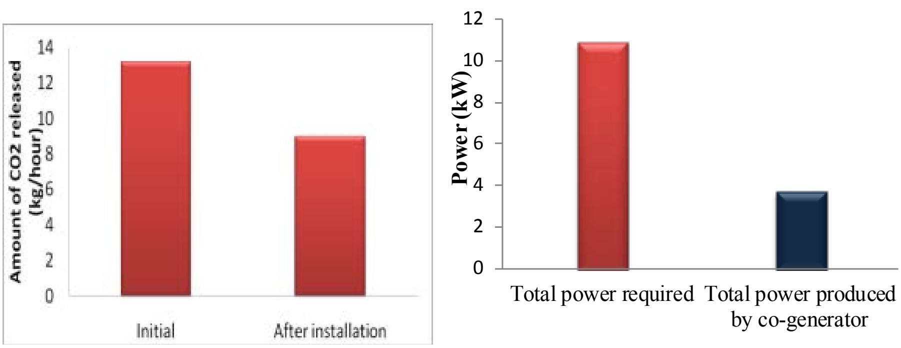


Figure 7: Magneto electric model result

Regulatory Prediction Process

Figure 7 shows risk based process for system regulatory requirement. However based on risk analysis outcome, regulation influence can be predicted and quantified by assigning a numerical weighting value to each link between factors (Figure 7). Future system will require design based on risk that matches system functionality with requirement. The ship design spiral shown in Figure 8 does not include most of the process described above, and some will require mandatory insertion in the spiral. Figure 9 shows cost benefit analyses that can be deduced from potential consequence in risk of do nothing.

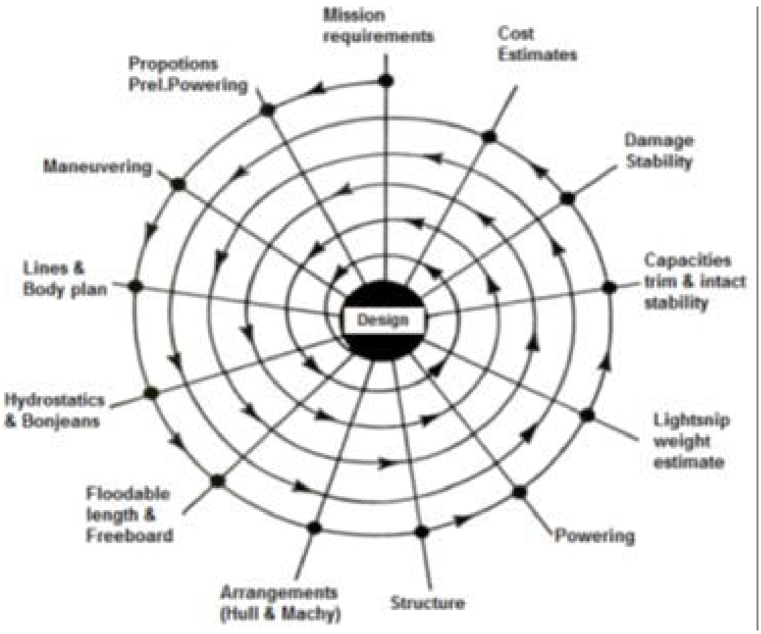


Figure 8: Ship Design Spiral .

In estimation of regulation, the concordant process require expert rating which is translated into the weighing factors, this weighting can be placed on factors at a lower level in the diagram, factors at a higher level that are influenced by that lower level factor and also by assigning a numerical rating value to every factor. The weighting values between factors quantify the relative importance of the influence of lower level factors upon higher level factors. Weighting values are assigned as percentages on a scale of zero to 100%, such that for any factor at a higher level, the sum of the weightings of all the lower level factors which influence that higher level factor is 100%.

$$W1+W2+W3+W4=100\% \quad (1)$$

Where W1, W2, W3, & W4 are the weightings linking factor E1, E2, E3, & E4 to factor P1. Consider the environmental level factors which link with the first policy level factor, P1. Say these environmental level factors are E1, E2 and E4. Let the weightings of these environmental factors on the first policy level factor be W (E1, P1), W (E2, P1) and W (E4, P1) respectively. Furthermore, let the respective ratings of these factors be R (E1), R (E2) and R (E4. W(E1, P1) W(E3, P1) W(E2, P1). A calculated rating value for factor P1 is derived as being:

$$R(P1c)=R(E1) \times W(E1,P1)+R(E2) \times W(E2,P1)+R(E4) \times W(E4,P1) \quad (2)$$

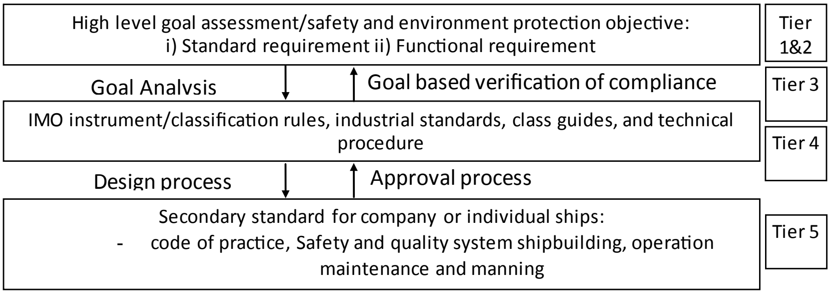


Figure 9: High Level Goal standard Assessment.

Figure 10: below shows cost and sustainability analyses instrument graph

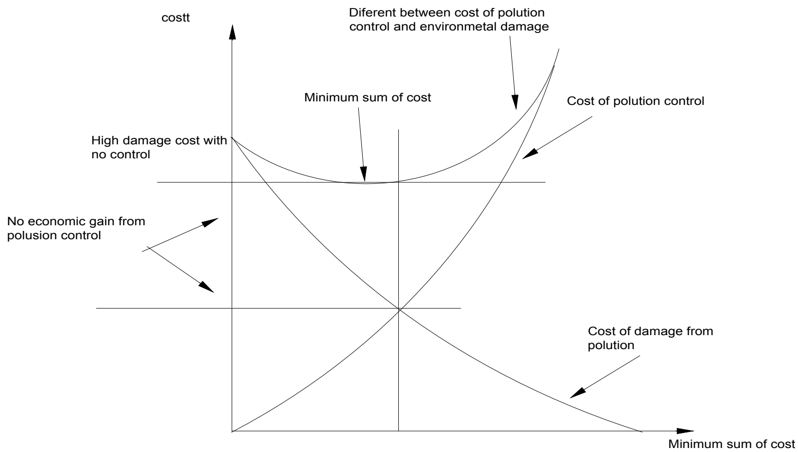


Figure 10: Cost and Sustainability Components.

The Way Forward

Recent Safety and Environmental Strategic focus on developing metrics to measure and evaluate progress. The key issues and actions are incorporated in the clean ship concept. Ships owner and operators must understand the need to include wastes stream management in mission requirement in the design stages, with the goal of ships being in compliance. Ship designer must pursue technologies to reduce or eliminate waste streams. The metrics use to monitor progress towards achieving environmentally sound ships will focus on shipboard pollution control equipment installations, specifically the planned versus actual installations. Each waste stream or environmental pollutant, equipment installations, the percentage of total installations completed versus the planned percentage, will be used as a measure of progress for that waste stream. For waste streams and contaminants for which no equipment has been approved or anticipated, the metric will born many R&D for necessary findings. There is need for effectively integration of pollution prevention and safety into the design and life cycle of our ships, systems, ordnance into the execution of our processes and into the operation. Managing the whole process is another thing, environmental management can be optimizing by incorporating the following concept in our system Table 11 shows potential marine technology research are for waterborne transportation:

- Total cost minimization concept,
- Innovative safety and environmental strategy management and integration
- Planning for uncertainty and risk,
- Use of probabilistic and holistic methods
- Education and training

Marine Technology areas	Need	Technology platforms
Efficient, safe and environmentally friendly ships and vessels of the future	Improvement of concepts of multi-site design, engineering or environmental kindliness production	Fast vessels for passengers, cars and cargo: -deep-sea ships for passengers and unit cargo - deep-sea floating structures for production storage and off-loading of gas; - unmanned, autonomous and remotely operated survey vehicles; and - new concepts for short-sea operations and polar shipping.
Maximizing interoperability, transshipment and vessel performance	Improvement of port infrastructures, reducing operating costs, improving maneuverability of ships in restricted waters and ports and efficient cargo handling and transshipment.	Research is focusing on integrating advanced concepts for unitised cargo and for ship types operating in coastal, restricted and limited waters. The strategic aim is to demonstrate concepts for multimodal cargo units and reinforcing intermodal links to ease improve and facilitate cargo flows between inland waterways and the sea.
Innovative technologies for monitoring, exploration and sustainable exploitation of the sea	Development unmanned surveying, in-situ monitoring and industrial operation.	
Competitive shipbuilding	Hull design to reduce environmental impact from loss of structural integrity, fuel consumption through hull form optimization, wave/wash generation, corrosion noise and vibration and use of new material.	Research is helping to demonstrate streamlined and seamless vessel development processes and systems, and support advanced production systems which improve customer response, product quality and manufacturing process flexibility and control

Table 11: Marin technology and research areas for waterborne transportation

Conclusion: Working Better by Working Together

This paper discussed environmental technology issue and potential research direction for green technology for ship. Beside miniaturization, use of nature and system integration will be next in line in the process for system to work efficiently. Even thus the environment has naturally integrated everything in this planet between air, water and soil. The same apply to maritime industry on the issue of safety and marine environmental impact control and protection. Environmental issue has become so sensitive because it is more or less of evidence that nature has exercise enough patience, impact has reach flash point and those who are knowledgeable about the behavior of matter and environment have been giving predictive data about potential of contagious chain reaction of climate change and potential consequential heavy calamity damage and lost. Existing engine and future engines will be forced to adapt new technologies presented in this paper in the near future. Green technology highlighted in this paper will be a major catalyst to ignite a series of research activities to solve the current energy and environmental problems. Data collected from such research will be utilized to enforce relevant climate change control and compliance laws.

The data can be used for simulation purposes and support the deployment of new systems. The evolving technology discussed could help meet the current demand by IMO for the implementation of Energy Efficiency Design Index (EEDI), Ship Energy Efficient Management Plan (SEEMP) and Ship Energy Efficiency Operational Indicator (SEEOI) rules which was launched recently towards global warming, climate change and ozone depletion in the maritime industry. The following are commended for future technological compliance to regulation:

- It is important for the main players in marine time industry (pilots, regulators, channel designers, simulator experts and ship operators) to share experience regarding differences in rules and design requirement for clean system.
- Among regulators it is important to review rules that are taken too light, most of which are currently being implemented unilaterally because of variability in environment.
- Naval architects and ship handlers alike should take the importance of GHG, green ship issue, risk based design and ship maneuvering unrestricted in ship design process. It is important o integrate design requirement related to this in ship design spiral.
- Tackling the issue of environment equally required hybridizations of all the methodology we have been using reactive process. The use of proactive approach that consider sensitivity of area, degrees of hazard for various ship types, and of course employment holistic institutionalized risk based system design method that compare and consider trend analysis of every elements of the new sustainable technology system development is recommended.

The political will for green technology is a wakeup call for all ship owners to be ready for new regulatory regime that will dictate technology for ship. Green ship technology will also be main factors shipper and ship charters and insurance company look for in order to make decision for future business deal. Adoption of green ship technology will define significant ship, award winning vessel and qualification of green passport of next generation ship. That ship will be able to go anywhere and will face no delay in their transportation activities.

Appendix: IMO Conventions

- Convention on the International Maritime Organization (IMO CONVENTION) (in force).
- 1991 amendments to the IMO Convention which were adopted by the Assembly of the Organization on 7 November 1991 by resolution A. 724(17) (IMO AMENDS -91) (in force).
- 1993 aamendments to the IMO Convention which were adopted by the Assembly of the Organization on 4 November 1993 by resolution A. 735(18) (IMO AMENDS-93) (in force).
- International Convention for the Safety of Life at Sea, 1974, as amended (in force).
- Protocol of 1978 relating to the International Convention for the Safety of Life at Sea, 1974, as amended (in force).
- Protocol of 1988 relating to the International Convention for the Safety of Life at Sea, 1974 (in force).
- Agreement concerning specific stability requirements for ro-ro passenger ships undertaking regular scheduled international voyages between or to or from designated ports in North West Europe and the Baltic Sea (in force).
- Convention on the International Regulations for Preventing Collisions at Sea, 1972, as amended (in force).
- Protocol of 1978 relating to the International Convention for the Prevention of Pollution from Ships, 1973, as amended.
- Annex III to MARPOL 73/78 (in force).
- Annex IV to MARPOL 73/78 (in force).
- Annex V to MARPOL 73/78 (in force).

- Protocol of 1997 to amend the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (in force).
- Convention on Facilitation of International Maritime Traffic, 1965, as amended (in force).
- International Convention on Load Lines, 1966 (in force);
- Protocol of 1988 relating to the International Convention on Load Lines, 1966 (LL PROT 1988) (in force).
- International Convention on Tonnage Measurement of Ships, 1969 (in force).
- International Convention Relating to Intervention on the High Seas in Cases of Oil Pollution Casualties, 1969 (INTERVENTION 1969) (in force).
- Protocol relating to Intervention on the High Seas in Cases of Pollution by Substances other than Oil, 1973, as amended (INTERVENTION PROT 1973) (in force).
- International Convention on Civil Liability for Oil Pollution Damage, 1969 (in force).
- Protocol to the International Convention on Civil Liability for Oil Pollution Damage, 1969 (in force).
- Protocol of 1992 to amend the International Convention on Civil Liability for Oil Pollution Damage, 1969 (in force).
- Special Trade Passenger Ships Agreement, 1971 (in force).
- Protocol on Space Requirements for Special Trade Passenger Ships, 1973 (in force).
- Convention relating to Civil Liability in the Field of Maritime Carriage of Nuclear Material, 1971 (in force).
- Protocol of 1992 to amend the International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage, 1971 (in force).
- Protocol of 2000 to the International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage, 1972 (in force).
- Protocol of 2003 to the International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage, 1992 (in force).
- International Convention for Safe Containers (CSC), 1972, as amended (in force).
- Athens Convention relating to the Carriage of Passengers and their Luggage by Sea, 1974 (in force).
- Protocol to the Athens Convention relating to the Carriage of Passengers and their Luggage by Sea, 1974 (in force).
- Protocol of 1990 to amend the Athens Convention relating to the Carriage of Passengers and their Luggage by Sea, 1974 (not yet in force).
- Protocol of 2002 to the Athens Convention relating to the Carriage of Passengers and their Luggage by Sea, 1974 (not yet in force).
- Convention on the International Mobile Satellite Organization (Inmarsat), as amended (INMARSAT C) (in force).
- Operating Agreement on the International Mobile Satellite Organization (Inmarsat), as amended (INMARSAT OA) (in force).
- Convention on Limitation of Liability for Maritime Claims, 1976 (in force).

- Protocol of 1996 to amend the Convention on Limitation of Liability for Maritime Claims, 1976 (in force).
- International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978, as amended (in force).
- International Convention on Standards of Training, Certification and Watchkeeping for Fishing Vessel Personnel, 1995 (not yet in force).
- International Convention on Maritime Search and Rescue, 1979 (in force).
- Convention for the Suppression of Unlawful Acts against the Safety of Maritime Navigation (SUA) (in force).
- Protocol for the Suppression of Unlawful Acts against the Safety of Fixed Platforms Located on the Continental Shelf (SUA PROT) (in force).
- Protocol of 2005 to the Convention for the Suppression of Unlawful Acts against the Safety of Maritime Navigation (not yet in force).
- Protocol of 2005 to the Protocol for the Suppression of Unlawful Acts against the Safety of Fixed Platforms Located on the Continental Shelf (not yet in force).
- The International COSPAS-SARSAT Programme Agreement (COS-SAR 1988) (in force).
- International Convention on Salvage, 1989 (in force).
- International Convention on Oil Pollution Preparedness, Response and Co-operation, 1990 (in force).
- Protocol on Preparedness, Response and Co-operation to Pollution Incidents by Hazardous and Noxious Substances, 2000 (in force).
- Torremolinos Protocol of 1993 relating to the Torremolinos International Convention for the Safety of Fishing Vessels, 1977 (not yet in force).
- International Convention on Liability and Compensation for Damage in connection with the Carriage of Hazardous and Noxious Substances by Sea, 1996 (not yet in force).
- International Convention on Civil Liability for Bunker Oil Pollution Damage, 2001 (in force).
- International Convention on the Control of Harmful Anti-fouling Systems on Ships, 2001 (in force).
- International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004 (not yet in force).
- Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972, as amended (in force).
- 1996 Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972 (LC PROT 1996) (in force).
- Nairobi International Convention on the Removal of Wrecks, 2007 (not yet in force).

Instruments which are in force or applicable but which are no longer fully operational because they have been superseded by later instruments[1]

- International Convention for the Safety of Life at Sea, 1948.
- International Convention for the Prevention of Pollution of the Sea by Oil, 1954, as amended.
- International Convention for the Safety of Life at Sea, 1960.

- International Regulations for Preventing Collisions at Sea, 1960.
- International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage, 1971.
- Protocol to the International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage, 1971.

Instruments Not Yet in Force and Not Intended to Enter into Force

- International Convention for the Prevention of Pollution from Ships, 1973.
- Torremolinos International Convention for the Safety of Fishing Vessels, 1977.
- Protocol of 1984 to amend the International Convention on Civil Liability for Oil Pollution Damage, 1969.
- Protocol of 1984 to amend the International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage, 1971.

Air Emission from ship driving force for next generation Marine Technological and policy change.

Abstract

Main and auxiliaries machineries that move the ship are considered the heart of the ship. Climate Change, Ozone Depletion and Global warming that has been recognized as threat of this generation is linked to ship machineries. This in reciprocal manner is driving the wave of change in policy and technological for new built and existing ship. The current challenges being faced are the balance between efficiency and low pollution and lack of data for engine performance and how much emission is being released and how much impact release to air Green House Gas (GHG) affluence from machineries has health, acidification and structural damage make implementation of evolving policy difficult. This paper discuss review of current direction policy technological change emanating from impact of air emission and its inherent consequence of powered shipping, chemical behavior of Green House Gases. The paper also present result of evolving mitigation option being explored by marine engine manufacturers of retrofit system for existing ship and new energy technology for new built. The paper also presented data base management requirement that can be effective for require implementation.

Introduction

The search for a better managed human society and what brought humans to today's civilization is as old as man itself. The triple bottom factors is the quest for knowledge, the need for production exchange and the organising power of social community which are interrelated and self reinforcing with each advanced technology. The invention of language or ability to communicate and the facilitation of mobility, scale, the trio of energy, economic environment are matters which remained as keys to human technologicakl civilization, all of which went through their course slowly by building stones out of stumbling blocks and some amazingly came out via extraordinary revolution. These dynamic changes through differential approach and methods which can be categorised as a combination of conventional methods made up of ideas, hypothesis, experimentation and observations. [Karma] Over the years, time needs, growth, speed, knowledge, scarcity and competition have created a demand that necessitated man to build a complex institution, all of which requires energy to move them. Likewise, a vast range of human development involves precise measurement of energy and manipulation of delineated discrete objects which has no doubt, reduced the crushing board of physical work and freed man for other pursuits.

This development produces waste of non-renewable energy source. Today, air pollution from energy carries a very large percentage of GHG release and consequential depletion of earthly body oxygen contents, the depletion of ozone layers that is protecting the planet and climate change leading to the anomalies in systems behaviour. Reactive methods has been used to build existing systems as conventional assessment focus more on economics, while environment and its associated cycle is put to oblivion due to the difficulties associated with uncertainties [9] noting that formany years, everything which runs in the air is infinite; the atmosphere and the ocean which is the source of freshening, winds and currents are far more vulnerable to polluting activities and may ceased to serve their purpose if care is not taken to prevent pollution. To this end, the challenge of air emissions is recognized as [24,26]:

- Main inherent consequence of powered shipping
- Have link to fuel oil burning as main source
- Have links with continuous combustion machineries-boilers, gas turbines and incinerators

System design analysis requires environmental account for indexing and performance of the system. Most human activities are powered by non-renewable energy source whose pollutant has turned into poison through point form contamination which has an adverse effect on the quality of air, water and health of the environment and its ecosystem. The two worlds of man dominated by biosphere and techno sphere had tipped the balance with a potential conflict where man is caught in the middle. Historical records shows that the number of calamites has led to damage as a result of pollution which led to the calling for a new philosophy of doing things by making modest sustainable choices through an assessment of economics and environmental issues relating to the use of energy, without compromising the latter. There is also an increase call for a new set of regulations which will result in a policy change on procedures designed from new systems with modifications to the existing one (27). When it comes to energy, it all starts with the environment and the natural source of energy, be it animal, windmill, watermill, steam, electricity or nuclear. With so much water, wind and sun as the primary sources of energy that goes through a natural cycle to support human life and the planet; they remain the cleanest inherited sources of new technology that has yet to turn into a vast potential of income to usable supplies [28]. Figure 11, shows the contribution of the components of green house gases from ships and the Figure exit point of affluence, as well as the impact to ozone from refrigerated machinery.

This paper aimed to discusses the challenges to climate change, ozone depletion and how global warming has touched the shipping and ship powering including the engineering requirements of ship operations, the impact of emissions from ship, rising egalitarian balance between policies, social, technological, economic and environmental sustainability abatement methods to reduce and control emissions.

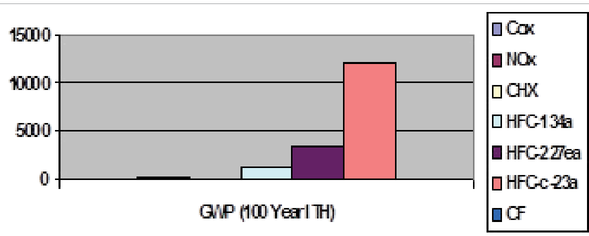


Figure 11: Global warming potential.

The paper also presented the results based on research efforts being made by engine manufacturers which are required to match the developments and the improvements in energy efficiencies as well as the performance of new propulsion system at low pollution. The paper also discusses the significance of the evolving technologies of all electric ships for short sea shipping and hybrid gas electrical system for high sea shipping, the retrofitting control system for existing ships and the possible use of comparison, predictive risk reliability and simulation techniques on extreme conditions analysis which requires decision suppor for testing new technology. This review paper contained the necessary information from policy demands and technology development working towards meeting these standards. This paper also hopes to highlight the emerging research areas for marine power plant technology development in particular the green energy technology, which requires a decision support process that involves:

- Preliminary Information, Needs and a Goal Base Object.
- Standards and Systems Capability Matching Requirement Assessment.
- Analysis for Efficiency, Low Pollution System Requirements Which Are Relevant to Saving.
- Uncertainty, Reliability and Sustainability Analysis.

Emission Impact to Ship and Shipping and Reciprocal Potential Policy Change

For years the cleanest and the safest energy systems lies among the inexhaustible. The use of energy is linked to reckless trial and error, age of experimentation that discovers the big gap between renewable and non-renewable energy. Human adventurism has led to the replacement of renewable nature by non renewable and associated environmental impact is calling for new ways of doing things especially using the advantage of nature. Heinrich [24] discussed some ways to improve the performance of diesel engine and reduce GHG release. Generating energy from waste derived biomass can help to prevent the breakage of the food chain which has an escalating effect and increased the cost of consumer goods and foods. Figure 12 shows the air emission that is released from the power and propulsion plant machinery. This remains the technology center for clean planet. Recent critical environmental revolt such as the issue of the rising sea levels and floods has brought about a sense of awareness with regards to environmental degradation.There is an increased awareness that everything on this planet is interconnected. Water will flow to the rivers through the ground and eventually end up in the sea. This makes the management of the quality of water and air, the balance of their purity and the prevention of the substance running into them a crucial point in protecting the environment from further deterioration [15]. As a result of this, international environmental organisations are seriously encouraging all concerned parties to galvanize their community by setting up panels, collaboration with scientists and technical bodies, to encourage the use of existing scientific bodies and research centers for global observation systems.

This includes the taping of the informal sources of information related to early warning as part of the solution to deal with the problem of sharing data among countries, as well using human capacity and the rapid spread of internet as a tool for information compilation, discussions and news dissemination. Some of the land and sea based regulations that have been passed are [17,18]:

- MARPOL 78: Cover Annex I, includes Oil, Annex II-Noxious liquid chemicals, Annex III -Harmful Goods (package), Annex IV-Sewage, Annex V-Ballast water.
- Adoption of control and prevention measures in 2003 by IMO, as well as problems associated with the transfer of harmful aquatic organisms in ships ballast water to address greenhouse gas emissions from machineries and power plants.

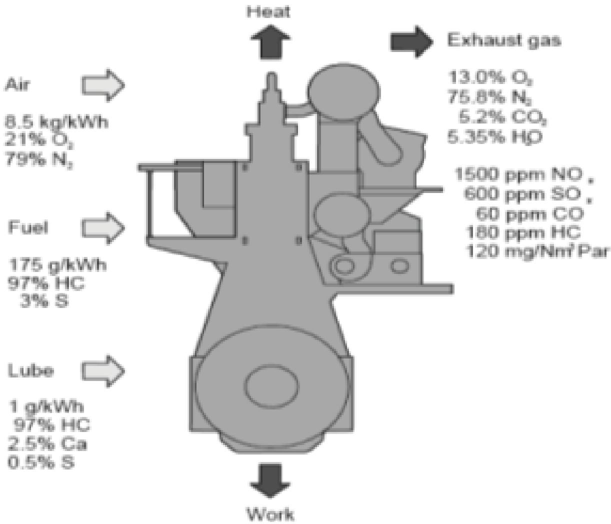


Figure 12: Emission from Marine Engine

- IMO also passed the MARPOL Annex VI during a diplomatic conference and bypassed the usual tacit procedure. Whereby Annex VI-emission and air pollution (SOx, NOx and green house gas, emission of Ozone Depletion Gas (ODG) are addressed.
- Adopt the convention in 2004 to support the International Convention on the Control of Harmful Anti-fouling Systems on Ships 2001. The diplomatic conference also addressed the implementation of the International Convention on Oil Pollution Preparedness, Response and Co-operation 1990.
- Global prohibition of TBT in antifouling coating-phase out scheduled for 2008.
- International convention on oil pollution, response and cooperation.
- Policy to combat major accidents or threats, control to prevent, mitigate or eliminate the danger of marine pollution from the port to its coastline from a maritime casualty.
- Protocol on the carriage of Hazardous and Noxious Substances (HNS).
- Oil Spills Protocol: Specially Protected Areas and Wildlife (SPAW Protocol).
- Protocol concerning Pollution from Land-based Sources and Activities (LBS Protocol).
- Agenda 21 debut on sustainable development.

High pressure associated with air pollution due to the rapid climate change, led IMO diplomatic conferences to introduce the new Annex VI, Chapter III which deals with the requirements for the control of emissions from ships [15]:

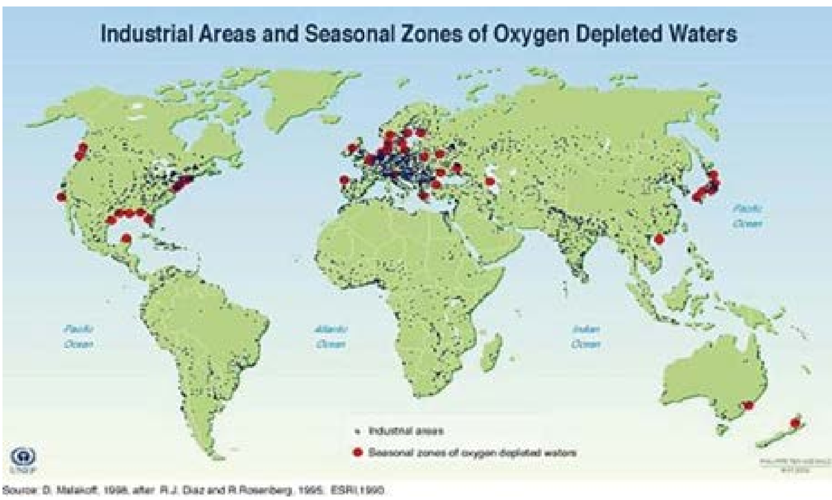
- Regulation 12: Ozone depletion substances
- Regulation 13: NOx
- Regulation 14: SOx
- Regulation 15: Volatile organic compounds
- Regulation 16: Shipboard incinerator

- Regulation 17: Reception facilities
- Regulation 18: Fuel oil requirement
- Regulation 19: Requirement for platform and drilling rigs

However of late, the issue became increasingly serious with the Marine Environment Protection Committee (MEPC) in its 60th session concluding that more work needs to be done before it could finalized the proposed mandatory application of technical and operational measures which was designed to regulate and reduce the emission of Greenhouse Gases (GHGs) from international shipping. IMO has been waiting for the outcome of the COP 15 before they hit the industry with the new emission regulations where unilateral options for the maritime industry were being considered. The technical and operational measures which was adopted includes the interim guideline on the methods of calculation and the voluntary verification of the Energy Efficiency Design Index (EEDI) for new ships, which will stimulate innovation and the technical development of all the elements influencing the energy efficiency of a ship, as well as the guidance on the development of a Ship Energy Efficiency Management Plan for all ships in operation that target GHG emission release.

Maritime Regulatory Regime

Today, only a few countries have ratified the IMO regulations while countries such as Sweden and Norway have introduced reductions in harbour fees for ships operating on low sulphur fuel with a low NOx level in order to reduce pollution. A similar scheme is being proposed in Hamburg. Figure 13 shows the reason why Baltic region in Eurozone are being pressurized for GHG release. As a result of critical GHG release in this region, in 2000, the Swedish authorities had aimed for a 75% emissions reduction. The authorities applied financial incentives in the form of environmentally differentiated fairway and port dues. Reduced fees will stimulate the ferry traffic and other maritime traffic to and from Sweden, irregardless of the ship's flag state to take measures which would benefit the environment such as using catalytic converters or making other technical improvements to decrease the nitrogen oxide emissions and promote the use of low sulphur bunker fuel. The environmental differentiation means that the ship-based portion of the fairway dues is differentiated according to the ship-generated emissions of nitrogen oxide and sulphur. In other words, the authorities will offer a rebate on port dues when a ship reduced its emissions level.



Source: D. Malakoff, 1998, after R.J. Diaz and R.Rosenberg, 1995. ESRI,1990.

Figure 13: Atmospheric oxygen depletion.

For example, a ship will be given additional rebate of SEK 0.90 per unit of the ship's gross tonnage if its sulphur content of the bunker fuel is lower than 0.5 mass percent for passenger ships and 1.0 mass percent for other ships. Apart from that, the Norwegian Maritime Directorate has also issued guidelines on emission limits where the limits do not apply to all hip types and are based on a calculation of the total emission load factor from NOx, SOx, the type of fuel and the use of redundant machinery. The higher the emission factor, the better the protection of the environment and the less will be paid in tonnage tax by Norwegian owners and operators. This rule came into effect on 28 November 2000 and applies to ships above 1000 net register tons [12]. Major responses to air emission from ships are:

- A technical code for the prevention of air emissions from ships
- Diesel engine test
- Survey
- Certificate of compliance (IAPPC)
- NOx compliance limit -30% reduction
- Review of 5 years interval
- Restriction on the use of fluorocarbons on board
- Carbon dioxide emission from ships
- Fuel quality
- SOx Emission Control Areas (SECA)
- Deduced requirement and standards for the control of emissions from the ship includes:
- Fuel grade: ISO 8217
- Emission test: ISO 8178
- One common limit for all engines: International harmonisation of the regulations and equipment standards

IMO and the shipping industry received their credit today in the management and the monitoring of the ship and shipping activities. Nonetheless, the value and the nature of water and the environment requires near zero intolerance to discharge or emit. The regulation of the maritime business and operations has for many years focused on the philosophy of a safer sea and a cleaner ocean. However, the protection of the marine environment is an important international issue in respect to the conservation and the preservation of the world's ocean. It is likely to linchpin into a new international legislation to fulfill a sustainable development philosophy. Pollution from shipping only contributes 10% of all discharge, while years of marine operation pollution paid little attention to air pollution. IMO declaration for a reduction of air pollution under new Annex VI of MARPOL changes this. NOx is given a limit of 30% reduction and sulphur capping of 0.5 to 5.0% limit. The emission from the ocean is forecast to increase between 9% to 13% in 2010 and 20% to 29% by 2020. Bulk carriers, containers and tanker vessels formed three of the largest contributors [9]. This is also due to large number f ships plying the world ocean.

Complete combustion and efficiency is a measure of emission release. The overall energy efficiency is highly dependent upon the type, size and speed of the ship and its machinery systems that are suited for certain types of ships. The interaction between the propeller, the underwater hull and the rudder is important to propel efficiency which indicates energy conversion from the shaft power to thrust power. The tradeoff between efficiency and low pollution poses a big challenge for the environmental technology. Studies conducted by ABS concluded that the following configuration is the best practice hybrid option for large LNG carrier (See Figure 14). In Table 12, it shows how a respective technology can be adopted for the propulsion train.

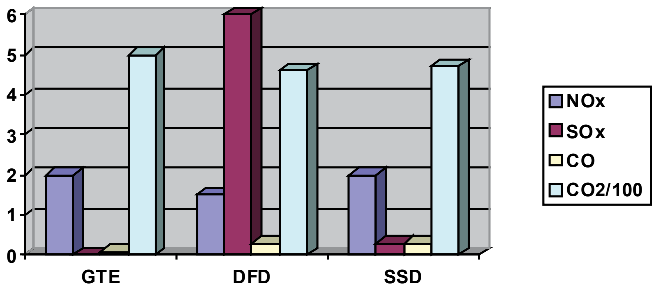


Figure 14: The emission levels for different prime moves .

Slow Speed Engine	Direct Drive
Medium Speed Engine & High Speed Engine and Gas Turbines	Reduction Gear
	Electric Propulsion

Table 12: Curent propulsion configurations.

Understanding the basis of how fuel efficiencies are obtained makes it apparent that the efficiency and emissions will vary for conventionally powered ships and vessel types. The hybrid of gas turbine or diesel electric coupled with dual fuelling including natural gas is a possible option for existing Transocean vessels. While all electric ships use natural gas, micro turbine generators can also be explored for coastal ships. The development for new ships also needs the exploration of technologies to improve its integrated full electric propulsion with advanced power management systems which comes with an.

- Improved converter and power electronics technology.
- Improved generators and motors.

Land based technology is expected to transfer sympathetically to the marine industry through the availability of engines, systems and technical assistance.on the other hand, the inland water transportation will also witness various technological changes, while the marine craft operation in inland water operation will require fuel supplied in bulk. The use of an alternative fuel for vessel propulsion will lead to the review of the design of the power plant, policy associated with the fuel system and a propulsion train.

This can effectively reshaped areas such as machinery arrangement, hull form, compartmentalization, cargo deck, payloads, superstructure, interior layouts, escape and safety as well as route options and etc. There is also a need to strengthen the efficiency and the effectiveness of vessels engaged in short sea service towards a more sustainable distribution and intermodal inland waterways link and deep water operation. At a time when pollution is caused by vehicular traffic playing havoc with the environment, the eco-friendly mode of transportation such as IWTS can be of help. The inland water transportation for one has proven to be the cleanest mode of transportation [29].

The Future Best Practices of Generic Technology

Recent times have seen the rapid general augmentation of awareness on environmental issues which is creating pressure for the need to have a deeper understanding of the engine propulsions system, treatment options, engine modification and its associated tradeoff between efficiency and emission. Emission restrictions has long been imposed on land based power plant by authorities, but the advent of GHG impact has resulted in it being extended to marine powered engines in port and coastal traffic areas. This is not surprising as ships are a significant contributor of NOx with a large volume of ships operating on high seas and coastal water. Subsequent to this, IMO passed a resolution on Annex VI under MEPC for a new limit to prevent air pollution at sea and coastal waters in a diplomatic conference. It was mooted to provide a solution to the degrading climate, the thinning of ozone layers, acid rain, smog formation and the quality of water. According to a research conducted by the Norwegian University of Technology and the British Maritime Technology Limited (Table 13 and 14), they recommended for a research to be conducted based on the technical abatement which relates to a technological energy efficiency and the fuel used in fleet. Table 15 shows the possible mitigation and measures.

Category	Components	Sources	Current methods of reduction
Emission to air	Cox	Machineries/incinerator/boiler	Operational and energy efficiency measures
	SOx		Low sulphur fuel exhaust washing
	NOx		Exhaust cleaning, engine modification or input media
	HC		Exhaust gas recirculation
	Noise		Insulation
	Particles		Electronics lubrication and injection
	HFC/Halon	Fire extinguisher/refrigeration system	Vapor return, recovery plant
	VOC	Cargo operations	Sequential loading

Table 13: Emission and reduction measures

Category	Components	Current reduction potentials
Emission to air	Cox	1-40% operational planning and speed selection 3-7% efficiency improvement of machineries
	SOx	70-80% by limiting the sulphur content in the fuel/means of sea water washing
	NOx	80-90% by selective catalytic reduction (SCR) 10-30% by engine turning/injection retarded 20-30% by engine modification Fuel or injected in cylinder, several alternative methods available with varying reduction potential 30-60% by sequential loading gas transfer
	VOC	70-90% by recovery plant

Table 14: Reduction potentials

Mitigation and Reduction Measures:

Figure 15 describes various retrofitting system for affected parts of the engine and Table 15 describes the primary and secondary fixture model.

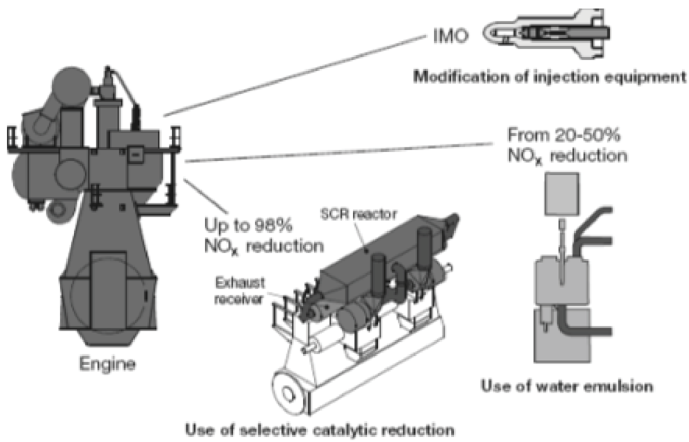


Figure 15: Mitigation and Measures (ABS).

Best practice and compliance

- Lloyd performed a research on exhaust gas emission assessment.
- Rolls Royce built Allen 5000 Series engine with electronic fuel injectors which controls NOx.
- Develop new MDS engine which reduces NOx without fuel penalty.

Evolving Technological Change: There are currently three major ways which are being employed in technology change to control air pollution such as:

- Cleaning fuel prior to combustion (fuel preparation such as fractionation, catalytic cracking and desulphurization)
- Reducing the production of pollutants during combustion (state of combustion, exhaust gas recirculation and reduced temperature levels)
- Cleaning exhaust gas

All these methods involved major design modification which may impact the economics of energy balance. These technological changes are elaborated in the following subsections.

NOx Technology: Environmental impact ofNOx emission involves the increase of acidification and eutrophication.NOx emissions also promotes the formation of ozone and smog (particulates) in the lower atmosphere in heavily populated urban areas. Ozone in the lower atmosphere is very harmful to vegetation and human health. Minimizing the NOx emissions from diesel engines is a pressing international problem. In response to this, engine manufacturers are exploring all means of reducing NOx emissions. The graph in Figure 16 shows the international regulatory standards adopted by IMO for new engines. The IMO emission limit graph is compulsory for manufacturers of new engines to follow.

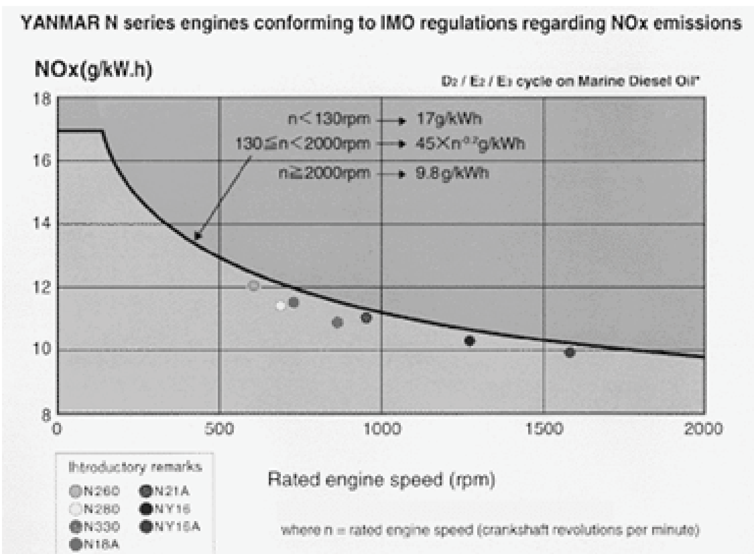


Figure 16: NOx Compliance limit.

Low NOx type marine diesel engines for new series engines use the following methodsto reduce NOx emissions: NOx depends on fuel efficiency, large bore and low speed. Therefore, most mitigation technology is after the above characteristics for combustion system:

- NOx is generated when combustion gas is held at high temperature.

- To reduce NOx generation, the following steps is required:
- – Lower the combustion temperature.
- – Shorten the combustion time.

Other methods to reduce oxide of nitrogen emission in engines are:

- Delay the fuel injection time
- Reduce the temperature and pressure of the combustion air in the cylinders
- Optimize the geometry of the combustion space and the compression ratio
- Introduce water to the combustion space to reduce the temperature by humidification of the combustion air (Wetpac H) or by injecting water directly into the cylinders (Wetpac DWI) or by emulsifying water into the fuel (Wetpac E)
- Delay fuel injection timing which will reduce the in-cylinder duration of the combustion gas at a high temperature
- Raise the degree of premixing and in a gas engine to increase the amount of air
- Advance the closing time of the inlet valve to lower the final combustion temperature (Miller valve timing)

There are many measures aimed at reducing NOx emissions, while increasing the fuel consumption and the formation of particulates. Therefore, the optimization of an engine's emission levels requires that all of these factors are taken into account. **Feasible emissions reduction technology is theu**se as Selective Catalytic Reduction (SCR) catalytic converter. Figure 17 shows the NOx reduction technology rating in respect to reduction measure mentioned above.

Stages	Remarks
Primary measures:	1.Use of low sulfur fuel – (less than 6g/kwh)
	2.HFO sulfur content-Need for oil company to change their equipment for low sulfur oil production-> ship-owr cost, additive solution has been expensive so far
	3. Reduction of NOx, SOx,+cost saving through boiled off gas reuse.
Secondary measures:	1. Exhaust gas cleaning system or technology Sox for SECA (Emission Control Area) & Fuel change over.
	2.Nitrogen reduction through choice of propulsion system
	3.Sulfur reduction -in bunker fuel
	4.Reliquification plants for Liquified Natural Gas (LNG)/Liquified Petroleum Gas(LPG) carriers
	5.Use of Turbo generator plant –> Paticulate matter (PM)- SAC volume is the void space in the fuel valve do closing face
Operationally	1.On board Catalytic system like : Converter, water injection Emulsion
	2. Speed reduction (10-20%).
	3.Use of shore power connection
	4. Dual fuel option for low sulfur restricted areas (1.5-4.5), this comes with need for additional tanks.
	5. The content of hydrocarbons in the exhaust gas from large diesel engines depends on the type of fuel, the er and design.
Retrofitting for existing engines:	1. Use of NOx injectors.
	2.Retarding injection timing
	3. Temperature control of the charge air.
	4.Exhaust Gas Recirculation (EGR)
	5.Fuel/water emulsion
	6.Water injection
	7.Humid Air Motor (HAM) Technique- addition of wet steam to the engine 50% reduction
	8.Selective Catalytic Reduction (SCR)

For new engines	1.Engine certification
	2.Pre-certification,
	3.Technical file clarification on engine family and group,
	4.Final certification
	5.Alfa Lubricator system 6.Reduction in cylinder oil consumption-> reduction in particulate emission
	7.Electronic control engine Programmed fuel injection for exhaust valve emission reduction
	8. Use of high efficiency air flow for power take off reduce fuel and reduction of emission.

Table 15: Reduction potentials [NTNU].

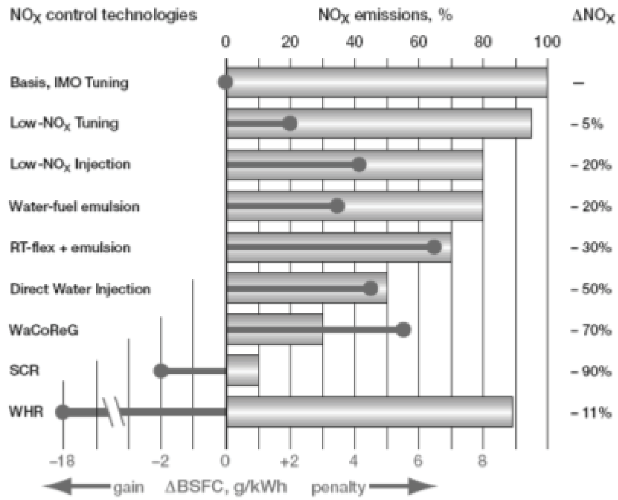


Figure 17: NOx reduction technology rating .

Use of Ammonia through Selective Catalytic Reduction (SCR) Technology

The IMO NOx emission limit is likely to reduce the average NOx emission factors for ocean-going vessels by 4.1% for main engines and 8.3% for auxiliary engines. NOx reduction by means of SCR can only take place in certain temperature window. NOx production takes place at very high temperatures (2,200°K and above) and increases exponentially with the temperature.If the temperature is too high, NH3 will burn rather than react with the NO or NO_2. If the temperature is too low, the reaction rate would be too low and the condensation of ammonium sulfates would destroy the catalyst input into the system to reduce the NOx levels by up to 98%. Therefore, it is necessary to make use of the SCR technique. Through this method, the exhaust gas is mixed with ammonia NH3 or UREA (as NH_3 carrier) before passing through a layer of a special catalyst at a temperature between 300 and 400C. Here NOx is reduced to N_2 and H_2O and the chemical reaction is as follows [30]:

$$4NO + 4NH_3 + O_2 \rightarrow 4N_2 + 6H_2O$$

The urea solution reducing agent (40wt% solution), which is a harmless substance used in agricultural sector is injected into the exhaust gas directly after the turbocharger. Urea decays and turns to ammonium and carbon dioxide based on the following formula.

$$6NO_2 + 8NH_3 \rightarrow 7N_2 + 12H_2O$$

The mixture then passed through the catalyst where NOx is converted into harmless nitrogen and water. The amount of NH3 injected into the exhaust gas is done in proportion to the NOx produced by the engine according to the engine load. NOx reduction system can also be affected by the hybrid employment of water emulsion and the use of electronically controlled engine. When operating an SCR catalyst, it is difficult to maintain the engine dynamics and the turbocharger stability at transient engine loads. This problem however, can be fixed by using electronic controlled engine together with an exhaust and injection timing. Figure 18 is a typical diagram of an SCR system application block diagram.

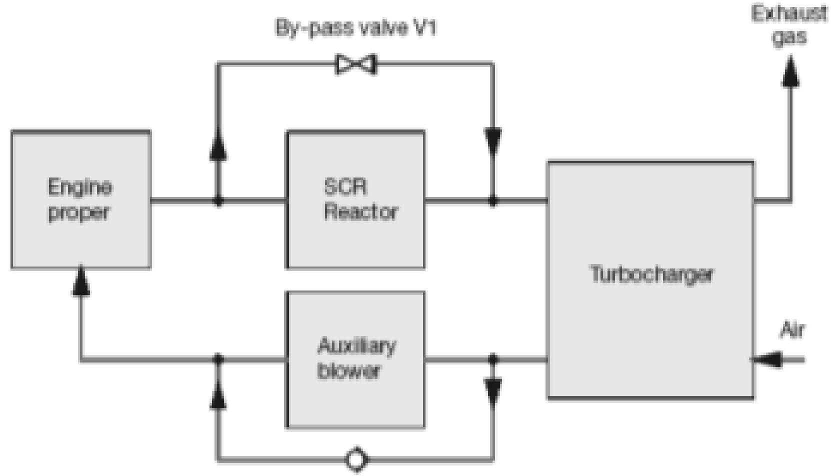


Figure 18: SCR Technology.

A typical SCR plant consists of a separate rector for each engine and contains several catalyst layers, dosing and storage system for the reagent including a control system. The SCR reactor is a steel container which is large enough to house the layers of catalytic elements. An exhaust gas silencer can be incorporated to the design of an SCR system. Figure 19 shows an SCR system arrangement. Design consideration for SCR installation:

- Positioning of the catalyst: Owing to temperature limitation between 300 and 400 degrees Celsius, at a high temperature, urea will burn instead of reacting with the NO or NO_2. At a low temperature, the reaction rate would be slow and the condensation of ammonium sulphates would destroy the catalyst. The exhaust system is located before the turbocharger turbine for 2 stroke engine and after the turbine for 4 stroke engine.
- The size of the urea tank depends on the size of the engines, the load profile and how often the ship will be entering the port where the urea is available.
- The design and the dimension of the reactor are influenced by the exhaust gas flow, exhaust gas temperature window and the reduction rate.
- The space required in engine room system can be compacted while ensuring an easy access for maintenance and operation
- Fuel oil used metals trace which may act as poisons catalyst and deactivate the catalyst
- Soot blowing system which are to be installed in the reactor contains catalyst elements (especially when operating on liquid fuels)

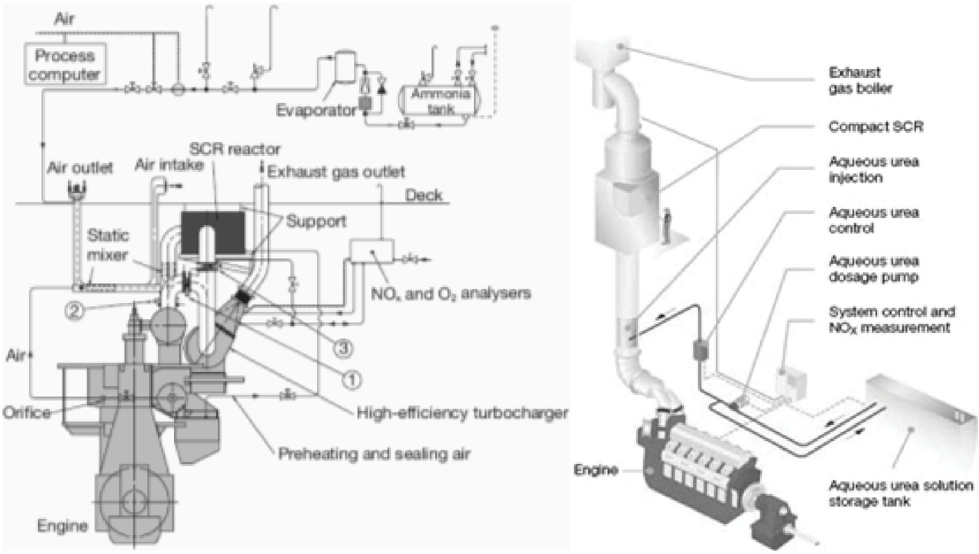


Figure 19: SCR system arrangement .

The Use of Humid Air Motor (HAM) Technology

The HAM method is partly based on reducing the oxygen content of the cylinder charge and partly on increasing the heat capacity of the cylinder charge by using the addition of water vapour. Figure 20a shows a recent NOx reduction performance HAM and Figure 20b shows a typical retrofitting arrangement. This involves the addition of water to the HFO as the homogenization increases the viscosity to keep the viscosity at the engine inlet at 10 to 15 cSt, with a maximum of 20 cSt. It is necessary to raise the temperatures to more than 150oC which is the standard temperature (maximum 170°C at 50% water) to raise the fuel oil loop. When a 10% NOx reduction for each 10% water added is achieved, it will result in the injected amount to fuel oil (31).

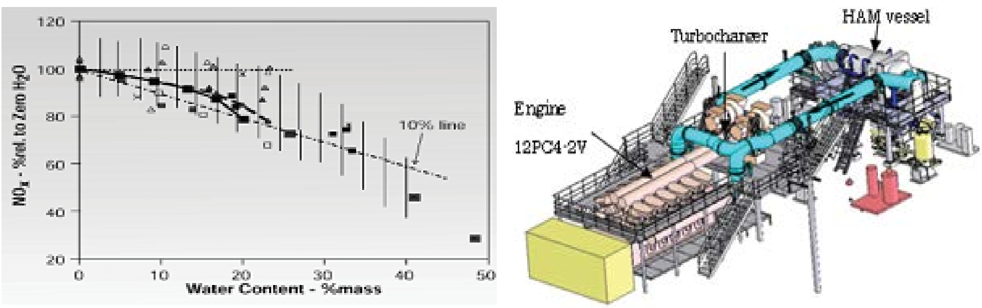


Figure 20: a) NOx reduction from HAM performance, fuel at 380 cst and 50 degrees Celcius b) Typical HAM system

Particulate Matter (PM) Technology

Slide Valve Technology

Reduced sac volume in the fuel valves through slide valve has greatly reduced PM emissions. Emission cut brought by fuel valve brings advantages using SAC as shown in Figure 21.

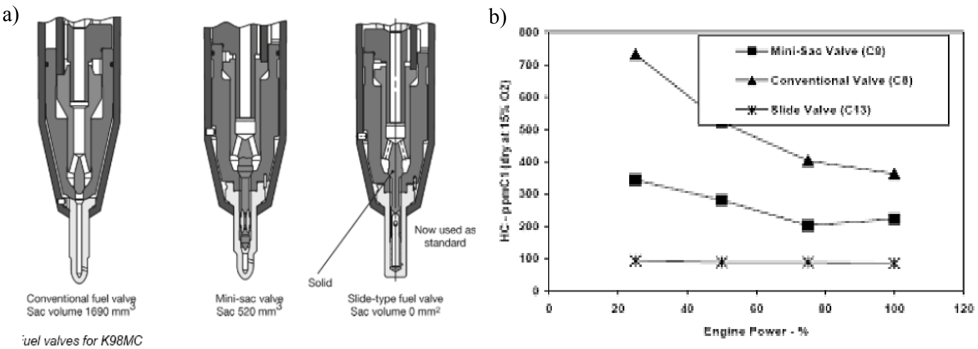
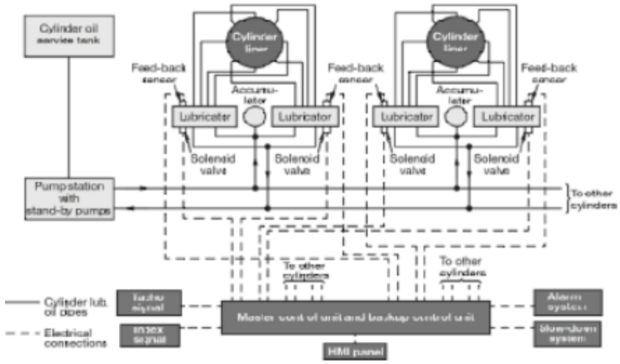


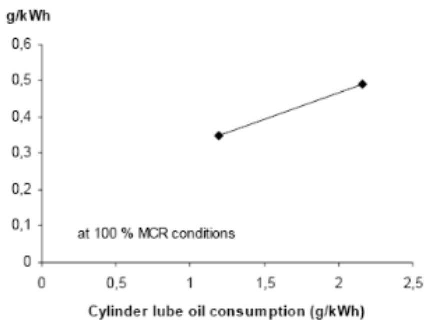
Figure 21: a. Fuel valve b. Valve performance for K98MC engine .

Alpha Lubricator Technology

This involves the application of high-pressure electronically controlled lubricator that injects the cylinder lube oil into the cylinder at the exact position and time. Figure 22 shows the use of alpha lubricator to reduce lubricating oil consumption. The system optimizes conventional lubrication lubricators. A parallel line is followed by the Swirl Injection Principle (SIP) lubricator, where the oil is injected prior to piston passage thereby having the oil distributed by the air swirl. It is use for marine engines and engines for power generation purposes. Its performance has very low feed rates with oil consumption down to 0.5g/bhph. By applying low oil dosage, emissions are lowered and less cylinder oil is wasted on the engine.



a. System



b. Performance for PM

Figure 22: Alpha Lubricator.

Exhaust gas after filter: PM reduction can also be done through the use of these filters used for dilution tunnel PM. Figure 23 shows the measurements taken before and after the scrubber at 75% load and 15% recirculation.

Figure 23: Exhaust gas after filter for PM mitigation performance.

SOx Technology: Annex VI to MARPOL 73/78 limits the sulphur content of MFO to 1.5% per mass in designated Sulphur Emission Control Area (SECA). The first SECA is the Baltic Sea and enters into force on 19 May 2006, while the North Sea area and the English Channel SECA entered into force on 22 November 2007. The geographical boundaries for these two SECAs are defined in MARPOL 73/78. Meanwhile, the EU directive 2005/33/EC, requires ships to burn fuel oil with less than 1.5% sulphur in the North Sea SECA effective of 11 August 2007). There will be more new SECAs which are expected to be adopted in future, based on certain criterias and procedures for the designation of the SECAs MARPOL areas. Annex VI, Regulation 14 (4b) also gives the option of using an Exhaust Gas Cleaning System (EGCS) which reduces the total SOX emissions to 6.0 g/kWh. Figure 24 shows SECA areas in the Baltic. EU favours the adoption of the IMO MARPOL convention, thus expanding the low-sulphur restricted area to include the French coast in the English Channel and the North Sea. The environmental impacts of sulphur are:

- SOx emissions increase acid rains and acidification.
- SOx have an unfavourable effect on vegetation and human health and a corrosive effect on buildings.
- SOx contribute to the formation of secondary particulates in the atmosphere.
- This estimate disagree on the negative impact of SOx emissions into the oceans because seawater is alkaline and the importance of the long-range transboundary atmospheric transport of SO_x is not fully understood.
- CO_2 is the most important greenhouse gas which is believed to cause global warming.

Emissions reduction strategy in engines includes the following:

- Raising the engine's efficiency i.e. reducing a specific level of fuel consumption.
- Using low-sulphur fuels i.e. Change from heavy fuel oil with high-sulphur content to low-sulphur content, heavy to light fuel oil or using natural gas.
- Change to a low carbon-to-hydrogen ratio, i.e the change from fuel oil to natural gas reduces CO_2 emissions. Correspondingly, adopting the use of biofuels will essentially eliminate the net CO_2 emissions altogether.
- **Feasible emissions reduction technologies:**
- No commercial technology exists for reducing CO_2 emissions. However there is a potential for carbon capture.
- Several alternatives are available for reducing SO_x emissions, i.e. Wet scrubber technologies.

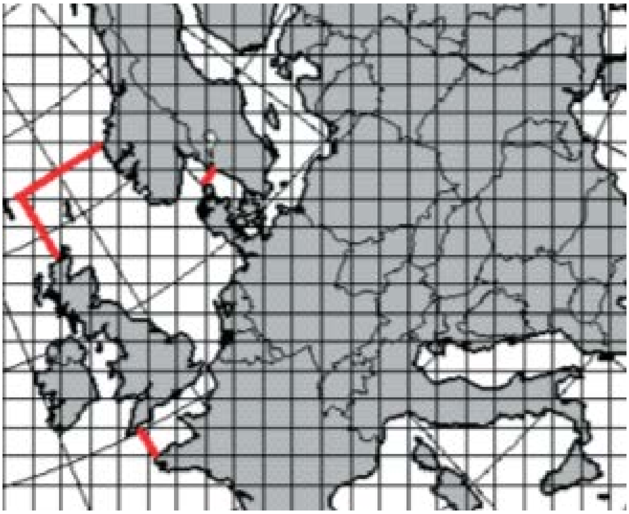


Figure 24: SECA Area .

Heat Recovery Option

Exhaust Gas and Waste Recirculation Measure Performance

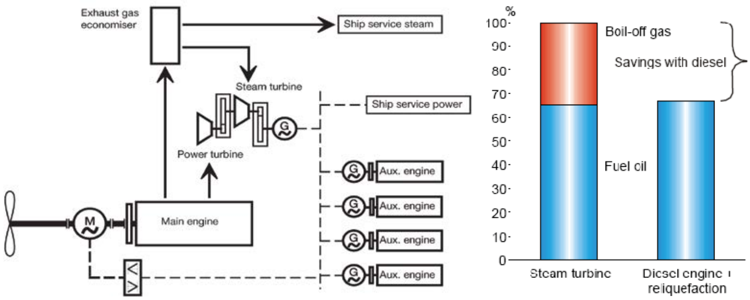


Figure 25: a. EGR system, b. Cost saving .

Exhaust Gas Recirculation (EGR) is based on a reduction of the oxygen content in the cylinder charge and the process of passing the exhaust gases of the ship's main engine through an economiser to generate steam for a turbine-driven generator. EGR system has two water injection stages with a water separator unit for both. The first water injection stage involves the humidification of salt water in order to ensure that there is no freshwater consumption in the second freshwater injection stage. The outlet temperature of the first stage is approximately 100°C, where it has a single multi-nozzle injector. This system is connected to the exhaust system in the same way as the simple EGR system, but the EGR line is routed to a bubble-bath scrubber which cleans and cools the exhaust gas. The water loop in the scrubber system is cooled and monitored in a water treatment skid with a filter and settling system, cleaning the used sea water. Figure 25a and b shows a typical heat recovery system and costs saved from such system [24]. From Figure 25b, the operating cost of steam turbine is estimated at 7.5 miillion USD (with boil of gas cost of 2.5 million and heavy fuel oil cost of 4.9 million), the operating cost for diesel is at 5 million (heavy fuel oil), in comparison 2.5 million USD/ year saving was realised with diesel with reliquification.

Exhaust Gas Recirculation with Steam Power Turbine Configuration

A multi-stage dual-pressure steam turbine and an exhaust gas power turbine can be incorporated with EGR. The recovered energy is supplied to the ship's main switchboard services including heating services and employed a shaft synchronous machine to assist in ship propulsion. However, the quantity of energy which can be recovered from the exhaust gases is maximized by adapting the engine to the lower air intake temperatures. By drawing the intake of air from outside the ship (ambient air) through matching the engine turbochargers for the lower air intake temperatures, it will result in the reciprocal increase of the exhaust energy. At increased recirculation amounts, the HC and PM emissions reduced according to the reduction of the exhaust gas flow from the engine. The exhaust gas economiser consists of a high-pressure part with HP evaporator and superheating section and a low-pressure part with LP evaporator and superheating section. The pressure in the high-pressure steam drum is at about 9.5 bar (g) pressure. The economiser outlet temperature meanwhile, is about 160°C to avoid sulphur corrosion in the economiser outlet. With a pinch point of 10 degrees centigrade, a pressure of about 3.8 bar (g) in the low-pressure steam drum is achieved in Figure 26.

Saturated steam is drawn from the HP steam drum for ship service heating.The feed water is heated from the engine's jacket cooling water to a temperature of 85°C. The feed water for the high-pressure section is further heated in the engine's scavenging air cooler to about 150°C to 170°C [23]. The advantages of waste heat recovery are:

- An environmentally clean solution to reducing ships fuel consumption.
- The quantity of energy recoverable in the exhaust-gas economiser
- The power turbine increased without affecting the air flow of the engine.
- Thus resulting in no increase in the thermal loading of the engine
- There is no adverse effect on engine reliability.
- Generate fuel savings
- Reduces exhaust-gas emissions such as CO_2, NO_x and SO_x.

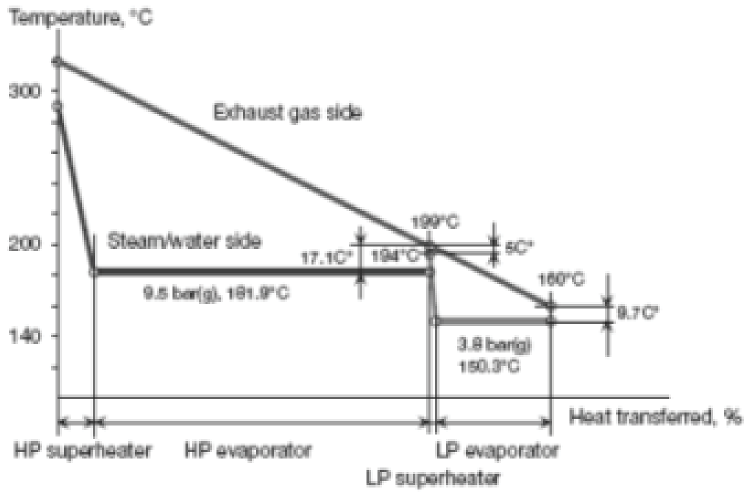


Figure 26: Feed water reheats bleeding system [Wartsilla].

The turbo generator has dual-pressure steam turbine running at 6750 rev/min with the high-pressure side working at about 8.5 to 9.5 bar (g) inlet pressure. This involves three stages at a condenser pressure of 0.065 bars. A typical six turbine stages power turbine has condensing pressure of 0.065 bar with a speed-reduction gear and clutch between steam turbine and generator which reduces the turbine speed to 1800 rev/min generator speed. On the other hand, power turbine uses a part of the exhaust gas stream (about 10%) from the diesel engine to generate shaft power which can be added to the steam turbine thus driving the generator. The gas flow to the power turbine can be controlled according to number of operation modes and operates between 55% and 100% engine load. The flow of exhaust gas from the exhaust gas manifold is controlled by an orifice at the outlet of the exhaust gas manifold. At less than 55% engine load, the gas flow to the power turbine is turned off as the efficiency of the turbochargers at less than 55% load is not high and does not allow exhaust gas to be branched off to drive a power turbine [18,31].

Motor/Synchronous machine magneto-electric power recovery

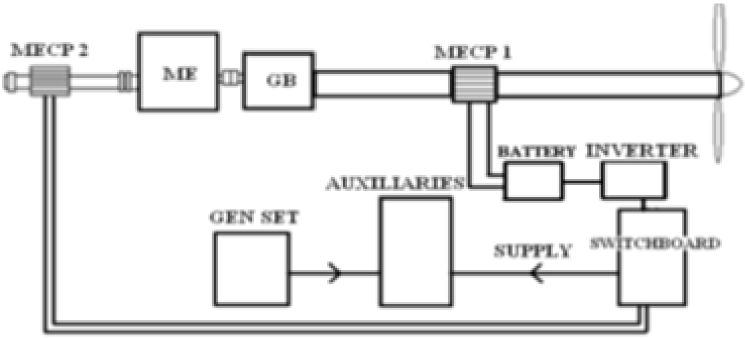


Figure 27: Magneto electric system model .

Synchronous machine includes shaft motor and alternator that can be of low-speed type which are directly mounted in the propeller shaft line designed to operate on a variable electrical supply with a frequency control system. For a merchant ship, a 6600V high voltage system is very common. The number of auxiliary diesel generating sets can be reduced by employing a heat recovery system. The operating modes for the power management system includes motor mode where the system generates more electrical power than is needed for a shipboard service. The surplus electric power on the other hand, is applied in a motor or alternator adding power to the propeller shaft and the alternator mode where the system generates less electrical power than is needed for shipboard service. Figure 27 shows a magto-electric waste energy recovery system modeled numerically at UMT, while Figure 28 shows the amount of additional energy which can be produced from the system [25].

a. Carbon capture b. Recovered power

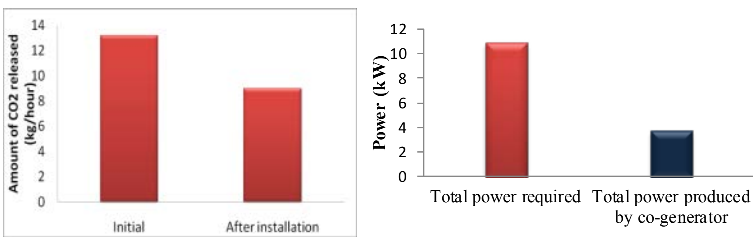


Figure 28: Magneto electric model result .

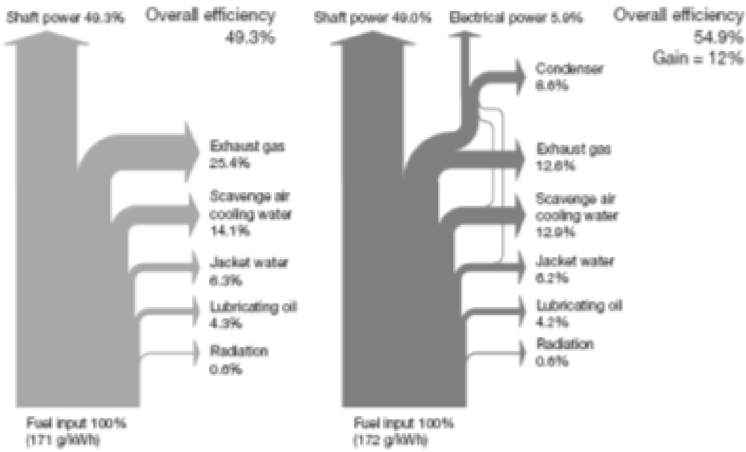


Figure 29: Typical energy balance for shaft power.

The system offers flexibility in optimizing plant operations to minimize operation costs or maximize propulsion power. The use of these sets is considerably reduced thereby providing a further potential to reduce operating costs. Figure 16 shows various heat recovery paths and how much power can be recovered from various lengths of a shaft for a Wasilla power plant. Meanwhile, Figure 29 shows a typical energy, balance and corresponding efficiency along a propulsion shaft.

Electric Propulsion Technology

The overall power train efficiency with diesel electric propulsion is around 87 to 90%. The use of permanent magnets in electric generators and motors as well as general advances in semiconductor technology may improve this Figure to around 92 to 95%. The electrical transmission consists of three basic energy conversions:

- From (rotating) mechanical energy into electrical energy: E-generator
- From electrical energy into (rotating) mechanical energy: E-motor
- Some form of fixed or controlled electrical conversion in between: power converter

Simulation, risk assessment and emission quantification remains as supporting methods for decision and the selection of new systems. Electric propulsion system requires the development of the following technological areas: E-generator-The following tree gives a systematic overview of existing types whose improvement will be sought: Mechanical-Electrical E-Generators.

- DC Generators
- AC Generators

E-Motors: The following tree gives a systematic overview of existing types Electrical to Mechanical E-motors.

- Driving motors
- Synchronous Motor
- Positioning motors

Power converters: The following tree gives a systematic overview of existing types: Electrical power conversion or transformation.

- Fixed transformers
- Controlled converters
- Static converters
- Inverter

Technology for New Built

- Alternative energy: wind and solar power assisted ship (stand alone and hybrid)
- Alternative fuel and dual fuel engines hybrid
- Infusion of water mist with fuel and subsequent gas scrubbing units for slow speed engines
- Additional firing chamber
- Potential for gas turbine complex cycle
- Potential for turbocharger diesel engine
- Compound cycle with gasified fuel, external compressor, combustion with pure oxygen
- Exhaust after treatment for medium speed engines
- Azipod

Impact of Using New Fuel: Technology will transfer sympathetically to the marine industry via the availability of engines, systems and technical assistance. Marine craft operation in inland water operation as well as the deep sea will require fuel supplied in bulk to render the NG distribution viable and effectively reshaping areas such as machinery arrangement, hull form, compartment, cargo deck, payloads, superstructure, interior layouts, route options, escape and safety. Figure 30 shows the efficiency levels for the various prime movers. The use of an alternative fuel for vessel propulsion will lead to a design review of [10]:

- Power plant
- Associated fuel system
- Propulsion train

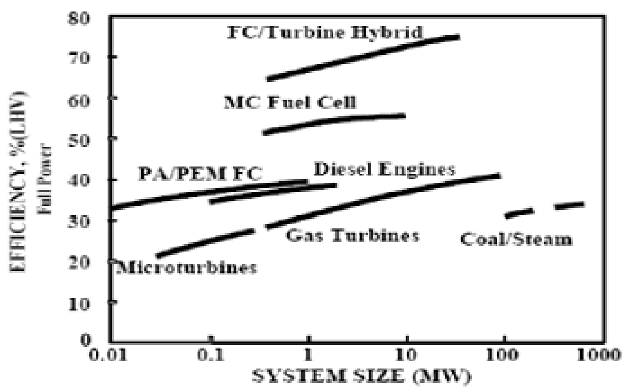


Figure 30: Fuel efficiency.

Challenges on Meeting Policy Sustainability Requirement: Enforcement can only be made through data availability on emission release, impact and technology model performance. The emissions quantification can be done through parameters that relates to engine power, load factor, emission factor and time mode. There are many options and the cost involves all the technology that is available. It is better to use a formal risk analysis method for accessing the various alternatives. Where Risk=Hazard (Toxicity) x Exposure (the estimate on the probability that certain toxicity will be realised).Risk management is the evaluation of alternative risk reduction measures and the implementation of those that appear to be cost effective). It must be remembered that zero discharge is equal to zero risk, but the challenge is to bring the risk to acceptable levels, while at the same time derive a maximum benefit. Figure 31 depicts a risk cost benefit analysis graph which can be used for sustainability analysis, while making the necessary decision for the system [13,32].

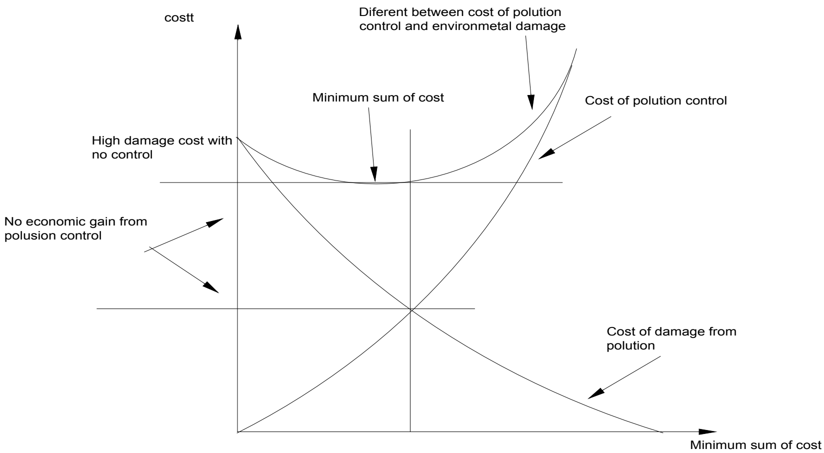


Figure 31: Sustainability analysis.

Conclusion

Land based air pollution regulation is a foundation for future legislatures in the marine industry. Fossil fuel is considered as the single largest contributor to emissions. Apart from the NO_x and SO_x regulation which has been introduced, CO_x smoke emission is likely to be regulated. To facilitate the adoption to emission regulations, operators, officers, engine builders, yards and ship-owners are doubling their efforts to adopt new technologies to make this earth a better place to live in. The latest generation of electronically controlled engines is an integral part of the policy of technological change. The navigation data and the mission inventory tool will provide a good basis for estimating, updating emissions and providing a solid decision to support the policy and technology. Existing engine and future engines will be forced to adapt new technologies presented in this paper in the near future. Future technology highlighted in this paper will be a major catalyst to ignite a series of research activities to solve the current energy and environmental problems. Data collected from such research will be utilized to enforce relevant climate change control and compliance laws. The data can be used for simulation purposes and support the deployment of new systems. The evolving technology discussed could help meet the current demand by IMO for the implementation of Energy Efficiency Design Index (EEDI), Ship Energy Efficient Management Plan (SEEMP) and Ship Energy Efficiency Operational Indicator (SEEOI) rules which was launched recently towards global warming, climate change and ozone depletion in the maritime industry.

Emissions of Green House Gas of Ships in Port in Johor Port (Malaysia)

Abstract

Emission of GHG is linked to ship machineries. Ship traffics increase in port has possible increase of gaseous emissions and particulate pollutants in port. Present emission index in port areas are estimated from surrounding industries and airports. Ship is about port and port is about ships, therefore emission in port is predominantly from ships machineries. This study investigated the associated problem of green house gas in Johor Port. This paper present result of computation of emission from port related activities emissions estimation. The result can be use as part of Green House inventory data base.)

Introduction

In the era of logistics and global supply chains, the fast and efficient movement of goods is an economic imperative. Investments are currently being deployed to modernize and expand ports and intermodal facilities in order to accommodate growing cargo volumes. Growing ship traffic and machineries in ports will add to local air quality problems and global climate change risks unless ship and machineries emissions are further controlled. Air pollution from shipping activities is a growing problem that is drawing increased attention around the world. Local and regional air quality problems associated with ship and machineries gaseous emissions are a concern because of their public health impacts. Exposure to air pollution is linked to a host of health risks including premature death, cancer, heart and respiratory diseases.

Air pollutant emissions in port currently remain unregulated. The inventories of air pollutants have usually been made on a port mainly for general administrative purposes and public information. Systematic data published for the use of the scientific community is rather scarce [33,34] Therefore this study attempts to investigate the emissions of gaseous and particulate pollutants in Johor Port. This study focuses on the emissions concentration of pollutants consisting parameters like SO_2, NO_2, CO, CO_2 and PM_{10} carried out in Johor Port. Emissions sources can come from a lot of categories, so this study will only focus on board vessel source categories. The emission parameters will be monitored using portable air sampler and toxic gas probe. In order to compile the air emission inventory and to estimate the emission rates, mathematical equation from the Unites States Environmental Protection Agency will be used [35,36].This paper discusses the emission sources and estimation of concentration of SO_2, NO_2, CO, CO_2 and PM_{10} from marine source categories in Johor Port. The paper also discusses the compilation of air emission inventory of for Johor Port Area. Johor Port as shown in Figure 32 is a modern port equipped with all facilities to meet the requirements of international level cargo and ship handling operations. It is located in Pasir Gudang, Johor. This port is highly equipped with a communication network system linked to the whole of peninsular Malaysia from north to south. The port area of operation has been gazetted as a Free Trade Zone. Thus this port functions as a centre for increasing the flow of port entry trade (import, export and transshipment) and encouraging the manufacturing industry in the port's area of operation. Johor Port can accommodate 43 million tons of cargo including 1 Million TEUs of containers.

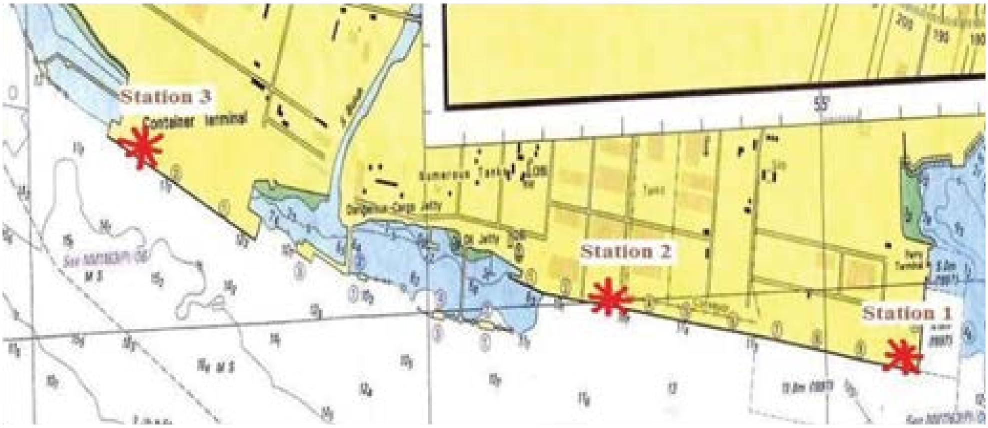


Figure 32: Johor Port Berhad.

Background

Air pollutants sources are from two predominantly types of pollutants:

i. primary pollutants and

ii. Secondary pollutants.

The primary pollutants or emission involve points form usually provide the greatest contribution to overall emissions. The secondary pollutants or emissions sources are not as obvious as the primary pollutant emission sources which obviously act as emitters of air pollutants. Secondary pollutant sources are greater insignificant but not as significant as primary pollutants sources [35,37].

Sources of air pollutants in ports are from mobile sources. Mobile sources is a term used to describe a wide variety of vehicles, engines and equipment that generate air pollution and that move from place to place. These mobile sources are divided into on-road and non-road sources. On-road can be described as licensed motor vehicles, including automobiles, trucks, buses and motorcycles but as for non-road, it can be described as 2- or 4-stroke and diesel engines, non-road vehicles, aircraft, marine vessels and locomotives. Air pollutants from both on-road and non-road sources can come from gasoline or diesel fuels [38-40].

Port emissions are generated by marine vessels and by land-based sources at ports. Marine emissions come primarily from diesel engines operating on ocean going vessels, harbour vessels, dredges and other vessels operating within a port area [41]. Emissions of gaseous and particulates contribute significantly to the total emissions from the transportation sector [37,38].Key compounds emitted from the shipping sector are sulphur dioxide (SO_2), nitrogen dioxide (NO_2), carbon oxides (CO, CO_2), Particulate Matters (PM) [42]. Normally, there are two types of engines on a ship: the main engines propel the vessel while navigating and manoeuvring arre powered by the auxiliary engines that supply electricity for other functions [42]. As shown in Figure 33, numbers of vessel entering Johor Port decreases from year 2007 to 2008.Emission inventory is a list of the amount of pollutants from all sources entering the air in a given time period. The boundaries of the area are fixed [43,44]. An emissions inventory is also best understood as an estimate of the quantity of pollutants that a group of sources produce in a given area, over a prescribed period of time [44].

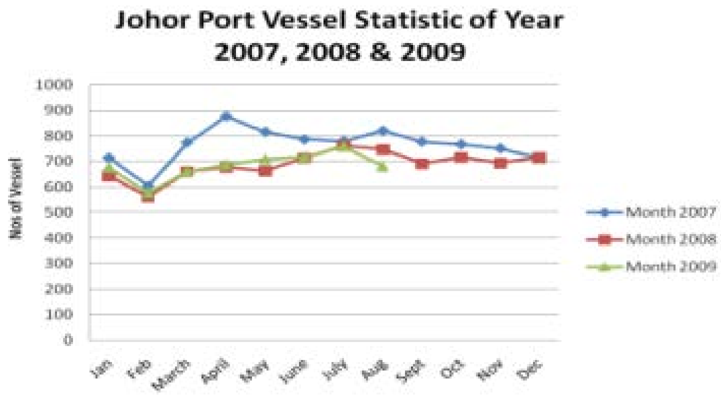


Figure 33: Johor Port Vessel Statistic year 2007 until mid 2009.

Data Acquisition Process

The monitoring of emission parameters of pollutant such as sulphur dioxide (SO_2), nitrogen dioxide (NO_2), carbon oxides (CO, CO_2) was conducted using Gray Wolf Direct Sense TOX PPC Kit and TSI-IAQ Calc equipment. Particulate matter contributes less than 10 µm (PM_{10}) was monitored using Mini Vol Portable Air Sampler. The frequency of sampling was carried out once a month and it is conducted until three sets of data are collected. Three sampling points were chosen on each port. The criteria of sampling points consider the emissions from vessels, is placed as near as possible to the vessels emissions sources in port area and lastly the sampling points that were chosen are installation are made on the on the pier/wharf/dock.

For ocean going vessel, emission specific quantification, the emissions estimation methodology can be graphically broken down into steps which are used to estimate the ocean-going vessel emissions which can be use to compile air emission inventory (Figure 34). Survey data is provided by Johor Port authority according to what are the information needed for this study and the technical literature consist of emission factors, load factors and fuel correction factors follows United States Environmental Protection Agency (U.S. EPA, 1999) and Entec 2007. In this study, basic equations that will be use to estimate harbour vessels emissions is:

$$Emission(E)=MCR \times Act \times LF \times EF \times FCF \quad (1)$$

Where; E=emission in (g/year) but converted to (tons/year) by dividing by 453.6 g/poundand 2000 pounds/ton, MCR=maximum continuous rated engine power, (kW), Act=activity, (hr/year), LF=load factor, (unitless), EF=emission factor, (g/kW.hr), FCF=fuel correction factor.

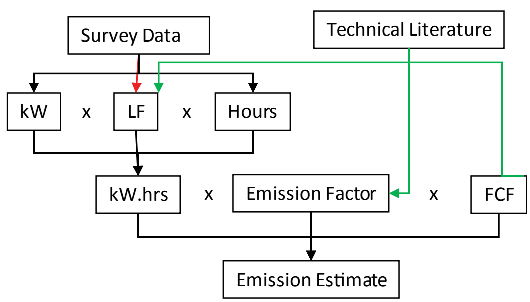


Figure 34: Ocean-Going Vessels Emission Estimation Flow Chart.

Result and discussions

Below are the marine air emission quantification studies, the study of air pollutants concentration in Johor Port which is compared with Recommended Malaysian Air Quality Guidelines (RMAQG). The result of emission estimation for each pollutant in Johor Port area from port activities source are presented.

Air Pollutants Concentration in Johor Port

Based on the study of air pollutants concentration in Johor Port, RMAQG was used in this study for standards comparison purposes. As for gaseous concentration (SO_2, NO_2, CO, CO_2) one hour averaging time was used while for particulate (PM_{10}) 24 hour averaging time are used. The summaries are shown in Table 16. From this table, it is observed that the highest NO_2 detected in sampling station 2 with a concentration of 0.18 ppm exceeding the RMAQG limits of 0.17 ppm by 5.9 percent while other gaseous at station 1, 2 and 3 are still within the RMAQG limits. Basically, the limits of NO_2 at station 2 exceeded due to heavy operation (cargo loading and unloading) during the sampling work.

Station	Sampling Range	(ppm)				Mg/m³	RMAQG				Comment
		NO_2	SO_2	CO	CO_2	PM_{10}	NO_2	SO_2	CO_2	PM_{10}	
1	High	0.12	0.2	ND*	353	4.8	0.17	0.13	30	150	All within recommended guidelines
	Low	0.01	0.0		351	2.4					
2	High	0.18	0.1		364	9.6					Highest NO_2(0.18)> 0.17
	Low	0.02	0.0		350	2.4					
3	High	0.17	0.2		365	9.6					All within recommended guidelines
	Low	0.02	0.0		351	2.4					

Table 16: Summary Table of Sampling Result.

*Gaseous not detected

Emissions Inventory

The 2007 and 2008 emissions for Johor Port are summarized in this section. Emissions estimate for each pollutant are presented by mode which is at manoeuvring and hotelling. Table 17 presents emissions estimate for year 2007 and Table 18 presents the emission estimate for year 2008.

Mode	NO_x	VOC	CO	SO_2	PM_{10}	$PM_{2.5}$	CO_2	N_2O	CH_4
Maneuvering	13698	489	1076	6301	802	641	662425	29	39
Hotelling	15234	414	1139	7138	849	679	748249	31	41

Table 17: Year 2007 Emissions Estimate by Mode in Johor Port (kT yr^{-1}).

Mode	NO_x	400VOC	CO	SO_2	PM_{10}	$PM_{2.5}$	CO_2	N_2O	CH_4
Maneuvering	11203	400	880	5153	656	524	541781	24	32
Hotelling	12458	339	932	5837	694	555	611926	25	33

Table 18: Year 2008 Emission Estimate by Mode in Johor Port (kT yr^{-1}).

Based on the inventory presented above, manoeuvring mode emits less emission than hotelling mode due to the activity period. For vessel manoeuvring in Johor Port, the average duration for manoeuvring period (inbound and outbound) are 4 hours while what makes hotelling emits greater emission are due to the average hotelling period of 9.6 hours which are used in computing the inventory which is far longer than the manoeuvring mode period. Main reduction in the number of vessel are due to economic downturn starting in mid 2008 which affect the business of shipping worldwide and the numbers of vessels are closely related to the amount of emission that are emitted. They are indirectly, affect the amount of emission sources from seaport that are emitted within port area as shown in Table 17 and

18. The decreasing of seaport total emission by approximately 10 percent in the year 2008 is influenced by the reason stated above and does not relate to any emissions reduction approach. Perhaps, the amount of emission will continue to grow when the economy starts to improve if none reduction approach are being considered.

Emission sources concentration of sulphur dioxide (SO_2), nitrogen dioxide (NO_2), carbon oxides (CO, CO_2) and particulate matter contribute less than 10 µm (PM_{10}) in port were obtained. From the results obtained and based on the comparison with Recommended Malaysian Air Quality Guidelines (RMAQG), NO_2 concentration surprisingly exceed the limit by 5.9 percent in sampling station 2 while other gaseous at station 1 and 3 are still within the recommended guidelines. The results clearly shows that major pollutants contributor in Johor Port are oxides of nitrogen (NO_x) and sulphur dioxide (SO_2) with a percentage value of 60 and 28 percent for ship hostelling and manoeuvring mode. Other pollutants contribute are below than 10 percent for both modes.

Based on the results obtained from sampling, it can be seen that NO_2 produce some high values of concentration even though two from station 1 and 3 are still below the limits. There is concern about this. As for station 2, the NO_2 values exceeds the limits mainly are caused by pack vessels in operation is high NO_2 values were recorded during sampling work, during cargo loading and unloading heavy operation period. Apart from that, gaseous emission like SO_2 and CO has very low concentration values low emission. The biggest factor causing such value is because of strong wind which depletes the concentration abruptly. Besides, the equipment used is not very sensitive to gaseous substance during outdoor sampling. Theoretically, SO_2 and CO should be at certain value when there is an emission. As for particulates and carbon dioxide, the value recorded does not differ as much and the particulates are well below the limits of 24-hour averaging time when compared to RMAQG.

Benefit of Emission Quantification

Emission database of engine characteristics of naval and commercial vessels would be invaluable for IMO growing data for technical code for new machineries and harmonization of emission control laws in the pipelines. This study will record the emission data from ships plying Malaysian ports and the result is useful for port control operation limit definition, regulation on ship machineries. The research will input in deduction of emission impact to the community, engine manufacturing technical code and emission input to decision support for retrofitting systems for existing ships. This pilot study would leads to develpment of:

Comprehensive data base system for emision released from ship.

- Models for ship emision inventory in Malaysia and Europe in order to meet national communication to FCCC to deal with challenge pose by data.
- The formulation of rules, regulations, guidelines and policies for emision regulation from ships.
- The development of local expertise for national, regional and international centre of reference.
- Meeting IMO deadline for Energy Efficiency Design Index (EEDI), Ship Energy Efficient Management Plan (SEEMP) and Ship Energy Efficiency Operational indicator (SEEOI).

In addition to the above emission quantification will:

- Input into worldwide focus of machineries exhaust gas emission law by IMO and possible local implementation.
- Input into emission limits requirement for adoption of development and adaptation to new energy and retrofitting technology.
- Provide solution anticipated to maintenance of ship life cycle at average of 25 years.

- Regulatory preparedness for control of NOx and Sox, HC, CO and particulate matter.
- Consideration for fuel use, design and operational issues.

Green house gas release is very linked to machinery combustion. Inseperability of energy, environment and technology couple with reactive challenge of climate change, GHG is putting presure to all industry to find new source of energy or retrofiting system to conserve energy. This effort also required monitoring of emision from the ship to impliment new IMO regulation in support of multdimentional effort to preserve the planet for the right of future generation. The research is highly needed for decision support by regulators, machineries manufacturers, IMO port control, ship aquisation, insurance and other ship and shiping operation. The project will lead the effort for other developing nation to follow road to new cleaner technolofy opportunity and compliance rich in doctrine of sustanability. Emsion quantification will help prety well with environmetal and regulatory agencies and will complement their effort to prevent health hazard and environmetal damages.

Conclusions

Based on the study conducted, several conclusions can be made as follows:- The Johor Port ocean-going vessels emission inventory shows that manoeuvring mode contributes NO_x(60%), VOC(2%), CO(5%), SO_2(27%), PM_{10}(3%) and $PM_{2.5}$(3%) while hotelling mode contributes NO_x(60%), VOC(2%), CO(4%), SO_2(28%), PM_{10}(3%) and $PM_{2.5}$(3%). NO_x emissions from OGVs are relatively high because most marine engines operate at high temperature and pressures without effective reduction technologies. Besides, SO_2 emissions are high because of the high average sulphur content (2.5%) of marine fuels used by most OGVs within Johor Port boundaries. Given uncertainties in all emissions inventories, the best estimate for carbon dioxide (CO_2) of the base year of 2007-2008 in Johor Port, is within the bounded range of 500,000-750,000 kilo tons per year (kT yr^{-1}).

Quantification of Emissions of Green House Gas for Decision Support towards International Maritime Organization (IMO) Rule Making

Abstract

The industrial shipping industry is responsible for the carriage of 90% of world trade since it is the most energy efficient mode of transport. The international shipping is expected to have greater impact on global warming considering size of vessel plying the world ocean. The Green House Gas (GHG) emissions are the main air pollutants in maritime transportation. In 2007, CO_2 emission from the shipping amounted to 847 million tones or about 2.7% of global CO_2 emission and it is expected to reach 18% in 2050. In July 2009, Marine Environment Protection Committee (MEPC) approved to circulate interim guidelines on the method of calculation of Energy Efficiency Design Index (EEDI) to create stronger incentives for further improvements in ship's fuel consumption, resulting CO_2 emissions on a capacity basis. This paper present outcome of GHG emission data collection and quantification from ship, the study hop to contribute to regulation and reduction of GHG emission in shipping industry and subsequent mitigation of climate change, Equipment used to measure the concentration of gas and total suspended particulate in the atmosphere are MiniVol Portable Air Sampler, Graywolf Direct Sense Monitoring Kit and TSI IAQ-Calc. The equipments are used to determine the gas concentration, nitrogen dioxide (NO_2), sulphur dioxide (SO_2) and carbon dioxide (CO_2) concentration respectively. Carbon dioxide (CO_2) is the most important anthropogenic GHG. The experimental data analysis is used to validate recommended EEDI calculation.

Introduction

Air pollution is the on demand case as it has been debated all over the world. The sources of air pollution are varying starting from the individual pollutants until the huge industry activities. Maritime industry responsible in this part of pollution since there are many types of maritime transports maneuvering at the sea. The Green House Gas (GHG) emissions from maritime transport must be reduced because it is expected to increase if no mitigations are taken. This paper will discuss the result of exhaust emission of University Malaysia of Terengganu (UMT) boat called Discovery II involving two types of gas, Carbon Dioxide (CO_2) and Nitrogen Dioxide (NO_2).The result is based on the pilot study from Pengkalan Arang Jetty to Bidong Island and it is divided into two modes, maneuvering mode and hotelling mode.

The international shipping is the most carbon efficient mode of commercial transport and generally considered as an environmentally friendly means of transportation. This brings the maritime and shipping industry to the rapid development and the number of vessels sailing in the ocean continues to increase. However, the significant improvements that have taken place in these industries lead to the increasing of Green House Gas (GHG).The using of hydrocarbons and their derivatives as fuel contributes to air pollution. The amount of emissions depends on the design, operating conditions and the characteristics of the fuel. If complete combustion of fuel was possible, the exhaust would contain only Carbon Dioxide (CO_2) and water vapor. Carbon Dioxide (CO_2) emission depends on fuel consumption and carbon content in the fuel.

Some factors that influencing emission are cold starts, speed, maintenance, engine design and fuel used [46]. The most troublesome emission from diesel engine is NOx and soot (particulates). The black smoke observed from certain ships or boats are due to high carbon particles content and it is obvious during rapid load increase and older engine at high load. As a response towards the GHG emissions problem, another dimension has been added to the ship's design and operational practices. The improvement in design includes the propeller, hull and superstructure. For the operational practices, the maintenance of the ships are ensure to follow the schedule and guidelines and also by slowing the speed of the ship during at sea.

This study focuses on the emissions concentration of Carbon Dioxide (CO_2) and Nitrogen Dioxide (NO_2) that are released from the exhaust of Discovery II. The emissions concentrations are measured by using the Gas Detector IQ-1000. The Discover II started maneuvering to Bidong Island at initial speed 6 knots and continue at speed 12 knots during at sea. The distance of Bidong Island from Kuala Terengganu is 40 km. Table 19 show the principal particulars of the Discovery II that has been operated in 12 years:

Length overall	16 m
Breadth	4.05 m
Depth	2.15 m
Fuel	4000 L
Fresh water	1000 L
Main engine	300 HP/1800 RPM
Speed (design)	12 knots
Cruise speed	1 0knots
Gross tonnage	43T
Net tonnage	16.82 T

Table 19: The principal particulars of Discovery II.

The experiment is divided into two which are maneuvering mode and hotelling mode. The hotelling mode data is recorded near Bidong Island so that the data is not influence by the land activities.

Methodology

Study Location

Discovery II is maneuvered from Pengkalan Arang Jetty to Bidong Island. The data is collected during its maneuvering. For hotelling mode, the data is recorded near to the Bidong Island that is far from the land. Therefore, the concentration of gases recorded by the equipment is mainly coming from the boat emission.

Equipment

The equipment used for collecting the concentration of gases is the Gas Detector IQ-1000. It can detects over 100 toxic and combustible gases using a single sensor. The calibration is simple and automated with no manual adjustments necessary. The power is provided by 6 'D' size alkaline or nickel cadmium batteries. The data that successfully recorded is displayed on the unit and then transferred to the computer or send to printer for further analysis. This equipment is placed on the safe and balance area near the exhaust of Discovery II. The sensor is then pointed 20 cm away from the exhaust hole. The setting of the equipment is changed by selecting three types of gases, Carbon Dioxide (CO_2), Nitrogen Dioxide (NO_2) and Sulphur Dioxide (SO_2) as parameters that are going to be measured. The procedure of using the Gas Detector IQ-1000 is as follows:

- AC power supply is connected to the unit.
- Sensor is connected to the unit.
- Gas detector IST IQ-1000 is turned on by pressing the POWER button and waits until the reading appeared at every sensor.
- The pump is turned on by pressing the PUMP button.
- The LOG DATA button is pressed to record the data.
- The LOG DATA and PUMP are turned off after the sampling is finished.

Figure 35 shows the experimental setup of the pilot study conducted on Discovery II.

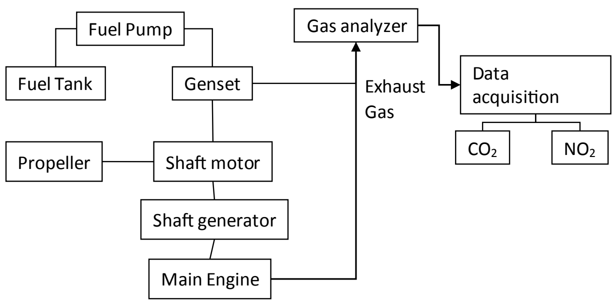


Figure 35: Experimental setup.

Figure 36: shows the flow chart of the research methodology.

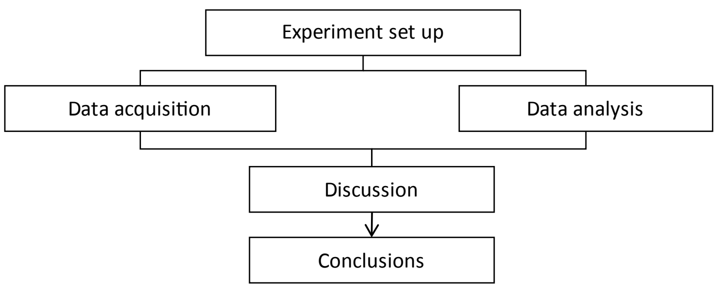


Figure 36: Research methodology.

Result and Discussion

The Gases Concentrations

From three types of gases that have been selected, only two types are successfully detected by the Gas Detector IQ-1000 which is Carbon Dioxide (CO_2) and Nitrogen Dioxide (NO_2). The data of exhaust emissions are analyzed by using Microsoft Excel and Minitab 15. Table 20 shows the summary of the test when Discovery II starts maneuvering at 6 knots.

Time (am)	Carbon Dioxide (ppm)	Nitrogen Dioxide (ppm)
9:21:59	0	0
9:22:07	0	0.7
9:22:08	70	4.2
9:22:09	290	8.7
9:22:10	820	13.4
9:22:11	1650	17.5
9:22:12	2000	20
9:22:59	2000	20

Table 20: The concentration of Carbon Dioxide (CO_2) and Nitrogen Dioxide (NO_2).

Based on the data collected, the graph time versus amount of gas concentration (ppm) is plotted. Figure 37 and 38 show the graph of the concentration of the Carbon Dioxide (CO_2) and Nitrogen Dioxide (NO_2) respectively.

According to the graph for both gases concentration, the reading recorded increasing drastically until they reached the maximum value. This is because the engine of the boat needs high energy to maneuver at the initial. The maximum reading for Carbon Dioxide (CO_2) is 2000 ppm while for the Nitrogen Dioxide (NO_2) the maximum reading is 20ppm. The Figure 39 and 40 below show the data analyzed by using Minitab 15.

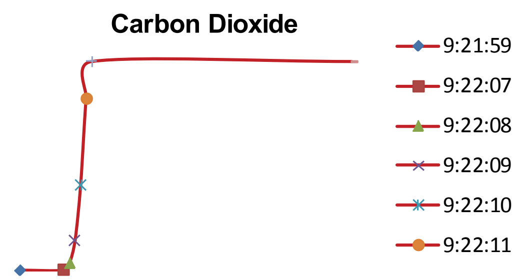


Figure 37: The concentration of Carbon Dioxide (CO_2) versus time.

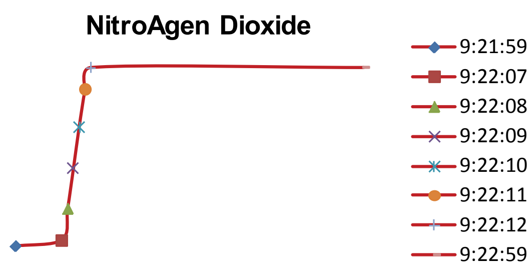


Figure 38: The concentration of Nitrogen Dioxide (NO_2) versus time.

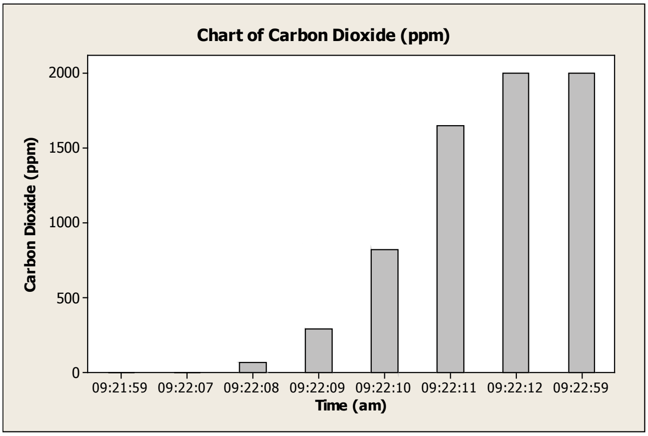


Figure 39: The concentration of Carbon Dioxide.

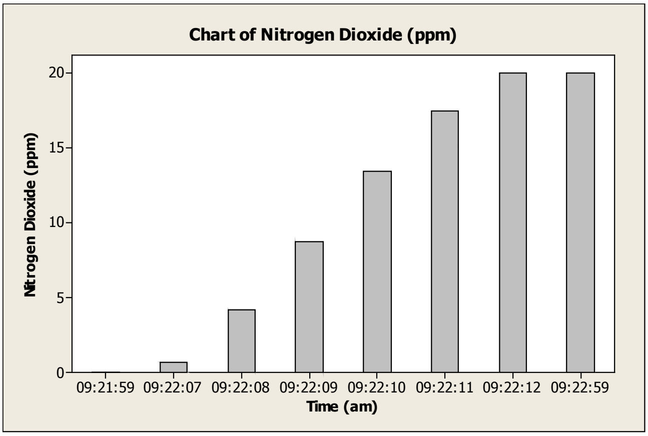


Figure 40: The concentration of Nitrogen Dioxide.

Based on the data collected, the graph time versus amount of gas concentration (ppm) is plotted. Figure 41 and 42 show the graph of the concentration of the Carbon Dioxide (CO_2) and Nitrogen Dioxide (NO_2) respectively. Table 21 shows the summary of the test during Discovery II maneuvering at sea.

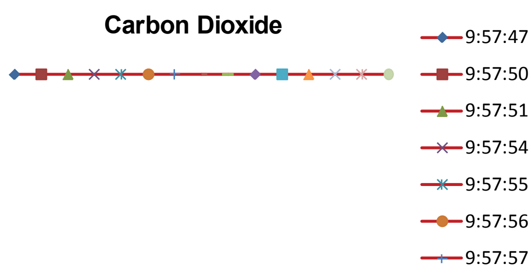


Figure 41: The concentration of Carbon Dioxide (CO_2) versus time.

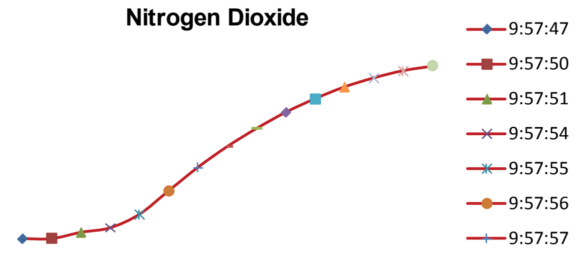


Figure 42: The concentration of Nitrogen Dioxide (NO_2) versus time

Time (am)	Carbon Dioxide (ppm)	Nitrogen (ppm)
9:57:47	2000	0.9
9:57:50	2000	0.9
9:57:51	2000	1.6
9:57:54	2000	2.1
9:57:55	2000	3.6
9:57:56	2000	6.2
9:57:57	2000	8.8
9:57:58	2000	11.1
9:57:59	2000	13.1
9:58:00	2000	14.9
9:58:01	2000	16.4
9:58:02	2000	17.7
9:58:03	2000	18.7
9:58:04	2000	19.5
9:58:17	2000	20

Table 21: The concentration of Carbon Dioxide (CO_2) and Nitrogen Dioxide (NO_2)

According to the graph, The concentration of Carbon Dioxide become constant at maximum value of 2000 ppm. For the concentration of Nitrogen Dioxide, the graph plotted is smoother than the previous graph during the boat starts to maneuvre. It is increasing slowly at the beginning and continue without drastic until it reach the maximum value. The Figure 43 below shows the data analyzed by using Minitab 15 for Nitrogen Dioxide only. Table 22 shows the summary of the test during Discovery II is in hotelling mode.

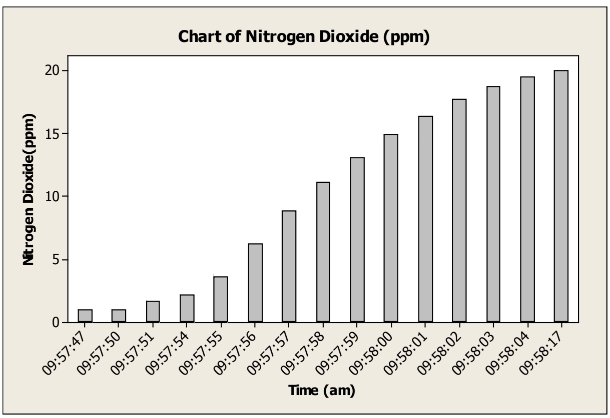


Figure 43: The concentration of Nitrogen Dioxide.

Time (pm)	Carbon Dioxide (ppm)	Nitrogen (ppm)
12:21:52	2000	0.4
12:21:52	2000	0.4
12:21:55	2000	0.9
12:21:56	2000	1.8
12:21:57	2000	2
12:21:59	2000	3.8
12:22:00	2000	6.8
12:22:01	2000	10.1
12:22:02	2000	12.9
12:22:03	2000	15.2
12:22:04	2000	17.1
12:22:05	2000	18.7
12:22:06	2000	20
12:23:10	2000	20

Table 22: The concentration of Carbon Dioxide (CO_2) and Nitrogen Dioxide (NO_2)

Based on the data collected, the graph time versus amount of gas concentration (ppm) is plotted. Figure 44 and 45 show the graph of the concentration of the Carbon Dioxide (CO_2) and Nitrogen Dioxide (NO_2) respectively.

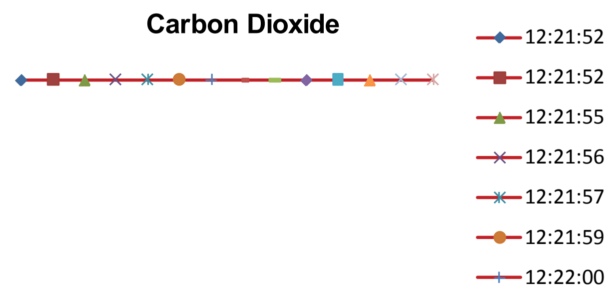


Figure 44: The concentration of Carbon Dioxide (CO_2) versus time.

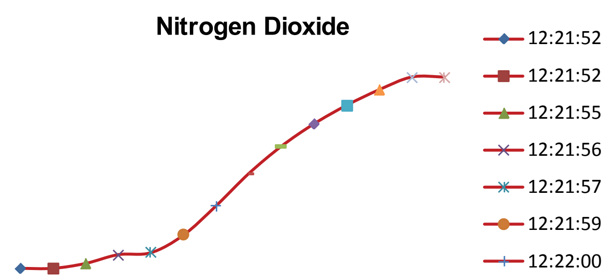


Figure 45: The concentration of Nitrogen Dioxide (NO_2) versus time.

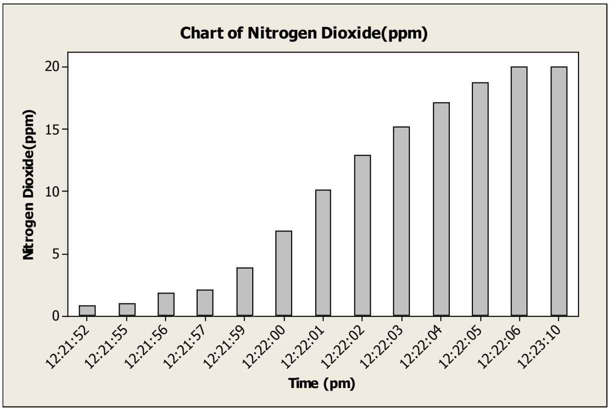


Figure 46: The concentration of Nitrogen Dioxide

According to the graph, the concentration of Carbon Dioxide (CO_2) still not change and keep consatnt. For the concentration of Nitrogen Dioxide, it is increasing slowly and sometimes constant at the beginning then it continue to increase until it reach maximum value. The Figure 46 below shows the data analyzed by using Minitab 15 for Nitrogen Dioxide only.

Conclusion

The maximum reading of Carbon dioxide and Nitrogen Dioxide that can be detected by the Gas Detector IST IQ-1000 are 2000 ppm and 20 ppm respectively. At the initial of the experiment, the amount of Carbon Dioxide increased dramatically and it remains constant until the experiment is finished. For the Nitrogen Dioxide, it also increased dramatically at the initial of the experiment and its amount keeps changing and not constant until the experiment is finished. The overall data showed that the Nitrogen Dioxide measured keep changing and not uniform. For the first reading, the data collected finished in 5 seconds while the second reading, third reading and fourth reading finished in 33 seconds, 18 seconds and 8 seconds respectively. For the hotelling mode which is fifth reading and sixth reading, the data collected finished in 25 seconds and 14 seconds respectively. The amount of Nitrogen Dioxide in each data collected is increasing, decreasing and sometimes constant. As we all know, the data collected in this pilot study is based on the unsophisticated device that has possibility in facing data accuracy problem. The experimental set up is also one of the factors since this is the first experiment we have done in measuring the gas emission. We will go further in this study and analyze the inadequacy for the future research. A conclusion section must be included and should indicate clearly the advantages, limitations and possible applications of the paper. Conclusion should have answered all the objective of the study and extracted from results and discussion.

Global Warming

What Is Global Warming?

Global warming is the unusually rapid increase in Earth's average surface temperature over the past century primarily due to the greenhouse gases released by people burning fossil fuels. The current climatic warming is occurring much more rapidly than past warming events. In Earth's history before the Industrial Revolution, Earth's climate changed due to natural cause's unrelated to human activity. These natural causes are still in play today, but their influence is too small or they occur too slowly to explain the rapid warming seen in recent decades. Models predict that as the world consumes ever more fossil fuel, greenhouse gas concentrations will continue to rise and Earth's average surface temperature will rise with them. Based on plausible emission scenarios, average surface temperatures could raise between 2°C and 6°C by the end of the 21st century. Some of this warming will occur even if future greenhouse gas emissions are reduced, because the Earth system has not yet fully adjusted to environmental changes we have already made.

Greenhouse Effect

The greenhouse effect is the warming that happens when certain gases in Earth's atmosphere trap heat. These gases let in light but keep heat from escaping, like the glass walls of a greenhouse. First, sunlight shines onto the Earth's surface, where it is absorbed and then radiates back into the atmosphere as heat. In the atmosphere, greenhouse gases trap some of this heat, and the rest escapes into space. The more greenhouse gases are in the atmosphere, the more heat gets trapped. Levels of Greenhouse Gases (GHGs) have gone up and down over the Earth's history, but they have been fairly constant for the past few thousand years. Global average temperatures have stayed fairly constant over that time as well, until recently. Through the burning of fossil fuels and other GHG emissions, humans are enhancing the greenhouse effect and warming Earth. Scientists often use the term climate change instead of global warming. This is because as the Earth's average temperature climbs, winds and ocean currents move heat around the globe in ways that can cool some areas, warm others, and change the amount of rain and snow falling. As a result, the climate changes differently in different areas. The rapid rise in greenhouse gases is a problem because it is changing the climate faster than some living things may be able to adapt. Also, a new and more unpredictable climate poses unique challenges to all life.

Historically, Earth's climate has regularly shifted back and forth between temperatures like those we see today and temperatures cold enough that large sheets of ice covered much of North America and Europe. The difference between average global temperatures today and during those ice ages is only about 5 degrees Celsius (9 degrees Fahrenheit), and these swings happen slowly, over hundreds of thousands of years. Now, with concentrations of greenhouse gases rising, Earth's remaining ice sheets (such as Greenland and Antarctica) are starting to melt too. The extra water could potentially raise sea levels significantly. As the mercury rises, the climate can change in unexpected ways. In addition to sea levels rising, weather can become more extreme. This means more intense major storms, more rain followed by longer and drier droughts (a challenge for growing crops), changes in the ranges in which plants and animals can live, and loss of water supplies that have historically come from glaciers. Scientists are already seeing some of these changes occurring more quickly than they had expected. According to the Intergovernmental Panel on Climate Change, eleven of the twelve hottest years since thermometer readings became available occurred between 1995 and 2006.

Causes of Global Warming

Scientists have spent decades figuring out what is causing global warming. They've looked at the natural cycles and events that are known to influence climate. But the amount and pattern of warming that's been measured can't be explained by these factors alone. The only way to explain the pattern is to include the effect of Greenhouse Gases (GHGs) emitted by humans.

One of the first things scientists learned is that there are several greenhouse gases responsible for warming, and humans emit them in a variety of ways. Most come from the combustion of fossil fuels in cars, factories and electricity production. The gas responsible for the most warming is carbon dioxide, also called CO_2. Other contributors include methane released from landfills and agriculture (especially from the digestive systems of grazing animals), nitrous oxide from fertilizers, gases used for refrigeration and industrial processes, and the loss of forests that would otherwise store CO_2.

Different greenhouse gases have very different heat-trapping abilities. Some of them can even trap more heat than CO_2. A molecule of methane produces more than 20 times the warming of a molecule of CO_2. Nitrous oxide is 300 times more powerful than CO_2. Other gases, such as chlorofluorocarbons (which have been banned in much of the world because they also degrade the ozone layer), have heat-trapping potential thousands of times greater than CO_2. But because their concentrations are much lower than CO_2, none of these gases adds as much warmth to the atmosphere as CO_2 does.

Effects of Global Warming

Some impacts from increasing temperatures that already happened are ice is melting worldwide, especially at the Earth's poles. Besides, the number of penguins on Antarctica has fallen from 32,000 breeding pairs to 11,000 in 30 years. Sea level also rises faster over the last century. Some butterflies, foxes, and alpine plants have moved farther north or to higher, cooler areas. Precipitation (rain and snowfall) has increased across the globe, on average. Spruce bark beetles have boomed in Alaska thanks to 20 years of warm summers. The insects have chewed up 4 million acres of spruce trees.

Other effects could happen later this century if warming continues such as the rises of sea level between 7 and 23 inches (18 and 59 cm) by the end of the century, and continued melting at the poles could add between 4 and 8 inches (10 to 20 cm). Hurricanes and other storms are likely to become stronger. Species that depend on one another may become out of sync. For example, plants could bloom earlier than their pollinating insects become active. Floods and droughts will become more common. Rainfall in Ethiopia, where droughts are already common, could decline by 10 percent over the next 50 years. Besides that, less fresh water will be available. Some diseases will spread, such as malaria carried by mosquitoes. Ecosystems will change and some species will move farther north or won't be able to move and could become extinct. Wildlife research scientist Martyn Obbard has found that since the mid 1980s, with less ice on which to live and fish for food, polar bears have gotten considerably skinnier. Polar bear biologist Ian Stirling has found a similar pattern in Hudson Bay.

Ozone Depletion

The ozone layer is a belt of naturally occurring ozone gas that sits 9.3 to 18.6 miles (15 to 30 kilometers) above Earth and serves as a shield from the harmful ultraviolet B radiation emitted by the sun. Ozone is a highly reactive molecule that contains three oxygen atoms. It is constantly being formed and broken down in the high atmosphere, 6.2 to 31 miles (10 to 50 kilometers) above Earth, in the region called the stratosphere. Today, there is widespread concern that the ozone layer is deteriorating due to the release of pollution containing the chemicals chlorine and bromine. Such deterioration allows large amounts of ultraviolet B rays to reach Earth, which can cause skin cancer and cataracts in humans and harm animals as well.

The ozone layer above the Antarctic has been particularly impacted by pollution since the mid-1980s. This region's low temperatures speed up the conversion of CFCs to chlorine. In the southern spring and summer, when the sun shines for long periods of the day, chlorine reacts with ultraviolet rays, destroying ozone on a massive scale, up to 65 percent. This is what some people erroneously refer to as the ozone hole. In other regions, the ozone layer has deteriorated by about 20 percent. The Figure 47 below showed the total global ozone change.

About 90 percent of CFCs currently in the atmosphere were emitted by industrialized countries in the Northern Hemisphere, including the United States and Europe. These countries banned CFCs by 1996, and the amount of chlorine in the atmosphere is falling now. But scientists estimate it will take another 50 years for chlorine levels to return to their natural levels.

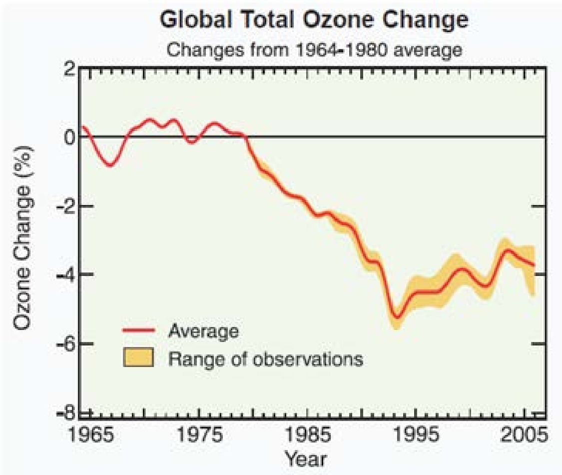


Figure 47: Total global ozone change.

Green House Gas (GHG) Emission from Shipping

If global shipping were a country, it would be the sixth largest producer of greenhouse gas emissions. Only the United States, China, Russia, India and Japan emit more carbon dioxide than the world's shipping fleet. Nevertheless, carbon dioxide emissions from ocean-going vessels are currently unregulated. Like all modes of transportation that use fossil fuels, ships produce carbon dioxide emissions that significantly contribute to global climate change and ocean acidification.Besides carbon dioxide, ships also release a handful of other pollutants that contribute to the problem. Over 90 percent of world trade is carried across the world's oceans by some 90,000 marine vessels, and as a result, the shipping industry is responsible for a significant proportion of the global climate change problem. More than three percent of global carbon dioxide emissions can be attributed to ocean-going ships.

The International Chamber of Shipping recognizes that reductions of 15 to 20 percent of the carbon dioxide emitted per tonne of cargo transported are possible from 2007 to 2020, primarily through use of operational and technical measures. These measures can have an almost immediate effect on emission reductions and a reduction of 33 percent below the business-as-usual baseline could be attained at no cost. Previous attempts by the industry to calculate levels of carbon emissions were largely based on the quantity of low grade fuel bought by shipowners. The latest UN Figures are considered more accurate because they are based on the known engine size of the world's ships, as well as the time they spend at sea and the amount of low grade fuel sold to shipowners. The UN report also reveals that other pollutants from shipping are rising even faster than CO_2 emissions.

A spokesman for the Department for Environment, Food and Rural Affairs said the government would support the development of a global emissions trading scheme through the IMO and was also investigating the feasibility of including maritime emissions in the EU's trading scheme. He said the shipping industry must take its share of responsibility for tackling climate change.

International Maritime Organization (IMO) regulation of GHG and requirement of implementation

Requirement of Implementation

Mandatory measures to reduce emissions of Greenhouse Gases (GHGs) from international shipping were adopted by Parties to MARPOL Annex VI represented in the Marine Environment Protection Committee (MEPC) of the International Maritime Organization (IMO), when it met for its 62nd session from 11 to 15 July 2011 at IMO Headquarters in London, representing the first ever mandatory global greenhouse gas reduction regime for an international industry sector. The amendments to MARPOL Annex VI Regulations for the prevention of air pollution from ships, add a new chapter 4 to Annex VI on Regulations on energy efficiency for ships to make mandatory the Energy Efficiency Design Index (EEDI) for new ships and the Ship Energy Efficiency Management Plan (SEEMP) for all ships. Other amendments to Annex VI add new definitions and the requirements for survey and certification, including the format for the International Energy Efficiency Certificate. The regulations apply to all ships of 400 gross tonnages and above and are expected to enter into force on 1 January 2013.

However, under regulation 19, the Administration may waive the requirement for new ships of 400 gross tonnage and above from complying with the EEDI requirements. This waiver may not be applied to ships above 400 gross tonnage for which the building contract is placed four years after the entry into force date of chapter 4, the keel of which is laid or which is at a similar stage of construction four years and six months after the entry into force, the delivery of which is after six years and six months after the entry into force or in cases of the major conversion of a new or existing ship, four years after the entry into force date. The EEDI is a non-prescriptive, performance-based mechanism that leaves the choice of technologies to use in a specific ship design to the industry. As long as the required energy-efficiency level is attained, ship designers and builders would be free to use the most cost-efficient solutions for the ship to comply with the regulations.

Work Plan Agreed

The MEPC agreed a work plan to continue the work on energy efficiency measures for ships to include the development of the EEDI framework for ship types and sizes and propulsion systems not covered by the current EEDI requirements and the development of EEDI and SEEMP-related guidelines. The MEPC agreed to the terms of reference for an intersessional working group on energy efficiency measures for ships, scheduled to take place in February/March 2012, tasked with further improving, with a view to finalization at MEPC 63, draft Guidelines on the method of calculation of the EEDI for new ships, draft Guidelines for the development of a SEEMP, draf Guidelines on Survey and Certification of the EEDI and draft interim Guidelines for determining minimum propulsion power and speed to enable safe maneuvering in adverse weather conditions.It also considering the development of EEDI frameworks for other ship types and propulsion systems.It is not covered by the draft guidelines on the method of calculation of the EEDI for new ships. Identifying the necessity of other guidelines or supporting documents for technical and operational measures. It considering the EEDI reduction rates for larger tankers and bulk carriers and considering the improvement of the guidelines on the Ship Energy Efficiency Operational Indicator (EEOI).

Enhancing Energy Efficiency

Shipping is permanently engaged in efforts to optimize fuel consumption. While ships are universally recognized as the most fuel-efficient mode of bulk transportation, the Second IMO GHG Study in 2009, identified a significant potential for further improvements in energy efficiency mainly through the use of already existing technologies such as more efficient engines and propulsion systems, improved hull designs and larger ships or in other words through technical and design-based measures that can achieve noteworthy reductions in fuel consumption and resulting CO_2 emissions on a capacity basis (tonne-mile). The study also concluded that additional reductions could be obtained through operational measures such as lower speed, voyage optimization and others. The EEDI addresses the former type of measure by requiring a minimum energy efficiency level for new ships by stimulating continued technical development of all the components influencing the fuel efficiency of a ship and by separating the technical and design-based measures from the operational and commercial ones. It is already being used to enable a comparison to be made of the energy efficiency of individual ships with similar ships of the same size that could have undertaken the same transport work.

Applicability

The EEDI formula is not supposed to be applicable to all ships. Indeed, it is explicitly recognized that it is not suitable for all ship or for all types of propulsion systems. Indeed, the first iteration of the EEDI has been purposefully developed for the largest and most energy-intensive segments of the world merchant fleet, thus embracing 72% of emissions from new ships and covering the oil and gas tankers, bulk carriers, general cargo ships, refrigerated cargo carriers and container ships. For ship types not covered by the current formula, suitable formulae will be developed in due course to address the largest emitters first. IMO's Marine Environment Protection Committee (MEPC) is poised to consider the matter in detail at future sessions, with a view to adopting further iterations of the EEDI.

Safe Speed

The need for a minimum speed to be incorporated into the EEDI formula has been duly acknowledged by the MEPC and a draft EEDI regulation (22.4) states that "For each ship to which this regulation applies, the installed propulsion power shall not be less than the propulsion power needed to maintain the maneuverability of the ship under adverse conditions, as defined in the guidelines to be developed by the Organization." It should, therefore, be clear that IMO fully supports the view that a minimum installed power to maintain safe navigation in adverse weather conditions is of critical importance to ensure both the safety and efficiency of international shipping. While the EEDI instrument therefore contains the standard to be achieved on this matter, implementation of that standard will be enabled through guidelines that are also to be adopted. A draft set of such guidelines will be considered by the MEPC in July 2011. With technical input from all concerned parties, these guidelines will be further developed.

Installed Power

Although the easiest way to improve a vessel's fuel efficiency is reduce speed hence, the move to slow steaming by a significant number of ships. There is a practical minimum at which fuel efficiency will decrease as a vessel is slowed down further. There are other ways to improve fuel efficiency, such as waste heat generators which do not impact on speed. Indeed, improvements in road transport efficiency have been made through advances in technology that have, however, not led to a sacrifice in speed; rather, quite the opposite.

Quantification of Emissions and Data Collection

Data Collection and Validation

For a number of reasons, organizations need to ensure that their GHG inventory does not significantly overestimate or underestimate emissions particularly if regulations are adopted, since the emissions inventory may potentially be the basis for award of allowances. Therefore, accuracy needs to be assured in each stop of the GHG inventory process. The higher the accuracy of the GHG inventory, the better positioned the company will be when regulations are adopted. Data validation and verification procedures are important since facility personnel may incorrectly enter data, use incorrect units, or apply incorrect conversions.

For organizations that have performed a GHG inventory for more than one year, a valuable second data validation step that can be conducted post-calculation is to compare emissions between years for each operation and also review production data to ensure that the emissions are accurately estimated and pass a primary logic test. In order to minimize the errors in the data gathering process, a central e-mail database can be established to which the facility representatives could present their questions and issues. This may be essential if a corporate or second party team is conducting the GHG inventory development process. This email database can preclude potential problems with the data entry (if any) by facilities, serve as documentation for the guidance provided to facilities, and also support the data validation and verification effort.

Factors Influencing Marine Emissions

Apart from a very few exceptions where power cables from land sources are connected and used on board vessels in port, ships are self sufficient regarding energy supply. In terms of number and emission magnitude, Main (ME) and Auxiliary (AE) diesel engines dominate by far, followed by turbine machinery. Emissions from boilers, emergency diesel engines and waste incinerators are relatively very small and can be considered negligible. Rather than size, ME and AE engines are normally sub-divided according to their engine speed at the crankshaft as high speed, medium speed and slow speed. Slow and medium speed engines are more abundant than high speed engines for main engines. For auxiliary engines, high and medium speed engines dominate. Old steam turbine systems, which use steam to drive turbines geared to the propeller shaft, have a relatively low efficiency and consequently are being replaced by diesel engines.

In general, emission correlations with engine size (MCR kW) age, condition (service intervals) and power output are difficult to isolate from a limited dataset of measurements on board operating ships. Since considerable variation and spread can exist in the data, the significance of a suspected correlation can often prove questionable. Some data show that with increasing engine MCR size, specific emissions4 of CO and HC decrease slightly at a given % engine load (Lloyds Register Engineering Services, 1995). In view of the spread in data however, a differentiation of assigned emission factors based on engine size appears not to be warranted. Engine age and condition have an affect on all emissions to some degree, but these factors are difficult to quantify.

The specific emission across the power output range of engines, irrespective of engine size, varies depending on the pollutant in question. SO_2 and CO_2 emissions follow the specific fuel consumption curve which normally remains fairly constant over the power range but tends to have a minimum at the designed operating load (usually ca. 80% of MCR). Specific HC, PM and CO emissions show increased levels at lower engines loads which are further accentuated for relatively cold engines at start-up. For NOx no clear and universal trend is apparent, thus specific NOx emissions have been observed to both increase and decrease with power for different engines. Emissions expressed as a mass flow rate, kg/hr, will generally always increase as the power of the engine increases.

Carbon Trading

What is Carbon Trade?

The carbon trade came about in response to the Kyoto Protocol. Signed in Kyoto, Japan, by some 180 countries in December 1997, the Kyoto Protocol calls for 38 industrialized countries to reduce their greenhouse gas emissions between the years 2008 to 2012 to levels that are 5.2% lower than those of 1990. Carbon is an element stored in fossil fuels such as coal and oil. When these fuels are burned, carbon dioxide is released and acts as what we term a greenhouse gas. The idea behind carbon trading is quite similar to the trading of securities or commodities in a marketplace. Carbon would be given an economic value allowing people, companies or nations to trade it. If a nation bought carbon, it would be buying the rights to burn it, and a nation selling carbon would be giving up its rights to burn it. The value of the carbon would be based on the ability of the country owning the carbon to store it or to prevent it from being released into the atmosphere.

Carbon Trading System

A carbon trading system allows the development of a market through which carbon (carbon dioxide) or carbon equivalents can be traded between participants, whether countries or companies. Each carbon credit is equal to one hundred metric tons of carbon dioxide, which can be traded or exchanged in market. There are two kinds of carbon trading which are emission trading and trading in Project-based credits. The two categories are put together as hybrid trading system. Carbon trading is also called pollution trading.

For emission trading, a company can reduce its emission by half the cost of allowance bought from other company. On the other hand, a company with higher expenditure for reduction of its emissions buys the required allowance from other company to save its emission cost. In either ways, the company saves half the expenditure they would have to spend for reduction of carbon emissions without carbon trading. Some emissions trading scheme allow companies to save any surplus allowances they have for their own use in future years, rather than selling them. Emission trading is also sometimes call [3]cap-and-trade.

For trading in project-based credits, government and World Bank subsidized credit for such project-based trading to the companies, covering part of the cost of building the projects and calculating how much carbon dioxide equivalent they save. Project-based Credit trading includes a baseline-and-credit trading and an offset trading.

In Hybrid trading system, both emission trading and offset trading are used and try to make allowance exchangeable for project-based credits. Hybrid trading system is enormously complex as it is not only difficult to try to create credible credit and make them equivalent to allowance. Mixing emission and project-based credit trading also changes the economics.

Carbon Trading Market Mechanism

The simplest type of carbon trade involves an entity preparing a contract that describes and specifies the kind of activity they are undertaking to either reduce or offset emissions. The contract may or may not be independently verified, although doing so will increase buyer confidence and probably attract a higher price. This contractual commitment is then sold to another entity that wishes to make use of the specified amount of the reduction or offset .Contractual commitments are usually traded over the counter (OTC), which means that the trade is usually a bilateral one between a willing buyer and a willing seller without the need for a market to exist. OTC trades are usually single trades where the terms are either partially or fully confidential. OTC markets are relatively simple and operate where there is limited liquidity or where the product being traded is somewhat unique for each trade.

In contrast, a carbon trading market is more akin to a share market. Products traded on a market are generally more homogenous, for example all types of carbon sequestration that meets the rules defining the creation of a carbon sequestration certificate may be deemed to be identical in the market. This both increases the liquidity of the product and helps market participants understand and have more confidence in the product being traded. The existence of a set of enforced rules associated with the creation of both emission reduction and emission offset certificates also increases market confidence in the product. Carbon network or market is a complex structure as seller can sell carbon credits in primary and secondary market and also seller and buyer can have direct or indirect relation with or without help of consultant and intermediaries.But by entry of brokers and consultants in market trading becomes easier as compared to earlier trading platforms.

Advantages, Key Risk and Uncertainties of Carbon Trading

Carbon credit trading can open up a new cash source to companies who are able to maintain their emission levels well within the permissible limits. The overall ecological balance is preserved. The company or country gets rewarded for applying clean technology in its production process and much better corporate and social image which wins public approval. It also encourages activities like tree plantings which would help reduce soil salinity, improve water quality and enhance biodiversity.

The key risks and uncertainties associated with carbon trading markets are the extent to which the Kyoto Protocol guidelines are implemented and followed.Besides, the attitude of US which is the biggest polluter and had refused to sign the treaty. In addition, the next five years will see the JI market deliver its first credits and possibly an emerging market in national Kyoto allowances or AAUs. Beyond Kyoto, the ten-state RGGI has already produced the first US compliance trade, and more is expected.

Emission and Health

Exhaust emissions: What are they?: The exhaust fumes contain a large number of different chemicals or emissions.Once released into the air, exhaust emissions are breathed in and transported in the bloodstream to all the body's major organs. Diesel seems potentially to be more of a problem than petrol. Potentially dangerous vehicle emissions include carbon monoxide, nitrogen dioxide, sulphur dioxide and particulate matter.

What are the risks? : Although research has clearly linked exhaust emissions to a range of health problems in the population, the exact risk to any individual is difficult to define. However there is no doubt that the more you are exposed the greater the risk is likely to be and some people, for example those who already have respiratory conditions such as asthma or bronchitis, are especially vulnerable.

The most obvious health impact is on the respiratory system. It's estimated that air pollution of which emissions are the major contributor is responsible for 24,000 premature deaths in the UK every year. Many of these deaths are due to asthma, bronchitis and other respiratory diseases all of which are known to be aggravated by exposure to fumes. A Dutch study of 632 children aged seven to 11 years found that respiratory disorders worsened as air pollution increased and a longer term study of older Dutch residents, published in 2009 found that illness due to lung disorders increased in areas of high nitrogen dioxide and particulate matter associated with exhaust emissions. Some of the impacts to health due to the emissions are cancer, central nervous system may grow older and blood implication.

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