



MTCC CARIBBEAN
Maritime Technology Cooperation Centre

Assessment of GHG Emissions Reduction Measures on-board Commercial Ships Operating in the Caribbean Region



GMN | The Global
MTCC Network
A global network for energy-efficient shipping



THE UNIVERSITY OF TRINIDAD AND TOBAGO



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The contents of this publication are the sole responsibility of the MTCC Caribbean and can
in no way be taken to reflect the views of the European Union.

Meet the MTCC Caribbean Team



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Foreword

The International Maritime Organization (IMO) remains committed to the global fight against climate change and take urgent action to combat climate change and its impacts. Funded by the European Union and implemented by the IMO, the Global MTCC Network (GMN) initiative unites the maritime technology centres – Maritime Technology Cooperation Centres (MTCCs) in targeted regions into a global network. Together, they are promoting technologies and operations to improve energy efficiency in the maritime sector and help navigate shipping into a low-carbon future. The University of Trinidad and Tobago (UTT) was selected to host the MTCC for Caribbean region in 2016. Along with its capacity building activities, MTCC Caribbean undertook two pilot projects aimed at the promotion of the uptake of energy efficiency measures and reporting of fuels being used by ships, calling various ports in the Caribbean region. This assessment provides consolidation of the results from these two pilot projects. The MTCC Caribbean was able to generate baseline data that can assist relevant stakeholders with interests in the regional shipping. The assessment done during the pilot projects provides the Caribbean region with a new opportunity to collect and analyse data relating to the maritime shipping emissions.



Dr Jose Matheickal
Chief (Partnerships and Projects)
International Maritime Organization (IMO)

Global efforts to reduce greenhouse gas emissions from shipping rely heavily on improvements in energy efficiency and increased uptake of low-carbon technologies. The work from pilot projects have laid foundation and provides an opportunity to the maritime administrations and ship owners and operators in the region to extend the research on reducing GHG emissions from maritime shipping. I anticipate that maritime stakeholders will be able to use this report in conjunction with MTCC Caribbean's Technology Needs Assessment & Capacity Building Report to determine the priorities and create an enabling environment for the uptake of technology aimed at substantial reduction of GHG emission from the maritime shipping.

I wish to thank the European Union for its funding support to creating the MTCC network which allowed the MTCC Caribbean to undertake these two crucial pilot projects. I also congratulate the MTCC Caribbean team on the successful execution of the both pilot projects. I expect, MTCC Caribbean, with its collaboration and outreach activities will continue to support the region and GMN to assist countries develop their national maritime energy-efficiency policies and measures, promote the uptake of low-carbon technologies and operations in maritime transport.

Message from Technical Team

Deputy Director and Technical Head



Captain Sukhjot Singh
Deputy Director and Technical Head
MTCC Caribbean

The need for reducing emissions from shipping is urgent. Technological and operational measures are key to achieving GHG emission reduction targets. Pilot projects, under the GMN project provided an opportunity to carry out two pilot projects, specifically on promoting the uptake of low-carbon technologies and operations in maritime transport and establishing pilot scale voluntary data collection and reporting systems. However, identifying the lack of any existing data to support a demonstration project, MTCC

Caribbean recognised the need to establish relevant baselines. The pilot projects were designed to assist the region with an opportunity to collect and analyse data supporting decision making in reducing maritime shipping emissions. The Emission Control and Energy Efficient Measures (ECEEMs) baselines and Online Voluntary Reporting System (OVRs), established by the pilot projects provide the starting point for decarbonisation of maritime transport in the region. This assessment of commercial ships along with the Technical Needs Assessment (TNA) of the region completed by MTCC Caribbean in 2018, offers an insight into the current state of adoption of available technologies in the region. With continued support from the EU, IMO and UTT we aim to stay engaged with all stakeholders and serve the region in climate mitigation in the maritime shipping industry.

GHG Advisor

It has been a privilege to work so closely with colleagues across the Caribbean in progressing the agenda for decarbonisation of shipping. In leading the pilot project aimed at determining the main energy consumers and energy efficient technologies on board ships operating in the region and the types of fuels used on board these ships, MTCC Caribbean was able to produce the first assessment of Maritime transport GHG emissions for the Caribbean. Recognising the profound impacts of climate change to the Caribbean region, it is imperative that we undertake urgent action across all sectors to mitigate the impacts of climate change. The maritime sector therefore needs to play an active role in the blue growth initiatives that are currently being implemented across the region. Given the vast ocean resources of the region, accounting for more than 90% of the territorial space, the blue economy presents real opportunities for the sustainable development of the region. The regional seas are vital to both international and domestic shipping including activities ranging from fishing to exploring offshore energy prospects, rendering shipping an activity to be managed in a sustainable

manner.. The primary stage in managing an activity is to make an initial assessment of the operations, and ensure that improvements can be measured and monitored. Through the MTCC Caribbean pilots, this preliminary work has been undertaken and it is for the region to ensure that we continue to build on this data and momentum to ensure that maritime transport contributes to sustained blue growth. It is envisioned that with adequate data, and the ability to measure and monitor, decision makers of the region can better implement SMART initiatives with relevant KPIs toward sustainable shipping in the region.



***Mr Stephan Nanan
Greenhouse Gas Adviser
MTCC Caribbean***

Energy Efficiency Advisor



***Ms Suzette Balkaran
Energy Efficiency Adviser
MTCC Caribbean***

Energy efficient vessels promote environmentally sound solutions toward climate change mitigation, while improving energy consumption during operations. With the use of the energy efficiency operational indicator (EEOI) and other monitoring tools and techniques, vessels can be assessed, to maintain operational efficiency, and align with greenhouse gas reduction initiatives. Pilot projects undertaken by MTCC Caribbean mapped emission control and energy efficient measures (ECEEMS) utilised on board vessels and the subsequent carbon dioxide emissions of these vessels calling at

ports within the Caribbean Region. The EEOI of the vessels was also calculated and compared to the corresponding deadweight and gross tonnage of the vessels. Engagement by MTCC Caribbean with various stakeholders within the maritime field, inclusive of Maritime Administrations, Port Authorities, Shipping Agents, Vessel Owners/Operators and Technology/Alternative Fuel Providers, promoted information exchange, data sharing and knowledge transfer. MTCC Caribbean has presented baseline information upon which informed decisions can be made to improve decarbonisation strategies to effectively and collectively mitigate climate change within the Region.

Contents

Acronyms	8
List of Tables	9
Exploring the Unknowns - MTCC Caribbean's Pilot Projects	11
Setting Sail – Overview	16
Rough Waters – Maritime Shipping Emissions and the Challenge of Climate Change.....	19
Passage Plan – International Frameworks & Initiatives addressing GHG Emissions from International Shipping.....	21
GLOMEEP	26
The Global MTCC Network (GMN)	27
Initial IMO Strategy	29
Sounding the Water – Pilot.....	31
MTCC Caribbean's Data Collection	33
Data Collection Streams.....	35
Charting the Course – Online Voluntary Reporting System (OVRs)	36
Position Fixing – Energy Efficiency Baselines in the Region.....	40
GRT of total Sample	43
AGE of the total sample	44
Emissions Control and Energy Efficient Measures in Maritime Shipping in the Caribbean	45
Energy Efficiency Operational Indicator (EEOI) Baseline for the Caribbean.....	54
EEOI Baseline Calculations	55
Ships' GHG Emissions Baseline for the Caribbean	60
Emission and use of ECEEMs on-board ships.....	63
Relevance to the Regional Maritime Sector	67
Connecting the Dots – Stakeholder Engagement	70
Charting a New Course	72
Need for Future Projects in Ports to Support Green Ships	73
Final Thoughts – Overcoming Barriers.....	74

Acronyms

CF - Carbon Factor	MEPC - Marine Environment Protection Committee
CII - Carbon Intensity Indicator	MEPSEAS - Marine Environment Protection of the South East Asian Seas
CO ₂ - Carbon Dioxide	MGO - Marine Gas Oil
DCS - Date Collection System	MSD - Maritime Services Division
DPP - Department of Partnerships and Projects	MTCC - Maritime Technology Cooperation Centre
ECEEMs - Emissions Control and Energy Efficient Measures	ODSs - Ozone Depleting Substances
ECLAC - Economic Commission for Latin America and the Caribbean	OSVs - Offshore Supply Vessels
EEDI - Energy Efficiency Design Index	OVRS - Online Voluntary Reporting System
EEFP - Energy Efficiency Focal Points	RSC - Regional Steering Committee
EEOI - Energy Efficiency Operational Indicator	SDGs - Sustainable Development Goals
EEXI - Energy Efficiency Existing Ship Index	SEEMP - Ship Energy Efficiency Management Plan
GHG - Greenhouse Gas	SENSREC - Safe and Environmentally Sound Ship Recycling in Bangladesh
GIA - Global Industry Alliance	SEW - Single Electronic Window
GloMEEP - Global Maritime Energy Efficiency Partnerships Project	SIDS - Small Islands Developing States
GMN - Global MTCC Network	TAP - Technology Action Plan
HFO - Heavy Fuel Oil	TEU - Twenty-foot Equivalent Unit
ICAO - International Civil Aviation Organization	TNA - Technology Needs Assessment
IMO - International Maritime Organization	TORs - Terms of Reference
LDCs - Least Developed Countries	UNCTAD - United Nations Conference on Trade and Development
LFO - Light Fuel Oil	UNFCCC - United Nations Framework Convention on Climate Change
LNG - Liquefied Natural Gas	
LPG - Liquefied Petroleum Gas	
MARPOL - Convention for the Prevention of Pollution from Ships	
MDO - Marine Diesel Oil	

List of Tables

Table I - Growth of Container Trade in the Caribbean Region	17
Table II - ECEEMs in the Caribbean Region	46
Table III - Energy Efficient Technology & Alternative Fuel Providers	50
Table IV - Vessel type for the data sample collected using MTCC Data collection form	54
Table V - Bottom-Up Methods of Calculation & Estimation	55
Table VI - Vessel Type and respective EEOI Values	56
Table VII - Vessel Type and respective EEOI Values	57
Table VIII - GHG Emissions based on sample collected using MTCC Data collection form	60
Table IX - Types of fuel, Reference and Carbon Content CF (t-CO ₂ /t-Fuel) (MEPC.245 (66))	61
Table X - Vessel type for the data sample collected with the use of IHS Markit Database	62
Table XI - GHG Emissions based on sample collected using IHS Data	62
Table XII - Vessel Ownership	75

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Exploring the Unknowns - MTCC Caribbean's Pilot Projects

The Maritime Technology Cooperation Centre (MTCC) Caribbean was established in 2017 under the Global MTCC Network (GMN) project. The aim of the GMN project is to assist developing countries and, in particular, Least Developed Countries (LDCs) and Small Islands Developing States (SIDS) limit and reduce GHG emissions from their shipping sectors through technical assistance and capacity building to promote ship energy efficiency. Since its establishment, MTCC Caribbean has become a centre for regional and international collaboration for the purposes of enhancing ocean governance and shipping with particular emphasis on GHG Monitoring and use of energy efficient technology.

In this context, MTCC Caribbean's pilot projects were designed to meet the criteria of the terms of reference (TORs) for the GMN and facilitate capacity building to enhance implementation of energy efficient and energy abatement measures in the region by:

1. Promoting the uptake of low-carbon technologies and operations in maritime transport through the implementation of technology-related pilot projects, thus creating an enabling environment for energy-efficient practices within the shipping sector; and
2. Establishing pilot scale voluntary data collection and reporting systems to support ship-owners and maritime administrations, and feed the experience and understanding of these systems into debates and decision-making processes at the IMO.

Understanding the capacity building initiatives within the pilot projects it was critical for us to understand and utilise the collaboration among regional maritime actors within individual organisations and fuel local stakeholders' ambition and resources. Therefore, some key considerations in the design and execution of pilot projects were to:

- Engage with stakeholders in the entire project cycle and ensure shared ownership
- Guide regional maritime technology needs assessments and identify constraints
- Communicate meaningful results to diverse stakeholders
- Compare the execution and determine what does and does not work to advance the practice

Capacity Building in a multi-stakeholder processes and collaboration required MTCC Caribbean to work with multiple actors within and across public and private organisations within the sectors. A technical initiative within the scope of pilot projects was required to combine strong results-orientation with flexibility and learning. The stakeholder engagement-enhanced connections between local realities and macro policies or programmes. Various activities (formal and informal) during the pilot projects assisted in effective capacity development by developing professional knowledge, attitudes and skills.

“...capacity building is a risky, murky, messy business, with unpredicted & unquantifiable outcomes, uncertain methodologies, contested objectives, many unintended consequences, little credit to its champions and long-time lags...”
Morgan (1998)

In designing the pilot projects, major considerations included the variations between countries and the lack of any pre-existing data relevant to the scope of the GMN project. The countries within the Caribbean region differ significantly in terms of wealth, poverty and development indices. They also differ in the nature of their economies, legal and political systems; civil society relations; governments and private sectors; administrative processes; and their natural environments. As a region, there was no established baseline on GHG emissions and use of energy efficient technology on ships. The absence of any baseline data on the use of existing technology on-board vessels in the region made it difficult to promote uptake and identify potentially applicable technologies and justified the need to establish such a baseline. Further, an emissions baseline is the foundation of any estimate of the impacts of a project or of a mitigation measure.

The pilot projects under MTCC Caribbean were phased over three (3) years and promoted the uptake of energy efficiency in shipping and data collection associated with air emissions due to commercial shipping. This presented the region with a new opportunity to collect and analyse data relating to the maritime shipping emissions. MTCC Caribbean successfully completed its two Pilot Projects, which targeted the vessels calling at Caribbean ports.

Pilot Project 1 captured baseline data on the use of Emissions Control and Energy Efficient Measures (ECEEMs) by ships.

Pilot Project 2 established an Online Voluntary Reporting System (OVRs) that includes reporting of fuel consumption data from ships.

A single user-friendly data collection form was developed to facilitate data collection for both pilot projects and was designed for ease of use by vessels' crews, and associated shipping agents. This direct data collection was supplemented by the collection and collation of data from IHS Markit online database. Figure I identifies the key outputs from the data collected through the establishment of this voluntary reporting system under MTCC Caribbean's Pilot Projects.

Figure I - Outputs of MTCC Caribbean Data Collection





SUSTAINABLE DEVELOPMENT GOALS

The results of MTCC Caribbean's pilot projects baselines provide regional stakeholders with data to make informed decisions for mitigating climate change and supports the Sustainable Development Goals (SDGs) as follows:

1 NO
POVERTY



Promoting the most cost-effective & fuel-efficient way for the transportation of goods & basic materials to those in Poverty.

Promoting the most cost-effective & fuel-efficient way for the transportation of goods & basic materials to those in Hunger.

2 ZERO
HUNGER



3 GOOD HEALTH
AND WELL-BEING



Lobbying for the reduction of ship related pollution in ports, coastal regions and the wider ocean and the establishment of the Caribbean as an ECA.

4 QUALITY
EDUCATION



Providing high quality training to the Caribbean Region.

5 GENDER
EQUALITY



Encouraging and facilitating the participation & empowerment of women in our capacity building workshops, data collection & other associated activities.

6 CLEAN WATER
AND SANITATION



Promoting the use of effective waste management systems on-board commercial ships and ports.

7 AFFORDABLE AND
CLEAN ENERGY



Providing scope for the energy efficiency improvements, as well as highlighting the need for substantially increasing the percentage of renewables in the energy mix.

8 DECENT WORK AND
ECONOMIC GROWTH



Training personals such as port state control officers & seafarers on the international requirements & facilitating efficient productivity.

9 INDUSTRY, INNOVATION
AND INFRASTRUCTURE



Promoting innovation technical solutions towards reducing shipping emissions & providing a platform for technology transfer.

10 REDUCED
INEQUALITIES



Assisting Caribbean countries in complying with the provisions of MARPOL Annex VI & other regulatory requirements for the control of shipping emission.

11 SUSTAINABLE CITIES
AND COMMUNITIES



Promoting the use of sustainable energy sources and operations at ports.

12 RESPONSIBLE
CONSUMPTION
AND PRODUCTION



Lobbying for sustainable energy consumption by ships & port operators.

13 CLIMATE
ACTION



Improving education, awareness & institutional capacity for mitigating & reducing the impact of shipping to climate change.

14 LIFE
BELOW WATER



Supporting the use of sustainable technology that will reduce and prevent damage to the marine environment.

15 LIFE
ON LAND



Promoting the switch from paper generated reporting and system to technology oriented procedures

16 PEACE, JUSTICE
AND STRONG
INSTITUTIONS



Promoting the establishment of a Regional Maritime Cooperation Centre to facilitate transparency, data sharing & a common approach to addressing climate action.

17 PARTNERSHIPS
FOR THE GOALS



Functioning as a regional centre for partnership, a centre within a global network & a facilitator of sustainable development in the maritime sector.

The success of the pilot projects was the result of cooperation among stakeholders across the region demonstrating their commitment to reducing GHG emissions from the regional maritime sector. In addition to data collection, the pilot projects were key in increasing awareness of regional stakeholders with respect to shipboard energy efficiency measures, technology and emission abatement methods. The results of these pilot projects, in combination with MTCC Caribbean's Technology Needs Assessment (TNA) and capacity building activities can provide a clear path towards a Technology Action Plan (TAP) for any of the projects identified stakeholders. This is of significant relevance to the region, especially with enforcement of 2020 Sulphur cap and the implementation of the IMO's Initial GHG Strategy. The increased awareness for the need for maritime energy efficiency in all aspects of the maritime supply chain achieved during the execution of MTCC Caribbean's pilot projects, the region is now better positioned to lobby for better and greater use of the technology and emissions abatement measures. MTCC Caribbean stands ready to assist countries and territories of the region in the adoption and implementation of technology adoption and implementation plans.

Building from existing baselines, future projects may provide the insights into solutions to some of the existing energy efficiency and maritime emissions challenges within the Caribbean. The global nature of shipping and climate change mitigation demands coordinated solutions and partnerships. These are critical dimensions in achieving sustainable development. Significant steps toward stricter policies and regulations promoting alternative fuels and ship design aimed at decreasing carbon dioxide (CO₂) emissions need to be taken at the regional level.



Setting Sail – Overview

Extending from The Bahamas and Belize in the north to Suriname and Guyana in South America, the Caribbean consists of developing countries, SIDS, spanning 3200km long. With its proximity to Panama, the Caribbean region is located at the intersection of major East-West and North-South global maritime trading routes. By virtue of its geographical nature, while islands heavily depend on maritime transport for trade, they also form attractive trans-shipment hub port networks to serve the Atlantic side of Americas. Some islands have well-developed modern port infrastructure and offer their services as global and sub-regional trans-shipment hubs while others operate port services catering to domestic needs. The maritime traffic footprint of the Caribbean Sea at any given instant is approximately 4200 vessels¹.

This figure represents on average 1400 commercial vessels; 833 of these vessels are greater than 400 GT and 567 vessels are greater than 5000 GT. Fifteen percent of containerized global trade passes through the Caribbean by virtue of its proximity to the Panama Canal and the major markets of the East Coast of the United States and South America (Inter-American Development Bank, 2014). According to data compiled by Economic Commission for Latin America and the Caribbean² (ECLAC, 2020) the Caribbean (which includes Colombia's Caribbean coast, but not Venezuela's), marked a growth of 2.3% in the total movement of containers.

The Maritime Industry is an enabler of world economic trade by being responsible for the transportation of approximately 80% of goods by volume and 70% by value. As per the United Nations Conference on Trade and Development (UNCTAD) reports, total volumes of trade facilitated by maritime transport in 2018 were estimated to have reached an all-time high of 11 billion tonnes, which is an increase of 83% of the 2000 estimate of 6 billion tonnes. UNCTAD is projecting 2.6 per cent growth in 2019 over 2018 volumes and an annual average growth rate of 3.4% for the period 2019–2024.³ Table I below compares the total throughput of the countries of the region for the period 2017-2019 and the year-on-year variation in growth.

¹ Singh, S., Balkaran, S., Nanan, S., Razack, M., Rambarath-Parasram, V., Parris, T. and Mahabir-Lee, S. (2019). *MTCC Caribbean's Pilot Project Report 1: Uptake of Ship Energy Efficient Technology*. Chaguaramas, Trinidad: MTCC Caribbean.

² ECLAC (2020) *The calm before the storm: Behaviour of the movement of containers in the ports of Latin America and the Caribbean in 2019 and of the main ports during the first months of 2020*.

³ UNCTAD (2019) *Review of Maritime Transport 2019*

Table I - Growth of Container Trade in the Caribbean Region⁴

Country	Throughput 2017 (TEU)	Throughput 2018 (TEU)	Throughput 2019 (TEU)	Annual change in growth 2018/2017	Annual change in growth 2019/2018
Dominican Republic	1.842.616	1.906.487	1.894.225	3.5%	-0.6%
Jamaica	1.560.000	1.833.053	1.647.609	17.5%	-10.1%
Bahamas	920.652	1.182.836	1.555.803	28.5%	31.5%
Trinidad and Tobago	414.657	358.475	446.232	-13.5%	24.5%
Cuba	332.240	349.722	322.000	5.3%	-7.9%
Suriname	112.318	110.000	109.200	-2.1%	-0.7%
Barbados	107.098	100.952	98.435	-5.7%	-2.5%
Guyana	57.663	58.210	58.543	0.9%	0.6%
St. Lucia	28.549	32.500	39.328	13.8%	20.7%
Grenada	21.914	23.887	12.343	9.0%	-48.3%

⁴ Data collated from UNCTAD Online Database

This increase in trade in the region signals a growth in economic activity, which undoubtedly leads to social development, however the scale of sustainable development is unbalanced as the third factor, environmental protection, is not being uniformly weighted. With increased maritime traffic, there is a corresponding impact on the environment and air quality, in particular, is often unnoticed. The emissions from shipping contributes to many of the environmental sustainable challenges facing the world's population, however, the role of maritime transport in addressing the global sustainability imperative is increasingly being recognised. Safe, secure, energy-efficient, affordable, reliable, low-carbon, climate-resilient and rule-based maritime transport systems contribute to achieving economically efficient, socially equitable and environmentally sound development (UNCTAD, 2018).

Environmental sustainability requires awareness of the risks associated with GHG emissions, ocean health, and other impacts influenced by energy use, industrial processes and transportation operations. Sustainability demands that day-to-day operations of all economic sectors routinely give consideration to targets of the SDGs of the United Nations 2030 Agenda for Sustainable Development in their decision-making processes and operations. However, in order for maritime transport to contribute to the global sustainability imperative, unsustainable practices of the sector that result in wide-ranging negative externalities need to be addressed and targets under the SDGs achieved.

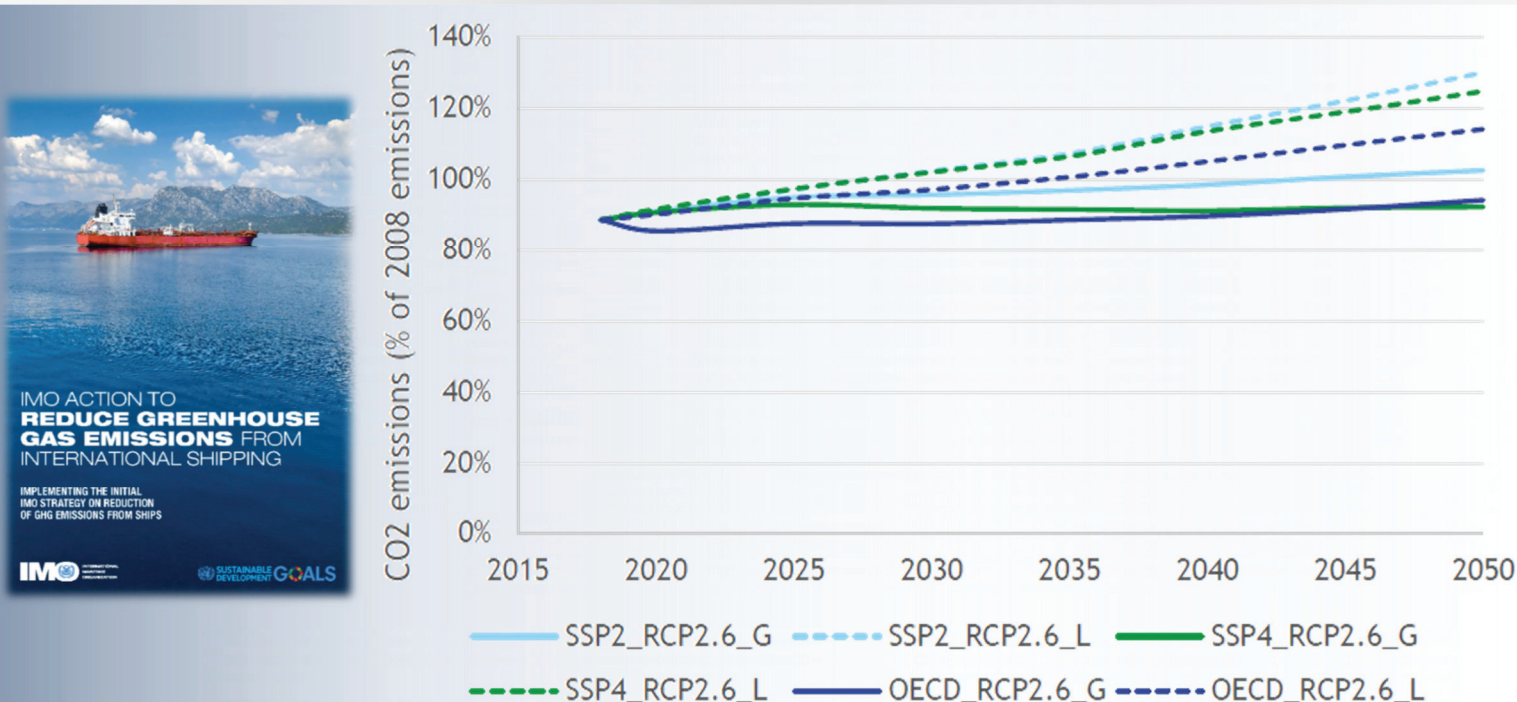
Whilst all 17 SDGs are intrinsically linked, the more relevant ones for consideration in managing the Maritime Industry are SDG 7 – Affordable and Clean Energy, SDG 13 – Climate Action and SDG 14 – Life Below Water. The addition of anthropogenic Carbon Dioxide (CO₂) and other GHG emissions from the onset of the industrial revolution to date have magnified the Earth's Greenhouse effect, leading to global atmospheric warming and all its associated impacts. Regions such as the Caribbean and the Pacific are extremely vulnerable to a number of these impacts, including; increased atmospheric temperatures, rising sea levels, and more intense and frequent inclement weather systems. In addition to these physical environmental impacts, these regions are also susceptible to the compounded social and economic impacts resulting from Climate Change. SDG 13 - Climate Action encompasses the development and implementation of initiatives to take urgent action to combat climate change and its impacts. Immediate and continuous action is required to peak GHG emissions from all economic sectors as soon as possible, reduce anthropogenic GHG emissions and drawdown on atmospheric CO₂. Decisive climate action is required by all stakeholders of the Maritime Industry to reduce the sector's GHG emissions in the short term, and eliminate these emissions completely in the medium to long term. Combatting climate change will continue to be a vital strategic direction for the IMO, both in the short and long terms. IMO continues to develop ambitious but realistic solutions to minimize shipping's contribution to air pollution and its impact on climate change.

Rough Waters – Maritime Shipping Emissions and the Challenge of Climate Change

There is a direct correlation between the concentration of atmospheric CO₂ and the increase in global atmospheric temperature. On the global scale, CO₂ accounts for approximately 76% of anthropogenic Greenhouse Gas (GHG) emissions, 65% coming from fossil fuel and industrial processes, and 11% from forestry and other land uses. Transportation is responsible for approximately 14% of global anthropogenic GHG emissions, estimated at 7.0 gigatonnes CO₂e in 2010 (IPCC, 2014). Although shipping is the least environmentally degrading mode of transportation, according to the IMO's Fourth GHG Study⁵, from the year 2012 to 2018 total shipping (international and domestic) was responsible for a 9.6% increase from 977 million tonnes to 1,056 million tonnes of CO₂e combining CO₂, CH₄ and N₂O emissions. It is theorised that there is a temporary reduction in emissions as a result of the drop in passenger and freight activity due to the COVID-19 pandemic, but the corresponding percentage decrease in associated GHG emissions is still to be determined. However, it is anticipated that as economies recover, there will be heightened activity leading to an increase in emissions as previously projected.

Shipping can be broken down into two categories: international shipping (i.e. the movement of goods and people across transnational boundaries from one nation to another) and domestic shipping (i.e. waterborne transportation of goods or people within the coastal and/or inland waters of one nation or territory with origin and destination in the same nation). Emissions from both categories of shipping are of direct consequence of the fuels (maritime bunker) used to power the internal combustion engines of the ships comprising the world's fleet. Ships of 5000 GT and above are responsible for approximately 85% CO₂ emissions from International shipping.

Figure II - Maritime Ship Emissions as a percentage of 2008 Emissions (IMO 4th GHG Study)



⁵ IMO (2020) IMO Fourth GHG Study

Figure III provides an illustration of the fuel types by percentage used for the year 2010 and projected figures up to 2030. It gives insight for the foreseeable future and suggests that heavy fuel oil (HFO) will continue to be the dominant fuel of the sector. This heavy dependence of maritime shipping on fossil fuels thus highlights the need for a framework to regulate the associated emissions. The framework must provide accountability, practices and regulations to be put in place for various stakeholders involved in the operation of ships. This supporting framework along with vessel emissions reduction measures must be accomplished in an accurate and timely manner to reduce their negative impact on the climate. Developing such mechanisms is vital to assist in the reduction of GHG emissions and therefore requires a comprehensive international instrument and framework.

Figure III - Status Quo fuel mix for ship (%) for various vessel types⁶.

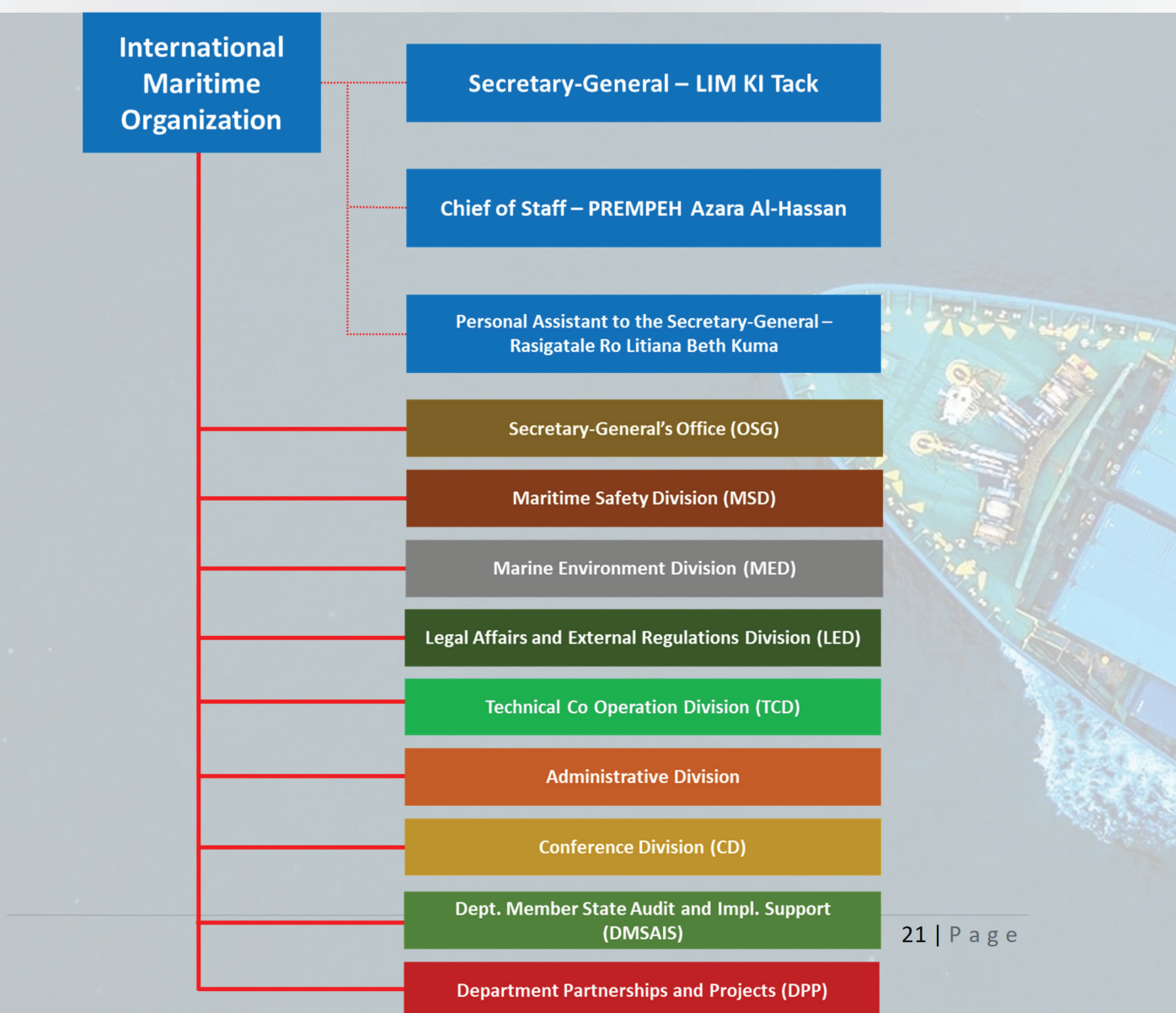


⁶ Smith, T., Raucci, C., Sabio, N., Argyros, D.(2014b). Global marine fuel trends 2030. Lloyds Register Marine; University College London Energy Institute, London.

Passage Plan – International Frameworks & Initiatives addressing GHG Emissions from International Shipping

The United Nations Framework Convention on Climate Change (UNFCCC) Kyoto Protocol called for GHG emissions from fuels used for both International Aviation and International Maritime transportation (bunker fuels) to be accounted for and reduced through initiatives from the International Civil Aviation Organization (ICAO) and the International Maritime Organization (IMO) respectively. The IMO is the United Nations specialised agency with the responsibility for the safety and security of shipping and the prevention of marine and atmospheric pollution by ships. In this regard, IMO develops the standards for the safety, security and environmental performance of international shipping while working towards the 2030 Agenda for Sustainable Development and the associated SDGs. In collaboration with ship owners/operators, shipbuilders, and ports, the IMO plays a leading role in formulating measures to reduce the GHG emissions from ships and ports. In 2011, the IMO became the first international body to adopt mandatory energy-efficiency measures for an entire industry sector with a suite of technical and operational requirements for new and existing vessels that entered into force in 2013. This framework was the first legally binding instrument to be adopted since the Kyoto Protocol that addresses GHG emissions and the first global mandatory GHG-reduction regime for an international industry sector. The structure of IMO can be simplified as below.

Figure IV - Structure of IMO



The Marine Environment Protection Committee (MEPC) is the technical body responsible for marine environmental management. This has changed over the last few decades to include a much wider range of measures to prevent marine pollution, and the original International Convention for the Prevention of Pollution from Ships (MARPOL) has been amended appropriately to include an Annex VI adopted in 1997 by a Protocol to MARPOL, to include air pollution and control of emissions from ships. MARPOL Annex VI specifically involves the prevention of air pollution from ships setting limits for sulphur oxides, nitrogen oxides and particulate matter, as well as the prohibition of the use and release of Ozone Depleting Substances (ODSs). In recent developments the Department of Partnerships and Projects (DPP) was established on 1st March 2020 within the IMO Secretariat to focus on supporting Member States to tackle key global issues in the context of international shipping. This is expected to strengthen partnerships with external stakeholders and donor agencies to tackle some of the major global challenges for international shipping, including decarbonisation, marine litter and biofouling. Major projects currently falling under the purview of DPP include the GMN, Global Maritime Energy Efficiency Partnerships Project (GloMEEP), GloFouling Partnerships, GreenVoyage2050, GloLitter Partnerships, Marine Environment Protection of the South East Asian Seas (MEPSEAS) and Safe and Environmentally Sound Ship Recycling in Bangladesh (SENSREC).

MEPC is the committee tasked with developing and implementing GHG reduction strategies relating to international shipping. The committee has been addressing this by assessing the contribution of the sector through the IMO's GHG studies. MEPC communicates guidelines through resolutions/circulars. Examples of these related resolutions are shown in the Figure V, the full Index of MEPC Resolutions and Guidelines related to MARPOL Annex VI can be viewed on the IMO's website.



Figure V - MARPOL Annex VI Chapter 4 and related MEPC Circulars and Resolutions



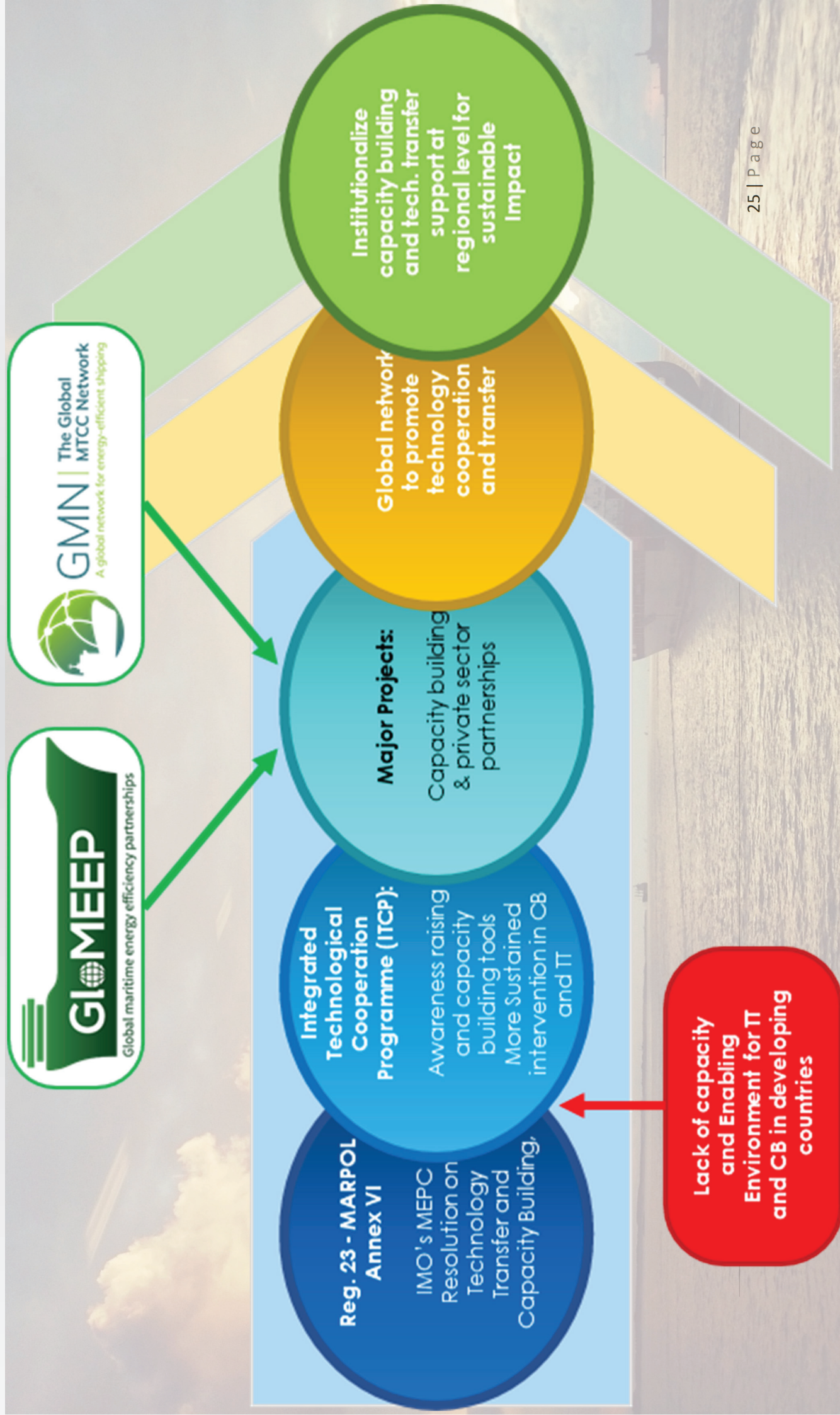
Discussions at the MEPC's 62nd session, demonstrated a shift in approach at the IMO. Deliberations from the UNFCCC influenced the IMO discussions on GHG emissions. In 2011, the IMO adopted a collection of technical and operational measures which, together, provides an energy efficiency framework for ships. With the adoption of this framework, IMO became the first international body to adopt mandatory energy-efficiency measures for an entire industry sector. This included a suite of technical and operational requirements for new and existing vessels that entered into force in 2013. These requirements will increase the energy efficiency of new ships so that they are 30% more energy efficient by 2025, compared to those built in 2014.



The amendments to the MARPOL Convention were adopted in July of the same year. A new chapter, outlining Regulations on energy efficiency for ships (Chapter 4) was added to MARPOL Annex VI, mandating the Energy Efficiency Design Index (EEDI) for new ships, and the Ship Energy Efficiency Management Plan (SEEMP) for all ships. All ships of 400 GT and above, engaged in international trade, are required to implement and maintain a SEEMP that establishes a mechanism for operators to improve the energy efficiency of ships. This should be achieved by monitoring the energy efficiency performance of a ship's transportation work, using, for example, the Energy Efficiency Operational Indicator (EEOI) as a monitoring/benchmarking tool and, at regular intervals, considering new technologies and practices to improve energy efficiency.

Regulation 23 of MARPOL Annex VI encourages the promotion of technical cooperation and transfer of technology relating to the improvement of energy efficiency of ships between States. Along with assisting in the efforts to promote low-carbon technologies by facilitating public-private partnerships and information exchange, the IMO continues to provide mechanisms for facilitating information sharing, technology transfer, capacity-building and technical cooperation.

Figure VI - IMO's ITCP GHG Reduction Initiatives



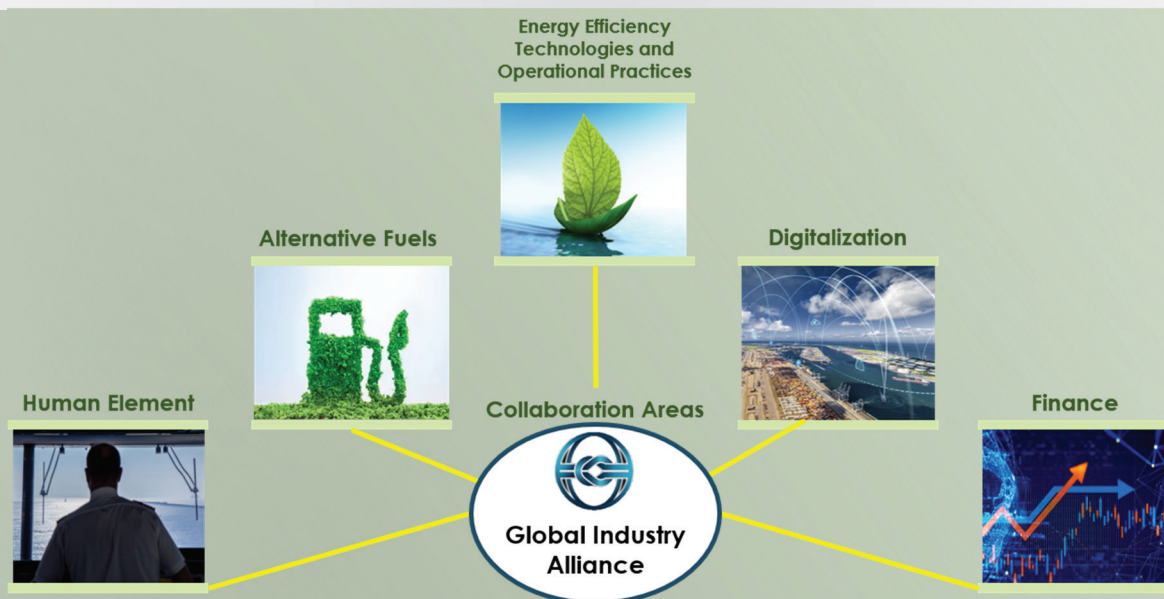
GLOMEEP

The Global Maritime Energy Efficiency Partnerships Project (GloMEEP) is a GEF-UNDP-IMO project promoting the uptake and implementation of energy efficiency measures for shipping, thereby reducing greenhouse gas emissions from shipping. GloMEEP focused on ten developing countries, to shift them to a low-carbon maritime sector. The Lead Pilot Countries (LPCs) of the GloMEEP project were; Argentina, China, Georgia, India, Jamaica, Malaysia, Morocco, Panama, Philippines and South Africa. They were chosen for their growing maritime sectors and the need to develop their ability to limit the negative externalities of this growth on the environment. The project developed a series of ship and port emission toolkits aimed at the assessment of emissions and development of an emission reduction strategy (IMO, 2020).

The project has utilised a series of workshops, targeting three principal areas:

1. Legal, policy and institutional reforms;
2. Awareness raising and capacity-building activities; and
3. Establishment of public-private partnerships to support low carbon shipping.

Figure VII - Global Industry Alliance (GIA) Collaboration



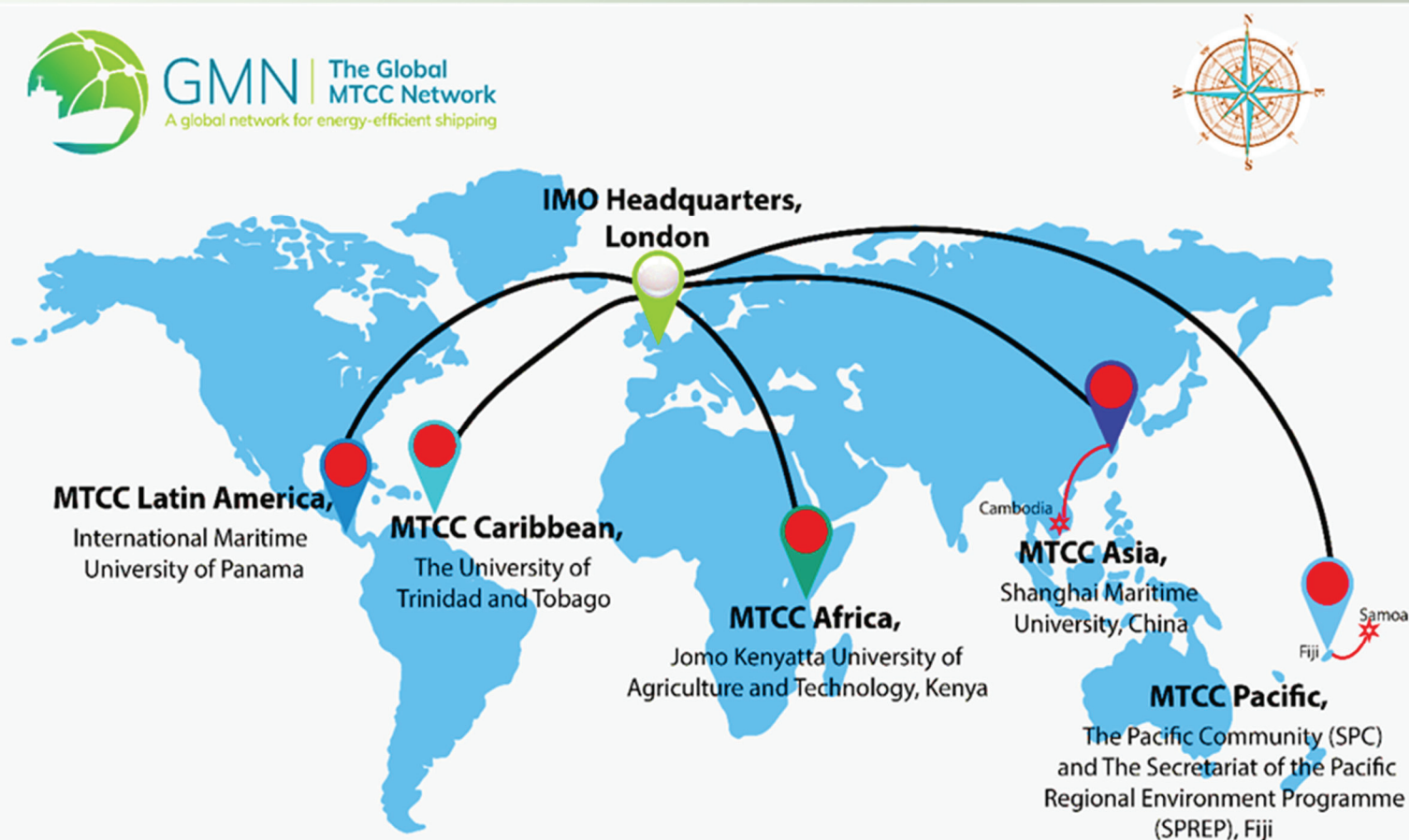
Under the GEF-UNDP-IMO-GloMEEP framework, the Global Industry Alliance (GIA) was established as a public-private partnership initiative. The GIA brings together 18 leading shipowners and operators, classification societies, engine and technology builders and suppliers, reputable data providers, oil companies and ports to support an energy efficient and low carbon maritime transport system. The GIA collectively identifies and develops innovative solutions to address common barriers to the uptake and implementation of energy efficiency technologies and operational measures.

Focusing on several priority areas including energy efficiency technologies and operational best practices, alternative fuels, and digitalisation, activities to be undertaken or promoted by the Alliance include, research and development; showcasing of advances in technology development and positive initiatives by the maritime sector, industry fora to encourage a global industry dialogue, and the implementation of capacity-building and information exchange activities (IMO, 2020).

The Global MTCC Network (GMN)

The IMO has established a global network of Maritime Technology Cooperation Centers (MTCCs), to promote the uptake of low-carbon technologies and operations in maritime transport. The project is funded by the European Union and designed to assist developing countries, especially LDCs, in five target regions; Africa, Asia, the Caribbean, Latin America and the Pacific. It aims to limit and reduce GHG emissions from their shipping sectors through technical assistance and capacity building. The activities under the GMN project are aimed at encouraging the uptake of energy-efficiency technologies through the widespread dissemination of technical information and know-how. The pilot projects being highlighted and explained in this document were conducted by the MTCC Caribbean under the GMN project.

Figure VIII - Global MTCC Network as established



The Global MTCC Network (GMN) stands out as an innovative model which is helping to institutionalize capacity building in-region and create long-term solutions. The Maritime Technology Cooperation Centers (MTCCs) act as regional focal points for a wide range of activities (IMO, 2017) including:

- Building compliance with existing and future international energy efficiency regulations;
- Helping participating countries develop national energy efficiency policies and measures for their maritime sectors;
- Promoting the uptake of low-carbon technologies and operations in maritime transport; and
- Establishing voluntary pilot-data collection and reporting systems to inform the global regulatory process.

[illegible]

Initial IMO Strategy

Recognising the magnitude of the climate change challenge and the need for global action to address it, the IMO has been pursuing the development and implementation of measures to address greenhouse gas (GHG) emissions from international shipping. The IMO has published four Greenhouse Gas Studies to date as mentioned below based on two approaches (Tier 1, Tier 2 and Tier 3) as shown in figure IX below.

Figure IX - IMO GHG Studies, Tier 1, Tier 2 and Tier 3

The First IMO GHG Study, published in 2000, estimated that shipping (Tier 1) in 1996 contributed about 1.8% of the global total anthropogenic CO₂ emissions.



The Second IMO GHG Study, published in 2009, estimated international shipping emissions (Tier 1 and Tier 2) in 2007 to be 880 million tonnes, or about 2.7% of the global total anthropogenic CO₂ emissions.



The Third IMO GHG Study, published in 2014, estimated international shipping emissions (Tier 2) in 2012 to be 796 million tonnes, or about 2.2% of the global total anthropogenic CO₂ emissions. The Study also updated the CO₂ estimates for 2007 to 885 million tonnes, or 2.8%.



The Fourth IMO GHG Study, published in 2020, estimated international emission (Tier 1, Tier 2 and Tier 3) in 2018 to be 1,076 million tonnes, or about 2.89% of the global total anthropogenic CO₂ emissions. The study also updated the CO₂ estimates for 2012 to 997 million tonnes or 2.76%.



The fourth IMO GHG Study (2020) using a new voyage-based methodology have estimated a 5.6% increase in CO₂ emissions for international shipping from 701 to 740 million tonnes in 2012 and 2018 respectively. These emissions represented approximately 2.0% of global anthropogenic CO₂ emission over the same period. The developments in data and inventory methods have resulted in the fourth report being the first one to distinguish between domestic and international shipping. The findings of the report have also concluded that the rate of increase of CO₂ emissions from international shipping was lower than that of total shipping. The Third IMO GHG Study (2014) projected CO₂ emissions from international to increase by 50 to 250% of 2008 emissions by the year 2050. This projection was revised in the fourth study to an increase range of 90 to 130% of 2008 emissions by the year 2050. The wide range of uncertainty is due to the inability to accurately predict future global trade and energy developments.

In April 2018, during its seventy-second session, the MEPC adopted resolution MEPC.304 (72) on Initial IMO Strategy on reduction of GHG emissions from ships. The vision of this Initial Strategy confirms IMO's commitment to reducing GHG emissions from international shipping and, as a matter of urgency, to phase them out as soon as possible in this century. The Strategy represents the continuation of work of IMO as the appropriate international body to address greenhouse gas (GHG) emissions from international shipping. It includes an overall vision for decarbonisation; GHG reduction targets through 2050, a list of potential short, mid, and long-term measures to meet these targets and barriers to achieving the targets and supportive measures to help achieve them. The Initial IMO GHG strategy targets (Figure X) will be revised based on the fuel oil consumption data collected during the period 2019-2021 and does not prejudice any specific further measures that may be implemented in Phase 3 of the three-step approach.

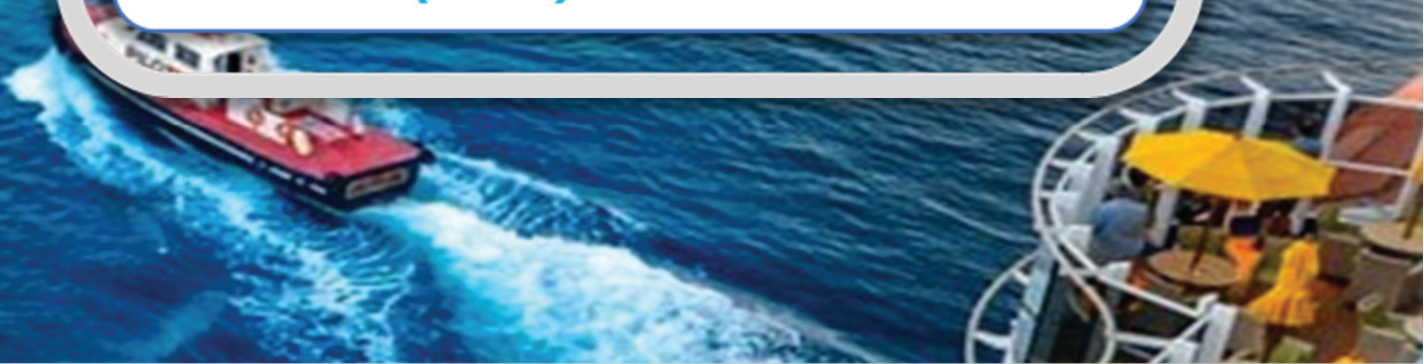
Figure X - Initial IMO GHG Strategy Targets

The initial IMO strategy incorporates quantitative carbon intensity and GHG reduction targets for the international shipping sector.

At least a 40% reduction in carbon intensity by 2030 and pursuing efforts towards a 70% reduction by 2050, both compared to 2008 levels

Peak GHG emissions from international shipping as soon as possible and reduce them by at least 50% by 2050 compared to 2008 levels, while pursuing efforts towards phasing them out consistent with the Paris Agreement goals

New phases of the Energy Efficiency Design Index (EEDI), to be reviewed within IMO's Marine Environment Protection Committee (MEPC)



Sounding the Water – Pilot

As stated previously, the, MTCC Caribbean was responsible for the implementation of two pilot projects under the GMN project. This presented the region with a new opportunity to collect and analyse data relating to maritime shipping emissions. The term “pilot project” has been used for a long time in research and projects and could become generic, resulting in confusion and misinterpretation in terms of what is ultimately required from such an effort. The lack of thorough studies assessing the technical feasibility of decarbonising international maritime transport; especially in alignment with the ambitious IMO Initial GHG Strategy, increases the risks and uncertainties associated with investing in more costly low-carbon technologies. Concrete, ambitious, and enforceable targets, fuelled by incentives, can prompt the industry to invest in low-carbon technologies on an impactful scale. One of the main reasons for the slow uptake of technologies is lack of relevant data. With the above in mind, the MTCC Caribbean created two focussed pilot projects (see below), designed to meet the criteria of the TORs for the GMN and facilitate capacity building to enhance implementation of Energy Efficiency and Energy Abatement measures in the region.

Figure XI - Geographical Scope of MTCC Caribbean’s Pilot Project



MTCC Caribbean's pilot projects provided the mapping of energy efficient operations and the establishment of an energy efficiency baseline and a baseline on the existing technology currently used on-board ships calling at Caribbean ports. Figure XI above illustrates the geographical scope of MTCC Caribbean's pilot projects. The pilots were phased over three (3) years and focused on the uptake of energy efficiency in shipping, and data collection associated with air emissions due to commercial shipping from the 16 territories under the purview of MTCC Caribbean. Figure XII identifies the two pilot projects implemented by MTCC Caribbean and their respective objectives.

Figure XII - MTCC Caribbean's Pilot Project and Action Items

Pilot 1

Uptake of ship energy efficient technologies and operations.



Create a baseline of existing technologies and best practices utilized on-board vessels trading in the Caribbean Area between 2017-2018.



Highlight the main energy consumers on board and the emissions abatement measures currently used in the region.



Facilitate technology uptake based on a cost benefit analysis

Pilot 2

Fuel consumption data collection and reporting in line with IMO regulations.



To establish a voluntary fuel consumption data reporting system to aid regional administration.



To provide a baseline of the fuel consumption and estimated GHG emissions for ships trading in the Caribbean region for different operating and load conditions.



Compile and communicate data to the IMO

Pilot project 1 captured the data on the use of ship energy efficient technology within the Caribbean region. Key objectives included the following:

- Mapping the existing energy efficient technologies and best practices utilised on-board vessels trading in the region;
- Collecting data highlighting the main energy consumers onboard;
- Collecting data highlighting the emissions abatement measures used onboard; and
- Promoting the use of energy efficient measures through workshops and online information dissemination.

Pilot Project 2 established a fuel consumption data collection system for the region. This project collected data on the types and volumes of fuels consumed by ships calling at ports in the Caribbean region. It also provided the flag states of the region with experience in the development and use of a reporting system in preparation for the implementation of the mandatory IMO Data Collection System (DCS).

This task was completed by identifying the equipment and machinery, inclusive of main propulsion engines, electrical generators, prime movers, and boilers on-board each vessel, as well as recording the fuel type(s) and the amount of fuel onboard at each port that the vessel berthed whilst in the region. The information and data collected assisted in the development of an Online Voluntary Reporting System (OVRs) to measure the overall efficiency and performance of participating ships.

The implementation of MTCC Caribbean's Pilot Projects involved:

- Data capture, information sharing and dissemination;
- Mapping the use of existing energy efficient technology by collecting data from vessels trading in the region;
- Promoting technology transfer and best practices to Caribbean territories through capacity building initiatives;
- Informing the maritime sector in the region of the development of new standards, guidelines and best practices in reducing GHG emissions from ships; and
- Establishing a voluntary fuel consumption reporting system.

MTCC Caribbean's Data Collection

A single user-friendly data collection form was developed to facilitate data collection for both pilot projects. The common data collection form was designed for ease of use by vessels' crews and associated shipping agents. The single unified document took into consideration the practical challenges of shipboard operations and was therefore expected to improve the rate of voluntary participation and implementation of the project.

Ships of 400 GT and above were required to submit data using MTCC Caribbean's Reporting Form. The data collected included the details on the use of equipment and machinery on-board including emissions abatement and energy

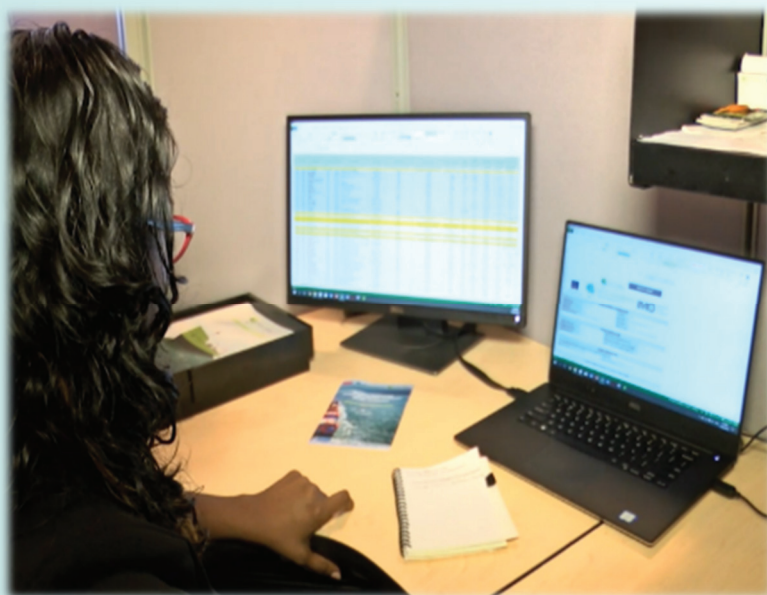
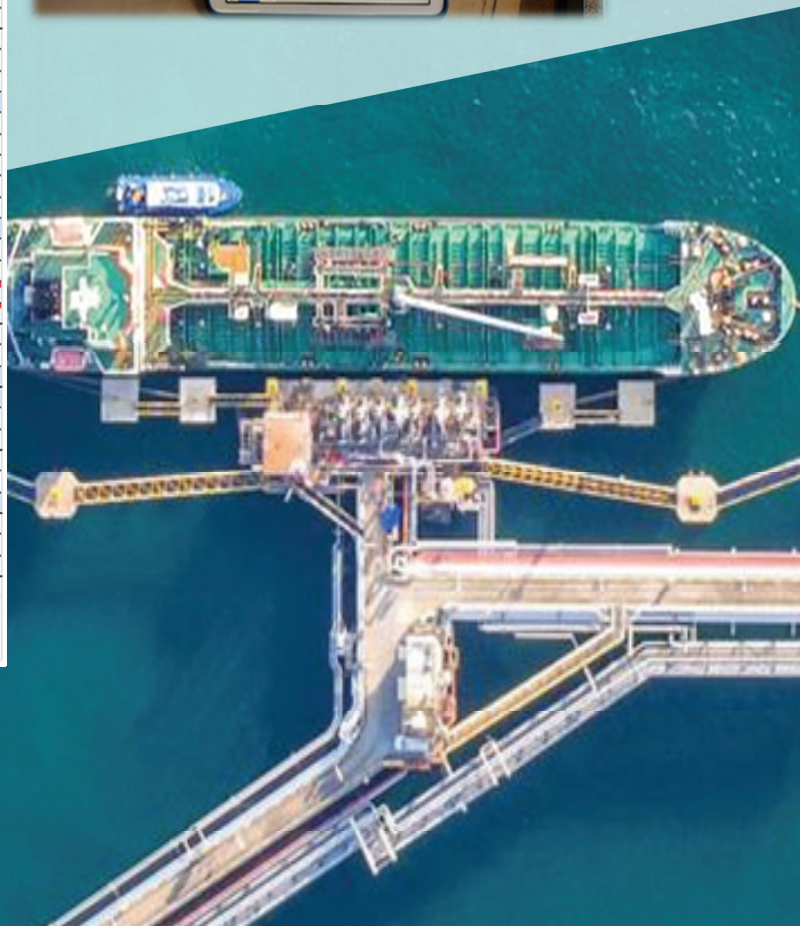


Figure XIII - MTCC Caribbean's Data Collection Form

			
Save for Upload			
1.0 VESSEL GENERAL INFORMATION			
Vessel Name:			Year Built:
IMO Number:			Ship Builder:
Ship Type:	Please, select the answer	Hull Number:	
Shipowner/Company:			Shipping Agency:
Please Proceed to Section 10 Voyage Data if information under Sections 2 to 9 has been previously submitted.			
2.0 VESSEL PARTICULARS			
Length Overall (m):		Length Between Perpendiculars (m):	
Breadth Moulded (m):		Deadweight at Summer Load Line Draught:	
Depth Moulded (m):		Summer Load Line Draught Moulded (m):	
3.0 VESSEL SPEED & FUEL			
V ₇₅ - ship speed in deep water at summer load line draught @75%MCR (knots)			
Dual-fuel Engines:	Please, select the answer Type(s) of fuel used:		
4.0 VESSEL ENERGY EFFICIENCY DESIGN INDEX (EEDI)			
Existing Manufacturer's EEDI	Please, select the answer	EEDI Value:	
5.0 PROPULSION SYSTEM			
Main Engine Type:	Maximum Continuous Rating(kW):		
Engine Manufacturer:	SFC (g/kWh)@75%MCR:		
# Main Engine set(s):	Fuel Type:		
Propeller Type:	Propeller Diameter & Pitch:		Dia = Pitch =
# Propeller set(s):	# Propeller Blades (per set):		
6.0 ELECTRIC POWER SUPPLY SYSTEM			
Engine Manufacturer:	Aux Engine Type:		
Auxiliary Engine Power (kW)	SFC (g/kWh):		
# Aux Engine set(s):	Fuel Type:		
Rated Output Power (kW):	Voltage (V):		
7.0 AUXILIARY BOILER			
Boiler Manufacturer:	Boiler Type:		
Boiler Pressure (Bars):	Fuel Consumption/hour (t/hr):		
Fuel Type:	Average Running Hours/month:		
8.0 ENERGY SAVING TECHNOLOGY			
Waste Heat Recovery:	Please, select the answer	Solar Panels:	Please, select the answer
M/E Shaft Generator:	Please, select kW =	Lighting System:	Please, select the answer
Steam Turbine Generator:	Please, select kW =	Vessel Trim/Draft Optimisation:	Please, select the answer
Air Cavity Lubrication:	Please, select the answer	Hull Coating Condition:	Please, select the answer
Contra Rotating Propeller:	Please, select the answer	Ship Operational Efficiencies:	Please, select the answer
Propeller Boss Cap Fins:	Please, select the answer	Other (please state):	Please, select the answer
Frequency Converters:	Please, select the answer	Other (please state):	Please, select the answer
9.0 EMISSION CONTROL MEASURES			
After Treatment Technology:	Please, select the answer	Engine Technologies:	Please, select the answer
Other (please state):	Please, select the answer	Other (please state):	Please, select the answer
Alternative Fuel:	Please, select the answer	Other (please state):	Please, select the answer
Other (please state):	Please, select the answer	Other (please state):	Please, select the answer
10.0 VOYAGE DATA			
Voyage #:	Voyage Distance (nm):	Voyage Time (hours):	
Departure Port:	Arrival Port:		
Date of Departure:	Date of Arrival:		
Time of Departure:	Time of Arrival:		
Departure Displacement (t):	Arrival Displacement (t):		
11.0 FUEL CONSUMPTION DATA			
Departure	Arrival	Total Fuel Consumed	
Total HFO (t):	Total HFO (t):	Total HFO (t):	
Total DFO (t):	Total DFO (t):	Total DFO (t):	
Total GFO (t):	Total GFO (t):	Total GFO (t):	
12.0 REPRESENTATIVE SEA CONDITIONS			
Beaufort Scale #:	Mean Wind Speed (m/s):		
Mean Wind Direction (deg):	Significant Wave Height (m):		
Mean Wave Period (s):	Mean Wave Direction (deg):		
Submit the completed form to: mtcc@utt.edu.tt			

efficiency technologies being employed. Vessels smaller than 400 GT were also encouraged to participate in this reporting system. Data collection using MTCC Caribbean's Data Collection Form began on 1st June, 2017 in Trinidad and Tobago. A shipping notice issued by the Trinidad and Tobago Maritime Services Division (MSD) of the Ministry of Works and Transport, facilitated the reporting through the creation of a maritime portal on the Single Electronic Window (SEW) hosted by the Ministry of Trade and Industry. The form was integrated into Trinidad and Tobago's SEW and updated versions were developed based on feedback obtained from the participating stakeholders.

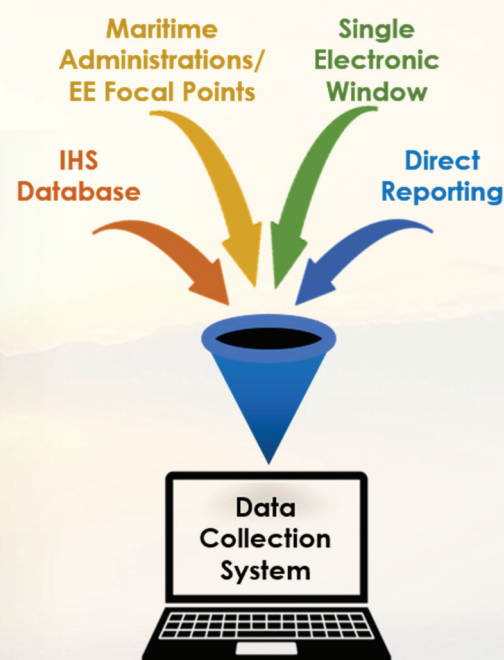


Data Collection Streams

There are four streams of data collection for the pilot projects detailed below. It should be noted that MTCC Data collection is ongoing in an effort to update the OVRs.

1. Single Electronic Window

MTCC Caribbean's data collection form is available on the TTBizLink website (www.ttbizlink.gov.tt), via the e-Maritime Services Module. This module is integrated with the SEW for reporting from vessels arriving and operating within Trinidad and Tobago's waters. The data is uploaded, along with other pre-arrival information, unto the SEW. The MTCC Caribbean Team has access through TTBizLink to download and store the submitted forms. As all vessels calling to the ports are required to register and report for inward clearance, MTCC Caribbean can confirm the total number of ships calling to the commercial ports of Trinidad and Tobago as well as the total number of ships that are reporting. The SEW continues to be an effective method for data collection as it integrates the reporting with the pre-arrival notification.



2. Data via Maritime Administrations/Energy Efficiency Focal Points

MTCC Caribbean has established Energy Efficiency Focal Points (EEFP) with all 16 Maritime administrations. These focal points are the MTCC's primary point of contact for advancing data collection efforts within their respective countries, and provide the main source of data for MTCC Caribbean's data collection efforts. Shipping agents or ships' masters within their respective territories submit completed forms directly to these EEFP, which are then forwarded to a Technical Officer at MTCC Caribbean. The EEFP also function as information dissemination conduits through which MTCC Caribbean updates its voluntary data collection system. The EEFP in The Bahamas, Belize, Guyana, St. Vincent & the Grenadines and Suriname, each submit data on a regular basis to MTCC Caribbean.

3. Direct Reporting to MTCC Caribbean

MTCC Caribbean also encourages shipping lines to report directly to MTCC Caribbean's designated email ID. The forms are completed by the master and then emailed directly to MTCC Caribbean for collation. Caribbean Cruise Lines operated by Carnival Corporation currently reports directly to MTCC Caribbean, an approach that is steadily increasing with other shipping operators reporting directly.

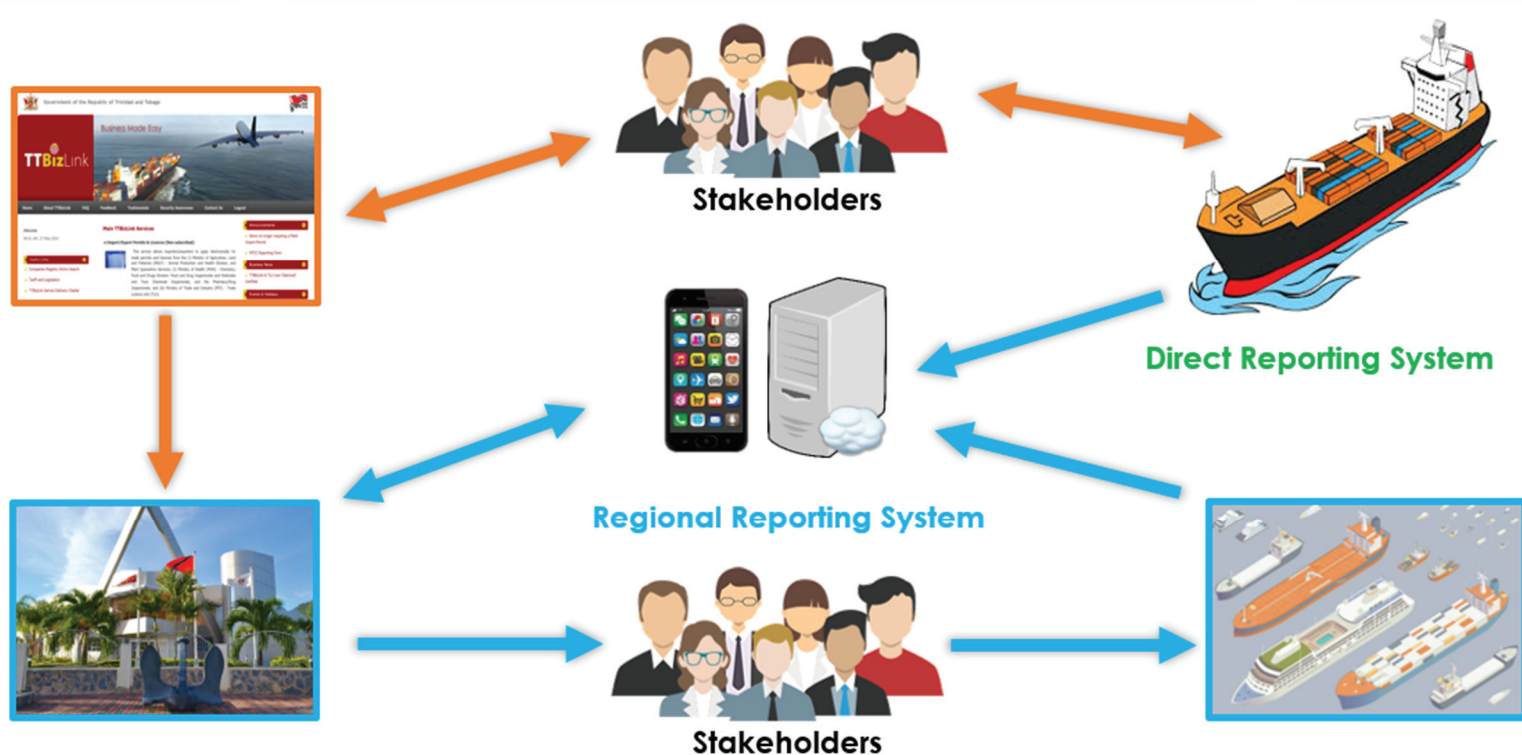
4. Data from IHS Markit

Collection of data from IHS Markit online database is the fourth method which supplements the other data collection methods of MTCC Caribbean. The data collection methodology is based on activity reporting, requiring both static and dynamic inputs. The data collection is limited to vessels calling at ports in the Caribbean and therefore not capturing the data for vessels transiting the region without calling at a port. Given the extensive shipping actors targeted to be involved in data collection and reporting, there was difficulty in implementing the uniform data collection form across the region. Therefore continuous stakeholder engagement and feedback from respective maritime administrations was key in enhancing data collection.

Charting the Course – Online Voluntary Reporting System (OVRs)

MTCC Caribbean launched an OVRs designed specifically for the reporting needs of the Caribbean Region, as illustrated in figure XIV below. The collation, analysis and dissemination of data with respect to the uptake of energy efficient technology, fuel consumption of vessels and related emissions, is facilitated through the OVRs. It provides a double feature as a controlled access platform for sharing tabulated data results and country specific information relating to MARPOL Annex VI. Flag states in the region can use the OVRs for greater efficiencies in streamlining data capture mechanisms, up to date data collection, and generation of reports. The OVRs also allows for the dissemination of data and information to stakeholders in relation to MTCC Caribbean’s pilot projects.

Figure XIV - Online Voluntary Reporting System (OVRs)



Data is collected from vessels calling at ports within the Caribbean Region, using MTCC Caribbean’s Data Collection Form, and then uploaded to the OVRs portal. The OVRs presents both static and dynamic ship specific data through the “Ship Data” Section. Static data presents the particulars of the vessel including details of the propulsion system, electric power supply systems, boilers, energy efficient technology and abatement methods installed on board. Dynamic data includes the fuel consumption (quantity and type) and representative sea conditions of the particular voyage.

The OVRs also captures specific data for the 16 countries covered under the geographical scope of the project, under its “Country Data” section. It provides the user with information on the various reporting mechanisms, status of implementation of MARPOL Annex VI, details of EEPF and port state control activities. The dashboard’s simple design allows the user to select between ship and country data sections as shown in figures XV and XVI.

Figure XV - OVRS Ship Detail Section

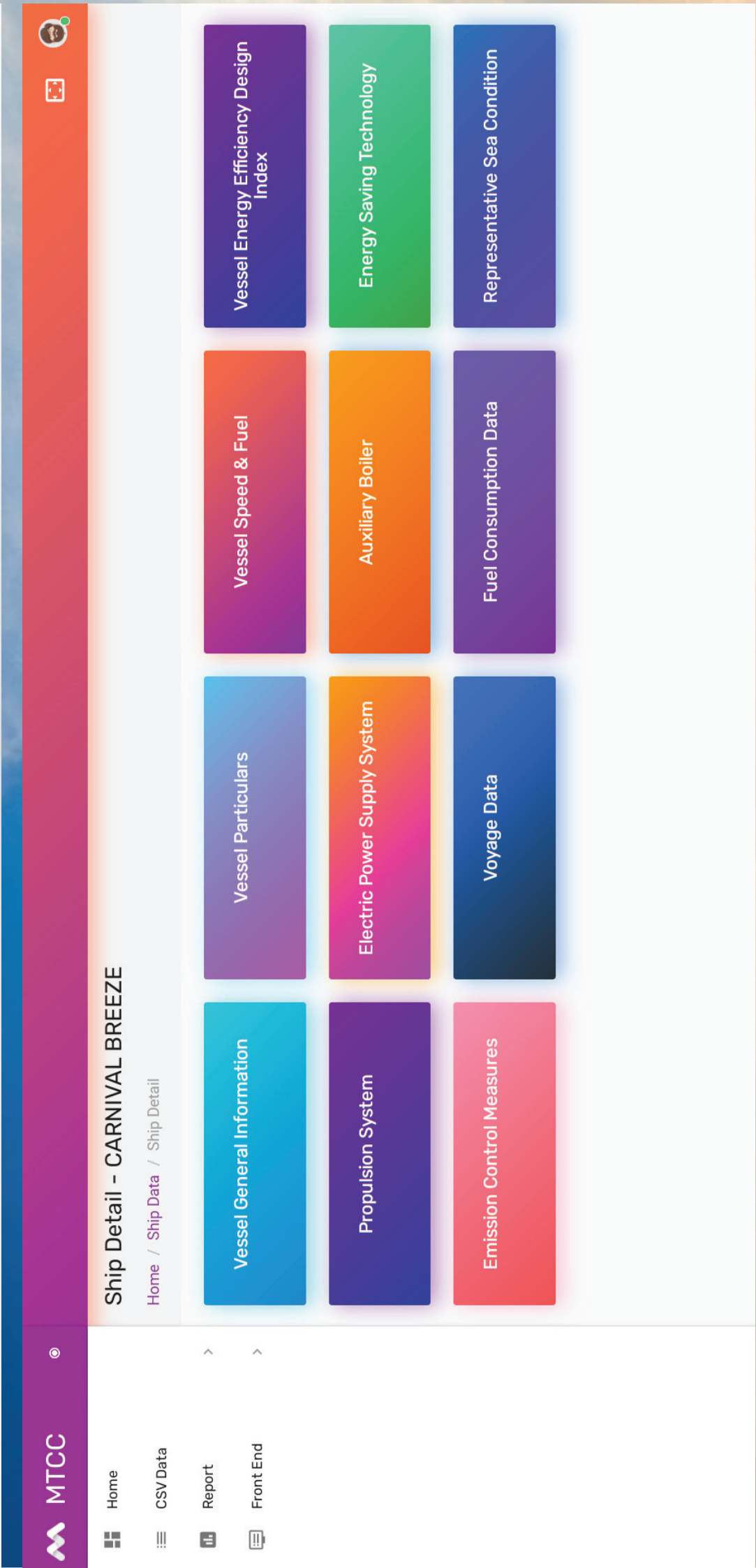
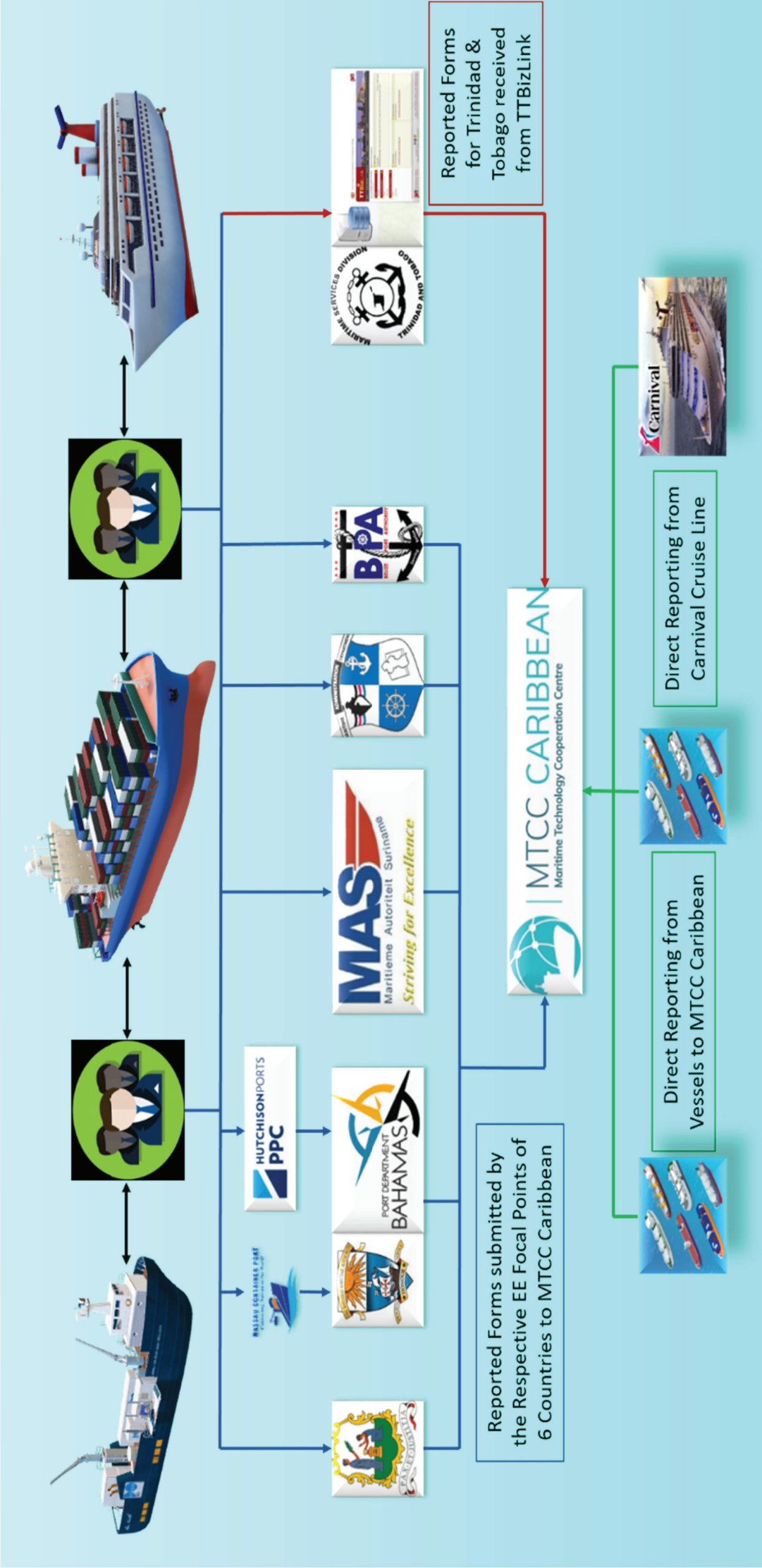


Figure XVI - OVRs Country Details Section



MTCC Caribbean’s OVRs has laid the foundation for continuous data collection to assist the shipping industry and maritime administrations in the monitoring and analysis of vessels operating within the region. The data collected through the OVRs and analysed by MTCC Caribbean provides policy makers with access to relevant reports and trends. These can facilitate informed decision making at the National and Regional levels. The OVRs can be updated and adapted to meet the demands of the region. The OVRs currently facilitates submissions from six maritime administrations, as well as direct reporting from 22 vessel owners/operators as illustrated in figure XVII below. Through continued outreach by MTCC Caribbean, widespread adoption and implementation of the OVRs is anticipated within the Wider Caribbean Region.

Figure XVII - Key Implementers of the Data Collection



Position Fixing – Energy Efficiency Baselines in the Region

MTCC Caribbean created the First Emissions Control and Energy Efficient Measures baseline for vessels trading within the region for the period June 1st, 2017 to May 31st, 2019. Using the MTCC Data Collection Form, the various types of emissions control and energy efficient technologies on board vessels trading within the Caribbean Region was collated. The data collected from the vessels was grouped and analysed by type: Tankers, Container Ships, Bulk Carriers, Cruise Ships, General and Refrigerated Cargo, Car Carriers and Others. “Others” included vessels such as Offshore Supply Vessels (OSVs), Ferries, Research Vessels and Heavy Load Carriers. Only data reported through MTCC Caribbean’s voluntary reporting system allowed for the analysis of existing energy efficient technology and abatement methods onboard, as the IHS database did not contain this information. Main findings from the collected data and how it created the First Emissions Control and Energy Efficient Measures baseline for vessels trading within the region are presented in this section. Figures XVIII and XIX illustrate this data by percentages of types of vessels and percentage of port calls by vessel types respectively. Figure XX and XXI illustrates the vessel registration type for data collected through MTCC Caribbean’s data collection form and IHS respectively.



Figure XVIII - Percentage of vessel type

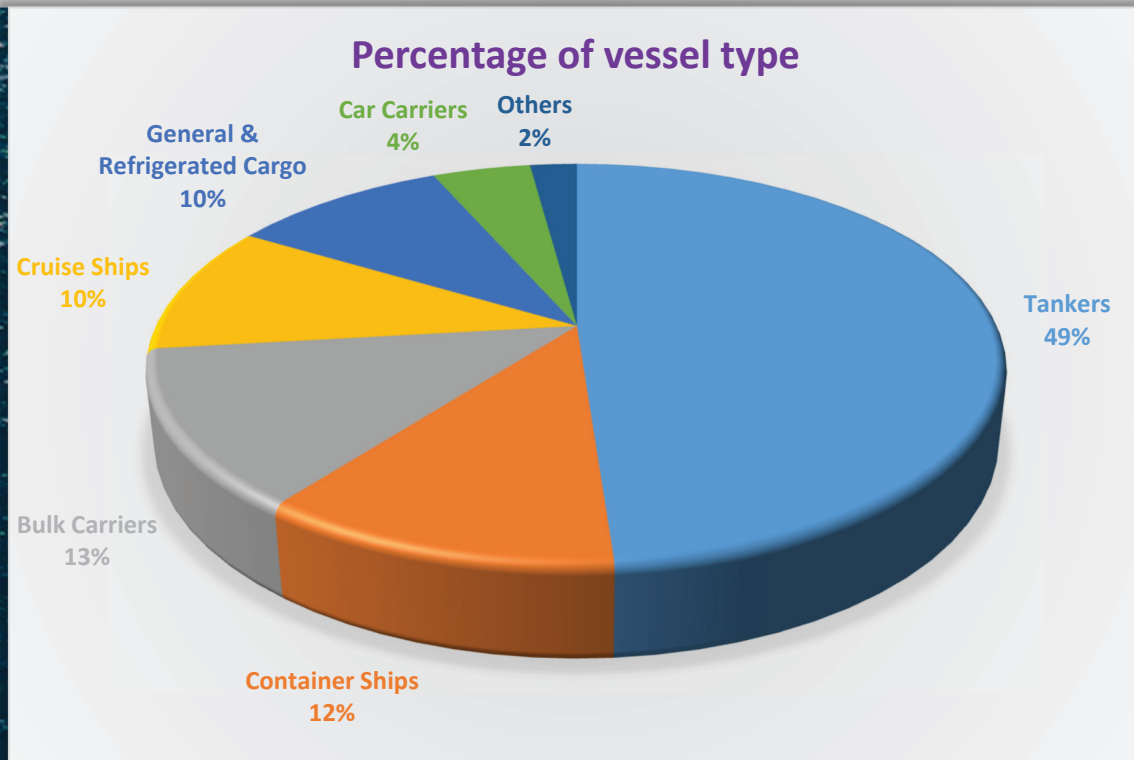


Figure XIX - Number of Port calls

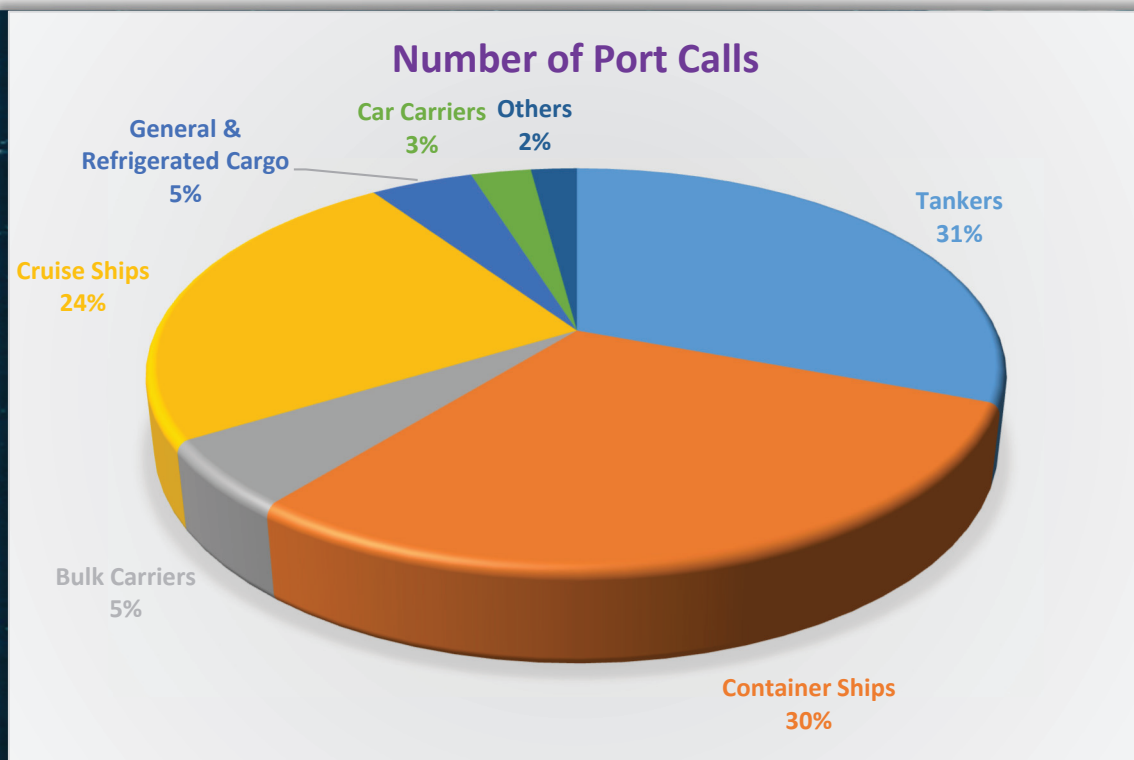


Figure XX - Vessel registration (MTCC Data Collection Form)

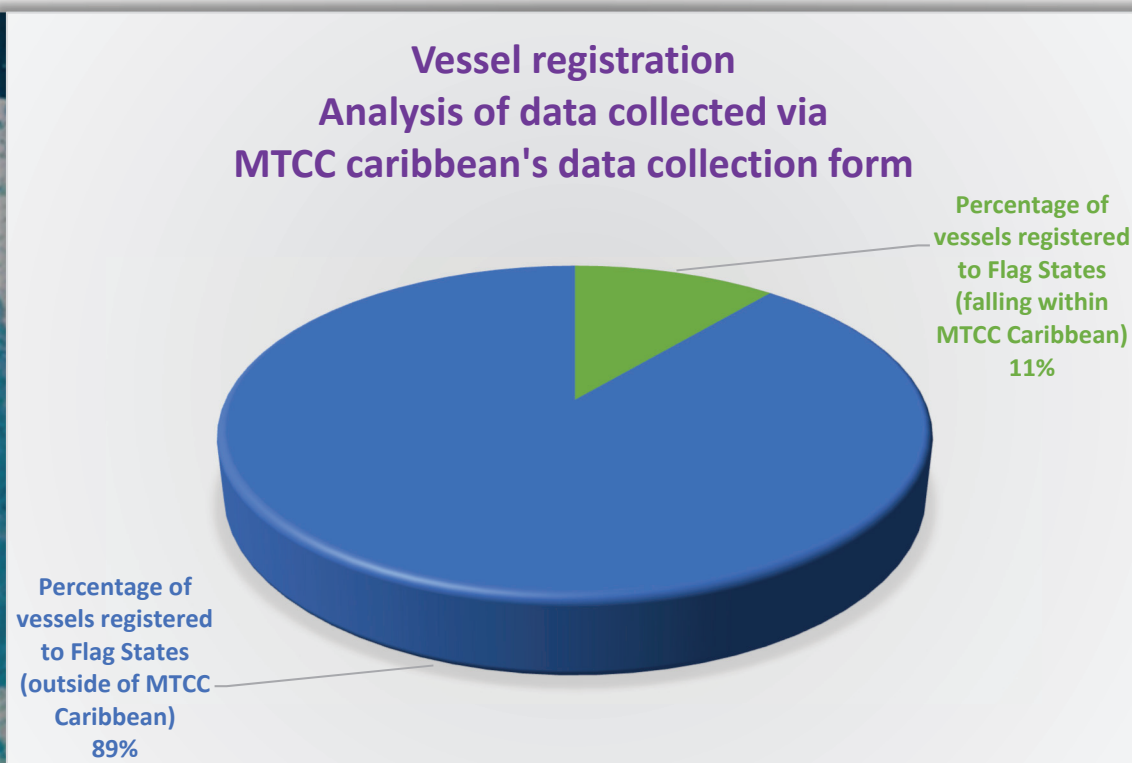
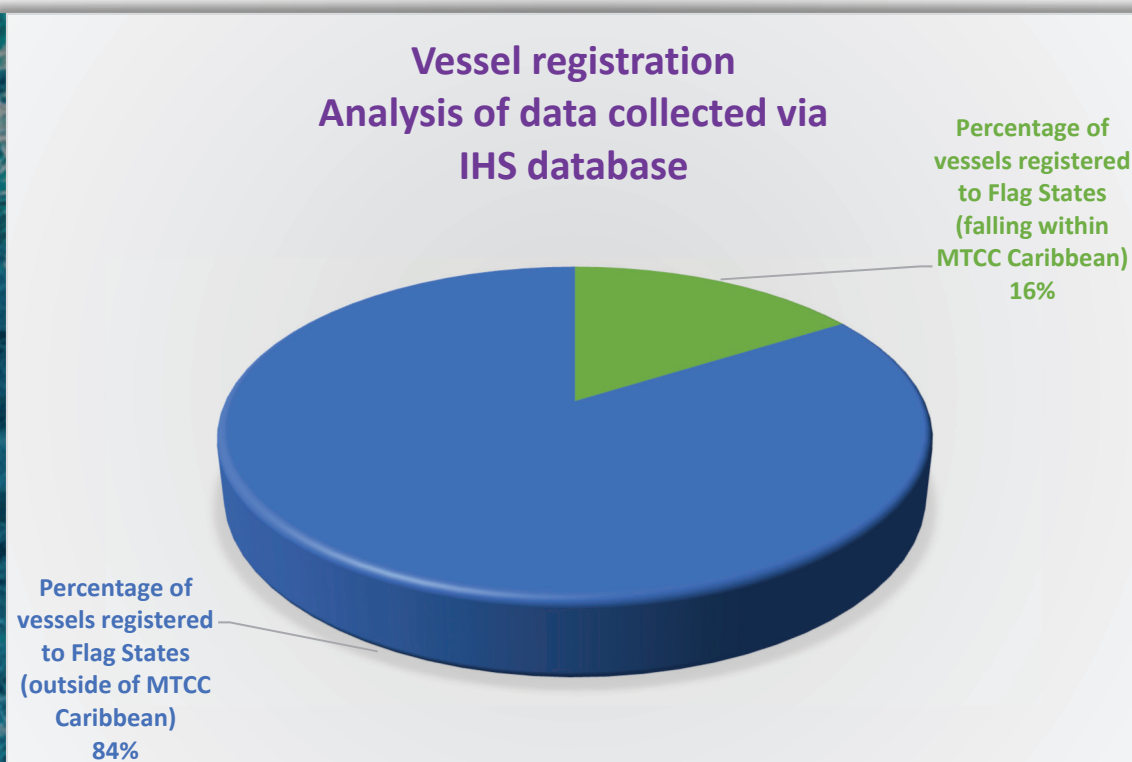


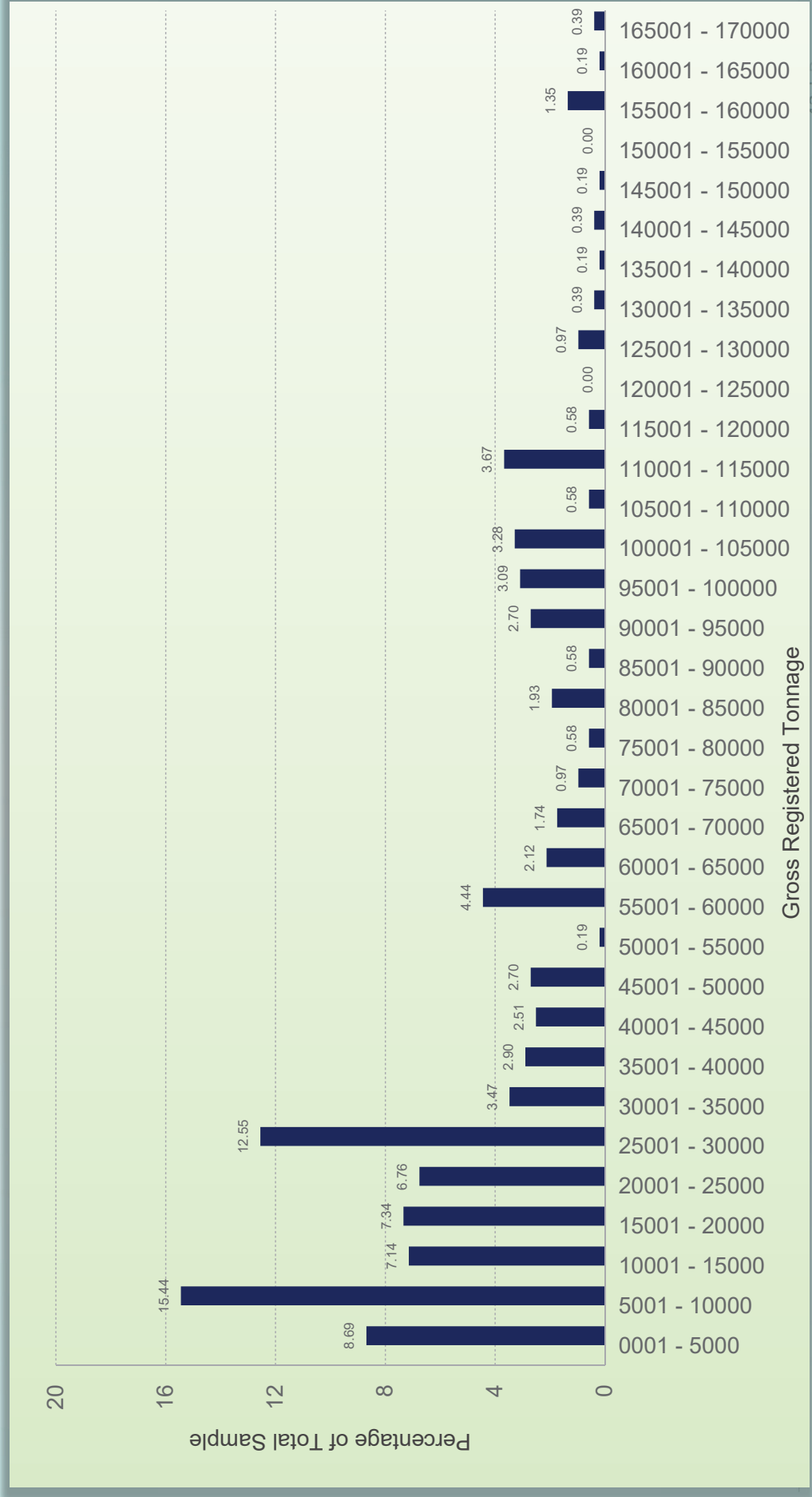
Figure XXI - Vessel registration (IHS Date Collection)



GRT of total Sample

The maximum GRT was 167,578 while the minimum was 255, with an average of 41,654.10 and a standard deviation of $\pm 39,133.58$. Figure XXII illustrates the percentage of the total vessels by tonnage.

Figure XXII - Percentage of Total Vessel Sample by GRT

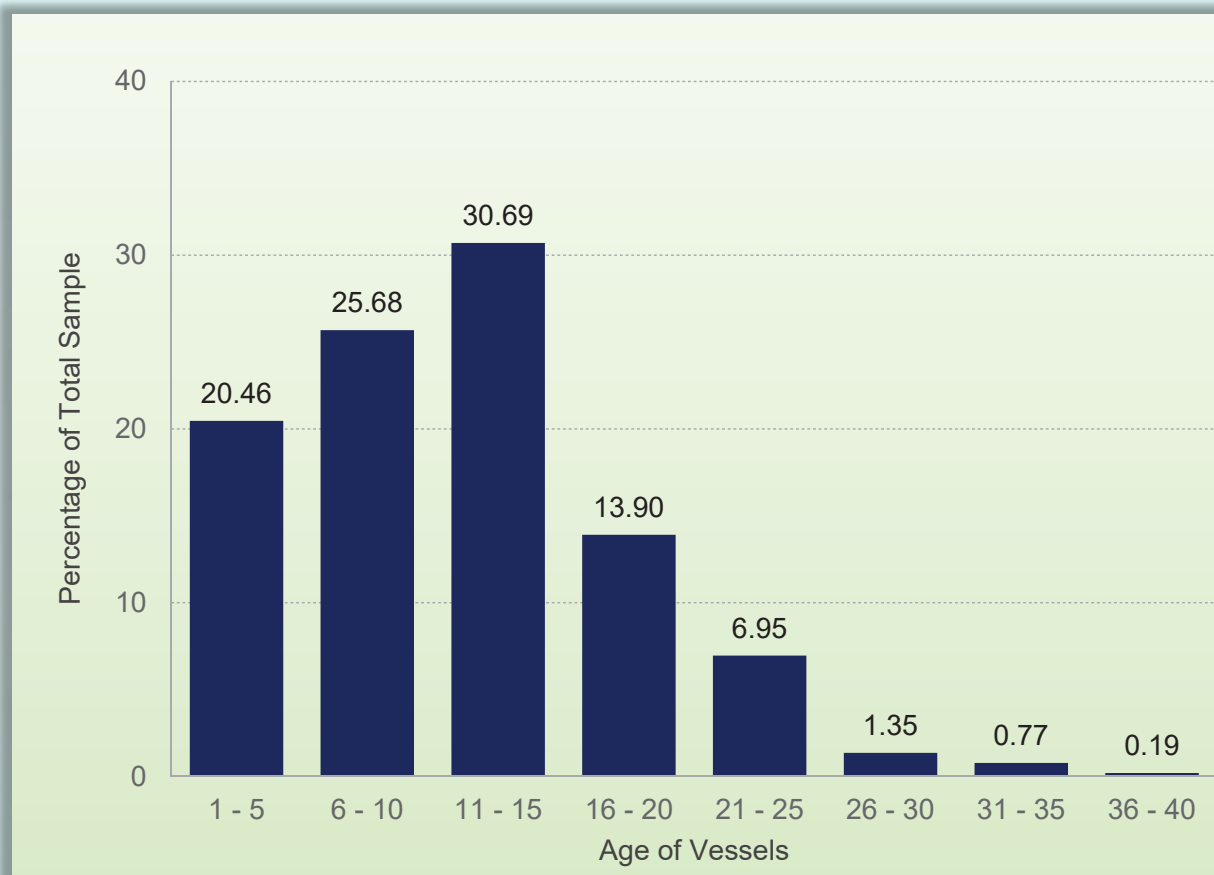


The data collected is of great relevance given that 91% of the vessels were 5,000 GRT and above in size, and it is estimated that 85% of GHG emissions from the sector are caused by vessels in this size range⁷. These are therefore the vessels to be targeted to reduce emissions within the sector.

Age of the total sample

It was noted from the vessels reporting during the period, that the maximum age is 40 years while the minimum is one year, with an average age of 11.37 years and a standard deviation of ± 6.60 . Figure XXIII below illustrates the percentage of ships by age.

Figure XXIII - Age of Total Vessels (%)



To implement new technology and abatement methods, the age of a vessel is a major factor as it determines the initial cost, operating cost and return on investment. 20% percent of the ships, as per the data reported, are less than five years of age. 70% percent of ships ranged between 6 to 20 years of age with half of these falling between 11 to 15 years of age. These results were in line with general industry feedback where older ships find it easy to trade in the Caribbean region due to enforcement and monitoring challenges experienced by flag, coastal and port states. However, this also indicates that many energy efficient and emission abatement technologies which require retrofitting may not be on the horizon for these ships. The operational measures and alternative fuels (also driven by low Sulphur mandatory requirements) seem to be the preferred options with these ships as evident from the ECEEM data.

⁷ The International Maritime Organization (IMO), (2016). *New requirements for international shipping as UN body continues to address greenhouse gas emissions*. IMO News Briefing. Retrieved 14th August 2019 from <http://www.imo.org/en/MediaCentre/PressBriefings/Pages/28-MEPC-data-collection--.aspx>.

Emissions Control and Energy Efficient Measures in Maritime Shipping in the Caribbean

The measures currently being pursued by the industry to address GHG emissions from ships are both technical and operational. Technical measures include Emissions Control and Energy Efficiency Measures (ECEEMs) and operational measures include numerous measures such as economies of scale, improved voyage planning, speed optimization, etc. Table II provides a summary of the findings of Bouman *et. al.*, (2017)⁸, DNV.GL and the GloMEEP assessment of the various ECEEMs with emphasis on the types of ship operating in the Caribbean region.

⁸ Bouman, E.A., Lindstad, E., Rialland, A.I., Strømman, A.H. (2017) State-of-the-art technologies, measures, and potential for reducing GHG emissions from shipping—a review. *Transp. Res. Part D: Transp. Environ.* 52, 408–421.

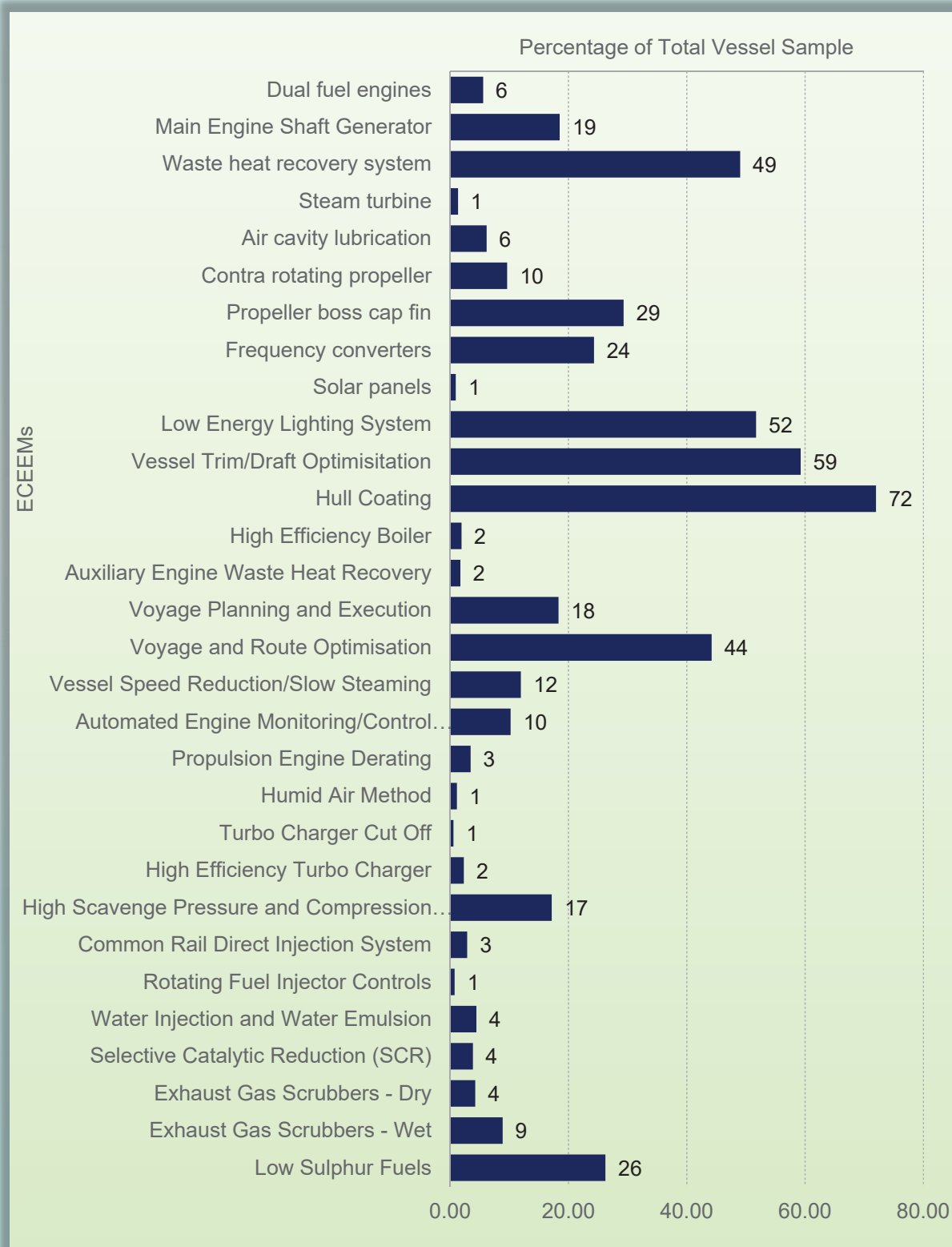
Table II - ECEEMs in the Caribbean Region

Measure	Average Efficiency	Retrofittable	Ship Type(s)	Payback Period	Ease of Application	Investment	Technical Maturity
Energy Efficient Technologies							
Main Engine Shaft Generator	2-5%	No	All Vessels with Diesel mechanical propulsion	Short (1-2 years)	Redesign Required	Medium (240k – 600k)	Mature
Waste Heat Recovery Systems	3-8%	No	All vessels	Medium (4-5 years)	Redesign Required	Medium	Semi - Mature
Air Cavity Lubrication	3-10%	No	New builds	Medium (4-5 years)		2-3% of New Build Cost	Semi - Mature
Hull Coating	1-8%	Yes	All vessels	Short (< 3 years)	Maintenance, Dry Dock	Medium (30k – 500k)	Mature
Contra - Rotating Propellers	2-5%	Yes	All vessels	Medium (4-5 years)	Maintenance, Dry Dock	High	Mature
Propeller Boss Cap Fins	2-5%	Yes	All vessels	Medium (4-5 years)	Maintenance, Dry Dock	Medium	Mature
Frequency Converters	2-10%	Yes	All vessels	Short (1-2 years)	Maintenance, Dry Dock	Low	Mature

Measure	Average Efficiency	Retrofittable	Ship Type(s)	Payback Period	Ease of Application	Investment	Technical Maturity
Solar Panels	CBC	Yes	All vessels			High	Non Mature
Energy Efficient Lighting System	1-5%	Yes	All vessels	Short (< 3 years)	Maintenance, Dry Dock	Low	Mature
Trim Optimization	.5-5%	Yes	All vessels	Short (1-2 years)	Maintenance, Dry Dock	Low	Semi - Mature
Main Engine De - Rating	3%	Yes	All except ferry and cruise	Medium (4-5 years)		Low	Semi - Mature
Common Rail Upgrade	0.3%	Yes	All vessels	Medium (4-5 years)		Very Low	Semi - Mature
Hybrid Power	15-30%	No	All vessels	Long	Dry Dock	High	Semi - Mature
Kite	1-5%	Yes	All vessels			Medium - High	Non Mature
Abatement Methods							
LNG		Yes	All vessels	Medium (2-5 years)	Maintenance, Dry Dock	>3 Million	Mature

The data requested from ships included the use of abatement technologies for reduction of emissions of air pollutants including NO_x, SO_x and PM, and the various types of fuels used on-board the vessels. The data was analysed to determine the various ECEEMs on board vessels trading in the region. Using the submissions made by the total vessel sample, the energy efficiency methods and abatement methods data was analysed to yield the results in figure XXIV below.

Figure XXIV - Total Sample of Vessels using ECEEMs (%)



Given that the average age of the vessels operating in the region is 11 years old, most vessels with ECEEMs have mature technologies onboard. 72% of vessels use hull coatings to achieve energy efficiency. Main Engine Waste heat recovery, which can be classed as a semi-mature technology, is being used onboard 49% of ships. The use of operational measures is common among all categories of vessels.



In terms of emission abatement methods, 13% of ships have scrubbers installed with the majority (approximately 9%) using wet scrubbers. Cruise ships represent the ship type with the highest use of scrubbers. As a result of low scrubber uptake, most ships in the region are relying on the use of low sulphur fuel oils.

The data collected on the types of fuel used reveal that HFO continues to be the dominant fuel of choice with close to 70% ships using it as the only fuel or in combination with distillate fuels. Further analysis reveals that 31% of these ships using HFO with distillates, use either marine gasoil (MGO) or marine diesel (MDO), with only 18% at this moment preferring either low-sulphur MDO or low-sulphur MGO.

The non-mature technologies based on energy recovery or renewable sources are rarely utilized, with only 1% of ships having solar panels installed. For ships operating within the Caribbean Region, the prevailing environmental conditions promote favorable scope for solar and wind based technologies.

Energy Efficient Technology and Alternative Fuel Providers

In building regional capacity to promote the energy efficient technology uptake by stakeholders and use of alternative fuels, MTCC Caribbean reached out to various technology and alternative fuel providers. These industry stakeholders participated in MTCC Caribbean’s various capacity building workshops and shared the technology details with regional participants. These exercises identified the scope of uptake and application of new technology with aim of reducing GHG emissions from ships. Table III below provides the summary of these technologies.

Table III - Energy Efficient Technology & Alternative Fuel Providers

Provider	Technology	Availability Globally	Availability in the Caribbean	ROI	% GHG Potential Reduction	Comments
International Windship Association (IWSA)	Kites Propulsion Systems	Europe	No project in Caribbean region yet. However, the technology providers are ready to have pilots in the region.	5-20% Savings on fuel as retrofits, 30% and higher for optimised new builds.	75% reduction of CO ₂ 3.5 - 7.5 Mt of CO ₂ by 2030	Primary renewable. Can facilitate the uptake of other secondary renewables or lead to Carbon neutral vessels.
	Rotor Sails	Europe, China		Fuel Savings confirmed in the 5-20% range.		
	Hard Sail	Sea Trial Phase			Carbon Neutral	
	Soft Sail	Smaller vessels operating, Larger vessels in development.				
	Suction Wings	Sea Trial Phase				
	Turbines	Sea Trial Phase 2021				
	Hull Form	Under development in Norway				

Provider	Technology	Availability Globally	Availability in the Caribbean	ROI	% GHG Potential Reduction	Comments
DNV-GL	Batteries and Battery Hybrids	Available Globally			5 – 10% GHG Reduction (Assuming that the onshore electricity is Carbon Neutral by 2050)	Reduces fuel consumption Vessel engine runs at more favourable load
	Satellite-based data and Analytics	Available Globally	Yes, Fulcrum is engaged with major flag states in monitoring sea traffic	Improves the efficiency of daily operations – saving fuel, time and berthing fees	Reduced emissions for port and ship	Emission Control Monitoring also provided
Methanex	Methanol	Available Globally. Methanol marine fuel technology is “dual-fuel”, allowing the ship operator to use either marine gas oil or methanol depending on prevailing prices and/or fuel availability	Available in the Caribbean	Minor modification requirements and modest incremental cost	Methanol is a lower carbon content fuel compared to Heavy Fuel Oil, resulting in 13% lower CO ₂ emissions on combustion (Energy Efficiency Design Index), thus, providing an immediate opportunity for the shipping industry to reduce CO ₂ emissions. Methanol also significantly reduces emissions of sulphur oxides (SO _x), nitrogen oxides (NO _x) (up to 60% on its own and to Tier III standards through water blending), and particulate matter (95%).	Meets IMO Tier III NO _x Emissions standards without the need for exhaust gas after-treatment

Provider	Technology	Availability Globally	Availability in the Caribbean	ROI	% GHG Potential Reduction	Comments
Trillion LLC	HydroDiesel	Certified for use in regions where ASTM D975 is acceptable to the user or the local authority, which is most regions excluding the European Union. Scheduled to complete their EN590 certification for the European Union in 2020	The Caribbean Maritime market is a high priority focus for Trillion. The intention is to produce HydroDiesel at key locations within the Caribbean as well as key locations along the US Gulf Coast including Texas and Florida.	4BBLs of ULSD is converted into 5BBLs of HydroDiesel, increasing fuel capacity by 120%. Improved fuel economy that ranges between nominal improvements of 10-25%. Improvement on operating cost is expected to be up to 15-20%.	Up to 30% Reduction in CO ₂ Up to 85% Reduction in NO _x Up to 30% Reduction in SO ₂ Up to 75% Reduction in PM 2.5 Up to 85% Reduction in PM 10 Up to 90% Reduction in Black Carbon Up to 15% Reduction in Engine Operating Temperature Up to 3% Reduction in Engine Noise	The Trillion HydroDiesel® fuel is a green, renewable fuel that is designed to significantly reduce emissions, extend the life of engines and maximize performance, all while providing a lower cost than regular diesel. The core of HydroDiesel is their HDAS additive that forms a stable emulsion, allowing water to mix with the diesel, creating greatly enhanced combustions.
NiQuan Energy	GTL Fuel	Availability planned in Trinidad by Dec 2020			Zero Sulphur	Can be used in diesel engines without modifications

Provider	Technology	Availability Globally	Availability in the Caribbean	ROI	% GHG Potential Reduction	Comments
ANSA Technologies	Ultimate Cell	Available Globally	Available in the Caribbean via ANSA Technologies	Savings on fuel up to 30% Average 10 years ROI	Reduction of harmful emissions by up to 80%	Ultimate Cell is a hydrogen technology, applied to all internal combustion engines to reduce energy consumption and harmful gas emissions. This dynamic and smart hydrogen production system promotes the optimization of the internal combustion engines of diesel, gasoline, and LPG fuels alike and ensures fuel savings of more than 5% and reductions in exhaust gases of up to 80%.
	Towing Kite Technology			Up to 40% savings on fuel consumption		
ABB	Azipod Propulsion systems	Available Globally		Up to 20% more energy efficiency	Lower fuel consumption reduces emissions	
	Electrical Systems	Available Globally				
	Automation & Software	Available Globally				
	Integrated operations	Available Globally				

Energy Efficiency Operational Indicator (EEOI) Baseline for the Caribbean

MTCC Caribbean created the First Energy Efficiency Operational Indicator (EEOI) baseline for vessels trading within the Caribbean Region for the period June 1st 2017 to May 31st 2019. Using the MTCC Data Collection Form, data was collected and analysed to determine the EEOI of vessels calling at ports within the Caribbean Region.

Table IV - Vessel type for the data sample collected using MTCC Data collection form

Category of Vessels	Number of Data Sets	Number of Vessels
Bulk Carriers	78	50
Gas Carriers	90	32
Tankers	252	127
Container Ships	387	37
General Cargo Ships	57	41
Refrigerated Cargo Carriers	6	5
Combination Carriers	3	2
Ro-Ro Cargo Ships (Vehicle Carriers)	17	18
Ro-Ro Cargo Ships	23	2
LNG Carriers	111	42
Cruise Ships	179	32
Total	1203	388

Although the total number of data sets collected was 1823, only 1203 data sets from 388 vessels as categorized in table IV above were usable for the purpose of calculating GHG emissions, EEOI and Reference Values. This was due to 623 incomplete data sets, as they did not contain one or more of the variables required for the calculations, and as such, they could not be used.

EEOI Baseline Calculations

To ensure consistency in the calculations, the following deductions were made:

- The total fuel consumed was calculated by tallying the total HFO, MGO and MDO used for the voyage as recorded on the MTCC Caribbean Data Collection Form;
- Standard values for the Carbon Factor (CF) for marine fuels were applied as per [Resolution MEPC.245(66)];
- The distance sailed in nautical miles was taken as the actual distance recorded on the MTCC Caribbean Data Collection Form;
- The cargo mass carried or work-done was expressed in metric tonnes for bulk carriers, gas carriers, tankers, container ships, general cargo ships, refrigerated cargo ships, combination carriers, Ro-Ro cargo ships (vehicle carriers), Ro-Ro passenger ships, Ro-Ro cargo ships, and LNG Carriers. For Cruise Ships the cargo mass carried/ work done was expressed in gross tonnes (MEPC.1/Circ.684); and
- Bottom-up methods of evaluation described in table V were used to calculate and estimate ships' fuel consumption and corresponding emissions. These calculations depend extensively on the accuracy of the ships' characteristics and activity data.

Table V - Bottom-Up Methods of Calculation & Estimation

Bottom Up - Method 1	Bottom Up - Method 2
Data is based on activity reporting of fuel consumption data from individual ships under various voyage conditions	Data is based on shipping activity using automatic tracking systems and models for energy consumption in the absence of such data
Data is gathered using MTCC Caribbean's Data Collection Form	Data is accessed using a global online database via IHS Markit

The EEOI (g CO₂ /ton n-mile) was calculated as per the following equation:

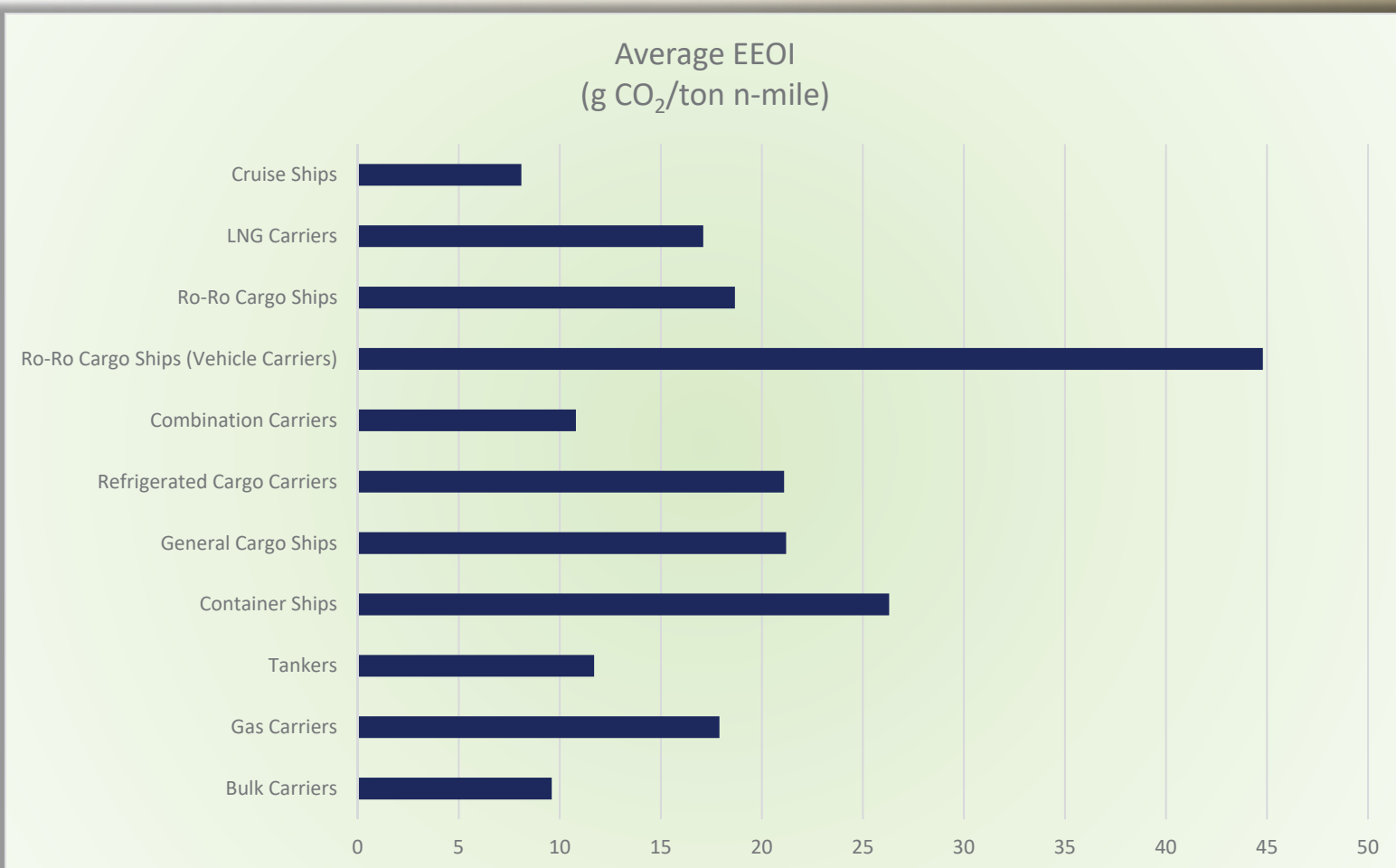
$$\frac{\text{Fuel Consumed (g)} * \text{Emission Factor}}{\text{Cargo Mass (tonne)} * \text{Distance Sailed(nautical mile)}}$$

The average EEOI values for each vessel type, based on bottom-up method 1, is captured in table VI and figure XXV below.

Table VI - Vessel Type and respective EEOI Values

Vessel Type	Average EEOI (g CO ₂ /ton n-mile)
Bulk Carriers	9.6
Gas Carriers	17.9
Tankers	11.7
Container Ships	26.3
General Cargo Ships	21.2
Refrigerated Cargo Carriers	21.1
Combination Carriers	10.8
Ro-Ro Cargo Ships (Vehicle Carriers)	44.8
Ro-Ro Cargo Ships	18.67
LNG Carriers	17.1
Cruise Ships	8.1

Figure XXV - Average EEOI Values

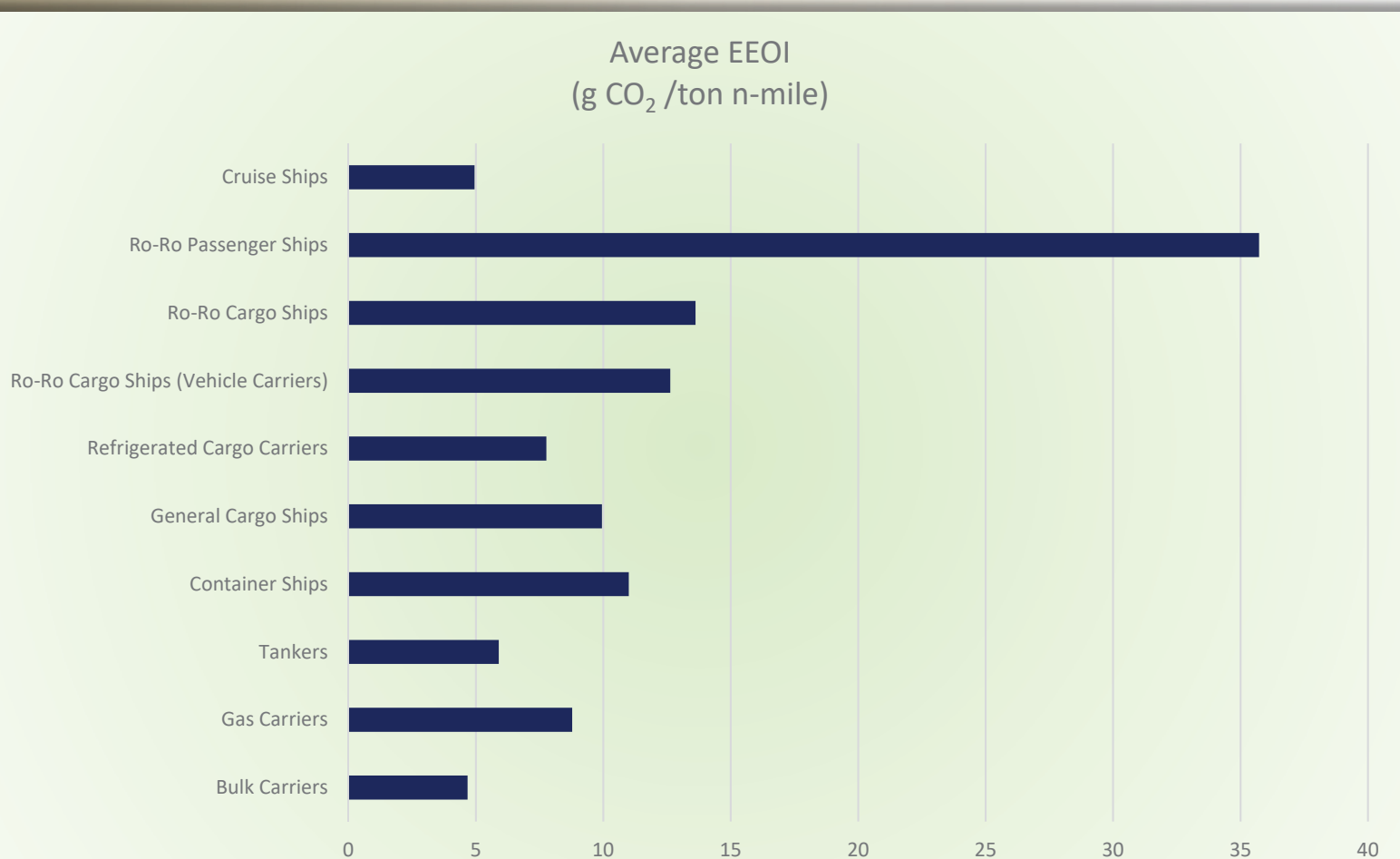


The average EEOI values for each vessel type, based on bottom-up method 2, is captured in table VII and figure XXVI below.

Table VII - Vessel Type and respective EEOI Values

Vessel Type	Average EEOI (g CO ₂ /ton n-mile)
Bulk Carriers	4.68
Gas Carriers	8.78
Tankers	5.9
Container Ships	11
General Cargo Ships	9.95
Refrigerated Cargo Carriers	7.77
Ro-Ro Cargo Ships (Vehicle Carriers)	12.63
Ro-Ro Cargo Ships	13.62
Ro-Ro Passenger Ships	35.73
Cruise Ships	4.95

Figure XXVI - Average EEOI Values



The EEOI results conclude that vessels trading in the region follow the trend where EEOI decreases with increase in deadweight. Data analysis using both methods (Bottom up method 1 and Bottom up method 2) showed that with increasing deadweight and cargo transported during voyages, the EEOI improved. Ships are designed and built for a certain specified load and speed range at which the overall operating efficiency is optimised. They are specifically designed, and their engines and propulsion systems installed, to maintain their optimised operating range i.e. load and speed. However, the operating demands may vary from these designed capacities. Such operational demands affect voyage performance. Variations in operating conditions such as higher speed and deadweight (amount of cargo moved) directly impact EEOI values. Speed was identified as the major factor contributing to higher fuel consumption and higher values of EEOI.

Specifically, in the case of container vessels, it was observed that vessels operated at a constant service speed regardless of the change in deadweight. In some instances, there were no speed reductions reported even when departure displacement was 38% less than the previous voyage. This may be due to several reasons, ranging from the lack of transport demand to poor design of the ship. If the ratio of speed and cargo carrying capacity can be maintained, ideally by eliminating reserve cargo capacity, the overall efficiency of the ship will improve as calculated in the EEOI.

Bulk carriers were the category of ship that had the youngest average age as 62% of the bulk carriers that reported using MTCC Caribbean's Data collection form, were less than 10 years of age, while another 18% were between 11 to 15 years old. The level of technology used on-board is mature and they are reliant on alternative or low Sulphur fuels for emission control. In comparison, even though 48% of cruise ships reporting were between 6 to 10 years old and 35% between 16 to 25 years of age, they also lead the vessel types in the level of existing technologies, especially emission

abatement methods. Consequently, cruise ships were also the greatest number of vessels equipped with scrubbers as 62% of these use HFO as their major fuel during the reporting period. The data on cruise ships is of high relevance given that 54 different ships participated in the data collection process which is equal to the total number of cruise ships within the Caribbean region at any given time.



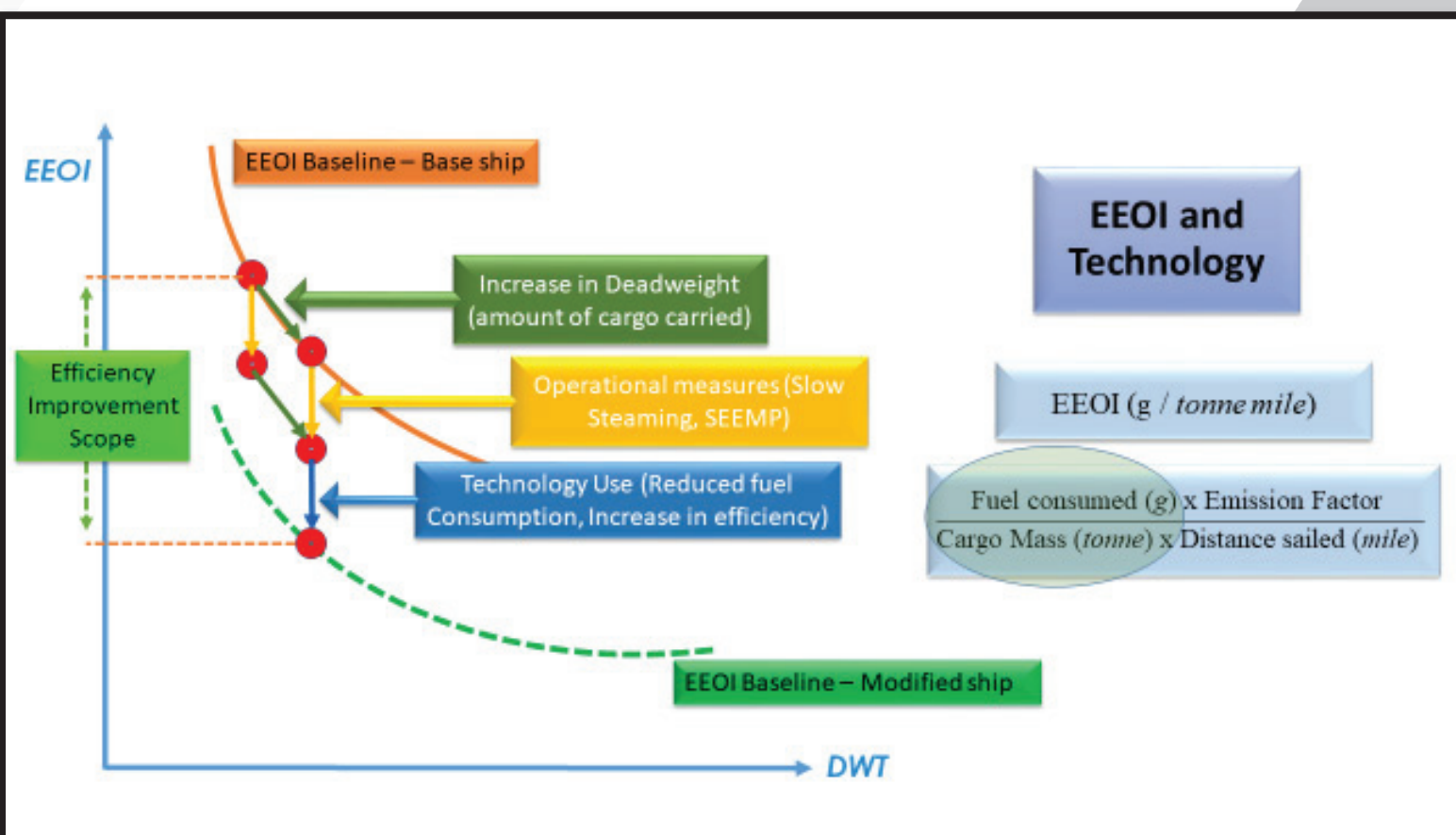
**Deadweight
Increases**

**ECEEMS
are used**



Lower EEOI values indicate more efficient operation of the vessel and lowered EEOI values can be achieved by increasing the deadweight, implementing operational measures and adopting technology use to reduce fuel consumption. The establishment of the EEOI baseline along with the database of existing energy efficient technology and emission abatement methods on-board ships provide a clear scope of energy efficiency improvement relevant to the vessels operating within the region. An example for determining the scope of energy efficiency is depicted in figure XXVII.

Figure XXVII - Relationship between EEOI and Technology



Given the findings of MTCC Caribbean's Pilot Projects, the existing technologies on-board the majority of vessels are mature in nature. However, the ships making their entire voyages within the Caribbean region are usually smaller in size (deadweight) when compared to the vessels with only one port call in the region. Smaller vessels, with associated power demand and short sailing distances, opens up the scope for improving EEOI in regional shipping using a suitable mix of semi-mature and non-mature technologies.

Ships' GHG Emissions Baseline for the Caribbean

MTCC Caribbean created the First Greenhouse Gas (GHG) Emissions baseline for vessels trading within the Caribbean Region for the period June 1st 2017 to May 31st 2019. Using the MTCC Data Collection Form, the types and quantities of fuel consumed by the vessels were collated, and the resulting CO₂ emissions were calculated. The focus was on the CO₂ emission as it was required for the calculation of EEOI (g CO₂ /ton n-mile) and it is the prominent product in the combustion process.

Calculation of GHG Emissions

CO₂ emissions were calculated by applying the appropriate Carbon Factor to the corresponding type and amount of fuel used.

Table VIII - GHG Emissions based on sample collected using MTCC Data collection form

Category of Vessels	GHG Emissions (tonnes of CO ₂)
Bulk Carriers	32058.51
Gas Carriers	57228.93
Tankers	115044.91
Container Ships	100990.17
General Cargo Ships	17684.00
Refrigerated Cargo Carriers	2959.63
Combination Carriers	295.19
Ro-Ro Cargo Ships (Vehicle Carriers)	5094.79
Ro-Ro Cargo Ships	4598.74
LNG Carriers	658718.81
Cruise Ships	32832.69
Total	1027506.36

Emissions from a fleet of ships are usually calculated by means of quantifying the fuel consumption by power production first and then multiplying the consumption by emission factors. Emissions from a marine engine will depend on the type of fuel used as well as on the characteristics of the engine. Marine diesel engines are the predominant form of power unit within the marine industry for both propulsion and auxiliary power generation. The engines are usually divided by engine speed into slow speed (60 – 300 rpm), medium speed (300 – 1000 rpm) and high speed (1000 – 3000 rpm). Most modern cargo ships use slow speed, two stroke engines or medium speed, four stroke engines.

CO₂ emissions were calculated by applying the appropriate carbon factor to the corresponding type and amount of fuel used.

$$\text{Fuel Consumed (tonnes)} \times \text{Carbon Factor} = \text{CO}_2 \text{ Emissions}$$

The major energy consumers onboard vessels include; the main engine, auxiliary engines and boilers with the principle fuels - HFO, MDO, MGO or liquefied natural gas (LNG). The emissions from shipping include mainly CO₂, SO_x, NO_x and PM; however, there are also emissions of CH₄ and N₂O as well. All ships currently require different types of bunker fuel for their operations that must comply with the IMO standards, class rules and expected operations. The relationship between fuel consumption and mass of CO₂ comes from the chemical composition of the fuel, which mainly consists of hydrocarbons, e.g. C₁₅H₃₂. The percentage of CO₂ emissions in exhaust per unit fuel combusted is linked to the carbon content of the fuel. Different types of fuel have different carbon contents and, consequently, different conversion factors as depicted in the table below.

Table IX - Types of fuel, Reference and Carbon Content CF (t-CO₂/t-Fuel) (MEPC.245 (66))

Type of fuel	Reference	Carbon content	CF (t-CO ₂ /t-Fuel)
Diesel/Gas Oil	ISO 8217 Grades DMX through DMB	0.8744	3.206
Light Fuel Oil (LFO)	ISO 8217 Grades RMA through RMD	0.8594	3.151
Heavy Fuel Oil (HFO)	ISO 8217 Grades RME through RMK	0.8493	3.114
Liquefied Petroleum Gas (LPG)	Propane	0.8182	3.000
	Butane	0.8264	3.030
Liquefied Natural Gas (LNG)		0.7500	2.750
Methanol		0.3750	1.375
Ethanol		0.5217	1.913

The total number of data sets collected through the use of the IHS Database for the purpose of calculating GHG emissions, EEOI and Reference Values, was 21,116. These data sets were collected from 1702 vessels calling at various ports within the Caribbean Region, and is categorized in table X below:

Table X - Vessel type for the data sample collected with the use of IHS Markit Database

Category of Vessels	Number of Data Sets	Number of Vessels
Bulk Carriers	1095	352
Gas Carriers	521	30
Tankers	3792	503
Container Ships	4887	210
General Cargo Ships	3460	287
Refrigerated Cargo Carriers	717	64
Ro-Ro Cargo Ships (Vehicle Carriers)	559	78
Ro-Ro Cargo Ships	597	13
Ro-Ro Passenger Ships	1850	7
Cruise Ships	3638	158
Total	21116	1702

CO₂ emissions were calculated by multiplying the appropriate carbon factor to the corresponding type and amount of fuel used as shown in table XI below:

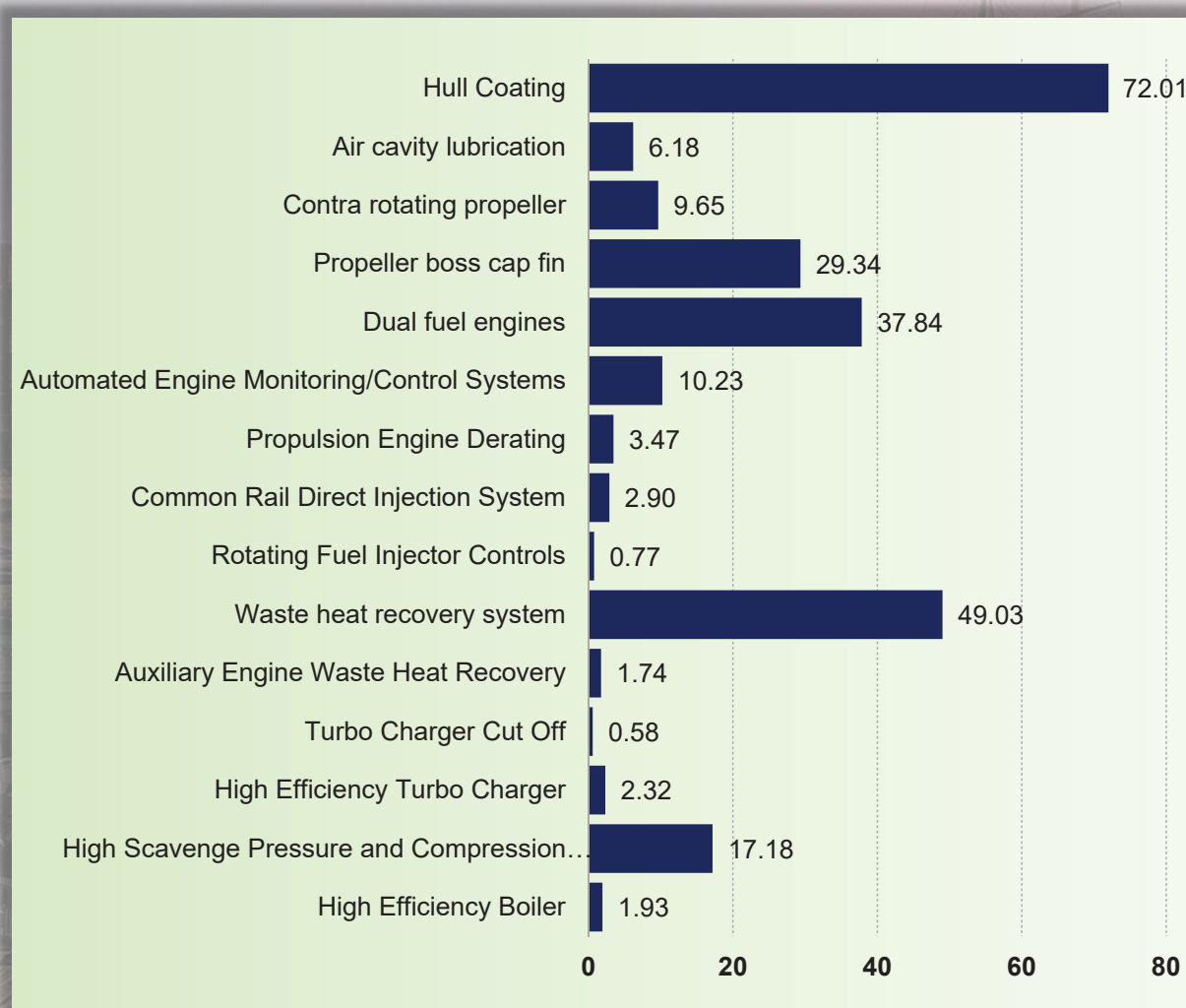
Table XI - GHG Emissions based on sample collected using IHS Data

Category of Vessels	GHG Emissions (tonnes of CO ₂)
Bulk Carriers	355204.40
Gas Carriers	78342.28
Tankers	466766.99
Container Ships	819041.10
General Cargo Ships	18469.18
Refrigerated Cargo Carriers	172122.87
Ro-Ro Cargo Ships (Vehicle Carriers)	49666.12
Ro-Ro Cargo Ships	12718.63
Ro-Ro Passenger Ships	21262.27
Cruise Ships	819957.11
Total	2813550.95

Emission and use of ECEEMs on-board ships

Ships of 5,000 GRT and above account for 85% of GHG emissions from the sector, and these vessels mainly comprise containerships and tankers. In 2010, an analysis of about 100,000 vessels indicated that marine diesels powered around 99% of the world's fleet, with steam turbines powering less than 1% (Trozzi, 2010)⁹. The principal fuels used are HFO, MDO, MGO and to a much lesser extent, LNG. As highlighted previously, MTCC Caribbean data analysis on fuel used revealed that HFO continues to be the dominant fuel of choice with close to 70% ships using it as the only fuel or in combination with distillate fuels. The major energy consumers on board include the main engine, auxiliary engines and boilers. Figure XXVII illustrates the energy efficiency measure used onboard the reporting vessels; from the data of the ECEEMs we see that the maximum technology used on 72% of the vessels is hull coating which is a mature technology. Mature technologies such as the propeller boss cap fin had an uptake of 29.34%, with main engine waste heat recovery, a semi mature technology, being used on almost 50% of the vessels.

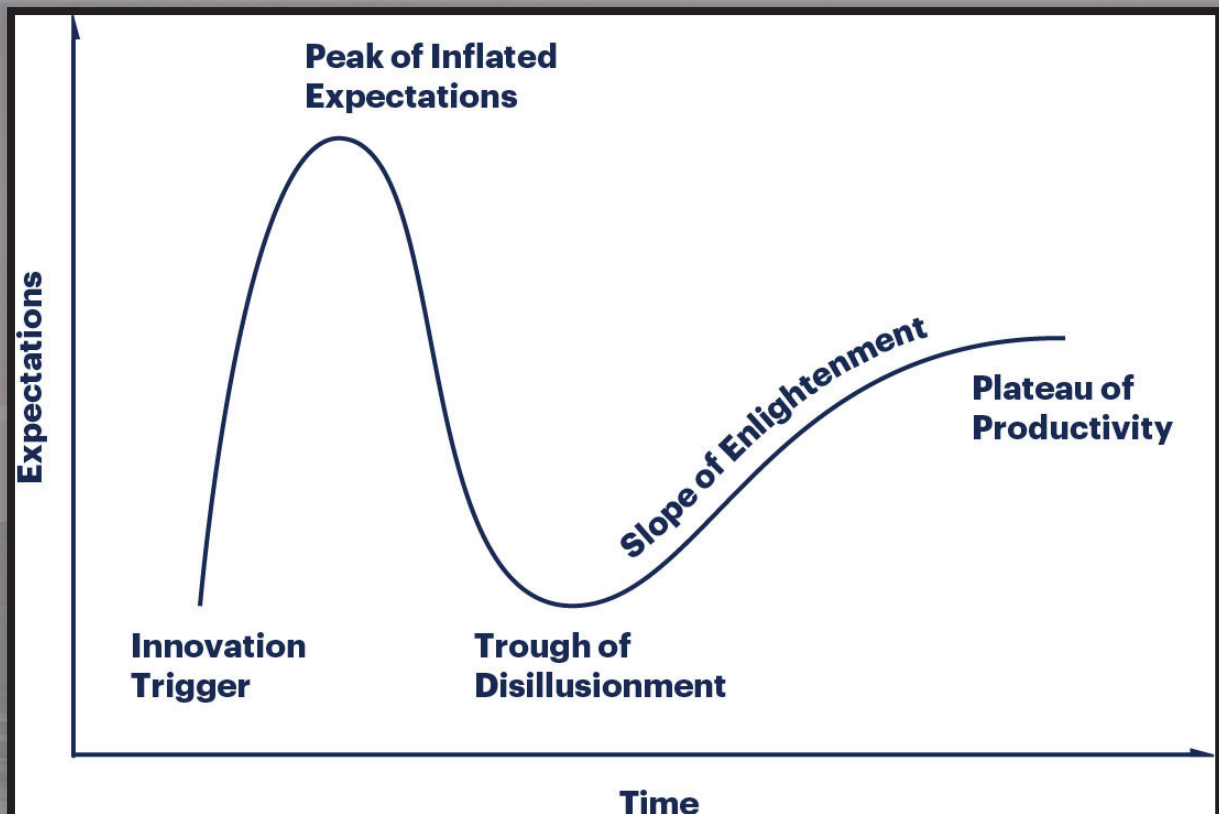
Figure XXVIII - Energy efficiency measure used on-board the reporting vessels



⁹ Trozzi C. (2010). 'Update of Emission Estimate Methodology for Maritime Navigation', Techne Consulting report ETC.EF.10 DD, May 2010. Available at: http://www.techneconsulting.com/images/stories/pubblicazioni/ETC.EF.092_DD_Rev.1.pdf

Technical measures such as adoption of ECEEMs are key to reducing GHG emissions by reducing energy demand and improving efficiency. The uptake of new technology is driven by economic and regulatory requirements but viability and maturity level are also key factors. Gartner Hype Cycle as shown in figure XXIX provide a graphic representation of the maturity and adoption of technologies and applications. The Gartner Hype Cycle methodology provides insight into the evolution of a new technology or application over time, providing a sound foundation to manage its deployment within the context of specific goals. This also provides guidance on how technologies are potentially relevant to solving real business problems and exploiting new opportunities.

Figure XXIX - Gartner Hype Cycle



Some shipping companies understand the argument for early investment, but insist on a sound cost/benefit analysis. When the uncertainty of the performance or commercial viability of an emerging technology is too high, companies wait until evidence of a tangible benefit is presented. The maturity level of the technology under consideration is a key component in the decision making of shipowners/operators. In the qualitative survey conducted during the MTCC Caribbean's Technology Needs Assessment, the following factors were highlighted by various stakeholders as major considerations in decision-making (Figure XXX):

- Other IMO regulations (e.g. future GHG);
- Shipowner financial condition (capital costs and operating expenses);
- Availability of finance (project specific);
- Ability to recover capital investment (operational incentives);
- Owner/operator - fuel and other operating costs;
- Charter rate differential;
- Existing vessel or new build; and
- Level of technology maturity.

The relevance of economic and regulatory factors driving the shipping sector was evident in the data collected. Any further uptake of technology is highly dependent on the economic viability of the technology. The results of these pilot projects, in combination with the technology needs assessment, can provide a clear path towards a technology action plan for the relevant stakeholders.



Figure XXX - Major Considerations in Decision Making



Relevance to the Regional Maritime Sector

The pilot projects executed by MTCC Caribbean successfully established a voluntary reporting system in addition to tracking energy efficient technology and fuel consumption onboard ships calling at ports within the Caribbean region. These baselines provide information that can be used in subsequent assessments and, establish a basis for setting targets and ensuring accountability to relevant stakeholders. They also provide data to make informed decisions towards investments in the following:

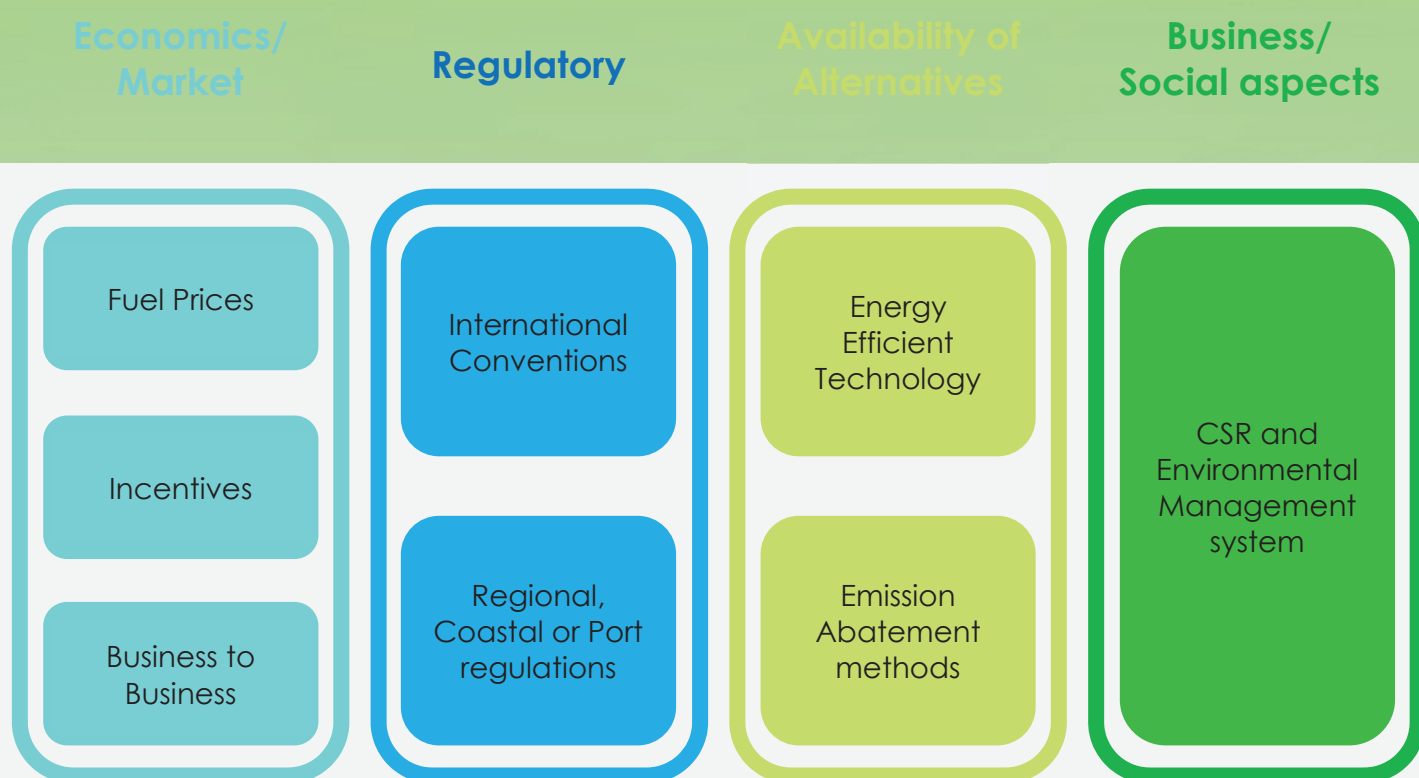
- Energy Efficient Technologies
- Emissions Abatement and Control Measures
- Climate Change Mitigation Measures
- Sustainable Development Initiatives

The OVRS has laid the foundations for ongoing data collection to assist the shipping industry and maritime administrations in the monitoring of vessels and their operations within the region. The data collected through the OVRS and analysed by MTCC Caribbean will provide policy makers with access to relevant reports and trends. The access to OVRS can provide stakeholders with the relevant data to facilitate informed decision making at the national and regional level. The OVRS can be also be adapted to meet the changing needs of the demands of the region.

In addition to data collection, the pilot projects were key in increasing awareness of regional stakeholders with respect to shipboard energy efficiency measures, technology and emission abatement methods. However, considerations on operational measures such as slow steaming cannot be finalised without considering three main factors - commercial perspectives, the technical capabilities of the main engine, and the availability of operational solutions. In order to reach the sustainability objectives for the shipping sector and decrease CO₂ emissions significantly, steps towards stricter policies and regulations related to alternative fuels and ship design need to be taken at the regional level. These steps should involve private partners from the industry, rather than relying solely on the regulatory environment, which is lagging in most of the participating countries, especially given that more than 85% of data was reported by vessels registered outside the region.



Figure XXXI - Main Drivers to the introduction of new and upcoming energy efficient technologies



The private stakeholders and ports in the region can facilitate the process by using environmentally differentiated port dues and by offering alternative fuel supplies in port. Figure XXXI above summarises the major drivers that will be catalytic to the introduction of new and upcoming energy efficient technologies to the region. There is a strong need for a regional approach to the establishment of a programme covering all interrelated actions for the diffusion of energy efficient technologies. These activities will require large scale funding and depend on international donors or public/private sector grants. The implementation of specific prioritised technologies can be sponsored by the stakeholders benefiting from such activity. Small-scale technology uptake pilot projects for ships within the region, as well as ports, will provide solutions to some of the existing energy efficiency and maritime emissions challenges within the Caribbean. Figure XXXII outlines some of the short, medium and long-term measures, which can be implemented to address the energy efficiency and emissions gap.

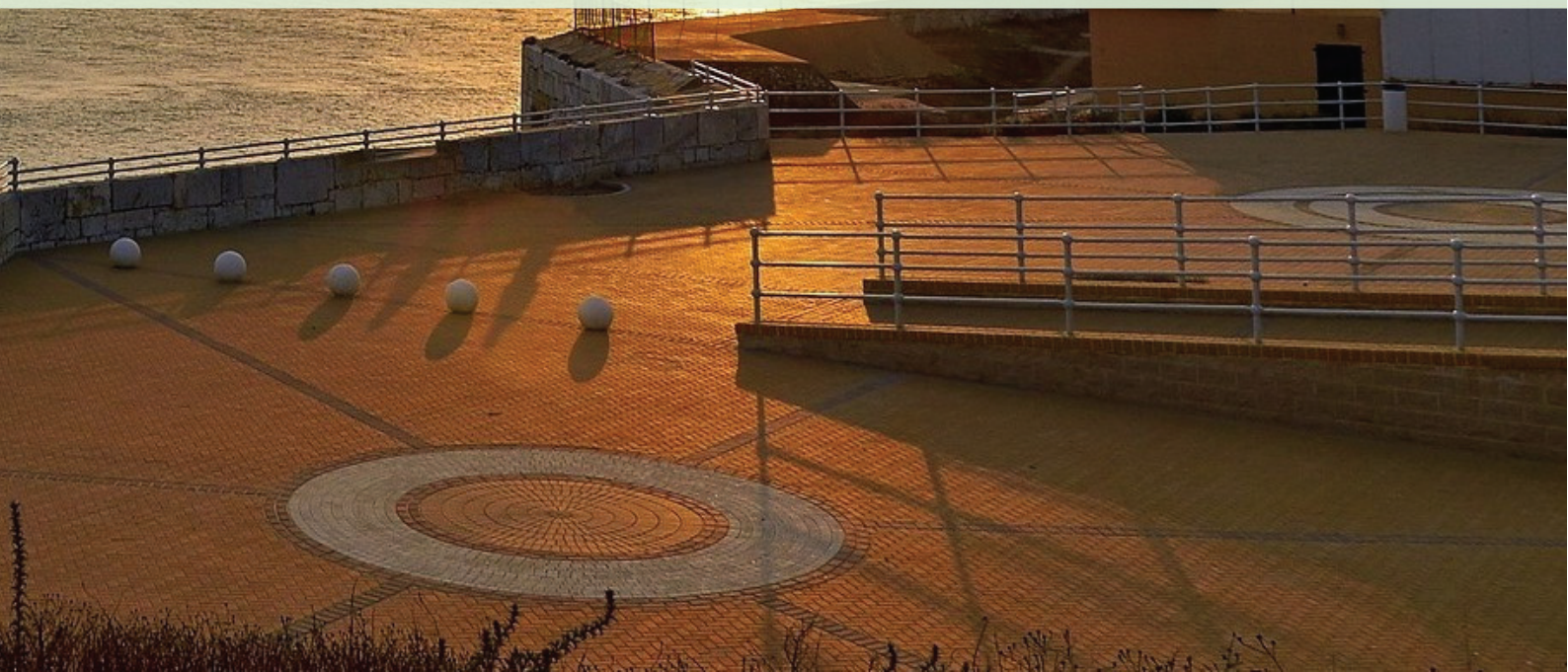


Figure XXXII - Short, Medium and Long-term Measures



2018 -2023

Short Term Measures

- Improving existing regulations (EEDI and SEEMP)
- Development of Technical and Operational efficiency measures
- Establishment of an Existing Fleet Improvement Programme
- Speed Optimisation and Speed reduction
- Other Emissions including Methane and VOC's
- National Action Plans
- Port Developments
- Enhance technical cooperation and capacity-building activities
- Research and development
- Incentives for first movers
- Develop robust lifecycle GHG/carbon intensity guidelines for all types of fuels



2023 -2030

Mid-Term Measures

- Implementation programme for low carbon and zero-carbon fuels
- Operational energy efficiency measures
- Possible MBM's to incentivize GHG emission reduction
- Further enhance technical cooperation and capacity-building activities
- Development of a feedback mechanism to enable lessons learned



2030 Onwards

Long-Term Measures

- Pursue the development and provision of zero-carbon or fossil-free fuels to assess and consider decarbonization
- Other possible new/innovative emission reduction mechanism(s)

Connecting the Dots – Stakeholder Engagement

The cooperation of all stakeholders across the region was crucial for ensuring that the objectives of MTCC Caribbean were achieved., Active and frequent engagement with relevant stakeholders was integral to the data collection process. Figure XXXIII below illustrates the key stakeholders involved in the data gathering.

Figure XXXIII - Stakeholders Involved in the Data Collection Process



Due to the level of interdependency between the stakeholders involved in maritime operations, successful implementation of data collection depended on the identification and understanding of different stakeholders, their practices, expectations and interests. It was determined within the early stages of the project that effective stakeholder engagement in this research and its implementation was important for improving the quality and quantity of data reported.

During the initial period of data collection there was some confusion between MTCC Caribbean's data collection system and the IMO's DCS. MTCC Caribbean issued an Information Notice explaining the requirements and differences between the

two systems. The notice emphasised that data requested by MTCC Caribbean is separate to IMO requirements and cooperation from all stakeholders is essential to achieve the objectives of MTCC Caribbean.

The purpose of MTCC Caribbean's data collection system was specifically:

- To facilitate the findings of the two pilot projects of the MTCC; and
- To create capacity within each administration to establish a reporting system

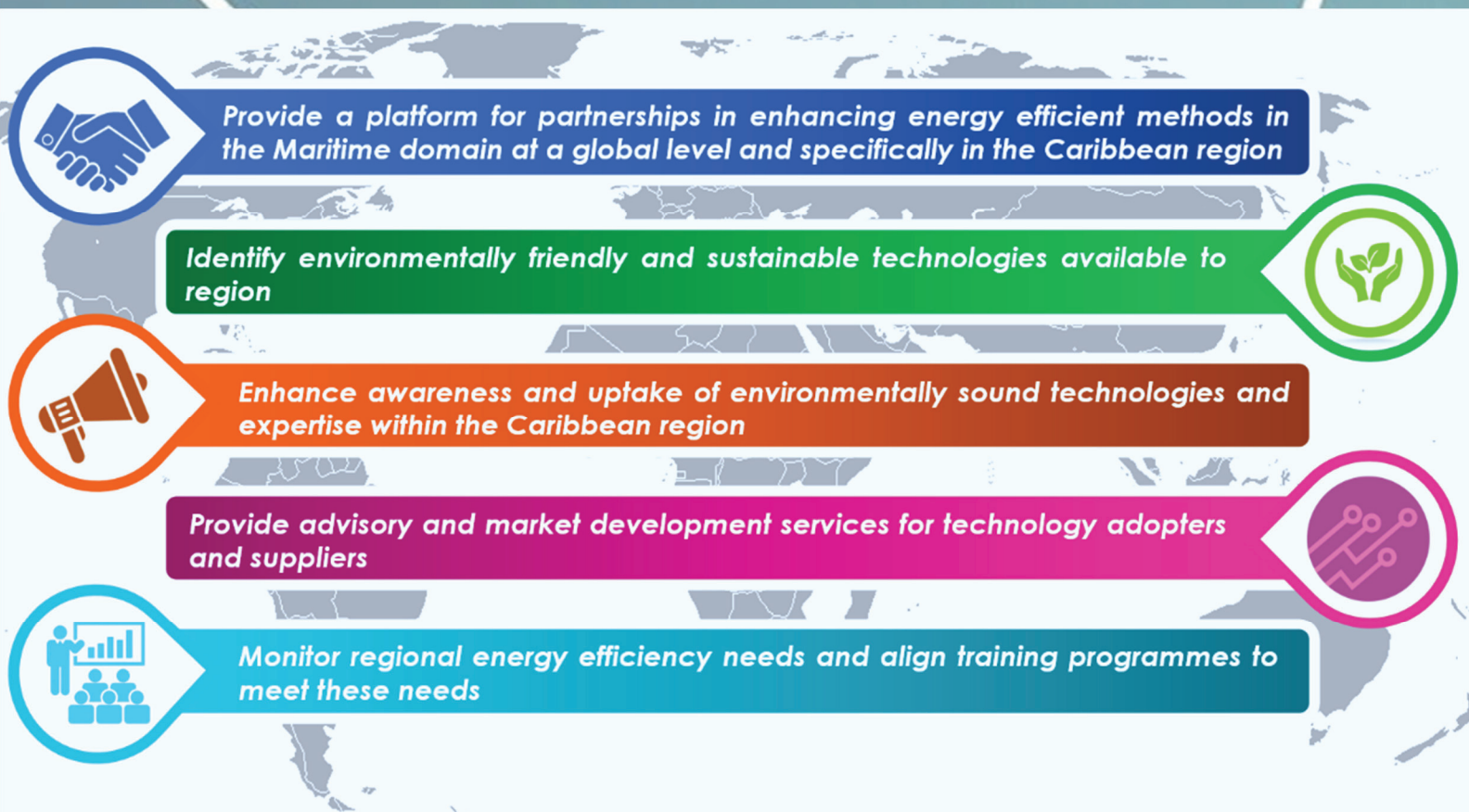
The impact of stakeholder engagement was evident in the form of increased reporting after every engagement activity. Various tools were employed for stakeholder engagement during the project duration. The process was two-fold as it not only conveyed the objectives of the project to stakeholders, but allowed the MTCC team to better understand obstacles to data collection. Figure XXXIV illustrates the stakeholder engagement tools.

Figure XXXIV - Stakeholders Engagement Tools



MTCC Caribbean established a Regional Steering Committee (RSC) to serve as voluntary facilitators and champions of its objectives. A network of EEFP was also established in the region, with a representative in this capacity within each maritime administration of the countries. These Energy Efficiency Focal Points are the first point of contact and direct liaison for matters relating to the project. As a regional centre of excellence, the MTCC is equipped with the requisite expertise and regional networks to solve challenges by building capacity in the region and championing low carbon initiatives. The MTCC's operations have achieved the objectives outlined in Figure XXXV below. Future research must continue to take into consideration stakeholders' participation and perspectives. This is vital to ensure that future projects are aligned to their expectations.

Figure XXXV - MTCC Caribbean Objectives Achieved



Charting a New Course

Sustainable development entails three interdependent components – economic development, social development and environmental protection. Maritime transport, a major facilitator of international trade, plays a significant role in any such development by providing a reliable and environmentally responsible supply chain element. Modern shipbuilding and operating practices take advantage of a variety of optimisations and frequently innovative solutions that are aimed mainly at reducing fuel consumption by ships' engines. In that sense, the direction for the maritime community's efforts is consistent with the Sustainable Development Goal relating to the reduction of ship-derived emissions.

The IMO Initial GHG Strategy represents a framework for further action, setting out the future vision for international shipping. It also sets the levels of ambition to reduce GHG emissions, and contains guiding principles; including candidate short, mid and long-term further measures with possible timelines and their impacts on States. The strategy also identifies barriers and supportive measures including capacity building, technical cooperation and research and development (R&D). Therefore, future pilot projects should be aligned to the framework of the initial IMO GHG Strategy.

Future work must also attempt to quantify the impacts of various measures on States. Pilot projects can provide assessment and consideration as appropriate before adoption of the targeted measure. Particular attention should be paid to the needs of developing countries, especially SIDS and LDCs. Disproportionately negative impacts should be assessed and addressed, as appropriate. Figure XXXVI below outlines the impacts of measures on SIDS and LDCs.

Figure XXXVI - Impacts of Measures on SIDS & LDCs

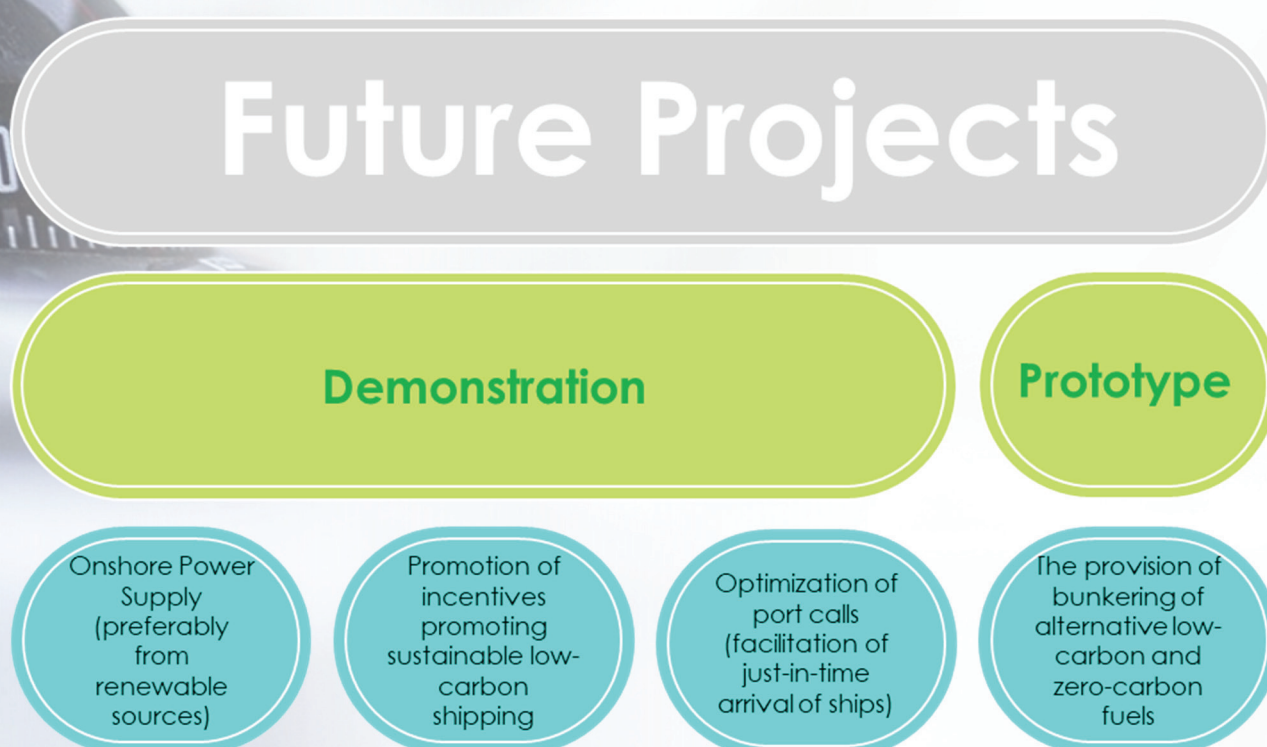


Need for Future Projects in Ports to Support Green Ships

Maritime transportation involves many stakeholders, where one decision and action can affect the entire logistics chain. Stricter regulatory requirements, and increasing pressure for a cleaner and more sustainable environment exerted by communities at large, are pushing global supply chain management practices to the next level. The sense of urgency rises in tandem with the escalating deterioration of the environment. This includes diminishing raw material resources, proven climate change impacts, and increasing levels of pollution among others. Ships and ports are two crucial players and their operational performance determines the level of efficiency achieved. Information exchange across the maritime logistics chain is still very traditional in most of the developing world.

The adoption of resolution MEPC.323 (74), on *Invitation to Member States to encourage voluntary cooperation between the port and shipping sectors to contribute to reducing GHG emissions from ships*, provides further scope for a variety of pilot projects. This resolution aims to promote regulatory, technical, operational and economic actions in the port sector. These include the development of Onshore Power Supply (preferably from renewable sources), the provision of alternative low-carbon and zero-carbon fuels, the implementation of incentives promoting sustainable low-carbon shipping, and the optimization of port calls, including the facilitation of just-in-time arrival of ships. These are illustrated in figure XXXVII below.

Figure XXXVII - Future Projects

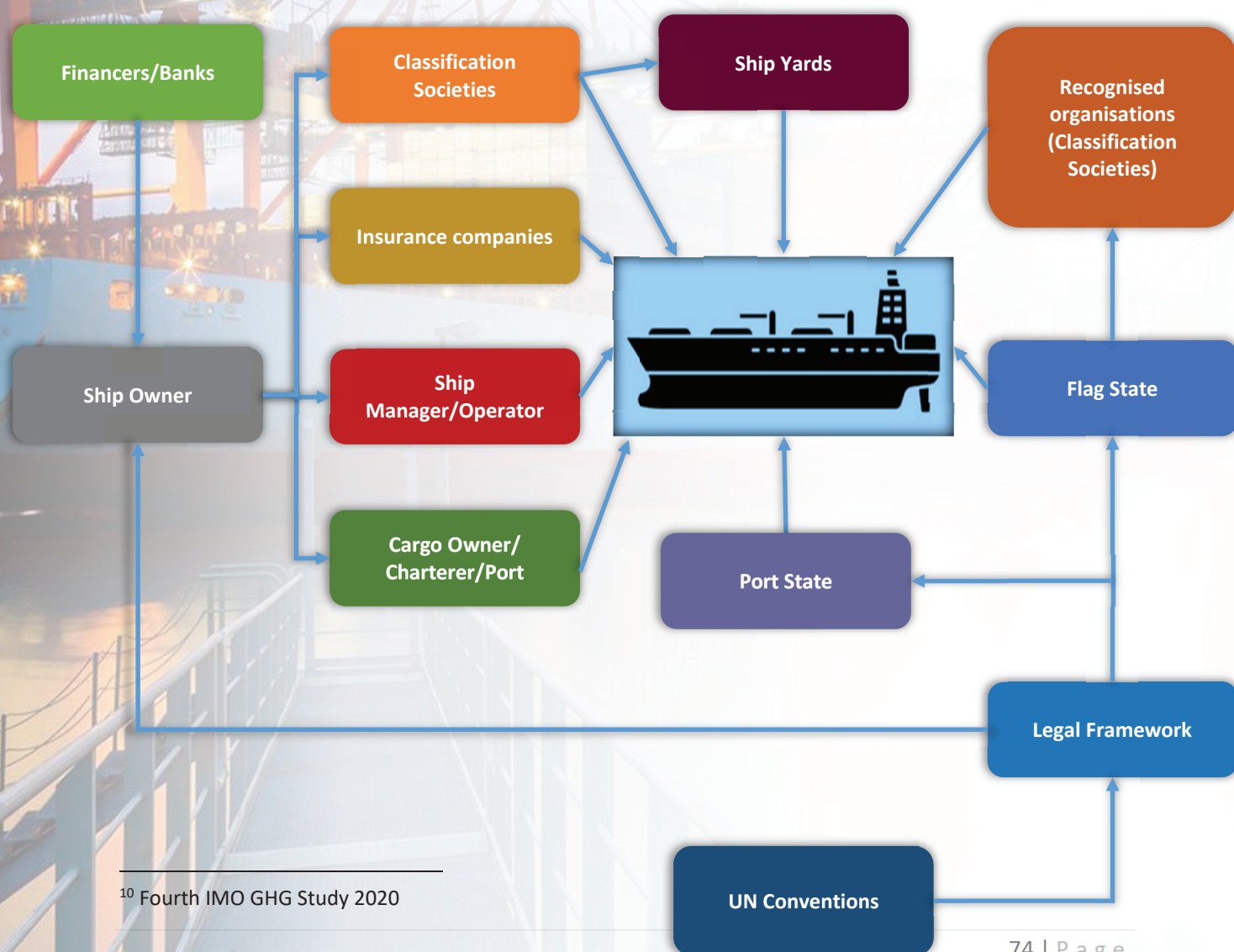


As nodes within global supply chains, ports generate environmental impacts through their various functions linked to cargo handling, connectivity to maritime and land transport networks, industrial and semi-industrial activities, logistics and distribution activities, and energy production and distribution. Future pilot projects must therefore be aligned to the emergence of the “green port” concept and closely associated with the growing environmental awareness of seaport actors, especially within the Caribbean region.

Final Thoughts – Overcoming Barriers

Decarbonisation of shipping is a major challenge to the global shipping industry. Emissions are projected to increase from about 90% of 2008 emissions in 2018 to 90-130% of 2008 emissions by 2050 for a range of plausible long-term economic and energy scenarios¹⁰. Following the implementation of Sulphur Cap 2020, which reduced the sulphur content of fuels, the sector now faces an even bigger challenge, as it needs to transition from high carbon to low carbon or cleaner alternative fuels. The public and private stakeholders within the sector have a critical role in preparing and implementing the pathway to decarbonisation of maritime sector. The stakeholders across the maritime value chain hold the keys to creating various opportunities to start the journey to low carbon pathways. The stakeholders can utilise the MTCC Caribbean's baselines and associated data to inform their strategies to balance the influence and interest. Multi-stakeholder pressure, based on financial and/or non-financial actions, promotes the uptake and implementation of sustainable activities within maritime operations. The figure below presents a simple linkage of stakeholders in a ship operation. The decarbonisation ambitions can be achieved if efforts are aimed at the transition to low emission shipping operations and are supported by each stakeholder within their capacity, while contributing towards multi-stakeholder consensus.

Figure XXXVIII - The stakeholder engagement in Ship Operations



¹⁰ Fourth IMO GHG Study 2020

The flag state administrations, as one of the primary stakeholders, play an important role. They can exercise regulatory control and impose penalties in cases of non-compliance. Compliance with MARPOL Annex VI requirements are specifically aligned to control harmful emissions from ships and implementation of initial IMO strategy on reduction of GHG emissions from ships. However, ratification and implementation of IMO conventions is critical in the context of ensuring that ships are compliant with applicable international requirements. The role of flag state is also critical especially when the fleet ownership is compared to the major flags of registration. As of January 2019, the top five ship-owning countries (Greece 18%, Japan 11%, China 11%, Singapore 6% and Hong Kong SAR 5%) combined accounted for 51 per cent of world fleet tonnage; 40% of the ships owned by Greek entities were registered in the Marshall Islands and in Liberia. Many commercial ships are registered under a flag that does not match the nationality of the vessel owner. Companies from Latin America and the Caribbean, Africa and Oceania has shares of one percent or less¹¹. The table below compares the vessels registered in the Caribbean against the beneficial ownership in the region.

Table XII - Vessel Ownership

Flag State	Registered in the region		Ownership in the region	
	Number of ships	Percentage of total world	Number of ships	Percentage of total world
Antigua and Barbuda	727	0.32	1	0.0001
Bahamas	1381	3.77	29	0.0495
Barbados	145	0.10	1	0.0001
Belize	790	0.16	11	0.0018
Cuba	55	0.01	17	0.0024
Dominica	98	0.05	0	0.0000
Dominican Republic	38	0.00	0	0.0000
Grenada	6	0.00	1	0.0001
Guyana	58	0.00	20	0.0022
Haiti	4	0.00	2	0.0005
Jamaica	46	0.01	1	0.0002
Saint Kitts and Nevis	218	0.06	5	0.0009
Saint Lucia	Not Available	Not Available	1	0.0001
Saint Vincent and the Grenadines	813	0.11	3	0.0005
Suriname	10	0.00	4	0.0005
Trinidad and Tobago	103	0.00	8	0.0007
Total	4492	4.59	104	0.06

¹¹ https://unctad.org/system/files/official-document/tdstat44_FS14_en.pdf

The vacuum created due to differences in legal vessel registration and beneficial ownership can be seen as one of the major barriers to the effective implementation of energy efficiency requirements. The present conventions place heavy reliance on flag states for inspection of vessels and enforcement of their provisions. Due to various challenges and other priorities, many countries in the Caribbean region are still to ratify and implement MARPOL Annex VI. The maritime administrations often lack the resources to enforce, investigate or prosecute breaches by vessels flagged to their registry. Therefore, in order to encourage the adoption of energy efficient technologies and operations, there is need to continue the focus on enabling the flag states and port states that lack the resource and capacity for effective implementation. The upcoming requirements of the Energy Efficiency Existing Ship Index (EEXI), operational Carbon Intensity Indicator (CII), which includes a rating scheme (A to E), and an enhanced SEEMP with mandatory content, approval and subsequent audits, further underscores the need for building appropriate capacity within flag state administrations.

In response to mounting regulatory challenges, Flag states can provide economic incentives to the ships registered under their flag to reduce CO₂ emissions. For example, Singapore offers 50% reduction of Initial Registration Fees and 20% rebate on Annual Tonnage Tax, if the vessel exceeds the IMO EEDI requirements. If the vessel adopts energy efficient ship design exceeding IMO requirements or adopts LNG as alternative fuel, these discounts are increased to 75% reduction of initial registration fees and 50% rebate on annual tonnage tax¹². Similar examples of incentives are offered by various ports around the globe with reduction in port dues and charges. However, to offer port incentives a harmonised approach is suggested for the region. A regional approach makes it economically attractive for ships to participate in incentive schemes, when calling at more than one port in the region, especially along major shipping routes. Incentive schemes present an opportunity, where transparency will enhance the flag state services, especially when major flag states in region are themselves most vulnerable to the impacts of climate change.

MTCC Caribbean's baselines and OVRs captures a snapshot of energy efficiency of vessel operations calling various ports in the region. These results can assist in the development of a consistent regional approach to rewarding ships with better energy efficiency and environmental performance. The data collected during the MTCC Caribbean's pilot projects, highlighted that in general, the uptake of energy efficiency technologies is low and technologies were mature in nature. These mature technologies offer small energy efficiency gains (0.5 – 5%) at the ship level. The current use of alternative fuels and dual fuel engines and renewable energy sources is very low. Therefore, the baselines and work highlights the need to promote greater awareness to align current stakeholder attitudes to the demands of the IMO GHG strategy. The work of MTCC Caribbean also provides the opportunity for the exchange of insights and experiences, and to collectively commence work on improving incentive schemes and building capacity in ports and maritime administrations of the Caribbean region.

¹² <https://www.mpa.gov.sg/web/portal/home/singapore-registry-of-ships/register-with-srs/incentives-schemes>

For More Information

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