April 2019 Development Paper

MariEMS Learning Material

This is the 32nd compilation by Professor Dr Reza Ziarati on the work of the EU funded Erasmus + MariEMS' partners and material extracted from the IMO TTT Course. The material is composed from Chapter 32 of the learning material. Readers are also advised to refer to the papers on IdeaPort and IdealShip projects led by C4FF and published by MariFuture.

32. IMO Response to control of GHG emissions from international shipping

32.1 Shipping GHG emissions context and IMO role

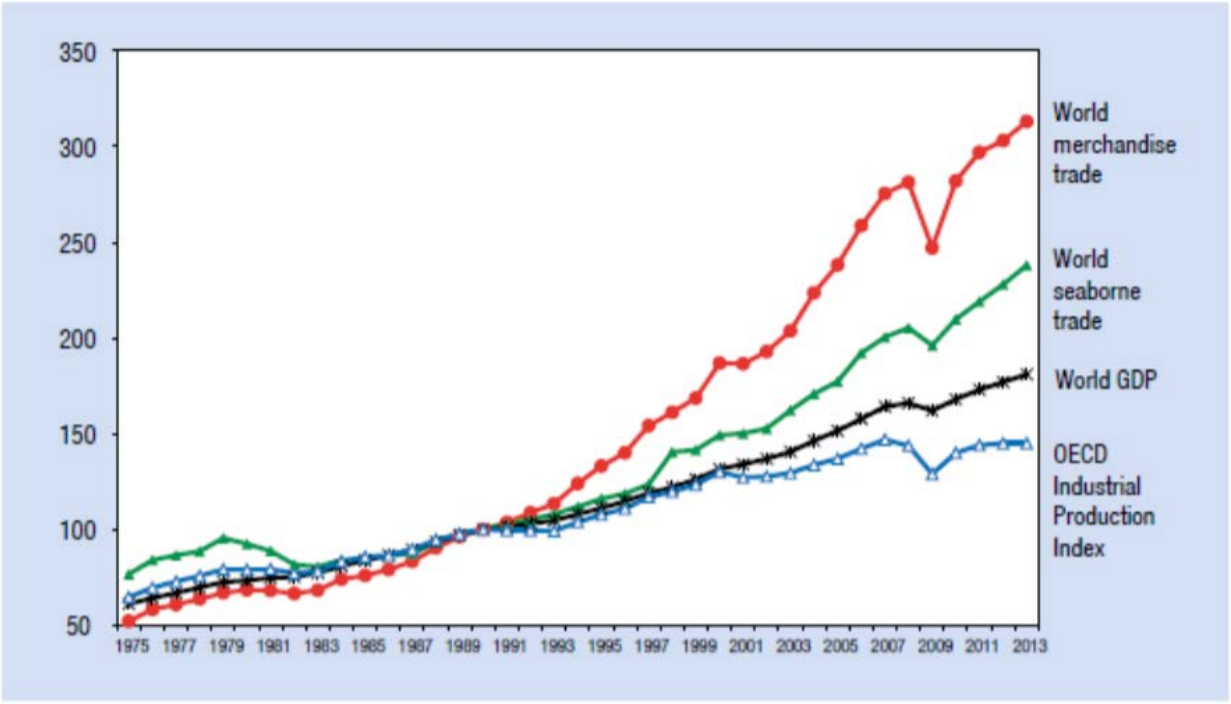
Growth of shipping transport

Around 90% of world trade is carried by the international shipping industry. Without shipping the import and export of goods for a modern and globalised world will not be possible. International shipping trade continues to expand, bringing benefits for producers and consumers across the world through competitive freight costs. There are over 50,000 merchant ships trading internationally, transporting every kind of cargo.

Shipping, world trade and the economy are very well intertwined and linked as clearly shown in Figure 32.1.1.

"Given that for shipping, all stands and falls with worldwide macroeconomic conditions, the developments in world seaborne trade mirrored the performance of the wider global economy."(UNCTAD, 2011)

Figure 1.1. The OECD industrial production index and indices for world gross domestic product, merchandise trade and seaborne shipments (1975–2013), (1990 = 100)



Sources: UNCTAD secretariat, on the basis of OECD *Main Economic Indicators*, May 2013; UNCTAD, The Trade and Development Report 2013; UNCTAD *Review of Maritime Transport*, various issues; World Trade Organization (WTO) (table A1a); the WTO press release 688, 10 April 2013, "World trade 2012, prospects for 2013". The value of the index measuring growth in world seaborne trade for 2013 is calculated on the basis of the growth rate forecast by Clarkson Research Services in *Shipping Review and Outlook*, spring 2013 (Clarkson Research Services, 2013a).

Figure 32.1.1: UNCTAD, Review of the Maritime Transport 2013

While shipping, in comparison to other transport modes, is the most efficient mode of cargo transport and was considered environmentally-friendly, the significant growth of seaborne trade and its externalities and societal costs have modified this perception. The growth of transportation by ships increased the energy consumed by shipping and, in spite of the improvement in the energy efficiency of ship engines, the global shipping emissions amplified quantitatively. This number and volume growth not only have implications for oceans as sea routes but also affects air quality in port areas and coastal zones.

Finally, it should be noted that oceans cover 70% of our planet; and nearly 50% of the world's population live in coastal areas. Therefore protection of the marine environment not only has implications for each country but also significant global benefits. This is especially true for environmental issues (in particular the GHG emissions) which is truly global in nature; and any benefits accrued at national level will fully contribute to the global benefits.

Responsibility under UN Framework Convention for Climate Change

As indicated before under UNFCCC and Kyoto Protocol, the responsibility for dealing with GHG emissions from international shipping and aviation are given to the IMO and the ICAO respectively (see Figure 32.1.2). Based on Article 2 of Kyoto Protocol: "The Parties included in Annex I shall pursue limitation or reduction of emissions of greenhouse gases not controlled by the Montreal Protocol from aviation and marine bunker fuels, working through the International Civil Aviation Organization and the International Maritime Organization, respectively"

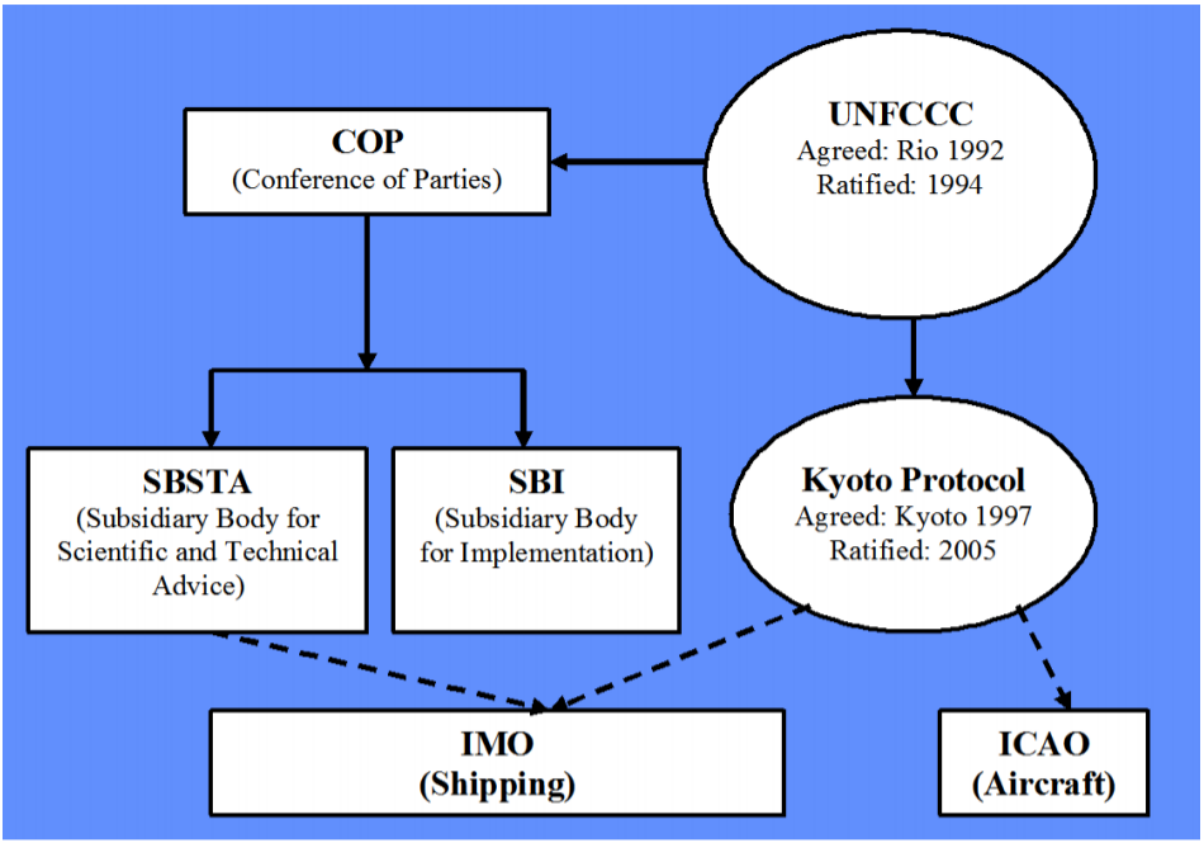


Figure 32.1.2: IMO responsibility within the international framework for control of GHG emissions [Reynolds and Bazari, 2005]

As such and after the adoption of Kyoto Protocol, shipping could not stay away from the international efforts on GHG reduction. Work by IMO started in 1997, lead to a number of regulations and work still continues on further regulatory measures. Before that, IMO relevant studies will be introduced first. During the period 1997 till now, IMO conducted three major studies on GHG emissions from international shipping as explained in the following sections.

32.2 First IMO GHG Study 2000

As an outcome of the 1997 MARPOL Conference, the decision to study CO_2 emission from ship led to the launching of a complete study on the topic. Released in 2000, the first study constituted the initial step of deliberations about the development of new rules to address the GHG controls in shipping. This study, using data from 1996, estimated that ships emitted about 420 million tonnes of CO_2 per year and thereby contributed about 1.8% of the world's total anthropogenic CO_2 emissions that year.

The Study also stated that technical and operational measures have a limited potential for contributing to reduced emissions from ships if the increase in demand for shipping services and market requirement for increased speed and availability continued.

The main outputs of the study were:

- Shipping is considered an efficient means of transportation compared to others.
- It is difficult to assess with accuracy the overall impact of shipping - because of discrepancy in data concerning bunker figures and the uncertainties in the fuel consumption models.
- The impact of air emission should include NOx, SOx and GHG emissions.

- Significant reduction of GHG emission can be achieved through operational and technical measures. However, the increase in demand for shipping services may impede operational and technical savings.
- Environmental indexing, market-based mechanisms and design standards may be appropriate measures to implement in the future.

Despite its relevance, no immediate regulation followed after the presentation of this study. The lengthy discussion on the IMO involvement and approach to the climate change necessitated an updated study.

32.3 Second IMO GHG Study 2009

The second IMO GHG study was commissioned in 2007 and delivered in 2009. This study updated the GHG emissions figures/inventory for shipping and estimated the potential for reduction of emission according to the implementation of different technologies and operational energy efficiency measures. In addition, cost effectiveness and policy evaluation options were considered. This second study initiated a proposed framework to support the regulatory decision making process.

Presented during the Copenhagen UNFCCC's COP discussions on climate change in December 2009, the Second IMO GHG Study 2009 forms the scientific background for the present IMO policy and regulatory frameworks that was developed soon thereafter. The intention of the document was to provide a solid research-based data and information to the shipping community in order to help them for regulatory decision making. Mr. Mitropoulos, the then Secretary General of the IMO recalled in a foreword to the document its objectives:

> "I trust that this Second IMO GHG Study will become the paramount reference for the Organization's Marine Environment Protection Committee in making well-informed and balanced decisions towards the development and adoption of a robust regime to regulate shipping emissions at the global level." (IMO, 2009)

This study is documented under nine chapters as follows:

1. Executive Summary
2. Introduction to shipping and its legislative framework
3. Emissions from shipping 1990–2007
4. Reductions in emissions achieved by implementation of MARPOL Annex VI
5. Technological and operational potential for reduction of emissions
6. Policy options for reductions of GHG and other relevant substances
7. Scenarios for future emissions from international shipping
8. Climate impact
9. Comparison of emissions of CO2 from ships with emissions from other modes of transport

A large number of Appendices are also included in the report. Below, some of the chapters more relevant to topic of this training course are further elaborated.

Chapter 3: Emissions from shipping 1990-2007

Before making the inventory of the GHG emission by shipping, the chapter begins with few introductory comments on the scope and uncertainties. Accordingly, the scope of the emission included in the inventory is taken the same as those in the UNFCCC guidance.

"In line with the above-mentioned guidelines for creating an inventory of emissions, the following pollutants were considered for exhausts: NOx, SO2, PM10, CO, CO2, N2O, CH4 and NMVOC."(IMO, 2009)

The limitations on estimation of the emissions levels are then deliberated and the following considerations are made:

- Exhaust gases uncertainties are the same as those of the previous study and are estimated to be around +/- 20%.
- Emission of ODS are detailed by sources: Refrigerants, reefer ships & reefer containers; calculation limits are presented.
- Limits and uncertainties in estimating the release of Methane (CH4) and Non-Methane Volatile Organic Compound (NMVOC) are presented.
- Sulphur hexafluoride (SF6) and Fluorocarbon (PFCs) on board ships are not emitted to any sufficient degree to be considered as significant issues.

Despite all these limitations, the emissions levels from international shipping were established. As Table 32.3.1 indicates, amongst various types of the GHG emissions, the GHG emissions from shipping are overwhelmingly dominated by CO_2. Thus, CO_2 is established as the main GHG concern for shipping that should be the subject of future regulations. All other GHG emissions by international shipping are considered as negligible.

	International shipping (million tonnes)	Total shipping	
		million tonnes	CO_2 equivalent
CO_2	870	1050	1050
CH_4	Not determined*	0.24	6
N_2O	0.02	0.03	9
HFC	Not determined*	0.0004	≤6

* A split into domestic and international emissions is not possible.

Table 32.3.1: Summary of GHG emissions from shipping in 2007 [Second IMO GHG Study 2009]

In addition, the data presented highlight that the emissions of GHG nearly doubled during the period concerned by the study (1990-2007), see Table 32.3.2:

	NOx	SOx	PM	CO	NMVOC	CO_2	CH_4	N_2O
Increase from 1990 to 2007	78.6%	89.9%	80.0%	92.3%	100.0%	86.8%	100.0%	200.0%

Table 32.3.2: Increase of exhaust emissions from total shipping 1990-2007 [Second IMO GHG Study 2009]

Chapter 4: Reduction in emissions achieved by implementation of MARPOL Annex VI

This chapter assesses the effectiveness of the existing regulations that existed at the time of study, to reduce emissions. The increase of seaborne trade induces an increase in absolute volumes of

emission. Therefore, the calculations consider the emission reduction according to two scenarios: no-regulation hypothesis and MARPOL Annex VI regulation.

Impact of Regulation 12 – Ozone-depleting substances. The MARPOL Annex VI plus the Montreal Protocol demonstrate a serious efficiency in emission reduction (see Table 32.3.3).

	1998 RTOC Total	2006 RTOC Total	Reduction
CFC	750	15	735 (98%)
HCFC-22	14,000	3,100	10,900 (78%)
HFC	100	415	−315 (−315%)

* Merchant marine, naval, fishing and reefer.

Table 32.3.3: Reduction in estimated annual emissions (tonnes) of refrigerants from ships [Second IMO GHG Study 2009]

Impact of Regulation 13 – Nitrogen Oxides (NOx): To address this element, typical emission levels before and after 2000 had to be assessed because NOx emission depends on engine type, conditions and settings but also on fuel quality. These numerous factors made the evaluation complicated. However, it was estimated then that the reduction achieved with the new regulation is about 7%.

Impact of Regulation 14 – Oxides of Sulphur (SOx): The SOx emitted is directly correlated with the sulphur content of the fuel burned. Therefore, the reduction of sulphur content from 4.5% to 3.5% is estimated to have a small impact on SOx emissions because even before the enforcement of this control limit, the fuel oil used by ships rarely contained more than 3.5% sulphur. So, in order to demonstrate the impact of stringent regulation on such emissions, the SOx Emission Control Area were analysed and compared to the total. As Table 32.3.4 indicates, most of the reductions are due to ECA-SOx (or SECA).

	Hypothetical baseline	MARPOL Annex VI	Reduction
Global total	14.9	14.4	3.4%
SECA	1.2	0.7	42%

Table 32.3.4: Estimated emissions (million tonnes) of SO2 (2008) [Second IMO GHG Study 2009]

Impact of Regulation 15 – Volatile Organic Compounds (VOCS): The study concludes that the regulation addressing the issue seemed to have been properly implemented on tankers but not on shore terminals. Overall, the analysis of NOx, SOx & VOCs demonstrated the effectiveness of the regulations to reduce the rate of emission of these pollutants.

Chapter 5: Technological and operational potential for reduction of emissions

This chapter proposes a number of technological and operational techniques for reduction of shipping CO2 emissions. This analysis supported the development of a comprehensive emission reduction policy that later on led to the shipping energy efficiency regulations.

Four solutions for reduction of GHG emissions from international shipping were investigated:

- Improving shipping operational energy efficiency.
- Using renewable energy sources as alternative technologies/energy.
- Using fuels with less total fuel-cycle emission per unit of work done.
- Using emission reduction and abatement technologies.

The first item above, improving energy efficiency of shipping, remains the main and easiest target to reduce GHG emissions. Table 32.3.5 highlights the main measures for improving the energy efficiency in shipping and their probable impact on CO2 emission reduction based on this study.

	Saving of CO_2/tonne-mile	Combined	Combined
DESIGN (New ships)			
Concept, speed and capability	2% to 50%†		
Hull and superstructure	2% to 20%		
Power and propulsion systems	5% to 15%	10% to 50%+	
Low-carbon fuels	5% to 15%*		
Renewable energy	1% to 10%		25% to 75%+
Exhaust gas CO_2 reduction	0%		
OPERATION (All ships)			
Fleet management, logistics & incentives	5% to 50%+		
Voyage optimization	1% to 10%	10% to 50%+	
Energy management	1% to 10%		

* CO_2 equivalent, based on the use of LNG.
† Reductions at this level would require reductions of operational speed.

Table 32.3.5: Assessment of potential reductions of CO2 emissions from shipping by using known technology [Second IMO GHG Study 2009]

Two other ideas emerged from this part of report are the potential for use of renewal energy on board as alternative power source; and LNG as alternative fuel; both of which in addition to CO2 reduction are serious alternatives to achieve significant reduction NOx, PM and SOx and compliance to relevant requirements.

Chapter 9: Comparison of emissions of CO2 from ships with emissions from other modes of transport

This part of the study investigates the energy efficiency in terms of CO_2 emission efficiency of various transportation means. The unit used to calculate and compare the modes of transport is CO_2 emitted per tonne*kilometres cargo carried as indicated in Figure 6.3; this is directly related to fuel consumption.

9.3 For a given period, the CO_2 emission efficiency is then defined as:

$$CO_2 \text{ efficiency} = \frac{CO_2}{\text{tonne} * \text{kilometre}}$$

where:

CO_2 = total CO_2 emitted from the vehicle within the period

tonne*kilometre = total actual number of tonne-kilometres of work done within the same period

Figure 32.3.6: CO2 emission efficiency calculation [Second IMO GHG Study 2009]

Despite large variations and uncertainties in the emission assessments, ranges of efficiencies are determined for sea, air, road and rail (Figure 32.3.7).

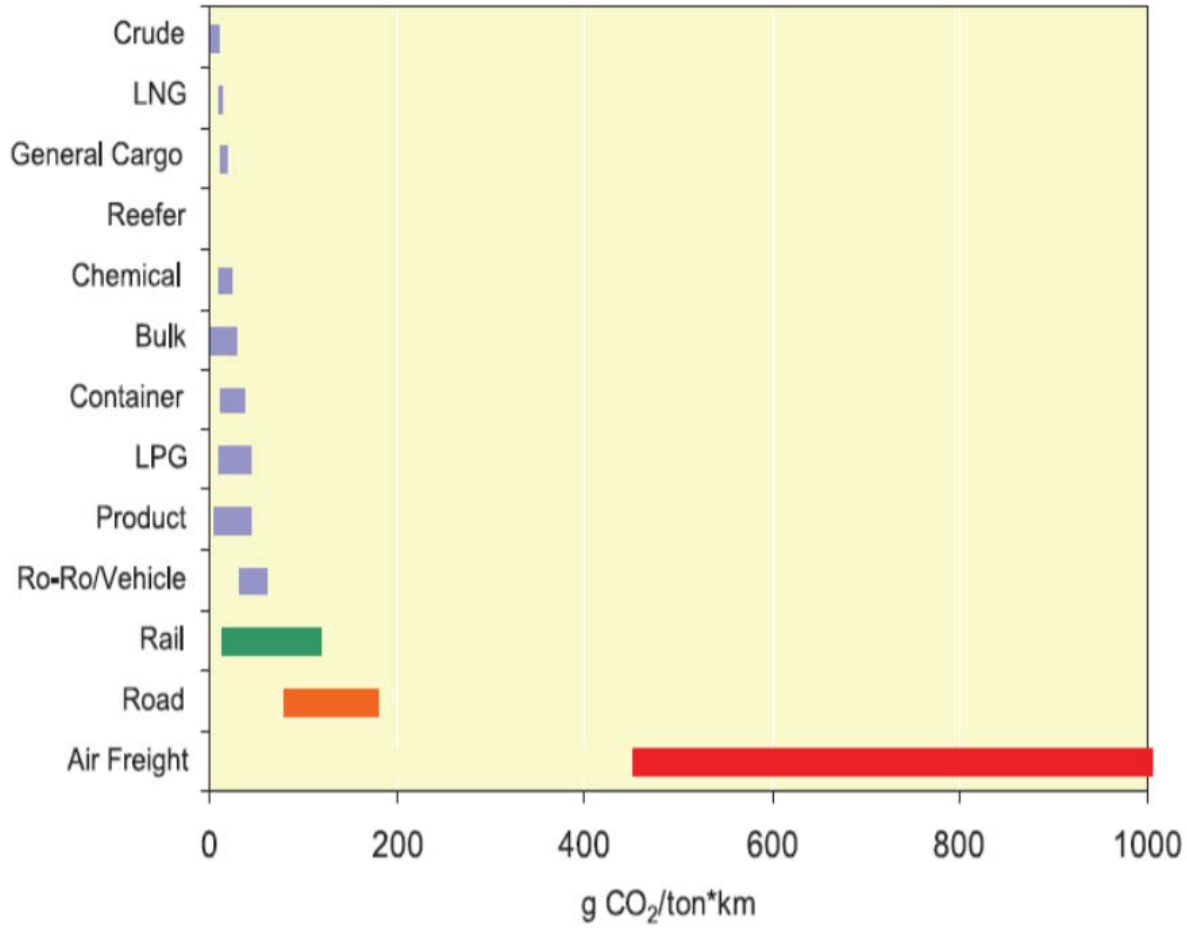


Figure 32.3.7: Typical range of ship CO2 efficiencies compared to rail, road and air freight [Second IMO GHG Study 2009]

The benchmarking of sectors highlights the significantly higher energy efficiency of sea transport modes. The historic trend toward efficiency is established and shows that the growing size enhances their efficiency. In addition, the share of shipping emissions is presented in relation with the total emissions (Figure 32.3.8).

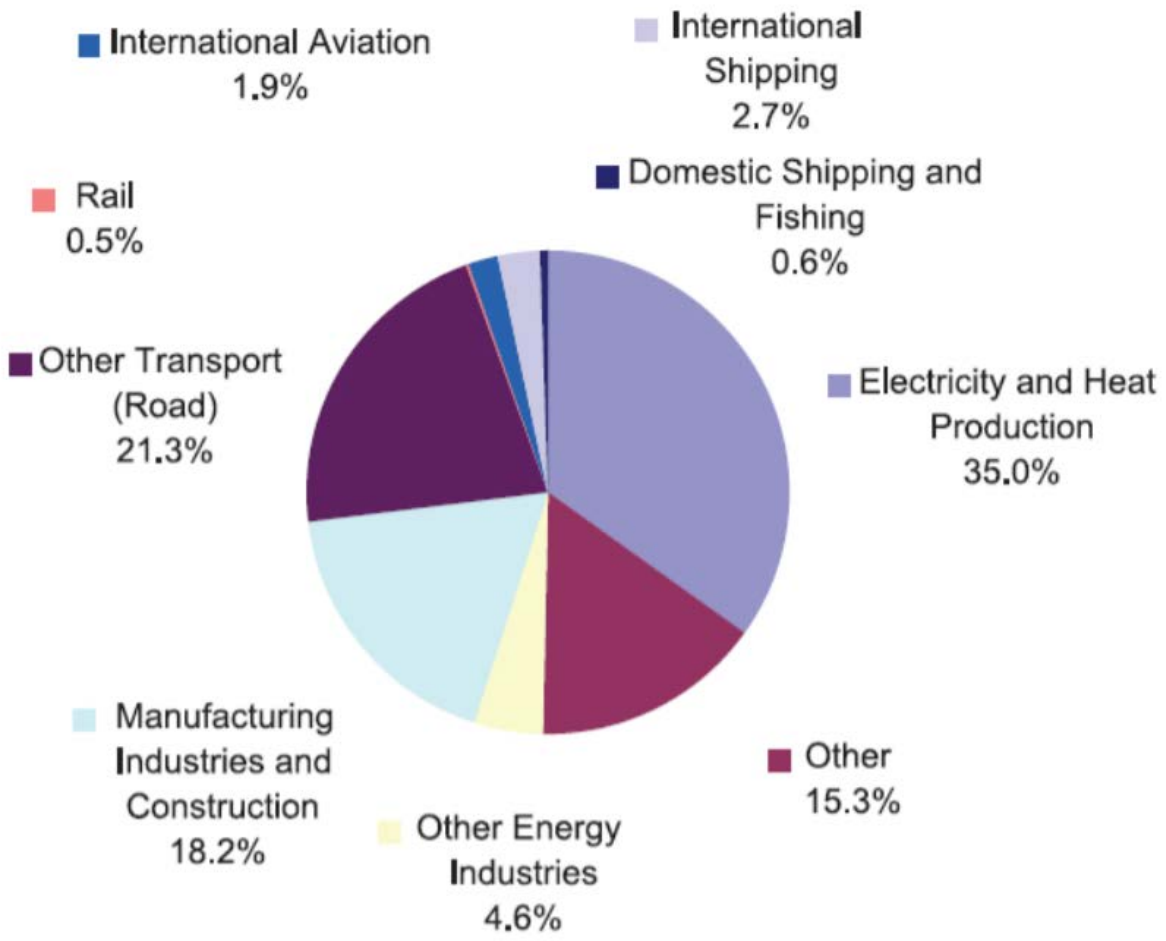


Figure 32.3.8: Emissions of CO2 from shipping compared with global emissions [Second IMO GHG Study 2009]

Policy options for international shipping

The Second IMO GHG Study 2009 discusses policy options that include technical, operational and market oriented approaches (see Figure 32.3.9). Among the several policies detailed in the Second IMO GHG study 2009, three groups of policies are intensively discussed at the IMO. The technical and operational approaches focus on ships and ship management while the economical approach seeks to achieve a global reduction of GHG by promoting incentives and penalties.

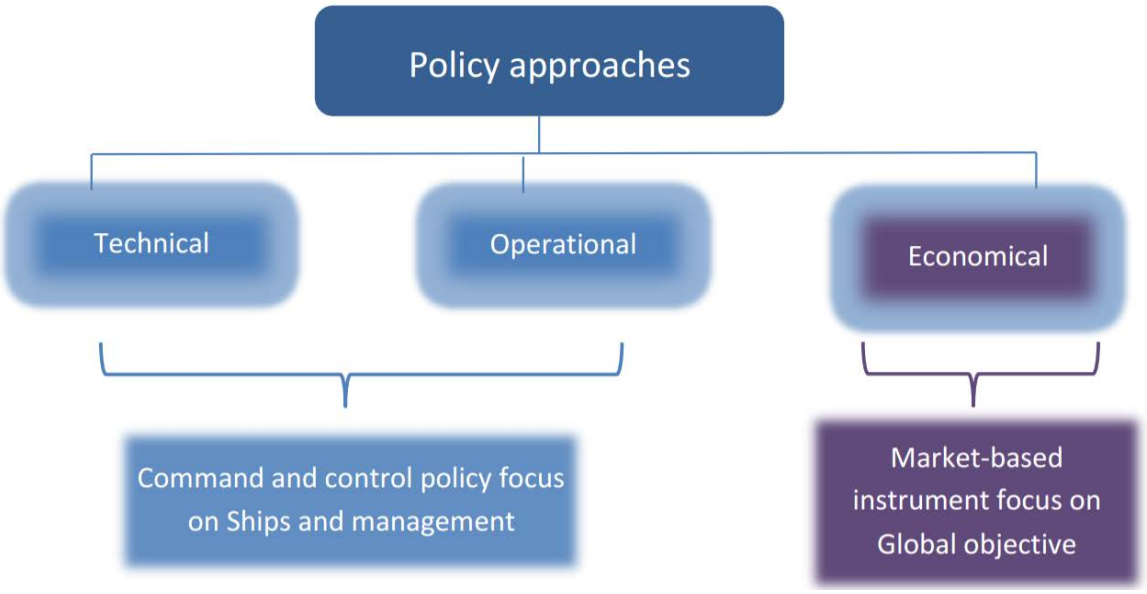


Figure 32.3.9: IMO policy approaches of the GHG emission reduction

Subsequently, the policy options on technical and operational measures were progressed and led to relevant regulations. The debate on Marked-Based Measures (MBMs) for the international shipping proved to be a particularly sensitive issue amongst IMO member States due to a number of reasons and the sheer complexity of the proposed schemes. As such, this policy option is still on hold within the IMO GHG control regulatory framework.

Main conclusions of report

The main conclusions reached by the Second IMO GHG Study 2009 include the following:

- Shipping was estimated to have emitted 1046 million tonnes of CO_2 in 2007, which corresponded to 3.3% of the global emissions during 2007. International shipping was estimated to have emitted 870 million tonnes, or about 2.7% of the global emissions of CO_2 in 2007.
- Exhaust gases were the primary source of air emissions and carbon dioxide was the most important GHG emitted by ships. Both in terms of quantity and of global warming potential, other GHG emissions from ships were less important.
- A significant potential for reduction of GHG emissions through technical and operational measures had been identified. Together, if implemented, these measures could increase efficiency and reduce the emissions rate by 25% to 75% below the current levels. Many of these measures appeared to be cost-effective, although non-financial barriers may discourage their implementation.
- A number of policies to reduce GHG emissions from ships were conceivable. The report analysed options and concluded that a mandatory limit on the Energy Efficiency Design Index for new ships was a cost-effective solution that could provide an incentive to improve the design efficiency of new ships. However, its environmental effect was limited because it only applied to new ships and because it only incentivized design improvements and not improvements in operations.
- Shipping had been shown, in general, to be an energy-efficient means of transportation compared to other modes.

If the climate was to be stabilized at no more than 2°C warming over pre industrial levels by 2100 and emissions from shipping continue as projected in the scenarios that were given in the report (growth of ship emissions by 200 to 300% by 2050 relative to 2007), then shipping would constitute between 12% and 18% of the global total CO_2 emissions in 2050. This would then require significant effort by shipping between 2050 and 2100 to achieve the stabilization targets.

32.4 Third IMO study on GHG 2014

Purpose of the study MEPC 63 noted that uncertainty exists in the estimates and projections of emissions from international shipping and agreed that further work should take place to provide the Committee with reliable and up to-date information to base its decisions. The Third IMO GHG Study 2014 was therefore commissioned by the IMO in order to update the Second IMO GHG Study 2009, with the main objective of focussing on the following topics:

- Development of the inventories of CO2 emissions from international shipping for 2007–2012
- Development of the inventories of other air emissions from international shipping for 2007–2012
- Development of future shipping scenarios and projection of shipping emissions for 2012–2050

The study was performed in 2013-2014 by an international consortium with a foresight role by a Steering Committee. The report of the study was approved by MEPC 67 in October 2014.

Methodology

Both, bottom-up and top-down methods were used, but consortium concluded that the bottom-up approach provides best-estimate. The bottom-up method used in this study, is similar to the Second IMO GHG Study 2009, however, in this study instead of using ship type, size and annual average activity for analysis purposes, the calculations of shipping's activity, fuel consumption and air emissions (GHG and pollutants) are performed for each in-service ship using detailed satellite information. The satellite data on an hourly basis for the full period of 2007-2012 were used for estimation of emissions. The hourly estimates are then aggregated to find the totals of emissions and fuel consumption, first per each fleet or ship type and then for international shipping and total shipping (international, domestic and fishing vessels combined) separately. Figure 32.4.1 shows an overview of satellite routes that represent the data used for this study.

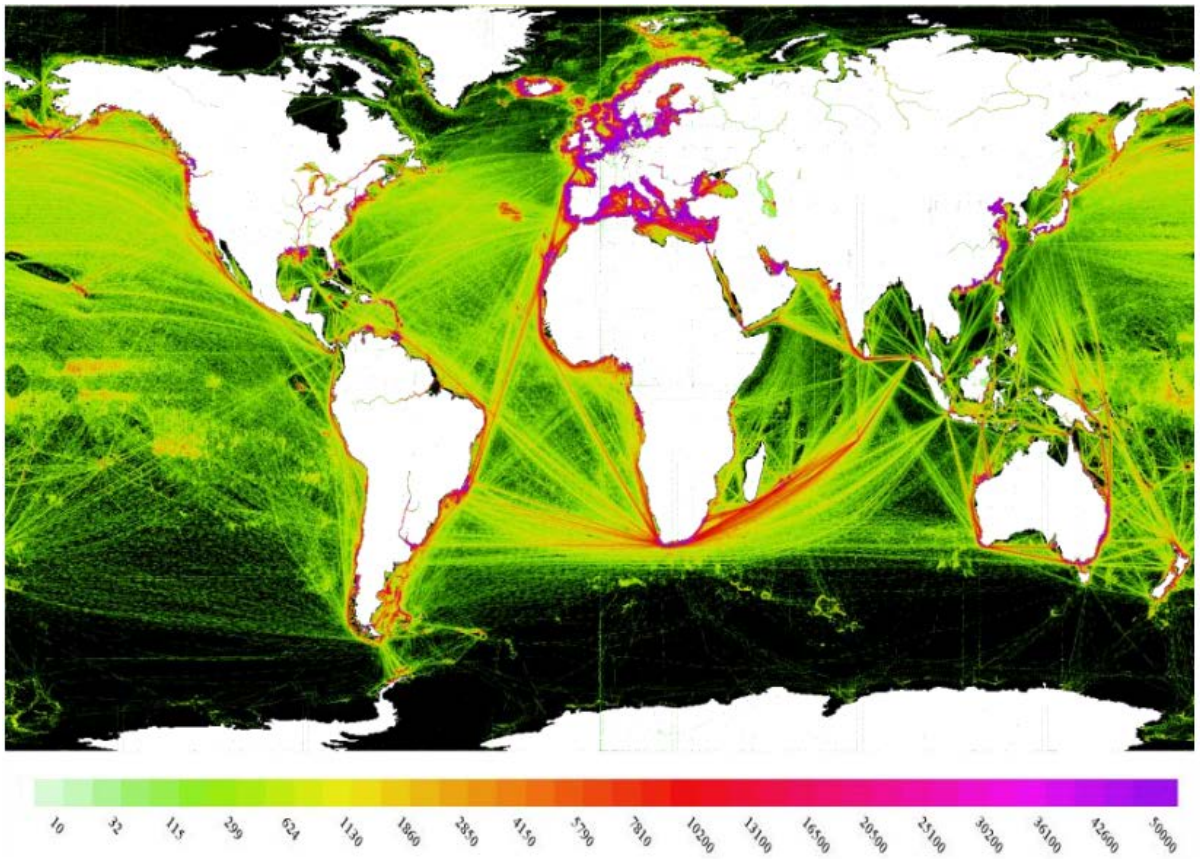


Figure 32.4.1: Geographical coverage using AIS data and shipping satellite data [Third IMO GHG Study 2014]

New CO_2 estimates (inventory)

Using the methodology, the international shipping CO_2 emissions estimates for 2007-2012 were established. The consensus CO_2 emissions estimate in tonnes and as a % share of global CO_2 emissions is shown in Table 32.4.2.

		IMO GHG Study 2014 CO_2			
Year	Global CO_2[1]	Total shipping	Percent of global	International shipping	Percent of global
2007	31,409	1,100	3.5%	885	2.8%
2008	32,204	1,135	3.5%	921	2.9%
2009	32,047	978	3.1%	855	2.7%
2010	33,612	915	2.7%	771	2.3%
2011	34,723	1,022	2.9%	850	2.4%
2012	35,640	938	2.6%	796	2.2%
Average	**33,273**	**1,015**	**3.1%**	**846**	**2.6%**

Table 32.4.2: Estimated emissions of CO_2 (million tonnes) from total shipping and international shipping [Third IMO GHG Study 2014]

The estimates in Table 6.6 indicate an overall reduction in CO_2 emissions from international shipping in both absolute terms and as a percentage of global CO_2 emissions for period 2007 to 2012.

For the year 2012, total shipping emissions were approximately 938 million tonnes CO_2 and 961 million tonnes CO_2e (CO_2 equivalent) for GHGs combining CO_2, CH_4 and N_2O. International shipping

emissions for 2012 are estimated to be 796 million tonnes CO_2 and 816 million tonnes CO_2e for total GHGs emissions combining CO_2, CH_4 and N_2O. Accordingly, international shipping accounts for approximately 2.2% and 2.1% of global CO_2 and GHG emissions on a CO_2 equivalent (CO_2e) basis respectively.

Figure 32.4.3 shows the breakdown of CO_2 emissions per ship type.

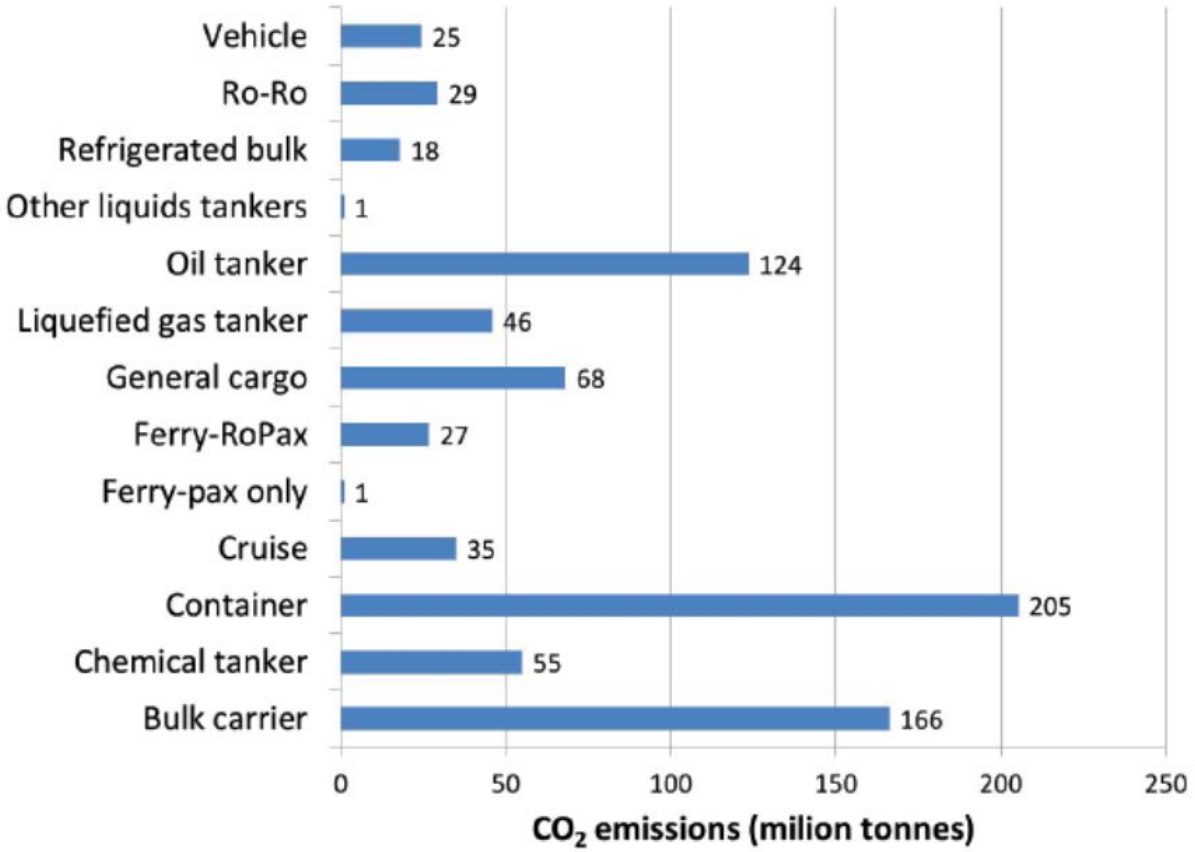


Figure 32.4.3: CO_2 emissions from international shipping by ship type for 2012 [Third IMO GHG Study 2014]

This Figure indicates that container ships, bulk carriers and oil tankers dominate the international shipping CO_2 emissions.

Trend and overall emissions inventories

Figure 32.4.4 shows the summary estimates of the air emissions inventories under this study.

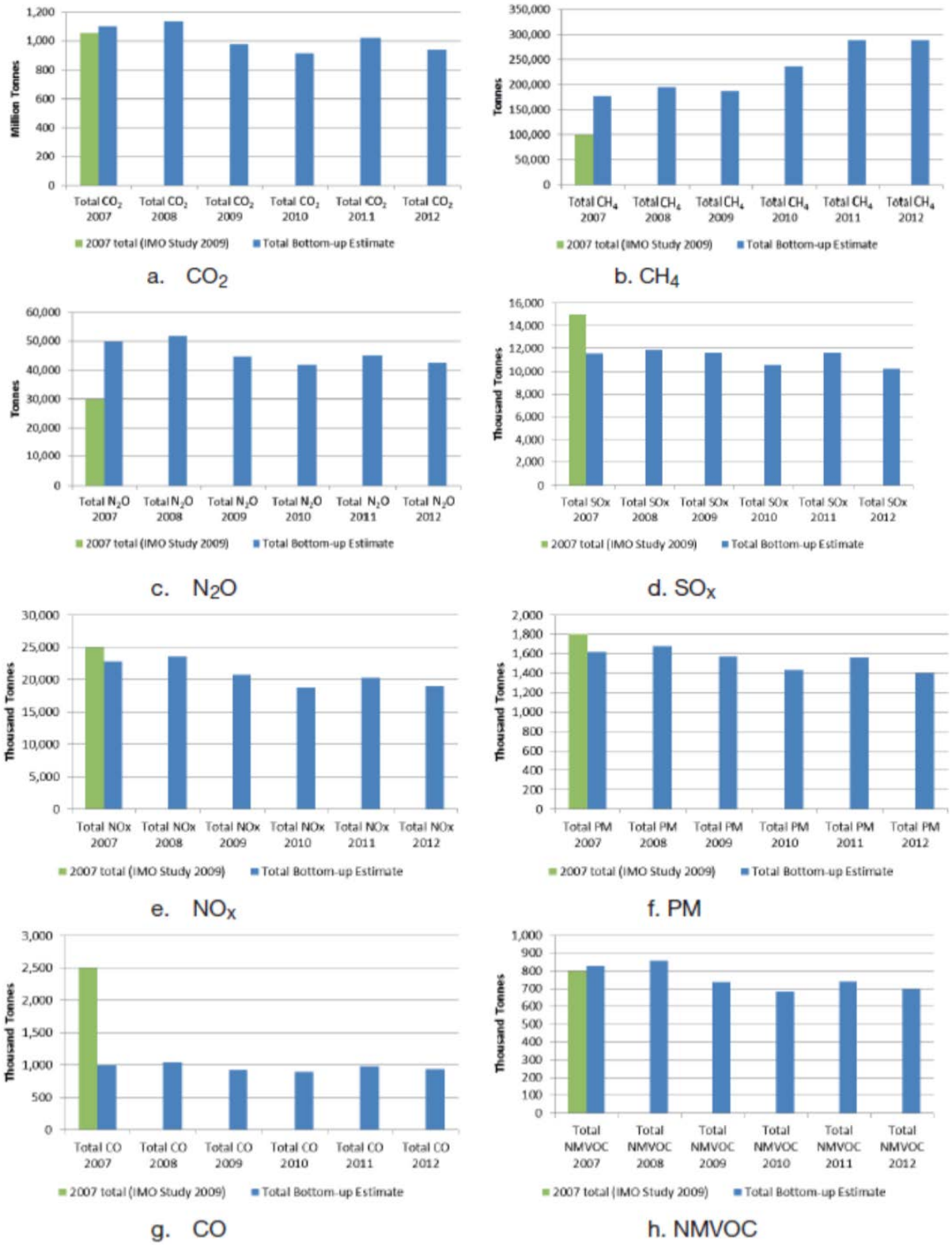


Figure 32.4.4: Emissions estimates for all shipping for period 2007 to 2012. Green bar represents the Second IMO GHG Study 2009 estimate [Third IMO GHG Study 2014]

From Figure 32.4.4, the following conclusions may be made:

NOx and SOx: This study estimates multi-year (2007–2012) average annual totals of 20.9 million and 11.3 million tonnes for NOx and SOx respectively from all shipping. Annually, international shipping is estimated to produce approximately 18.6 million and 10.6 million tonnes of NOx and SOx respectively. Global NOx and SOx emissions from all shipping represent about 15% and 13% of global NOx and SOx from anthropogenic sources reported in the IPCC Fifth Assessment Report (AR5), respectively. International shipping NOx and SOx represent approximately 13% and 12% of global NOx and SOx totals, respectively.

Fuel consumption: Over the period 2007–2012, average annual fuel consumption ranged between approximately 247 million and 325 million tonnes of fuel consumed by all ships within this study, reflecting top-down and bottom-up methods, respectively. Of that total, international shipping fuel consumption ranged between approximately 201 million and 272 million tonnes per year, depending on whether consumption was defined as fuel allocated to international voyages (top-down) or fuel used by ships engaged in international shipping (bottom-up), respectively. The total fuel consumption of shipping is dominated by three ship types: oil tankers, containerships and bulk carriers.

Figure 32.4.5 shows the breakdown of shipping fuel consumption per combustion system. As expected most of fuel consumption occurs in main engines followed by auxiliary engines. Consistently for all ship types, the main engines (propulsion) are the dominant fuel consumers while boilers use relatively smaller amount of fuel compared to auxiliary engines.

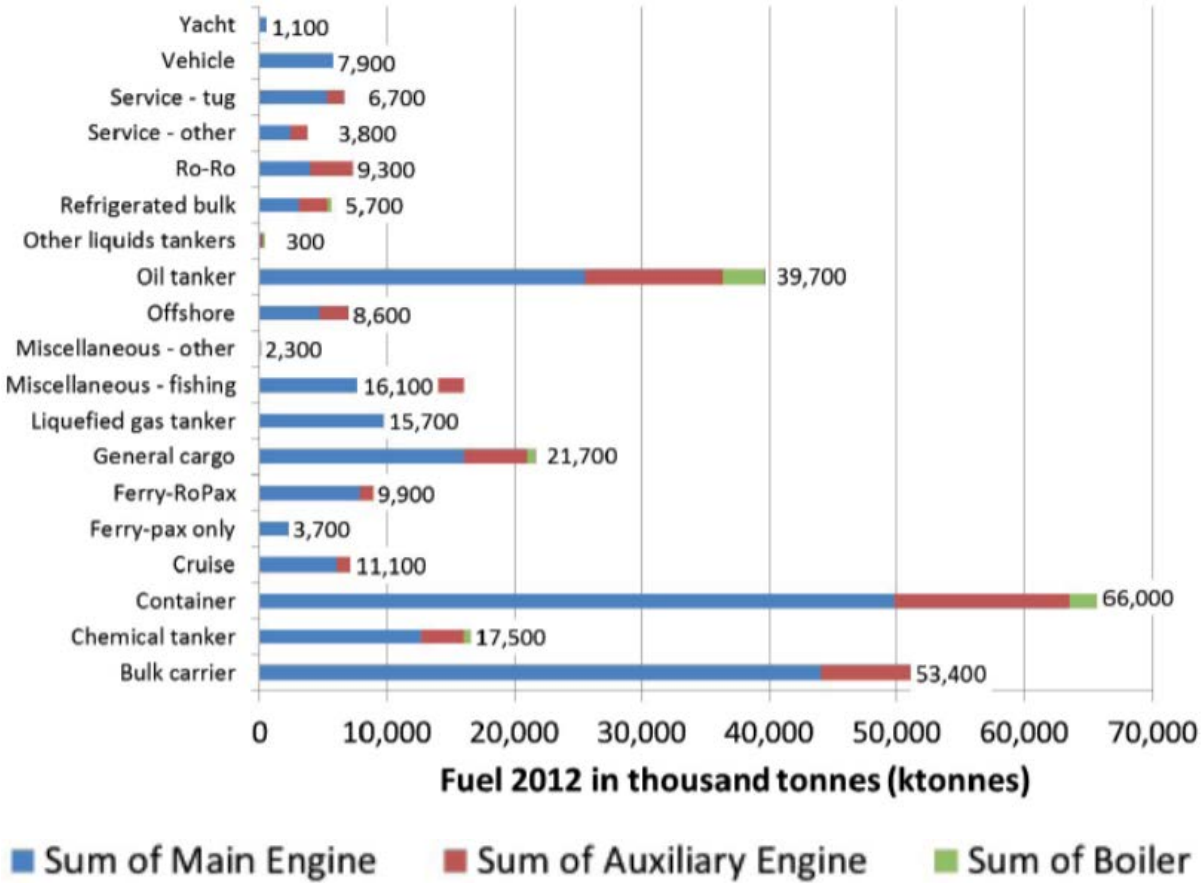


Figure 32.4.5: Annual shipping fuel consumption per ship type and combustion system [Third IMO GHG Study 2014]

CO_2 emissions: CO_2 emissions from shipping are estimated to range between approximately 739 million and 795 million tonnes per year in top-down results, and to range between

approximately 915 million and 1135 million tonnes per year in bottom-up results. International shipping CO_2 estimates range between approximately 596 million and 649 million tonnes calculated from top-down fuel statistics, and between approximately 771 million and 921 million tonnes according to bottom-up results.

CO_2 emissions projections for international shipping

As part of the study, scenario modelling was used to estimate the projected levels of the international shipping CO_2 emissions. A very large number of scenarios (altogether 16) were modelled that included the following options:

- Low and high LNG uptake as marine fuel
- Constant ECAs and more future ECAs
- High transport efficiency and low transport efficiency
- Various RCPs (Representative Concentration Pathways) for future shipping demand based on demand for commodities
- Various SSPs (Shared Socioeconomic Pathways) denoting economic activities and future economic growth

Figure 32.4.6 shows the CO_2 emissions projections for international shipping. The thick lines show the case for closely related scenarios.

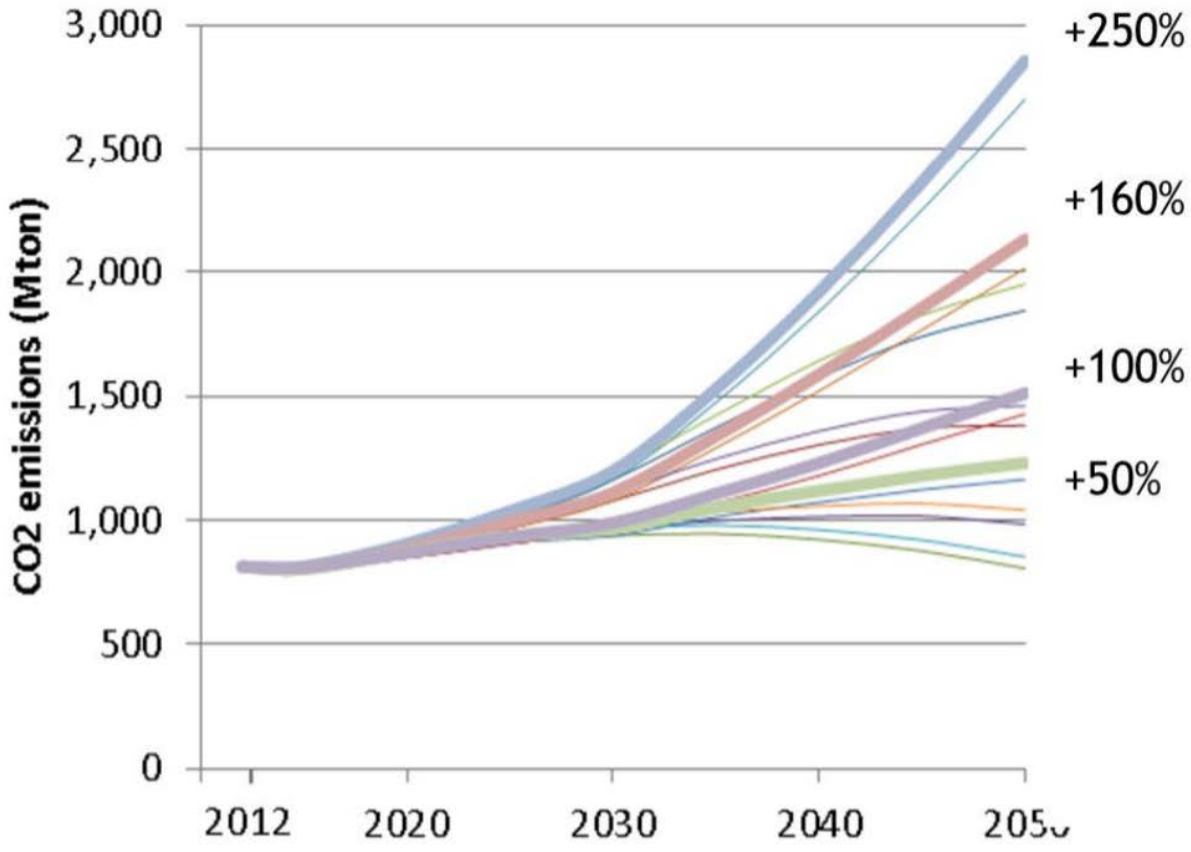


Figure 32.4.6: CO_2 emissions projections for international shipping [Third IMO GHG Study 2014]

Accordingly and depending on future scenarios, international shipping CO_2 emissions are projected to increase by 50% to 250% in the period to 2050, despite fleet average efficiency improvements of about 40% (in some scenarios, an efficiency improvement of 60% have been assumed). This study shows that under almost all the perceived scenarios, the CO_2 emissions will not decline in 2050

relative to 2012. Thus, further action on efficiency and emissions will be needed to stabilize GHG emissions from international shipping or bring it below 2012 levels in 2050.

Emissions projections demonstrate that improvements in efficiency are important in mitigating the emissions and reduce their rise. The scenarios also show that compared to regulatory or market-driven improvements in efficiency, changes in the fuel mix have a limited impact on GHG emissions, assuming that fossil fuels remain dominant.

32.5 History of IMO GHG-related activities

With a view to addressing the issue of air emissions from international shipping, IMO in its 1997 MARPOL Conference adopted MARPOL Annex VI on prevention of air pollution from ships and also adopted Resolution 8 on "CO2 emissions from ships" as a starting point inviting:

- the IMO Secretary-General to co-operate with the Executive Secretary of UNFCCC in the exchange of information on the issue of GHG emissions;
- IMO to undertake a study of GHG emissions from ships for the purpose of establishing the amount and relative percentage of GHG emissions from ships as part of the global inventory of GHG emissions; and
- The Marine Environment Protection Committee (MEPC) of IMO to consider feasible GHG emissions reduction strategies.

This was the starting point for IMO debates and decisions on GHG emissions from international shipping that still continues. Figure 32.5.1 provides the important chronological order of the IMO activities so far since 1997.

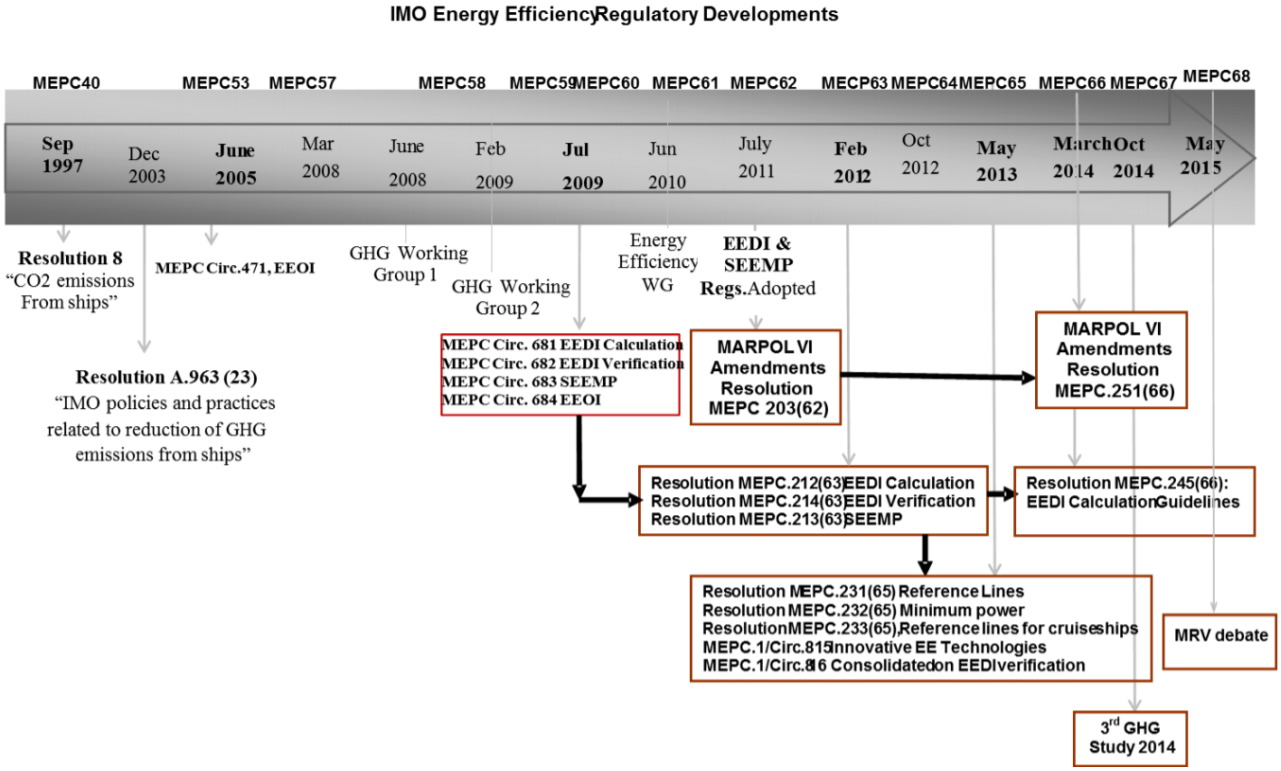


Figure 32.5.1: IMO GHG control related activities in chronological order

Further details of the IMO activities are given below in chronological order.

1997-2003

As a follow-up to Resolution 8, the First IMO GHG Study 2000 was completed and presented to the forty fifth session of the MEPC (MEPC 45) in June 2000.

2003-2008

In an effort to further address the issue of GHG emissions from ships, the IMO Assembly adopted, in December 2003, Resolution A.963 (23) on "IMO Policies and Practices related to the Reduction of Greenhouse Gas Emissions from Ships." As follow-up to this resolution, MEPC 55 (October 2006) approved the MEPC's "Work plan to identify and develop the mechanisms needed to achieve the limitation or reduction of CO_2 emissions from international shipping," inviting Member Governments to participate actively in the work plan.

MEPC 55 also agreed to update the "First IMO GHG Study 2000" to provide a better foundation for future decisions and to assist in the follow-up to resolution A.963 (23). MEPC 56 (July 2007) adopted the terms of reference for the updating of the study. The report of this study prepared by a consortium and was submitted to MEPC in 2009 under the title "Second IMO GHG Study 2009".

MEPC 59 (July 2009)

The MEPC work plan culminated at MEPC 59 with the MEPC agreeing to a package of technical and operational measures to reduce GHG emissions from international shipping and also agreed on a plan for further consideration and development of suitable and efficient Market Based Measures (MBMs) to complement the technical and operational reduction measures and to provide economic incentives for the shipping industry. The MEPC further agreed that any regulatory scheme to control GHG emissions from international shipping should be developed and enacted by IMO as the most competent international body

IMO's GHG / energy efficiency work plan at the time contained three distinct components:

- The technical measures that will mainly be applied to new ships. This was reflected in the development of EEDI related regulations.
- The operational measures for all ships in operation (new and existing). This was reflected in the development of SEEMP and EEOI.
- The MBMs providing market / competition incentives to the shipping industry by setting a sort of cost item for CO_2 emitters and incentives for those who reduce their CO_2 emissions.

Technical and operational measures: MEPC 59 finalized a package of technical and operational measures in the form of Guidelines for EEDI, SEEMP and EEOI. Relevant Guidelines developed and approved (in the form of Circulars) for the then voluntary application.

Market Based Measures (MBMs): The agreed package of the above technical and operational measures is a very important step in ensuring that the shipping industry has the necessary mechanisms to reduce its GHG emissions. However, the MEPC recognized that these measures would not be sufficient to satisfactorily reduce the amount of GHG emissions from international shipping in view of the growth projections of world trade. Therefore, MBMs was considered as a market-driven option by the MEPC in line with its GHG work plan. At the time, it was understood that a good MBM would serve two main purposes: (1) Offsetting in other sectors of growing ship emissions and (2) Providing a fiscal incentive for the maritime industry to invest in more fuel efficient ships and technologies and to operate ships in a more energy efficient manner.

MEPC 60 (2010)

The main work accomplished during this session was the preparation of the "draft regulatory text" on mandatory requirements for the EEDI for new vessels and on the SEEMP for all ships in operation. The MEPC realised that to finalise the regulatory text, it is required to decide on issues concerning ship size, ship types, target dates and reduction rate in relation to the EEDI requirements. The MEPC agreed in principle on the basic concept that a vessel's Attained EEDI shall be equal or less than the Required EEDI, and that the Required EEDI shall be drawn up based on EEDI reference lines and reduction rates. This became the subject of additional work and use of concrete methods for calculating the EEDI reference line using data from existing ships in the IHS Fairplay database. With regard to MBM, the MEPC agreed to establish an Expert Group on the subject to undertake a feasibility study and impact assessment of the various proposals submitted for a MBM instrument for international maritime transport.

MEPC 61 (2010)

Technical and operational measure: Having considered means by which technical and operational measures could be introduced in MARPOL Annex VI, there were further debates and agreement on how these regulatory texts should be introduced. The debate concentrated for the IMO Secretary-General to circulate proposed amendments to MARPOL Annex VI for mandatory application of EEDI and SEEMP regulatory text and relevant Guidelines that have already been disseminated for voluntary use. The issue of circulation by the Secretary General was the subject of much debate as some States did not consider it appropriate.

Market-Based Measures: The scope of the work of the Expert Group was to evaluate the various proposals on possible MBMs, with the aim of assessing the extent to which they could assist in reducing GHG emissions from international shipping, giving priority to the maritime sectors of developing countries, least developed countries (LDCs) and Small Island Developing States (SIDS). The MBM proposals under review ranged from a GHG Fund or levy on all CO2 emissions from international shipping or only from those ships not meeting the EEDI requirement, via emission trading systems, to schemes based on a ship's actual efficiency, both by design (EEDI) and operation (SEEMP).

The MEPC agreed Terms of Reference for an intersessional meeting of the "Working Group on GHG Emissions from Ships" to deal with relevant schemes and submissions and report back to MEPC 62.

MEPC 62 (July 2011)

The final breakthrough came at MEPC 62. As a result of lengthy deliberations, the amendments to MARPOL Annex VI in the form of "energy efficiency regulations for ships" were added as a new Chapter 4 to MARPOL Annex VI as a result of which EEDI and SEEMP became mandatory for applicable ships. Other amendments to Annex VI included addition of new definitions and the requirements for survey and certification, including the format for the International Energy Efficiency Certificate.

MEPC 63 (2012)

An important series of guidelines to support the uniform implementation of mandatory measures for ship energy efficiency (EEDI and SEEMP) was adopted by the MEPC in this session. During this session, the MEPC also continued its intensive discussion on MBMs for application to international shipping.

MEPC 64 (2013)

The MEPC continued to refine relevant Guidelines on calculation and verification of EEDI. MEPC additionally approved the following:

- A number of UIs (Unified Interpretations) on definition of "new ships" for various EEDI phases, on timing of ships to have a SEEMP on-board and also on "major conversion" for energy efficiency purposes.
- Decided on development of interim guidelines for determining minimum propulsion power to maintain the manoeuvrability of ships in adverse conditions and draft Guidelines on treatment of innovative energy-efficiency technologies.
- A debate on Regulation 23 of chapter 4 of MARPOL Annex VI on “promotion of technical cooperation and transfer of technology” that led to a text of a draft resolution3 on issues relating to technology transfer for the improvement of energy efficiency of ships.
- In principle endorsed and outline for an update of the previous GHG Studies including GHG inventory. Finally, it decided to defer debates on MBMs to MEPC 65.

MEPC 65 (2013)

During this MEPC meeting, the following were accomplished:

- Resolution on MEPC.229 (65) on Promotion of Technical Co-operation and Transfer of Technology Relating to the Improvement of Energy Efficiency of Ships was adopted.
- Study to update the previous GHG Study approved: The MEPC approved the terms of reference and agreed to initiate a study for an update of previous IMO GHG Studies.
- Development of energy-efficiency regulations continued: The MEPC continued its work on further developing the EEDI and SEEMP framework. This included approval of draft amendments to MARPOL Annex VI to extend the application of EEDI to ro-ro cargo ships (vehicle carrier), LNG carriers, cruise passenger ships having non-conventional propulsion, ro-ro cargo ships and ro-ro passenger ships; and to exempt ships not propelled by mechanical means, and platforms including FPSOs and FSUs and drilling rigs, regardless of their propulsion; as well as cargo ships having ice-breaking capability.
- Adopted amendments to update a number of Guidelines on EEDI. Adopted those Guidelines that were approved under MEPC 64.
- *Further measures to improve the energy efficiency of ships:* The MEPC considered the importance of enhancing the existing framework (EEDI and SEEMP) for further reduction of shipping GHG emissions. As such the MEPC agreed to establish a sub-agenda item for discussion of further technical and operational measures for enhancing energy efficiency for international shipping, and to establish a working group under this sub-agenda item at MEPC 66.

MEPC 66 (April 2014)

The following aspects were discussed but no substantive decision made:

- Energy-efficiency measures for ships considered: The MEPC continued its work on further developing guidelines to support the uniform implementation of the regulations on energy-efficiency for ships.
- Technical co-operation and technology transfer discussed: The MEPC discussed the implementation of resolution MEPC.229 (65) on Promotion of Technical Co-operation and Transfer of Technology Relating to the Improvement of Energy Efficiency of Ships. The Ad Hoc Expert Working Group on Facilitation of Transfer of Technology for Ships (AHEWG-TT),

established in accordance with the resolution, met during the session and agreed a work plan with the following terms:

- Assessing the potential implications and impacts of the implementation of the energy efficiency regulations in chapter 4 of MARPOL Annex VI, in particular, on developing States, as a means to identify their technology transfer and financial needs;
- Identifying and creating an inventory of energy efficiency technologies for ships;
- Identifying barriers to transfer of technology, in particular to developing States, including associated costs, and possible sources of funding; and making recommendations, including the development of a model agreement enabling the transfer of financial and technological resources and capacity building between Parties, for the implementation of the energy efficiency regulations.

- Further measures for improving energy efficiency of ship: The MEPC discussed various submissions relating to proposals to establish a framework for the collection and reporting of data on the fuel consumption of ships.

MEPC 67 (October 2014)

The following activities were carried out:

- Energy-efficiency measures for ships considered: During the session, the MEPC adopted a number of changes to various Guidelines including:
- The 2014 Guidelines on survey and certification of the Energy Efficiency Design Index (EEDI), updating the previous version to include, for example, identification of the primary fuel for the calculation of the attained EEDI for ships fitted with dual-fuel engines using LNG and liquid fuel oil.
- The MEPC also adopted amendments to the 2013 Interim Guidelines for determining minimum propulsion power to maintain the manoeuvrability of ships in adverse conditions.
- A correspondence group was established to review the status of technological developments relevant to implementing phase 2 of the EEDI regulatory framework as foreseen under Regulation 21.6.
- *Further measures* - Data collection system for fuel consumption of ships: The MEPC agreed, in principle, to develop a data collection system for ships and, having agreed on the general description of the data collection system for fuel consumption of ships, agreed to the reestablishment of an intersessional correspondence group to develop full language regulatory text so that it can be readily used for voluntary or mandatory application of the system. The core elements of the data collection system included: (1) data collection by ships, (2) flag State functions in relation to data collection including verification and (3) establishment of a centralized database by the IMO.
- *Third IMO GHG Study 2014 approved:* The MEPC approved the Third IMO GHG Study 2014 providing updated estimates for GHG emissions from ships (see Section 6.3 for details of this study).

MEPC 68 (May 2015)

In this session of the MEPC, the following were agreed:

- Further development of energy-efficiency guidelines for ships: The MEPC continued its work on further develop and approved/adopted guidelines to assist in the implementation of the mandatory energy-efficiency regulations in particular the EEDI.

- EEDI review work to continue: The progress of the Correspondence Group established to review the status of technological developments relevant to implementing phase 2 of the EEDI regulations, as required under regulation 21.6 of MARPOL Annex VI, was received and MEPC decided to re-establish the Correspondence Group to further the work.
- Text agreed for further development of a data collection system: On “further measures”, the MEPC agreed that the full language text for the data collection regulations need to be enhanced. The proposed text was preliminary agreed and the Correspondence Group was re-convened to continue work on this text and report back to future MEPC meetings.

All the above activities will be reported back to MEPC 69 in March 2016.

32.6 Current regulatory framework

As discussed in previous section, through extensive discussions within the IMO, mandatory measures to reduce emissions of GHG from international shipping were adopted by Parties to MARPOL Annex VI at MEPC 62 in July 2011. This provided the first ever mandatory global GHG reduction regime for an international industry sector.

This amendments to MARPOL Annex VI Regulations for the prevention of air pollution from ships, added a new chapter 4 on Regulations on Energy Efficiency for Ships to make mandatory the Energy Efficiency Design Index (EEDI), for new ships, and the Ship Energy Efficiency Management Plan (SEEMP) for all ships. Other relevant amendments to Annex VI included new definitions and the requirements for survey and certification, including the format for the International Energy Efficiency Certificate. Additionally, voluntary Guidelines for calculation of Energy Efficiency Operational Indicator (EEOI), that was developed and agreed in 2009, can be used for operational monitoring of ships energy efficiency measures.

These technical and operational measures are collectively shown in Figure 32.6.1, which also indicates how EEDI, SEEMP and EEOI will work collectively to cover both ship design and operation.

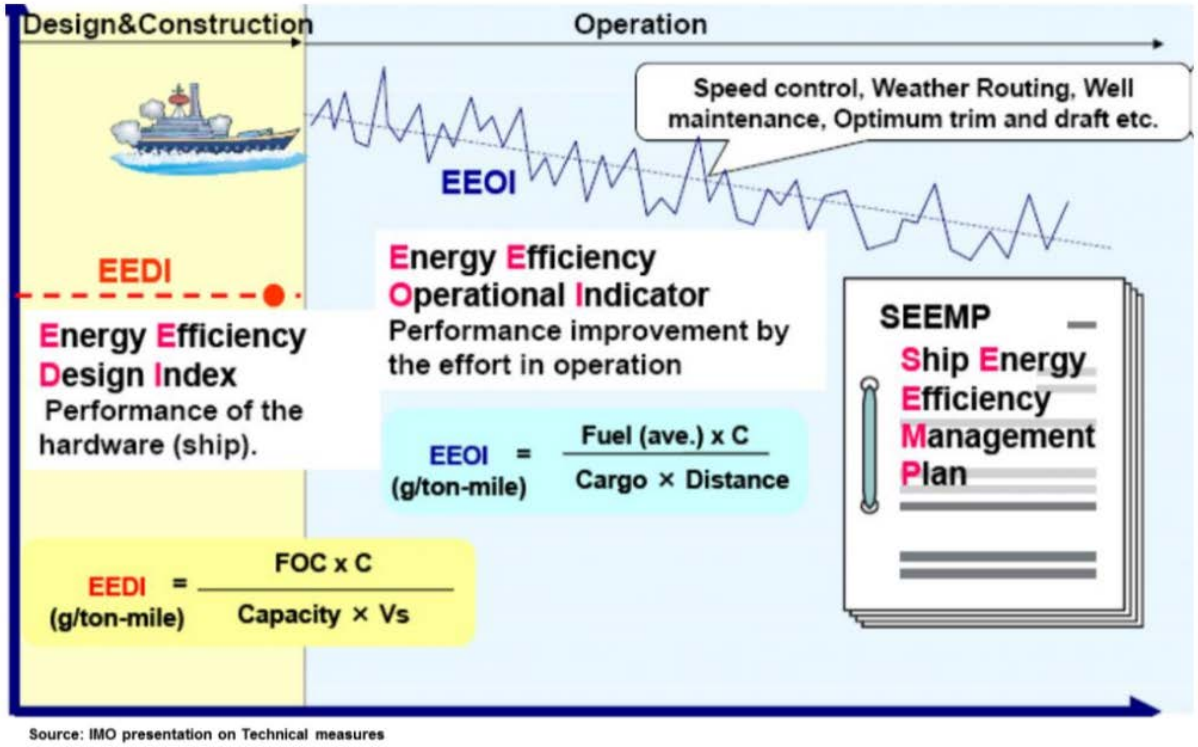


Figure 32.6.1: Main components of the IMO energy efficiency regulations

An important series of guidelines to support the uniform implementation of the above mandatory measures are adopted, paving the way for the regulations to be smoothly and uniformly implemented by Administrations and industry. Some examples of these Guidelines include:

- 2014 Guidelines on the method of calculation of the attained Energy Efficiency Design Index (EEDI) for new ships, as amended;
- 2012 Guidelines for the development of a Ship Energy Efficiency Management Plan (SEEMP);
- 2014 Guidelines on survey and certification of the Energy Efficiency Design Index (EEDI), as amended; and
- 2013 Guidelines for calculation of reference lines for use with the Energy Efficiency Design Index (EEDI).

32.7 IMO Further energy efficiency measures

A number of studies including IMO MEPC 63/INF.2 by Bazari and Longva (2011) and the Third IMO GHG Study 2014 indicate that successful implementation of the shipping technical and operational energy efficiency regulations could reduce shipping GHG emissions significantly, but on their own they are not sufficient to prevent the rising trend in shipping GHG emissions under all existing growth scenarios. Consequently, the IMO began working on further technical and operational measures including the development of a global shipping data collection system for energy efficiency as a first step priority area.

Since April 2014 as a result of MEPC 67 and 68 meetings, IMO reached preliminary conclusions on a general description of such a global data collection system. Based on results of the relevant MEPC working group deliberations, the data collection and reporting requirements would apply to ships involved in international shipping over a certain size threshold and regardless of their flag State.

The draft developed data collection system identifies three core elements including: (1) data collection by ships, (2) flag State functions in relation to data collected including verification and (3) establishment of a centralized database by the IMO. As it stands now (2015), the following features are under considerations for the IMO data collection system:

- Applicable to ships of gross tonnage more than 5000 GT
- Annual reporting
- IMO number for ship identification
- Confidentiality of some data such as transport work will be observed.
- Guidelines will be developed to deal with various details of data collection and verification activities.
- Registered owner will be responsible for submission of data to Administration
- Administration will be responsible for verification (can be delegated to Recognized Organizations).
- A Statement of Compliance (SoC) will be issued by the Administration to each ship annually.
- PSC (Port State Control) will examine SoC for enforcement
- In addition to ship's fuel consumption, other data may be collected such as transport work and distance sailed. These will be discussed and decided later.

Thus in summary, beginning at a specific date, ships should annually submit their data to a centralized database maintained and managed by the IMO. Flag States should put in place mechanism(s) to ensure compliance by the ships entitled to fly their flag with the annual data collection requirements; and that data included in annual reports is sent to the centralized database. The compliance system of the flag State should have provisions for the transfer of ownership and change of flag. The above is the current general agreement; however, this is a work-in-progress at

the IMO that is planned to be finalised in the future (expected by MEPC 70 in late 2016). It is worth noting that EU has already legislated an MRV (Measurement, Reporting and Verification) system for shipping that has similarities to IMO current work.

32.8 Implementation and enforcement suport

IMO supports to extent possible the implementation aspects of its regulations in particular supporting the developing countries. In this section, such activities are described further.

IMO Technical Co-operation (TC) programme

IMO through its Technical Cooperation Department and relevant budgets as well as through donor country funds organises a number of activities mainly in area of capacity building in the form of training workshops. In specific area of shipping GHG control, the following activities have been done so far:

- National and regional workshops on MARPOL Annex VI and GHG emissions from international shipping with the main aim of raising awareness on the subject. A number of such workshops have already been conducted in a number of countries and regions.
- Under the IMO's Integrated Technical Co-operation Programme, a sum of $400,000 was allocated for the 2012 to 2013 biennium for various national and regional capacity building activities. This sum financed regional training and seminars supporting capacity building and information exchange and sharing.
- A further $400,000 has been allocated for the 2014 to 2015 biennium to sustain the level of technical cooperation interventions in various regions, for the effective implementation and enforcement of energy efficiency measures for ships.
- In addition, some IMO members made donations for capacity building activities/workshops to support the implementation of the existing international energy efficiency rules and assess the need for technology transfer. The IMO completed in 2013 a major technical cooperation project on "Building capacities in East Asian countries to address GHG emissions from ships" with $700,000 funding support of the Korea International Cooperation Agency (KOICA). Additionally, funding received for other donors such as the Government of Canada in promoting adoption and implementation of the MARPOL Annex VI with specific emphasis on GHG emissions from shipping.

IMO-UNDP-GEF Initiative

In 2014, the IMO Secretariat submitted a proposal to Global Environment Facility (GEF) for funding a two-year global project entitled 'Transforming the Global Maritime Transport Industry towards a Low Carbon Future through Improved Energy Efficiency' to assist the developing countries in the implementation of new energy efficiency measures adopted by IMO. This project was endorsed by GEF in 2015.

The main activities under this project are foreseen to include the following components; all related to promotion of low carbon shipping in the participating pilot countries:

1. Legal, Policy and Institutional Reforms (LPIR): This is the priority component within the project and aims to improve the host country legal, policy and institutional frameworks. This will be achieved via carrying out country status / baseline assessment, development of global guidance and model legislations, support for customisation and finally the implementation.
2. Capacity building and knowledge exchange: The core of this activity includes the long-term capacity-building for the accelerated implementation of IMO energy efficiency regulations.

This will be achieved via extensive set of training activities, workshops, participation in international events as well as dissemination of information.

3. Public-private partnership for innovation and R&D: This activity primarily aims to catalyse maritime sector energy efficiency innovation and R&D. To achieve this, the project aims to promote partnerships such as (1) global forums to highlight best practices and R&D on maritime energy efficiency and (2) formation of a Global Industry Alliance for industry, academia and ship design and operation R&D community to promote debates and R&D.

9 Developing countries are taking part in implementation of this project.

Technology transfer debate

The amendments to MARPOL Annex VI which introduced "the energy efficiency regulations for ships" also included a new Regulation 23. Regulation 23 encourages the Parties to MARPOL Annex VI in cooperation with the IMO and other international bodies:

- To promote and provide, as appropriate, support directly or through the IMO to States, especially developing States that request technical assistance.
- Co-operate actively with other Parties, subject to its national laws, regulations and policies, to promote the development and transfer of technology and exchange of information to States which request technical assistance, particularly developing States, in respect of the implementation of Chapter 4 of MARPOL Annex VI.

Moreover, it was agreed at the time of the adoption of energy efficiency regulations, to complement them with a resolution on "promotion of technical co-operation and transfer of technology relating to the improvement of energy efficiency of ships", which was adopted in May 2013 as Resolution MEPC.229 (65). This Resolution provides a framework for the promotion and facilitation of capacity building, technical cooperation, and technology transfer to support the developing countries in the implementation of the EEDI and the SEEMP. Amongst others, it invites international and regional organizations, non-governmental organizations and the industry to contribute in any manner possible and as appropriate to enhancing the effective implementation of chapter 4 of MARPOL Annex VI.

An AHEWG-TT (Ad Hoc Expert Working Group on Facilitation of Transfer of Technology for Ships) was set up by IMO MEPC to deal with implementation of the Resolution with terms of reference that include:

- Assess the potential implications and impacts of the implementation of chapter 4 regulations, in particular, on developing States, as a means to identify their technology transfer and financial needs;
- Identify and create an inventory of energy efficiency technologies for ships.
- Identify barriers to transfer of technology, in particular to developing States, including associated costs, and possible sources of funding and make recommendations.
- Develop a model agreement enabling the transfer of financial and technological resources and capacity-building between Parties.

The AHEWG-TT activities had so far had a number of meetings and produced a number of documents. At the time of writing this Module (2015), the work of AHEWG-TT is in progress with completion date of MEPC 70 (October 2016).

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