# Chapter 2
# Mitigation of Air Emissions: Existing Policy Actions and Legislation

**Abstract** "Climate change is a serious problem and an international response is demanding, which must be based on a shared understanding of long-term goals and agreement on frameworks for action" (Stern in The economics of climate change-the stern review. Cambridge University Press, UK, Stern 2006). Reducing the environmental burdens of maritime transport is a challenging task, since such impacts are not only due to navigation but also due to activities carried out inside ports. In 2011 the IMO's Marine Environment Protection Committee (MEPC) adopted mandatory technical and operational energy efficiency measures for all ships irrespective of flag and ownership status. Also, the European Commission has recently settled down to a strategy for progressive inclusion of the GHG emissions from maritime transportation in the EU's policy for reduction of overall emissions. As a first step in implementing this strategy, the Commission has proposed a Regulation which would establish an EU-wide system for the monitoring, reporting and verification (MRV) of $CO_2$ emissions from large ships effectively starting in 2018. The EU has also expressed its concerns about the impact of transport on air quality through the Strategy for Sustainable Development published on its White Paper on Transport Policy, leading to the establishment of stringent sulphur regulation for marine fuels.

## 2.1 Environmental Legislation on Air Pollutants and Greenhouse Gases Related to the Maritime Sector

Climate change is the new term that triggers the common interest, which has been discussed broadly around the world and has been regarded as a factor contributing to all global issues (Shi 2016). GHG emissions are the largest contributors to climate change and therefore the international community has focused in adopting measures in order to mitigate such emissions effectively. Under the 2011 amendments to the Kyoto Protocol and UNFCCC, seven types of GHGs are listed: $CO_2$, $CH_4$, $N_2O$, HFCs, PFCs, $SF_6$ and $NF_3$ (IPCC 2007).



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In 2007, $CO_2$ emissions from maritime sector accounted for 3.3 % of the global amount of emissions while in 2012 shipping emits 949 million tonnes of $CO_2$ annually and is responsible for about 2.2 % of global greenhouse gas emissions (Buhaug et al. 2009; IMO 2014a, b). Shipping emissions are predicted to increase between 50 and 250 % by 2050—depending on future economic and energy developments. This is not compatible with the internationally agreed goal of keeping global temperature increase to below 2 °C compared to pre-industrial levels, which requires worldwide emissions to be at least halved from 1990 levels by 2050. The EU and its Member States have a strong preference for a global approach led by the IMO as this will be most effective. Considerable efforts to agree such an approach have been made over recent years within both the IMO and the United Nations Framework Convention on Climate Change (UNFCCC) (EU 2015).

The formulation of legislation related to the environmental impacts of the shipping sector is a serious challenge due to the unique characteristics of the shipping sector, the global operations in trade, the differences in the registration and owners' origins of ships and the fact that marine fuel can be bunkered throughout the world. These difficulties are evident in the ambition level set by the EU to tackle GHG emissions from international shipping which strongly differs from the targets set by the IMO (EEA 2013).

There are currently more than 150 countries belonging to the IMO, which is the most powerful international organization in the field of ocean shipping. The objectives of the IMO include sustaining safety in sea transportation, promoting navigational efficiency, and protecting the ocean environment (Han 2010). The IMO is responsible for drafting various international conventions related to maritime affairs, with regulations covering navigation, marine rescue, and ships' structural and equipment requirements. The Marine Environment Pollution Committee (MEPC), is a sub-organization of the IMO which is specifically responsible for drawing up relevant regulations to prevent ships from polluting the ocean and the atmosphere. As the rapid development of international commerce increased the number of shipping vessels, the pollution induced by these ships has become an issue of great concern. To address this, the IMO amended the International Convention for the Prevention of Pollution from ships in 1973. As the 1973 MARPOL Convention had not yet entered into force, the 1978 MARPOL Protocol absorbed the parent Convention (referred as MARPOL 73/78). It represents the main IMO Convention, currently in force, regarding the protection of the marine environment. The Convention's principle articles deal mainly with jurisdiction and powers of enforcement and inspection. More detailed anti-pollution regulations are given in the annexes, which were adopted or amended by the MEPC, with the positive opinion of a number of parties, representing 50 % of the GT of the world's merchant fleet. This protocol regulates the draining standards for used oil, sewage, and waste materials. Air polluting exhaust fumes, from marine power plants, have also become a cause for concern within the international community in recent years (IMO 2013). Six (VI) annexes of the Convention cover the various sources of pollution from ships and provide an overarching framework for international objectives but, without ratify caution and implementation by sovereign states, they are not sufficient to

protect the marine environment from waste discharges. A State that becomes party to MARPOL must accept Annexes I and II, while acceptance of Annexes III–VI is voluntary. All six Annexes have been ratified by the requisite number of nations. Each signatory nation is responsible for enacting domestic laws to implement the Convention and effectively pledges to comply with the Convention, its annexes, and the related laws of other member nations.

In the late 1980s, IMO started its work on prevention of air pollution from ships. These efforts were based on scientific information on adverse effects of atmospheric emissions from a multitude of sources (ships being one of them) on human health and vulnerable ecosystems. This was something of a departure, as IMO's focus, along with that of national regulators and of the society as a whole, had previously been on more visible sources of ship-sourced pollution—for example, on oil spills resulting from major ship accidents. The harmful long-term effects of exhaust gases on human health and ecosystems were not so immediately visible and had not earlier been fully recognized (IMO 2011a, b). The seventeenth session of the IMO Assembly, in November 1991, recognizing the urgent necessity of establishing an international policy on prevention of air pollution from ships, considered and decided to develop a new annex to the International Convention for the Prevention of Pollution from Ships (MARPOL Convention). In 1997, IMO acknowledged the importance of air pollution and through the MARPOL Convention of 1997, it added a new Annex VI, Regulations for the Prevention of Air Pollution from Ships, to the MARPOL Convention (MARPOL Annex VI). Annex VI, setting limits on sulphur oxide ($SO_x$) and nitrogen oxide ($NO_x$) emissions from ship exhausts and prohibiting deliberate emissions of ozone-depleting substances. Annex VI was ratified by 60 contracting States with 84.04 % of the world's merchant shipping tonnage. MARPOL Annex VI came into force on 19 May 2005. These regulations aiming at the prevention of ships' air pollution include the following:

1. Emission standards for $NO_x$ according to the power output of marine diesel engines and required installation of exhaust gas cleaning systems to reduce $NO_x$ emissions (Table 2.1);
2. Limits in sulfur content of fuel oil used in ships to reduce $SO_x$ emissions and requirements for exhaust gas cleaning systems or technologies to limit $SO_x$ emissions to 6.0 g $SO_x$/kWh or less;
3. Provision for vapor collection systems, or other vapor emission control systems to reduce the emissions of VOCs;
4. Requirement for shipboard incinerators;
5. Restricted use of CFC refrigerants, halon, and other ozone-depleting substances.

Moreover, Annex VI defined two sets of emissions and fuel quality requirements: global requisitions and stricter requirements for ships in Emission Control Areas (ECA). Existing ECAs include:

- The Baltic Sea for $SO_x$; was adopted in 1997 and entered into force in 2006.
- The North Sea (which also includes the English Channel) for $SO_x$; was adopted in 2005 and entered into force on 22 November 2007).

**Table 2.1** $NO_x$ emission limits (IMO 2016a, b, c)

| Tier | Date | $NO_x$ Limit (g/Kwh) | | |
|---|---|---|---|---|
| | | n < 130 | 130 ≤ n ≤ 2000 | n ≥ 2000 |
| | | n = engine's rated speed (rpm) | | |
| Tier I | 2000 | 17 | $45 \cdot n^{(-0.2)}$ | 9.8 |
| Tier II | 2011 | 14.4 | $44 \cdot n^{(-0.23)}$ | 7.7 |
| Tier III | 2016 | 3.4 | $9 \cdot n^{(-0.2)}$ | 1.96 |

- The North American ECA (including most of US and Canadian coast) for $NO_x$ and $SO_x$; was adopted in 2010 and entered into force in 2011.
- The US Caribbean ECA (including Puerto Rico and the US Virgin Islands) for $NO_x$ and $SO_x$; adopted in 2011 and came into force in 2014.

The first two areas, designated for $SO_x$ restrictions only, are commonly known as SECAs, while areas with limitations on the $NO_x$ emissions are designated as NECAs.

A revised Annex VI of the Convention was adopted in 2008, entered into force in 2010 and led to a progressive reduction in $SO_x$ from ships and further reductions in $NO_x$ emissions from marine engines. By October 2008, Annex VI was ratified by 53 countries (including the Unites States), representing 81.88 % of tonnage. $NO_x$ emission limits are set for diesel engines depending on the engine maximum operating speed (n) as shown in Table 2.1. The IMO emission standards are commonly referred to as Tier I–III standards. The Tier I standards were defined in the 1997 version of Annex VI, while the Tier II/III standards were introduced by the Annex VI amendments adopted in 2008, as follows: 1997 standards applied retroactively to new engines greater than 130 kW installed on vessels constructed on or after 1 January 2000, or which underwent a major conversion after that date. Tier I and Tier II limits are global, while the Tier III standards apply only in $NO_x$ ECAs. Ships built between 2000 and 2011 need to comply with $NO_x$ emissions at maximum engine speed of about 9.8–17 g/kWh (Tier I), those built after 2011 need to comply with 7.7–14.4 g/kWh (Tier II), and ships operating after 2016 in NECAs need to comply with emissions of 2.0–3.4 g/kWh (Tier III). To date there is no NECA in Europe, although assessments have been performed evaluating the potential impact of establishing, for example, a North Sea NECA (EEA 2013; Danish 2012). Due to the lack of NECAs and the fact that the $NO_x$ emissions limits refer to new ships, the impact of IMO $NO_x$ regulations seems to be limited at present.

As far as the reductions of $SO_x$ are concerned, under the revised Annex VI, the main change is a progressive reduction in $SO_x$ emissions with the global Sulphur cap being reduced initially from the current 3.5 % to, progressively, 0.5 %, effective from 1 January 2020, subject to a feasibility review to be completed no later than 2018. The limits applicable in SECAs have been reduced to 1 %, beginning on 1 July 2010, being further reduced to 0.1 %, effective from 1 January 2015 (IMO 2016a, b, c). One method to control these limits is via Port State Control

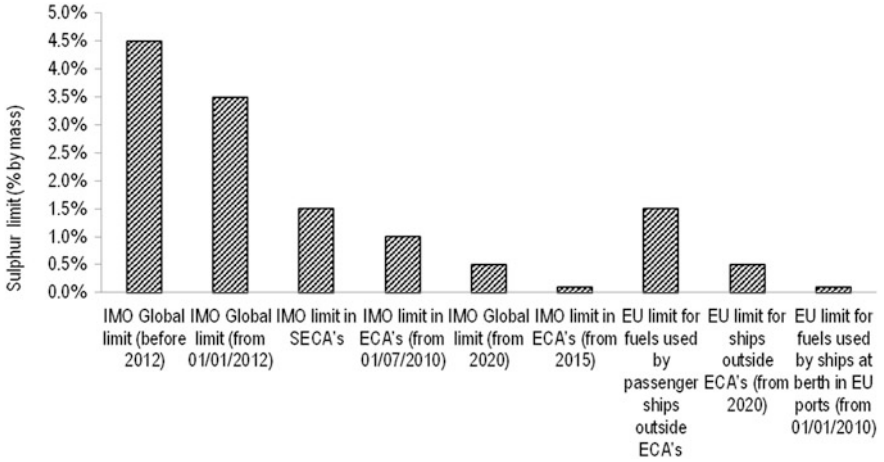


**Fig. 2.1** Overview of sulphur limits under IMO and EU legislation

by checking the so-called bunker delivery note (EEA 2013). Also, all passenger ships operating on scheduled services to or from any EU port should not exceed 1.5 % sulphur limit and all vessels calling an EU port should use low sulphur fuel (less than 0.1 %) during port stays longer than two hours. Figure 2.1 presents an overview of the different implemented and planned sulphur limits for marine fuels under IMO and EU legislation (EEA 2013).

It is also important to mention that Regulation 12 of Annex VI prohibits deliberate emissions of ozone depleting substances, including halons and chlorofluorocarbons (CFCs). New installations containing ozone-depleting substances are prohibited on all ships. But new installations containing hydro-chlorofluorocarbons (HCFCs) are permitted until 1 January 2020. According to the 2008 amendments, as of 1 July 2010 vessels should also keep on board a list of equipment containing ozone depleting substances and a Record Book in which ozone depleting substances resulting from certain operations are instantly recorded, including, for example, the full or partial recharging of equipment containing ozone depleting substances.

### *2.1.1 International Mechanisms for Reducing Maritime Transport Emissions: The Current Debate*

As far as the GHG emissions are concerned, the IMO is the entity responsible for their regulation within its MEPC. The most significant achievement is the adopted technical and operational measures in the form of amendments to revised MARPOL Annex VI in 2011 and 2014. Three categories of measures have been discussed within the IMO to tackle GHG emissions from ships: technical measures, operational measures and market-based measures (MBMs) (IMO 2011a, b).

In order to fully deliver its mandate as stipulated in Article 2.2 of the Kyoto Protocol to the UNFCCC,[1] the MEPC also analyzed the potential constraints of a new legally binding instrument addressing GHG emissions from international shipping. In particular, the Committee voiced concerns about the compatibility between the Kyoto Protocol's "common but differentiated responsibilities" approach, according to which legally binding emissions reduction commitments should apply only to Annex I Parties,[2] and the Paris MoU's concept, according to which relevant legal instruments (i.e. conventions) should apply also to ships which are under the flag of a State which does not participate to that convention. Using the obtained revenues to assist developing countries in addressing climate change would be in line with the provisions of the UNFCCC. The amounts that could be generated by maritime transport in reducing its carbon footprint are substantial with estimate over four billion US dollars per year (IMO 2009; Miola et al. 2010). A second way of combining both principles is to differentiate commitments for Annex I and non-Annex I countries without relying on the nationality of ships. A solution could be to differentiate responsibilities according to the route of the vessels or depending on the ship size. A justification for differentiated responsibilities in maritime policy is that the policy should not interfere with the growth potential of developing countries. As some countries are dependent on maritime transport for their exports, and countries are thought to develop based on periods of export-led economic growth, global coverage of the described policies could lead to lower economic growth (Faber and Rensema 2008). Kageson (2008), highlights that it may not be possible to achieve complete global coverage of an international maritime emission trading scheme, as support from developing countries might be limited. He therefore envisages three possible stages of implementation: Firstly the set-up of a scheme by the IMO and the UNFCCC that is open for voluntary participation by States and ports, and secondly, a scheme that covers all traffic in the ports of Annex I countries, which can finally be extended to a scheme covering all maritime traffic on a global level (Kageson 2008). The same could be applied on the basis of a tax or a levy system, although careful analysis of the effects is needed as a major threat to the environmental effectiveness of these systems is carbon leakage due to incomplete coverage. For the voluntary sectoral crediting option, this is not an issue. The debate is still open. However, within the evaluation of the best

[1]Article 2.2 of the Kyoto Protocol to the UNFCCC: "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".

[2]The group of countries included in Annex I (as amended in 1998) to the UNFCCC, including all the OECD countries and economies in transition. Under Articles 4.2 (a) and 4.2 (b) of the Convention, Annex I countries committed themselves specifically to the aim of returning individually or jointly to their 1990 levels of ghg emissions by the year 2000. By default, the other countries are referred to as Non-Annex I countries.

possible IMO regulatory framework on GHG emissions from ships, in particular $CO_2$, parties already agreed on a list of principles to be adhered to (Miola et al. 2010):

1. Effective contribution to the reduction of total GHGs;
2. Binding and equally applicable to all Flag States in order to avoid evasion;
3. Cost-effectiveness;
4. Limitation, or at least, effective minimization of competitive distortion;
5. Sustainable environmental development without penalizing global trade and growth;
6. Goal-based approach and not a prescriptive specific method;
7. Supportive of promoting and facilitating technical innovation and R&D in the entire shipping sector;
8. Accommodating to leading technologies in the field of energy efficiency;
9. Practical, transparent, fraud-free and easy to administer.

## 2.2 Recent Developments in Regulating Greenhouse Gas Emissions from International Shipping

According to IMO, the definition of international shipping is "shipping between ports of different countries, as opposed to domestic shipping", excluding military and fishing vessels (Buhaug et al. 2009). Consistent with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 2006 Guidelines), this definition also indicates that the same ship under an international voyage may frequently be engaged in both international and domestic shipping operations (IPCC 2006; Buhaug et al. 2009). This constitutes the main obstacle, to integrating the GHG emissions from international shipping in the State-based Kyoto Protocol to the UNFCCC, due to the difficulty of allocating ships' emissions in a country. The UNFCCC's Subsidiary Body on Scientific and Technological Advice (SBSTA) worked on this emission-allocation issue from 1995 to 1996, but failed to reach consensus among different States (Oberthür 2003). Currently, the IMO is the main international organization working on the regulation of GHG emissions from international maritime sector. It started its institutional work in 1997 and in the same year, MARPOL adopted Resolution 8 on "$CO_2$ emissions from ships", which requested the IMO to undertake a study on GHG emissions from ships and consider feasible $CO_2$ reduction strategies (Shi 2016; Buhaug et al. 2009). In 2003, the IMO Assembly adopted a resolution on "IMO policies and practices related to the reduction of greenhouse gas emissions from ships", urging the MEPC to identify and develop the mechanism or mechanisms needed to achieve the limitation or reduction of GHG emissions from international shipping (IMO 2003). Since then, the IMO has been working on this issue by means of negotiations and discussions within its MEPC.

Within MEPC 58 and 59, Parties adopted a list of guidelines for calculation and trial purposes and agreed on the fact that Energy Efficiency Design Index (EEDI) should be comprised of the following three components for better enforcement and compliance:

- Requirements: the EEDI should be calculated for each new ship following IMO guidelines
- Verification and certification: ships should be subject to surveys for verification of their compliance with the EEDI's requirements
- State Port control: ships may be subject to inspection by the Authority of the Parties when entering their ports or offshore terminals.

During the latest MEPC 61, Parties debated about whether to get the Secretary-General to circulate proposed amendments to MARPOL Annex VI in order to make the EEDI mandatory, but no consensus about how to proceed on this issue was reached. The EEDI was made mandatory for new ships and the Ship Energy Efficiency Management Plan (SEEMP) for all ships at MEPC 62 (July 2011) with the adoption of amendments to MARPOL Annex VI (MEPC. 203(62)), by Parties to MARPOL Annex VI. This was the first legally binding climate change treaty to be adopted since the Kyoto Protocol (IMO 2011a, b).

At the 66th MEPC meeting in April 2014, amendments to Annex VI to MARPOL 73/78 were adopted to extend the application scope of the EEDI to include an extra five types of ships. They are LNG carriers, roll-on/roll-off (Ro–Ro) cargo ships (vehicle carriers), Ro–Ro cargo ships, Ro–Ro passenger ships, and cruise passenger ships having non-conventional propulsion (IMO 2014a, b).

The main technical measures, adopted by the IMO, refer to the creation of the EEDI and the SEEMP. EEDI is applicable only to new ships of more than 400 Gt (bulk carriers, containers, Ro-Ro, cargo ships, and tankers). EEDI represents a non-prescriptive, performance-based mechanism that leaves the choice of technologies in specific ship designs to the industry. EEDI requires that the design of new ships needs be energy efficient and thereby lead to less greenhouse gas emissions. As long as the required energy efficiency level is attained, ship designers and builders are free to use the most cost-efficient solutions so that ship to comply with regulations. The mandatory implementation of EEDI will create a new more efficient and effective design status for ships. In considering how to improve the efficiency of ships, it is important to understand the relationship between EEDI and efficiency improvement measures, i.e., how each improvement measure affects the EEDI. Figure 2.2 illustrates the relationship between EEDI and improvement measures. Simply put, there are three approaches to improve the value of EEDI (Bose 2012).

On the other hand, SEEMP obligates the ship-owners to reconsider their operational techniques and upgrade technology in their ships in order to achieve improved energy performance. Other technological measures aim at the following categories: ship design, machinery and propulsion (Wartsila Corporation 2010). These measures include: greener fuels, weather routing, optimised trim and

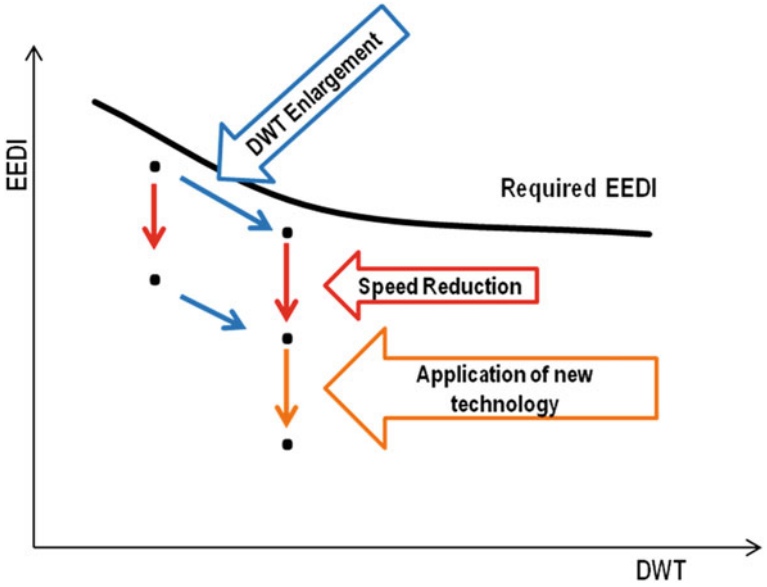


**Fig. 2.2** The conceptual relationship between EEDI and improvement measures (Bose 2012)

ballasting, fleet planning, improvements in propellers and engines, speed reduction (Maragkogianni et al. 2013). Both EEDI and SEEMP enter into force on 1 January 2013 (IMO 2013).

In line with the work plan adopted at MEPC 55 (October 2006), potential Market-Based Measures have been considered in-depth since MEPC 56 (July 2006). MEPC 55 work plan ceased at MEPC 59 (July 2009), where the Committee recognized that technical and operational 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. It was therefore agreed by overwhelming majority that an MBM was needed as part of a comprehensive package of measure for the effective regulation of GHG emissions from international shipping (IMO 2016a, b, c). At the MEPC 60 it has been established an Expert Group to evaluate the several proposals of possible MBM presented to the Committee. The Expert Group has analysed ten proposals (IMO 2016a, b, c):

1. An International Fund for GHG from ships (GHG Fund) proposed by Cyprus, Denmark, the Marshall Islands, Nigeria and IPTA.
2. Leveraged Incentive Scheme (LIS) to improve the energy efficiency of ships based on the international GHG fund proposed by Japan.
3. Achieving reduction in GHG from ships through Port State arrangements utilizing the ship traffic, energy and environment model, STEEM proposal by Jamaica.
4. The United States proposal to reduce GHG emissions from shipping, the Ship Efficiency and Credit Trading (SECT).

5. The Vessel Efficiency System (VES) proposal by World Shipping Council.
6. The Global emission trading System (ETS) for international shipping proposal by Norway.
7. Global Emission Trading System (ETS) for international shipping proposal by the United Kingdom.
8. Further elements for the development of an Emission Trading System (ETS) for international Shipping proposal by France.
9. Market-Based Instruments: a penalty on trade and development proposal by Bahamas.
10. A rebate Mechanism for a market-based instruments for international shipping proposal by IUCN.

Each proposal was assessed considering nine criteria: (**i**) environmental effectiveness; (**ii**) the cost effectiveness of the proposed MBM and impacts on trade and sustainable development; (**iii**) potential impacts on innovation and technological change; (**iv**) practical feasibility of implementing the proposed MBM; (**v**) the need of technology transfer to, and capacity building within, developing countries; (**vi**) the MBM proposal's relation with other relevant conventions; (**vii**) potential additional burdens, and the legal aspects for the national Administrations by implementing the proposed MBM; (**viii**) the potential additional workload, economic burden, and operational impact for individual ships, the shipping industry and the maritime sector; (**ix**) the MBM's compatibility with the existing enforcement and control provisions under the IMO legal framework (IMO 2010).

The results of this analysis has been discussed during the last MEPC 61 and the Committee set out the Terms of Reference for an inter-session Meeting of the Working Group on GHG Emissions from Ships, to be held in March 2011 and its report was submitted to MEPC 62. However, due to time constraints and the busy agenda of MEPC 62, it was agreed to postpone the consideration of MBMs to the next MEPC session, but MEPC 63 continued its consideration of proposed MBMs, and agreed on the need to undertake an impact assessment of the MBM proposals with focus on possible impacts on consumers and industries in developing countries, in general, and in particular, least developed countries, small islands developing States and remotely located developing countries with long trading distances, and considered in detail the methodology and criteria it should be based on. MEPC 65, in noting several submissions on this matter, agreed to suspend discussions on MBMs and related issues to a future session (IMO 2016a, b, c).

Although the transport sector has a significant abatement potential regarding its environmental consequences, there are some challenges that need to be overcome in order to make such a policy successful. These challenges include deciding on a method to allocate ship emissions to countries, diminishing the risk of carbon leakage, and designing a policy that is administratively and politically feasible with respect to allowance distribution and treatment of the great variety in ship type, size and usage. A global policy could overcome most of the above-mentioned challenges.

It is still very controversial whether MBMs should be adopted to further the reduction of GHG emissions from international shipping. For example, many States

and shipping organizations welcome MBMs, whereas large developing States, India as an example oppose the possible adoption of any MBMs by the IMO because it is feared that they would jeopardize the interests of their shipping industry.

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The Commission's 2011 White Paper on Transport suggests that the EU's $CO_2$ emissions from maritime transport should be cut by at least 40 % from 2005 levels by 2050, and if feasible by 50 %. However, international shipping is not covered by the EU's current emissions reduction targets. In 2013, the European Commission recognized the need for a global approach by setting out a strategy for progressively integrating maritime emissions into the EU's policy for reducing its domestic emissions. For this reason, the EC proposes a Monitoring-Reporting-Verifying (MRV) system to apply to all shipping activities as of 2018. This system may serve as the first step, while the ultimate goal is to reach a global agreement that may be achieved under the auspices of the IMO. The regulation 2015/757 of the European Parliament and of the Council, institute rules for the accurate monitoring, reporting and verification of $CO_2$ emissions and of other relevant information from ships arriving at, within or departing from ports under the jurisdiction of a Member State, in order to promote the reduction of $CO_2$ emissions from maritime transport in a cost effective manner (EU 2015). This MRV regulation, in which the first reporting period will start on 01/01/2018, requires large ships (over 5000 gross tons), to collect and later publish verified annual data on $CO_2$ emissions and other relevant information. In accordance with Articles 8–12 of 2015/757, companies operating large ships in EU ports, irrespective of where the ships are registered, will monitor and report, in an annual basis, the verified amount of $CO_2$ emitted to, from and between EU ports. Also, companies ought to monitor and report all the additional parameters, such as distance, cruising time, emission factors, activity data, and to submit to the Commission an emission report. Ships must carry a document of compliance, issued by an accredited verifier, proving that the ship is in compliance with the MRV obligations.

The MRV system is estimated to cut $CO_2$ emissions from the journeys covered by up to 2 % compared with a 'business as usual' situation, according to the Commission's impact assessment. The system would also reduce net costs to owners by up to €1.2 billion per year by 2030 (in average about 900 million per year), while costs of implementation are estimated at around 26 million € per year. Overall, the relative benefit/cost ratio of this option is very high (EC 2013a, b). In addition, it will provide useful insights into the performance of individual ships, their associated operational costs and potential resale value. This will benefit ship owners who will be better equipped to take investment decisions and obtain finance (EU 2015).

For the future projection (2012–2030), it is assumed that both technical measures and operational measures will be applied to new ships, and that operation measures

will be applied to existing ships. For the remaining vessel categories; ferry-pax, yacht, offshore, service, fishing and other, it is assumed that the abatement potential is 50 % of the average for the cargo vessels (TNO 2015).

## 2.3 Regulating Ships' Emissions in Ports

Undoubtedly, ports can play an important role in the economic development of a country, allowing a more efficient transport system. During the last decade, ports have increased their competitiveness by enhancing their productivity, providing better quality services while reducing operating costs. In addition, due to the increasing awareness of stakeholders arising from global climate change issues, more ports are trying to operate in a more environmentally friendly way. But, while some European ports operate under high efficiency (either commercial or environmental), other ports continually underperform or are in structural decline (EC 2013a, b). Under this concept, one of the main goals of port authorities should be economic, social and environmental viability, or in other words port sustainability which would ensure economic competitiveness, prosperity and cohesiveness with local urban environment, social acceptance and a continuously adapting environmental plan. Thus port authorities should adopt specific policies in order to bridge the gap between environmental practice and theory, verify the environmental risks and take specific actions towards their minimization. Due to this problem, ports have been active, either collectively or individually, in adopting voluntary measures, which aim at improving the air quality and achieving emission reductions of greenhouse gases.

Although most of air emissions take place at sea, the most directly noticeable part of shipping emissions takes place in port areas and port-cities (Merk 2014). Harbours are particularly influenced by emissions from ships and this can cause relevant contributions to local air pollution (Isakson et al. 2001; Cooper 2003; Saxe and Larsen 2004). However, the only European law concerning the reduction of emissions is the 2005/33/EC, which requires all ships at berth in European ports to use fuels with sulphur content less than 0.1 % by weight. The directive is not applied to ships that are due to stay at berth for less than 2 h and to those that switch off all engines and use shore-side electricity (Schembari et al. 2012; EC 2005). Because of the fact that the port industry is continually evolving, there is an increasing need for adaptation of new requirements on infrastructure and investments. Ports require the extension of berths, new quays, deepening of basins, new terminal passengers. Furthermore, stricter requirements on environmental performance and alternative fueling technologies (e.g. shore-side electricity, or LNG) are necessary. The Commission's Clean Power for Transport initiative and the proposal for a Directive on the deployment of alternative fuels infrastructure requires that all maritime ports of the Ten-T Core network are equipped with LNG refueling points according to common technical standards by 2020 (EC 2013a, b). Also, as far as the environmental performance of ports is concerned and the significant developments

in the energy trade, with a shift from oil towards gas, there is a need for significant LNG facilities in ports (EC 2013a, b). EU Commission welcomes the initiatives taken by the port sector to promote excellence in environmental management and performance by publishing guides for good practices. As it has been mentioned before, some ports have already adopted plans to better manage their environmental footprint and such initiatives should be encouraged. Ports should consider whether to reward operators who anticipate or exceed the application of mandatory environmental standards and promote the use of door-to-door low-carbon and energy efficient logistics chains. Last but not least, those ports that have already raised their environmental image should continue to be supported (EC 2013a, b).

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