Comparison of Market-based Measures to Reduce GHG Emissions from Shipping

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CE Delfts solutions are characterised in being politically feasible, technologically sound, economically prudent and socially equitable.

Preface

This research has been commissioned by the Dutch Ministry of Transport, Public Works and Water Management. The authors would like to thank Sibrand Hassing from the Ministry and the participants of a stakeholder meeting for their valuable inputs. All errors are ours.

Jasper Faber

Contents

Summary

The inclusion of maritime transport in global or European climate policies has proven to be difficult and debates have continued for over a decade.
Yet recently, the debate has received a new impetus centring around a number of concrete proposals for both global and European policy instruments.
In response, the Dutch Ministry of Transport, Public Works and Water Management seeks to make an informed decision on a position in these debates. It has commissioned CE Delft to analyse the proposals.
This report presents the analysis.

The goal of this study is to evaluate global and European policy instruments that address climate impact of shipping.

Global Market-based Measures
The global market-based measures (MBMs) are:
- An Emission Trading Scheme for shipping. In this system, ships need to surrender emission allowances for the amount of CO_2 they emit. Ships would receive a number of allowances up to the cap for the sector. In addition to the allowances available under the emission cap set for the shipping sector, ships would be able to buy additional allowances from other systems and/or use CDM or similar credits.
- A GHG fund. In this system, ships or fuel suppliers would pay hypothecated contributions on each quantity of fuel consumed or sold. The resulting fund would be used primarily to offset emissions by financing emission reductions in other sectors.
- A Baseline-and-Credit Trading Scheme. In this scheme, the regulator sets a fuel efficiency target for ships, depending on ship type and size. Ships that are more efficient than the target receive credits while ships that are less efficient need to surrender credits in order to compensate for their inefficiency. This scheme is closed to other trading systems, such as the EU ETS and the CDM.

Criteria for evaluation
The instruments are evaluated against nine criteria that global policies should meet, as set by MEPC 57. These criteria state that market-based measures should be:
1. Effective in contributing to the reduction of total global emissions of greenhouse gases.
2. Binding and equally applicable to all Flag States, in order to avoid evasion.
3. Cost-effective.
4. Able to limit – or, at least, effectively minimize – competitive distortion.
5. Based on sustainable environmental development without penalizing global trade and growth.
6. Based on a goal-based approach and not prescribing specific methods.
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; and
9. Practical, transparent, fraud-free and easy to administer.

We find that the main differences between the instruments are on effectiveness and cost-effectiveness. Hence, this summary focuses on those criteria.

Environmental effectiveness

As none of the proposals sets specific targets for either CO_2 emissions or efficiency, the environmental effectiveness can not be evaluated quantitatively. Nevertheless, the effectiveness of the various proposals can be assessed regarding the *certainty* that emission reduction will in fact be achieved.

We find that:

- Emission reduction is very certain under the ETS since a fixed cap is put on the CO_2 emissions by the maritime sector.
- Emission reduction is quite certain under the system of GHG contributions, but it depends to a larger extent on the quality of the offsets.
- Emission reduction is much less certain in a Baseline-and-Credit Trading Scheme because it does not set an absolute emission target for the maritime sector. If the demand for maritime transport grows faster than efficiency is improved, emissions may even rise. Moreover, insofar as the proposal is based on design efficiency, there is less scope to improve the efficiency indicator and consequently there are limitations to the stringency of the target.

Cost-effectiveness

From a social perspective, the costs of a policy instrument are the costs of the measures incentivised and the administrative costs.

We find that from a social perspective:

- The cost-effectiveness of the ETS is optimal as it incentivises actors in the shipping sector to implement all measures that are more cost-effective than the global carbon price. Further emission reduction is achieved against the global carbon price.
- The cost-effectiveness of the GHG fund is *sub*optimal as it incentivises actors in the shipping sector to implement measures up to a price *lower* than the global carbon price. Further emission reduction is achieved against the global carbon price. Consequently, emissions are reduced against the global carbon price while cheaper options are unused within the maritime sector.
- The Baseline-and-Credit Trading Scheme only incentivises measures that are reflected in the indicator, which is a subset of all measures. Hence, some cost-effective measures are not taken. Furthermore, the system is closed to other trading schemes. Consequently, there is the risk that expensive measures are taken within the maritime sector while cheaper options are available outside the sector.

As for the administrative costs, we conclude that they would be similar in all systems, because:

- Most of them are associated with requirements common to all systems. All systems require ship operators and/or fuel suppliers to monitor and report their emissions, fuel sales or transport work. These costs are equal for all proposals except for the variant of the GHG fund which makes the fuel supplier liable. As there are probably fewer fuel suppliers than shipping companies, and since the costs per actor are similar, the total administrative costs of this variant would be less.

- Most empirical studies show that the costs of paying taxes for companies are of the same order of magnitude as the costs of engaging in emissions trading.
- The costs of the organisation needed to administer the system would be similar, as long as the experience with tax systems and existing emissions trading schemes can be used as a guide.

Conclusion on global Market-based Measures

We conclude that an emissions trading scheme is the most effective and the most cost-effective global MBM. It also scores well on most of the other criteria. The GHG fund is slightly less effective and less cost-effective, because it does not incentivise the shipping sector to implement all cost-effective abatement options. The Baseline-and-Credit Scheme is less effective because it does not have an emissions cap, and less cost-effective because it does not incentivise all cost-effective abatement options and is closed to trade with other sectors and the CDM.

European Market-based Measures

The European MBMs analysed in this study are:

1. Inclusion of shipping emissions in the EU ETS.
2. A European tax on shipping emissions.
3. A Baseline-and-Credit System for ships in EU ports.

The main difference between global and European MBMs is the geographical scope. The European MBMs would apply to emissions on voyages to EU ports or to ships in EU ports. As a consequence, they would cover about one fifth of global emissions and open possibilities for avoidance. This has an impact on both the environmental effectiveness and the cost-effectiveness.

Avoidance would be especially large for the Baseline-and-Credit Scheme, where relatively inefficient ships can be put to work outside the scope of the system. This would displace emissions rather than reduce them. In both the EU ETS and the emissions tax, avoidance can be limited by the design of the system but not be eliminated completely. The most important way to limit avoidance is to define the voyage to the EU port as the route from the port of loading to the port of discharge as identified on the bill of laden.

Since the CO_2 price in the EU ETS and the emissions tax would be similar, and since the administrative costs would be of the same order of magnitude, these systems would be equally cost-effective. The cost-effectiveness of a European Baseline-and-Credit System would be significantly less because of evasion.

Conclusion on European MBMs

We conclude that the inclusion of shipping emissions in the EU ETS and a European tax on shipping emissions would be equally effective and cost-effective. Because unanimity amongst Member States is required for a harmonised tax, inclusion in the EU ETS seems to be politically more feasible.

2 Introduction

2.1 Background

In 2003, the International Maritime Organization's assembly adopted Resolution A.963(23) on 'IMO Policies and Practices related to the Reduction of Greenhouse Gas Emissions from Ships'. Among others, this resolution 'urges the Marine Environment Protection Committee to identify and develop the mechanism or mechanisms needed to achieve the limitation or reduction of GHG emissions from international shipping'. In doing so, the MEPC is urged to give priority to the evaluation of market-based solutions.

As follow-up to resolution A.963(23), MEPC 55 (October 2006) approved a 'Work plan to identify and develop the mechanisms needed to achieve the limitation or reduction of CO_2 emissions from international shipping'. The work plan culminated in the submission of ten proposals for Market-based Measures (MBMs) at MEPC 60, which are currently being evaluated by an Expert Group and will be discussed at MEPC 61. The ten proposals can be viewed as variants of three main MBMs:

- An International Fund for Greenhouse Gas Emissions from Ships, submitted by Cyprus, Denmark, the Marshall Islands, Nigeria and the IPTA (MEPC 60/4/8). This proposal is a follow-up to a proposal by Denmark (MEPC 59/4/5).
- A Global Emission Trading Scheme for International Shipping, submitted by Norway (MEPC 60/4/22), the United Kingdom (60/4/26) and France (MEPC 60/4/41). These proposals are follow-ups to a proposal by France, Germany and Norway (MEPC 59/4/25).
- A Baseline-and-Credit Trading Scheme proposed by the United States (MEPC 60/4/12).

At this point in time, it is uncertain whether the IMO will select one of the MBMs for implementation. The European Union has indicated several times that although it prefers global policies, it will implement its own policies if no global agreement can be reached. EU Directive 2009/29/EC sets a deadline for the global agreement:

'The European Council … made a firm commitment to reduce the overall greenhouse gas emissions of the Community … All sectors of the economy should contribute …, including international maritime shipping … In the event that no international agreement … has been approved … by 31 December 2011, the Commission should make a proposal to include international maritime emissions … in the Community reduction commitment, with the aim of the proposed act entering into force by 2013'.

It is currently not known which instrument the EU will choose if a global agreement cannot be reached. It is likely, however, that it will be a regional analogue of one of the three main instruments proposed to the MEPC.

2.2 Aim of this research and set up

In preparation to MEPC 61 and possibly a European decision-making process, the Dutch Ministry of Transport, Public Works and Water Management commissioned CE Delft to analyse and compare the MBMs on the basis of the criteria as set by the MEPC 57.

In Chapter 2 we shall first explain the general working of MBMs. In Chapter 3, the relevant IMO submissions on MBMs are analyzed. Chapter 4 and Chapter 5 discuss the European schemes. In Chapter 5, conclusions are given.

3 Introduction to MBMs

3.1 Introduction

In Chapter 4, a comparison will be made between the three groups of proposals to reduce greenhouse gas emissions from ships submitted to the MEPC: the International Fund for Greenhouse Gas Emissions from Ships, submitted by Cyprus et al. (MEPC 60/4/8), the Global Emission Trading Scheme for International Shipping, submitted by Norway (MEPC 60/4/22), the United Kingdom (60/4/26) and France (MEPC 60/4/41), and the Baseline-and-Credit Trading Scheme proposed by the United States (MEPC 60/4/12). To facilitate this comparison, we first explain the general working of market-based measures (MBMs). In particular we dedicate a separate chapter to the theoretical working of MBMs because the proposal for GHG contributions by Cyprus et al. rather deviates from what is normally understood by an MBM.

3.2 Why market-based measures and how do they work?

Generally, climate policy has two main objectives: to reduce GHG emissions and to reduce the cost-effectively, i.e. against lowest costs. In theory, emissions could be reduced cost-effectively by *command and control*, i.e. direct regulation. Authorities could investigate which measures are required to reach the target and subsequently prescribe these. In practice, however, a central authority simply lacks the time, manpower and detailed knowledge to determine the set of cost-effective measures as well as to enforce their implementation.

MBMs solve this problem by using the knowledge of all emitting parties involved in their own opportunities for emission reduction and accompanied costs to achieve emissions reduction against lowest costs. The main idea behind MBMs is that if there is a price attached to emissions, companies will determine for themselves whether it is cheaper to reduce emissions or to pay the price of these emissions. In this manner, all measures are implemented with costs below the emission price and measures that are more expensive (i.e. inefficient) will be refrained from[1].

A second important advantage of market-based measures over command and control is that the price mechanism offers an efficient incentive for all available measures to reduce emissions: not only technical and operational measures, but *volume* or *demand* measures as well. After all, in some cases, it may be cheaper to refrain from a certain economic activity (a specific cargo transport) than to reduce the accompanying emissions by technological options. This might be the case when a certain activity has only a very low

[1] Please note that in many cases, market-based measures can be effectively supplemented by different instrument types. This is especially the case when the private benefits of market-based measures are not clear, or when market failures are present (OECD, 2007: Instrument mixes for environmental policy, Paris; CE, 2008). In the case of shipping, the transparency of the charter market could potentially be enhanced by requiring ships to have an Energy Efficiency Operational Indicator (EEOI) and inform the charterer about its value. Moreover, the EEOI could be used as a labelling instrument to inform the shipper or the consignee about the carbon footprint of the ship it has engaged. Similarly, a limit value for the Energy Efficiency Design Index (EEDI) for new ships could potentially increases the incentive for ship builders to invest in fuel-efficient ship designs'.

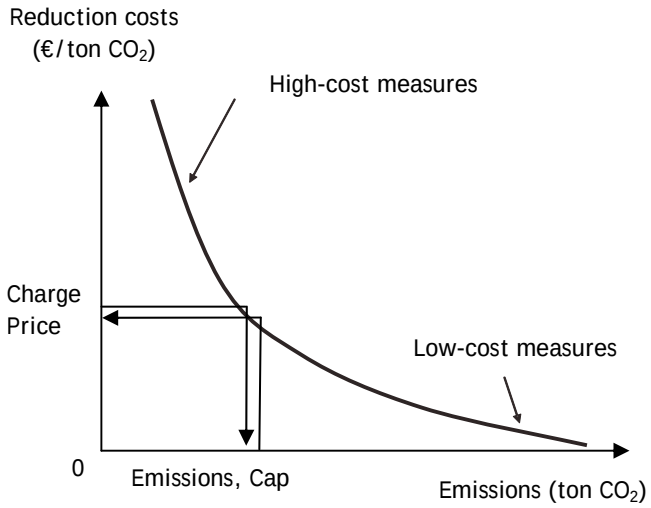
(marginal) added value. Command and control is generally not well equipped to address such volume or demand measures. However, if demand measures are not included in the set of measures, which is implemented to achieve the emission target, more expensive technical or operational measures have to be implemented, thereby increasing the overall costs of emission reduction.

There are two main MBMs, which attach a price to emissions: charges (taxes/levies) and cap-and-trade (tradable emissions rights/allowances/ permits). The Baseline-and-Credit System is a special case, which will be discussed separately in Section 3.5. In the case of charges, a regulator directly determines the price of emissions. Consequently, each economic actor decides whether it is cheaper to reduce emissions or to pay the charge. In the case of cap-and-trade, a central authority sets a cap on the amount of greenhouse gases that can be emitted. Emitters are allocated emission permits and are required to hold an equivalent number of allowances that represent the right to emit a specific amount. If the amount of allocated permits (the cap) is less than the participants to the system would have emitted in the absence of the cap, there is scarcity and the rights obtain an economic value. Consequently, each economic actor decides whether it is cheaper to reduce emissions or to buy emission allowances.

In Figure 1, the general working of MBMs is illustrated. Figure 1 shows the marginal costs of additional emissions reduction as a function of emissions, i.e. the additional costs of additional emission reduction. At the beginning, at business-as-usual emissions (the right side of Figure 1), emissions can be reduced against very low costs. However, the more emissions are reduced the higher the costs of additional emission reduction measures become.

If a charge is set, emissions are reduced up to a certain amount. If a cap is set, this results in a certain emission price. Consequently, there is no fundamental difference between the two measures, apart from the following fact due to ex-ante uncertainty about the marginal cost curve: in the case of a charge, the economic burden can be predicted with certainty, but the environmental effect cannot; in the case of cap-and-trade, the environmental effect can be predicted with certainty, but the economic impact cannot.

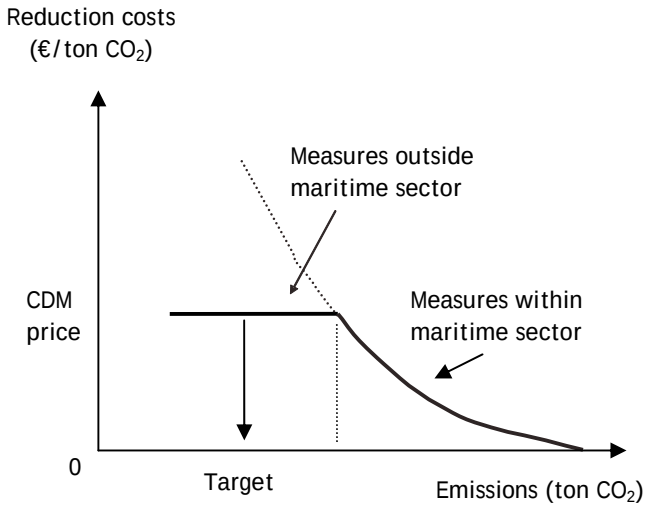
Figure 1 **Marginal costs of additional emissions reduction as a function of emissions**



3.3 Cost-effectiveness in an open system

If different sectors are required to make the same contribution to emission reduction in terms of percentage, these sectors may face different marginal reduction costs. It could be the case, for example, that emission reduction by the maritime sector is relatively expensive[2]. If that were to be the case, the most cost-effective option for the maritime sector to reach its target is to reduce emissions *within* the maritime sector up to the point where the marginal reduction costs become equal to the price of emission reduction outside the maritime sector, such as the price of CDM credits. Further emission reduction is then achieved by buying emission reduction outside the maritime sector. See Figure 2.

Figure 2 Marginal costs of additional emissions reduction in an open trading system



This cost-effective situation is automatically achieved under an emission trading scheme if allowances or credits can be bought from outside the maritime sector as well. In the case of an emission charge, the charge level has to be set equal to the price of emission reduction outside the maritime sector. Subsequently, part of the revenues of the charge has to be used to buy emission reduction outside the maritime sector up to the target.

3.4 Use of revenues, distributional effects and cost-effectiveness

There is no fundamental difference between charges and cap-and-trade systems with regards to distributional effects. The potential revenues are the same in both systems and both systems face the same choice: whether to recycle the revenues to the sector or to use the revenues for purposes outside the sector, such as adaptation. In the case of cap-and-trade the choice is between auctioning and free allocation. In the case of free allocation the difficult question arises which distributional key to use. In the case of charges, revenues are created. These can be recycled to the sector according to exactly the same distributional key as which otherwise would be used for the free allocation of emission rights. In other words, any distributional objective can

[2] See also the expectations expressed in the ICS contribution MEPC 59/INF.9, page 3. The possibility also exists, however, as proposed by Norway (MEPC 59/4/24), to set the target for the maritime sector in such a manner that *equal* marginal reduction costs exist.

be obtained with charges as well as a cap-and-trade system and the same distributional questions are faced.

It should be noted though that the recycling of revenues to the sector generally is at the expense of cost-effectiveness, since it introduces a market-distorting subsidy. As mentioned in Section 2.2, the cost-effective set of emission reduction measures includes volume measures as well. Recycling of revenues to the sector diminishes the incentive to consider such measures and therefore increases the costs of technical and operational measures.

Dedicated recycling of revenues for technological innovation may subsidize these options more than is cost-effective, i.e. may stimulate the application of technological measures with costs (high) above the costs of alternative emission reduction options, such as the Clean Development Mechanism (CDM).

3.5 Baseline-and-Credit

A special case of an MBM is the Baseline-and-Credit System. Although the system involves trading, there is no explicit emission target or cap on aggregate emissions. Instead, there is an *efficiency* target (cap): each company has the right to emit a certain baseline level of emissions per unit of output. In the case of shipping, output can either be defined as transport work or as distance sailed. If a ship emits less per unit of output than the baseline, she creates credits; if she emits more, she needs to surrender credits.

In a Baseline-and-Credit Scheme, total emissions are not limited because output is not limited.

A Baseline-and-Credit System implies that in equilibrium the total emissions above the baseline are equal to the total emissions below the baseline. Although credits may have a value because measures need to be taken to improve the efficiency of ships, the system creates no revenues. Thus, the economic working of the system is equal to the case of an emission charge where all revenues are recycled to the sector on the basis of a performance standard. There is no absolute cap on aggregate emissions and there is no incentive to take efficient volume measures.

4 Design of global MBMs

4.1 Introduction

In this chapter, we compare the three groups of proposals for market-based measures to reduce GHG emissions from ships submitted to the MEPC:

- The International Fund for Greenhouse Gas Emissions from Ships, submitted by Cyprus, Denmark, the Marshall Islands, Nigeria and the International Parcel Tankers Association (IPTA) (MEPC 60/4/8) and Japan (MEPC 60/4/37).
- The Global Emission Trading Scheme for International Shipping, submitted by Norway (MEPC 60/4/22), the United Kingdom (60/4/26) and France (MEPC 60/4/41). And
- The Baseline-and-Credit Trading Scheme proposed by the United States (MEPC 60/4/12).

4.2 Global Emission Trading Scheme

Norway, the United Kingdom and France have proposed a Global Emission Trading Scheme (MEPC 60/4/22, 26 and 41, and previously MEPC 59/4/25 and 26). In this system, ships need to surrender emission allowances for the CO_2 they emit. Ships would receive a number of allowances up to the cap for the sector. In addition, they would be able to buy additional allowances from other systems and/or use CDM or similar credits.

In MEPC 60/4/43 Norway, the United Kingdom, France and Germany explain that 'While (their individual proposals) differ on some elements of how best to implement a global emissions trading system for international shipping, they all agree on the interest to develop a global emissions trading system to address emissions from international shipping.'

Although the various proposals differ in the amount of words spent on specific design issues, we have not been able to discern significant differences as regards design content.

4.3 Hypothecated GHG contributions

Cyprus et al. have proposed a system in which ship owners pay GHG contributions (MEPC 60/4/8). Japan supports this system, albeit with a modification (MEPC 60/4/37). Although the system is proposed as an MBM, it is better described as *hypothecated contributions*. In the case of hypothecation, the *spending* of the revenues achieves the required emission reduction. In the case of an MBM, the *raising* of the revenues achieves the required emission reduction. The idea that the GHG contributions are *primarily* intended for hypothecation most clearly shows from section 35 of the proposal:

> "Regardless of which global market-based instrument is chosen in the IMO, the purpose of the specific scheme is to ensure that future GHG emissions from international shipping exceeding a global reduction target are offset. In other words, any market-based instrument should be conceived as a means of reducing total global GHG emissions that cannot be addressed through technical and operational measures only."

The GHG contributions in fact do offer an incentive to invest in more fuel efficient solutions, but not necessarily an *efficient* (i.e. sufficiently strong) incentive. As will be explained later, the GHG contributions are expected to be much lower than the marginal costs of emission reduction.

4.4 Baseline-and-Credit Trading Scheme

The United States has proposed to establish efficiency index standards for existing ships and the trading of efficiency credits as a means for achieving compliance. Ship owners performing better than the baseline can sell credits to ship owners performing worse. In contrast to the previous two systems, the system proposed by the United States is *closed* to other trading systems outside the maritime sector.

4.5 Allocation of revenues

Global Emission Trading Scheme

The United Kingdom, France and Norway suggest auctioning of the allowances thus creating revenues. France and Norway suggest the allocation of these revenues to similar purposes as proposed in the Danish proposal (MEPC 59/4/5):

1. Cover expenses for the central administration of the scheme.
2. Finance mitigation and adaptation efforts in developing countries, in particular the most vulnerable developing countries, such as the least developed countries, small island developing States and Africa, for instance through the Copenhagen Green Climate Fund. And
3. Finance R&D and technology transfer in the maritime sector and technical cooperation to assist developing country operators.

The proposals by Norway and the United Kingdom mention a 'phase-in period', however, which economically works the same as the gradual transition from a levy to a cap-and-trade scheme:

> "The first phase could be an introductory or transitional phase to allow for data gathering and the setting of more accurate emissions baselines. This would also allow shipping operators to become accustomed to the various obligations of the new system. This can be a shorter phase (of e.g., one or two years) but should also result in emissions reductions." (MEPC 60/4/26, section 20.4).

Hypothecated GHG contributions

The allocation of revenues of the GHG contributions proposed by Cyprus et al. is explained in section 54:

> "According to the basic proposal, the revenues of the GHG Fund should primarily be allocated for climate purposes in developing countries and in particular in the most vulnerable developing countries, i.e. the Least Developed Countries (LDCs) and the Small Island Developing States (SIDSs). Apart from being particularly vulnerable to the negative effects of climate change, SIDSs are also in many respects dependent on maritime transport. Given this, the needs of SIDSs have to be given special consideration. The remainder of the revenues should be allocated for purposes regarding R&D, technical cooperation within the IMO framework, as well as administrative expenses in connection with the GHG Fund."

Japan has added to this proposal the option to refund a part of the revenues to reward 'good performance ships', for example on the basis of EEDI values.

Baseline-and-Credit Trading Scheme

The system proposed by the United States is deliberately designed as not to create funds to be diverted outside the maritime sector (section 31, points 2 and 3). A Baseline-and-Credit System is designed such that no financial flows go to and from ship owners who perform according to the baseline efficiency. The only financial flows go from ship owners who perform below the standard to ship owners who perform above the standard.

4.6 CO_2 price

Global Emission Trading Scheme

In the proposal by the United Kingdom, France and Norway, the CO_2 price is determined by the international market for emission allowances, since it is proposed to couple the maritime ETS to other trading schemes.

Hypothecated GHG contributions

In the proposal by Cyprus et al., the CO_2 price (the GHG contribution) is unknown, but expected to be much lower than the marginal costs of emission reduction outside the maritime sector. If the revenues of the GHG Fund are entirely used to offset emissions (as suggested by sections 36-51 of the proposal), then the CO_2 price will only be a fraction of the global marginal costs of mitigation, i.e. the international market price for emission allowances. In approximation, this fraction is equal to the fraction of total emissions by the maritime sector that have to be offset. If, for example, the amount of emissions to be offset is a *third* of total emissions by the maritime sector, then the CO_2 price will be a *third* of the international trading price (CDM) as well. In reality, the price will be a little higher because the revenues need to cover costs for administration of the system, R&D and technical cooperation. If the target for the maritime sector reaches zero emissions (all emissions have to be offset), then the GHG contributions will become a little higher than the CDM price.

Baseline-and-Credit Trading Scheme

The CO_2 price established in the system proposed by the United States is unknown. It entirely depends upon the benchmark or efficiency index standards. The resulting CO_2 price can be above or below the price of the emission allowances in the international market depending upon whether the standards are relatively tight or loose, respectively. Please note that this CO_2 price only holds within the closed system. There is no inflow or outflow of credits outside the Trading Scheme.

Please note: since the US proposes a closed system, there is no safety valve if targets are more difficult to achieve than expected. If the baseline is set a bit too ambitious, this will lead to a strong demand for credits and very high prices. After all, it will be quite difficult in the maritime sector to increase technological efficiency on short notice.

5 Evaluation of global MBMs

At MEPC 57, States agreed on a set of criteria that market-based measures should meet (MEPC 57/21). They should be:

1. Effective in contributing to the reduction of total global emissions of greenhouse gases.
2. Binding and equally applicable to all Flag States, in order to avoid evasion.
3. Cost-effective.
4. Able to limit – or, at least, effectively minimize – competitive distortion.
5. Based on sustainable environmental development without penalizing global trade and growth.
6. Based on a goal-based approach and not prescribing specific methods.
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. And
9. Practical, transparent, fraud-free and easy to administer.

The remainder of this section evaluates the proposals against these criteria.

5.1 Effective in contributing to the reduction of total global emissions of greenhouse gases

The effectiveness of the various proposals is difficult to assess. Neither the IMO nor the proposals themselves have established quantitative reduction targets for the maritime sector against which it can be determined whether the proposals fulfil their purpose. The effectiveness of the proposals will depend, however, to a large extent upon the stringency of the targets that are set.

Nevertheless, the effectiveness of the various proposals can be assessed regarding the *certainty* that emission reduction will in fact be achieved.

Global Emission Trading Scheme

Emission reduction is **very certain** under the ETS as proposed by France, the United Kingdom and Norway, since a fixed cap is put on the CO_2 emissions by the maritime sector. Although the scheme allows the maritime sector to buy emission rights from outside the sector, and thus allows the maritime sector to emit more than its target, additional emissions by the maritime sector are perfectly compensated.

It should be noted, however, that the assumption is made that emission reductions credits bought outside the sector reflect real emission reductions. It has sometimes been argued that CDM projects are not additional. If this is true and the projects would also have been done in the absence of CDM, the credits would not reflect real emission reductions and the environmental effectiveness would be undermined.

Hypothecated GHG contributions

Emission reduction is **quite certain** under the system of GHG contributions as proposed by Cyprus et al., since the target can be achieved by financing emission reduction outside the maritime sector. Since its environmental effect depends almost completely on buying offsets, the quality of the offsets is even more important than in the case of the ETS. Moreover, there may be a time

lag between the moment the target should be achieved and the moment of emission reduction. After all, if there is a mismatch between the target and actual emissions, additional emission reduction has to be bought and the level of GHG contributions may have to be adapted.

Please note! The environmental effectiveness of the proposal by Cyprus et al. could be strongly undermined by sections 54-57. These sections could be read as a request to be allowed to count financing of adaptation as an offset for maritime emissions:

"According to the basic proposal, the revenues of the GHG Fund should primarily be allocated for climate purposes in developing countries and in particular in the most vulnerable developing countries, i.e. the Least Developed Countries (LDCs) and the Small Island Developing States (SIDSs). Apart from being particularly vulnerable to the negative effects of climate change, SIDSs are also in many respects dependent on maritime transport."

"It is true that financing of adaptation purposes does not in itself reduce GHG emissions. Therefore it would be necessary to ensure that the international shipping sector is also recognized for financing adaptation purposes. A procedure by which to recognize, register and record financing for adaptation purposes should be arrived at after further consideration by the UNFCCC and the IMO."

If, as suggested, a substantial amount of the fund is diverted for adaptation the proposal will be much less effective in reducing global CO_2 emissions.

Baseline-and-Credit Trading Scheme

Emission reduction is much less certain under the proposal by the United States for the following reasons:

1. The technical options available for emission reduction within the maritime sector are limited (CE et al., 2009). Only against very high costs substantial emission reduction can be achieved. Therefore, it is unlikely that under the US proposal ambitious targets can be set.
2. A Baseline-and-Credit Trading Scheme does not set an absolute emission target for the maritime sector in contrast to the other two sets of proposals. Instead, the proposal by the United States sets a relative emission target: only the efficiency is targeted, but if maritime's economic activities grow total emissions are allowed to grow as well.
3. Even the efficiency target is not certain. Since the system proposed by the US is closed to other trading schemes, there is no safety valve to compensate an overshoot of emissions outside the system.
4. It is likely that the US system will have different baselines for different ship types. Most probably, the baselines will be set at the level of the average ship of a certain type and size. Since container ships on average have much higher emissions per unit of transport than bulk carriers, their baseline will be higher. So if cargo is transported in containers instead of in bulk or as general cargo, it will emit more CO_2, even when the container ship is relatively efficient and the bulk or general cargo ship is relatively inefficient. Containerization of cargo has been one of the major drivers of increasing maritime emissions.

5.2 Binding and equally applicable to all Flag States, in order to avoid evasion

All proposed systems are intended to be binding and equally applicable to all Flag States. All systems require ships of all flags to participate, regardless of where they sail or by whom they are owned.

The reason for the global scope of both systems is that shipping is a global industry and excluding ships flying a certain flag would incentivize flagging out. This would undermine the environmental effectiveness of the measures.

Please note! The proposal by Cyprus et al. differs from its predecessor, the Danish proposal MEPC 59/4/5: where in the Danish proposal the fuel suppliers pay GHG contributions, in the proposal by Cyprus et al. the possibility is also explored that ship owners pay the GHG contributions.

5.3 Cost-effective

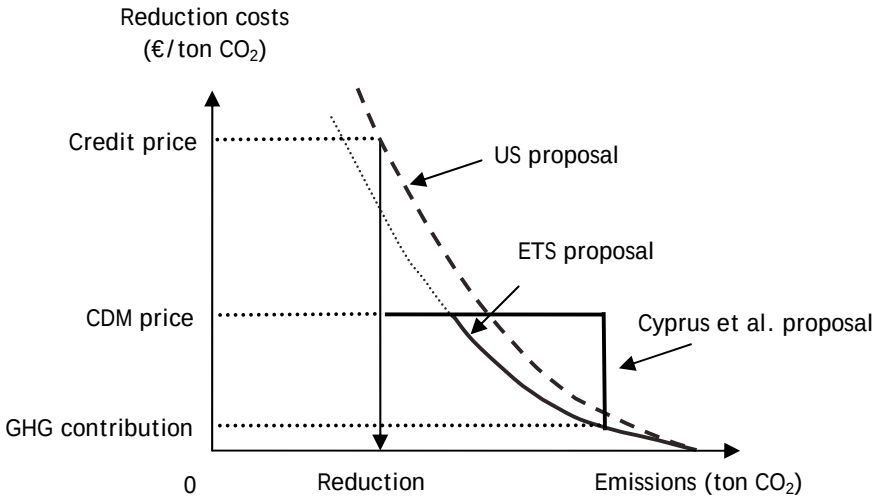
The requirement by the MEPC, that a future IMO regulatory framework on GHG Emissions from ships should be cost-effective, does not state whether this cost-effectiveness is to be assessed from the *social* (global) or the *sectoral* perspective. From a social (global) perspective, an MBM is perfectly cost-effective if the emission target for the maritime sector is achieved with the cheapest set of emission reduction measures available. From this perspective, *distributional* effects are irrelevant. For example, whether emission allowances are auctioned or allocated for free to the sector, is a matter of *distribution* and *equity*, but much less of *cost-effectiveness*. From a sectoral perspective, however, the overall costs to the sector may be included in the definition of cost-effectiveness: a system which achieves the same goal against lower costs for the sector is then considered more cost-effective.

Below we discuss the cost-effectiveness from a social and sectoral perspective, successively. In this discussion, we first focus on the marginal costs of emission reduction resulting in the various systems. To these costs the *administrative* costs still have to be added.

The social (global) perspective

From a social perspective, the proposal by France, the United Kingdom and Norway is the most cost-effective in comparison to the other proposals. To be more precise: the proposal by France, the United Kingdom and Norway is perfectly cost-effective, while the proposals by Cyprus et al. and the United States could turn out to be quite inefficient. The shape of the marginal reduction cost curve in the various proposals is illustrated in Figure 3 and further explained below. The *total* reduction costs are given by the area demarcated by the reduction cost curve, the x-axis, and the horizontal arrow showing the achieved emission reduction. For the sake of comparison, we assume that all systems achieve the same emission reduction. Also note that for illustrative purposes the emission reduction achieved within the maritime sector has been strongly exaggerated; in reality, the reduction cost curve is expected to be much steeper.

Figure 3 Marginal costs of additional emissions reduction in the three proposals



Explanation Figure 3

In the proposal by France, the United Kingdom and Norway all emission reduction options within the maritime sector are used which have marginal costs below the costs of additional emission reduction outside the maritime sector (the CDM price; see Figure 2 in the previous chapter). This is the most efficient reduction cost curve.

In the proposal by Cyprus et al. emission reduction options within the maritime sector are used which have marginal costs below the level of GHG contributions. Since the GHG contributions are much lower than the CDM price (see Section 4.6), much less emission reduction options are used within the maritime sector than in the proposal by France, the United Kingdom and Norway. Further emission reduction is achieved at the CDM price. As a result, many opportunities within the maritime sector are left unused and more expenses are made on emission reduction than necessary[3].

The Baseline-and-Credit Trading Scheme proposed by the United States faces two major inefficiencies:

1. It does not address the whole palette of cost-effective options to reduce CO_2 emissions. The proposal only offers strong incentives for *technological* mitigation options. The proposal is not yet sufficiently elaborated to judge to which extent efficient *operational* measures are addressed. In a Baseline-and-Credit Trading Scheme efficient *volume* or *demand* measures are left unused by definition[4]. In Figure 3 this is illustrated: the marginal abatement cost curve in the proposal by the United States lies above the cost curve which includes all available abatement options. As explained in the previous chapter, if demand measures are not included in the set of measures, which is implemented to achieve the emission target, more

[3] It should be noted that in the proposal by Cyprus et al. part of the revenues are used to fund R&D projects on more energy-efficient ship designs and propulsion systems. Japan has suggested the option to refund a part of the revenues to those ships ranked 'excellent' based on those ships' performance in terms of energy efficiency in a certain evaluation period. It is difficult to assess beforehand the additional emission reduction, which will be achieved by these options.

[4] A Baseline-and-Credit System does give an incentive for inefficient ships to lower their activities, but it equally gives an incentive for efficient ships to increase their activities. On average, demand is left unaffected.

expensive technical measures have to be implemented, thereby increasing the overall costs of emission reduction.

2. The proposed system is closed to systems outside the maritime sector. In other words, the system proposed by the United States may offer incentives for expensive measures within the maritime sector while cheaper options are left unused outside the maritime sector, such as via the CDM.

Note that we have assumed that the costs of the offsets would not be affected by the demand for offsets from the shipping sector. This is a reasonable first approximation as Bakker et al. (2007) and OECD (2009) estimate that by 2020, the supply of credits would be up in the order of several gigatonnes CO_2 eq. However, as demand for credits from the shipping sector increases, prices of offsets are likely to rise. As the demand for offsets is larger in the GHG fund (because less emissions are reduced in the shipping sector), the cost increase would be larger in the GHG Fund than in the ETS. This would reduce the cost-effectiveness from a social perspective.

The sectoral perspective

From a sectoral perspective, the cost-effectiveness depends on two variables that have not been parameterized in the proposals: the target in the proposal by Cyprus et al. and the level of auctioning in the ETS proposal. The more ambitious the target, the higher the costs to the sector. And the higher the level of auctioning, the higher the costs to the sector. Thus, an ETS with free allocation can have lower costs to the sector than a GHG Fund with a very ambitious target. Conversely, an ETS with full auctioning would be more expensive to the sector than a GHG Fund with an unimposing target (assuming that the auction revenues would not be ploughed back into the sector).

In the numerical examples given in the proposal by Cyprus et al., the costs to the sector appear to be lower than in the proposal by France, the United Kingdom and Norway. It should be noted, however, that a system can be designed which fares better than the proposal by Cyprus et al. against both definitions of cost-effectiveness. If the GHG contributions are set equal to the marginal costs of emission reduction outside the sector and the revenues of the system are partly returned to the sector, then lower costs for the sector are achieved *and* a better cost-effectiveness.

It is difficult to assess the efficiency of the US proposal from a sectoral perspective since it depends on both the shape of the marginal abatement cost curve and the required emission reduction. See Figure 3.

If the demand for CDM credits from the shipping sector would increase CDM prices, the effect would be larger in the GHG fund than in the ETS. In that case, the sectoral cost-effectiveness of the GHG fund would deteriorate, but still be better than ETS.

Administrative costs

In all systems, a number of administrative tasks have to be fulfilled. Table 1 presents an overview.

Table 1 Administrative tasks in proposals by Cyprus et al., and France, the United Kingdom and Norway, and the US

Actor	METS	GHG Fund		Baseline-and-Credit	
		Ship	Bunker Fuel supplier	EEDI	EEOI
Fuel supplier	Provide bunker fuel delivery note*	Provide bunker fuel delivery note*	Provide bunker fuel delivery note* Provide levy receipt Report amount of fuel sold to administrative body Pay levy to administrative body	None	None
Ship/ship owner	Keep bunker fuel delivery notes* Report on amount of fuel used Acquire allowances Surrender allowances to administrative body	Keep bunker fuel delivery notes* Report on amount of fuel used Pay GHG contributions to administrative body	Keep bunker fuel delivery note* Keep levy receipt Pay levy if fuel is bought from a non-registered fuel supplier	Establish EEDI Verify EEDI Report EEDI Calculate EI_A - EI_R Monitor and report output level Apply for credits from administrative body OR Acquire credits from other ship owners Surrender credits to administrative body	Establish EEOI annually - Fuel - Cargo - Distance Verify EEOI annually Report EEOI annually Monitor and report output level
Flag State	Monitor and enforce compliance for ships flying the flag	Monitor and enforce compliance for ships flying the flag	Register fuel suppliers Monitor and enforce compliance for ships flying the flag	Monitor and enforce compliance for ships flying the flag	Monitor and enforce compliance for ships flying the flag
Port State	Monitor and enforce compliance for ships in ports	Monitor and enforce compliance for ships in ports	Monitor and enforce compliance for ships in ports	Monitor and enforce compliance for ships in ports	Monitor and enforce compliance for ships in ports
International organization	Manage allowance registries Receive emissions allowances Distribute funds	Maintain register of payments Distribute funds	Maintain register of payments Distribute funds	Manage allowance registries Receive emissions allowances Distribute funds	Manage allowance registries Receive emissions allowances Distribute funds

Note: Tasks marked with an * are required in Marpol Annex VI.

Table 1 shows that the GHG fund and the ETS have roughly the same number of tasks to be fulfilled. The main difference is that the ETS requires ships to acquire and surrender emission allowances, whereas the GHG fund requires ships or fuel suppliers to pay a contribution.

Experiences of the EU ETS may give some insight in the magnitude of these costs, although it is difficult to distinguish between the costs of monitoring and reporting emissions, which would be required in both MBMs, and the costs of emissions trading itself. A survey of Irish businesses shows that it costs them a few cents per tonne of CO_2 to trade (Jaraite et al., 2009). In the EU, compliance costs of paying taxes are typically 2-4% of tax revenue (European Commission 2004), so at a CDM price of € 15 also a few cents per tonne of CO_2.

Both ETS and tax compliance costs tend to be higher for small firms than for large firms. One difference between the administrative costs of the GHG fund and the ETS is the number of actors that may be affected. If the GHG Fund is applied to fuel suppliers and not to ships, the number of actors would probably be smaller, so they would pay on average higher contributions per actor and have relatively lower costs of compliance. We cannot specify the savings in administrative costs.

What about the administration of the system? In order to assess the differences in costs, we compare the costs of administration of the EU ETS with the costs of administration of taxes.

The Dutch Emission Authority (NEA) employs approximately 25 people to administer about 400 installations in the EU ETS and over 300 installations engaged in NO_x emissions trading. Its costs in 2008 were approximately € 5 million (NEA, 2009). Assuming that half of the costs were in relation to the EU ETS, and taking into account that the Dutch emissions were a little over 80 Mt CO_2, the administration costs can be estimated at € 0.06 per tonne of CO_2.

In the OECD, the average ration of administrative costs and revenues of taxation were about 1% (OECD, 2009). Using this figure for the administration of the GHG Fund contribution, and CDM price of € 15, the administration costs for the GHG fund can be estimated at € 0.15 per tonne of CO_2.

Given the uncertainty in the data, we do not think the costs of administering a contribution and an ETS will be much different. Since the costs of compliance for companies also are similar, we conclude that there is no difference in administrative costs between the ETS and the GHG Fund in which ships are responsible for paying the contribution. If fuel suppliers would be liable for paying the contribution, the administrative costs of the fund could be somewhat lower.

Baseline-and-Credit Trading Scheme

The administrative requirements under the system proposed by the United States are as yet not clear since the proposal has not yet been well elaborated. Obviously, the US proposal requires substantially more information and consequently higher administrative costs than the other proposals. The following tasks have to be performed:

1. Development of efficiency index standards for existing ships, which are sufficiently differentiated to distinguish between various ship types and sizes. This is not a straightforward matter as explained in Deltamarin, 2009.
2. Calculation of attained efficiency index for each ship. The US proposal tries to build on the EEDI standard for new ships. However, as the US notices, such an approach 'does not account for periodic operational measures such as regular maintenance and cleaning to increase efficiency, and optimal voyage planning. Therefore, consideration of a different optional calculation to include these operational measures would be needed. For instance, the US recommends developing an optional methodology using records of the actual fuel consumed divided by the work performed (cargo tonne-miles), as the means for calculating the ship's Attained Efficiency Index (EIA).' (page 5, section 17). At best, the US proposal will only require information per shipment about fuel consumption and work performed (cargo tonne-miles). If the system is made more complicated, data has to be gathered per ship about past performance as well to establish individual ship's EIAs.

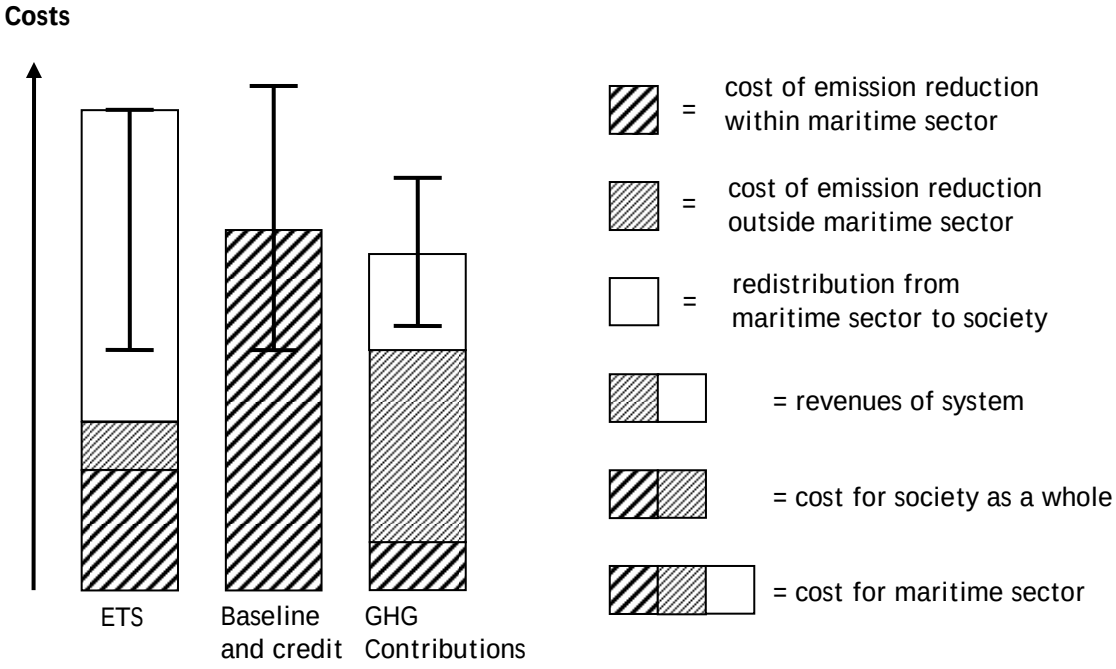
3. Establishment of efficiency credits for ships. For this purpose, the ship's activity level has to be measured in cargo tonne-miles or miles, based upon cargo and navigational logs.

The main difference between the Baseline-and-Credit Scheme and the other two schemes is that the Baseline-and-Credit Scheme requires ships to monitor and report their output instead of their fuel use. Since both output (be it defined as tonne miles, be it as miles) and fuel use are regularly registered by shipping companies, monitoring and reporting could be based on current information systems. We do therefore not foresee major differences in administrative costs.

Graphical illustration differences

The main differences between the three proposals are illustrated in Figure 4 under the assumptions that in the case of the ETS all allowances are auctioned and the revenues are spent outside the maritime sector, and that in the case of GHG contributions all revenues are used to buy emission reduction outside the maritime sector. Moreover, we disregard administrative costs as these are roughly the same for all systems. Once more, it should stressed that these assumption follow from the spirit of the proposals' text, but that choices can be made differently.

Figure 4 Graphical illustration of costs and redistribution in the various proposals assuming equal emission reduction



In Figure 4, the following conclusions are illustrated:

1. In the proposal by France, the United Kingdom and Norway more emission reduction is achieved within the maritime sector than in the proposal by Cyprus et al. but less than in the proposal by the United States. The reason is that the CO_2 price is expected to be the highest in the proposal by the United States and the lowest in the proposal by Cyprus et al. (see Section 4.6).

2. The social costs of emission reduction (costs within and outside maritime sector) are expected to be higher in the proposals by the United States and Cyprus et al. than in the proposal by France, the United Kingdom and Norway. The reason is that in the proposal by Cyprus et al. emissions are reduced outside the sector, while cheaper options are still available within the sector. In the case of the proposal by the United States it is the other way round.
3. In the proposal by France, the United Kingdom and Norway the cost for the maritime sector are higher than in the other proposals. The reason is that allowances are auctioned and revenues are assumed to be spent outside the sector.
4. In the proposal by France, the United Kingdom and Norway the revenues of the system are higher than in the proposal by Cyprus et al. The reason is that the price of allowances is expected to be higher than the GHG contributions.

5.4 Able to limit - or, at least, effectively minimize – competitive distortion

All proposed systems are intended to be binding and equally applicable to all Flag States (see Section 5.2). This global set up of all systems minimizes competitive distortion.

There are two main issues involved regarding competitive distortion. First, MBMs are intended to offer financial incentives for emission abatement. Since larger and newer ships are more efficient than smaller and older ships this means that the latter face a financial disadvantage and therefore are at a competitive disadvantage. They will become less competitive because in order to recover the costs of operating the ships, they will have to charge higher prices for the same service. However, this disadvantage is an *intended* effect of the MBMs and could therefore hardly be called a *distortion*.

Second, the administrative burden of the MBMs may be relatively lower for large companies than for smaller companies, due to economies of scale. This may give larger companies a competitive advantage. Since the administrative burden is not an intended effect of the MBMs, this difference between large and smaller companies may be called a distortion. The larger the administrative burden, the larger the distortion. While the proposals lack specific details on the administrative burden, we assume that the costs for smaller companies would be relatively larger based on an analysis of emissions monitoring and reporting costs in the EU ETS (Jaraite et al., 2009). Also, costs for either engaging in trading or paying contributions are generally higher in relative terms for smaller companies.

5.5 Based on sustainable environmental development without penalizing global trade and growth

This is a difficult requirement. In the long run, sustainable environmental development is a *prerequisite* for global trade and growth. In the short run, however, sustainable environmental development requires an *effort* compared to unsustainable environmental development, which necessarily penalizes global trade and growth. All proposals raise the costs of transport and, consequently, trade.

The extent to which a future IMO regulatory framework on GHG Emissions from ships penalizes global trade and growth depends on the framework's specific design. Generally, it could be stated that the more stringent the target for emission abatement and the less cost-effective the instrument (see Section 5.3), the more global trade and growth is penalized *in the short run*. In the long run, it is only the cost-effectiveness which is of relevance.

Presently, however, the uncertainty surrounding the various proposals is too large to tell which proposal fares better in the face of this 5th requirement.

5.6 Based on a goal-based approach and not prescribing specific methods

All proposed systems are based on a goal-based approach; none prescribes specific methods.

The proposal by the United States relies heavily on specific *efficiency standards* in the distribution of responsibilities. However, these standards are irrelevant for the incentives resulting in the proposal by the United States. The incentive to improve the efficiency of a ship does not depend upon the baseline technology.

It should be noted, though, that the United States in a certain sense prescribes technological options at the expense of efficient demand measures. If the system is based upon ship's EEDI, then efficient operational measures are discarded as well.

The idea in the proposal by Japan to refund a part of the revenues of GHG contributions to reward 'good performance ships', for example on the basis of EEDI values, can also be seen as partly prescribing specific methods.

5.7 Supportive of promoting and facilitating technical innovation and R&D in the entire shipping sector

All proposals are supportive of promoting and facilitating technical innovation and R&D in the entire shipping sector. However, the proposal by the United States performs best, while the proposal by Cyprus et al. performs worst.

In the proposal by Cyprus et al. *the least* emission reduction is achieved within the shipping sector and the marginal costs of emission reduction are the lowest. Consequently, the least technical innovation is promoted in the proposal by Cyprus et al. A small part of the GHG fund may be diverted for R&D, increasing the *supply* of innovation, but the resulting effect will be small compared to the effect in other proposals.

The proposals of France, the United Kingdom and Norway require more emission reductions in the shipping sector to achieve the same goal. Hence, they require more innovation.

In the proposal by the United States, all emission reduction is achieved within the shipping sector. However, it is doubtful whether the proposal can achieve the same emissions reduction within the shipping sector as it only incentivises technical abatement measures and not operational measures. This proposal can therefore not be compared to the other proposals. It is nevertheless clear that the system would be supportive of promoting and facilitating technical innovation and R&D.

5.8 Accommodating to leading technologies in the field of energy efficiency

All proposals accommodate existing technologies in the field of energy efficiency. The main difference is that the US proposal accommodates technologies that are reflected in the EEDI only, whereas the other proposals accommodate all technologies that result in improved energy efficiency.

As discussed in the previous section, the ETS provides a stronger incentive to improve the efficiency of ships and hence accommodates more technologies to do so than the GHG Fund.

5.9 Practical, transparent, fraud-free and easy to administer

In all systems, a number of administrative tasks have to be fulfilled. Table 1 presents an overview. It shows that roughly the same number of tasks have to be fulfilled in the different systems. We do therefore not expect large differences in practical feasibility, transparency and ease to administer.

We are not aware of many compulsory schemes which are fraud-free. There is evidence of fraud both in tax systems, in charges and levies and in emissions trading. Still, there are also many examples of efficient tax systems and efficient emissions trading systems. Hence, also in this case we conclude that there is no major difference between the schemes.

6 Design of European MBMs

6.1 Introduction

In this chapter, we focus on the design of the European MBMs as proposed in CE et al. (2009). We describe here mainly these features of the European instruments that would differ from the global proposals. For the details on the proposed design of these instruments, the reader is referred to CE et al. (2009).

6.2 Emissions trading scheme

The regional emissions trading scheme would in its basic principles not be different from the global emissions trading scheme as proposed by Norway, the United Kingdom, Germany and France. Both systems would be open for trade with other sectors, which would make them highly cost-effective.

The main difference between the systems lies of course in their scope: the global system would cover all ships (from a certain size threshold, which would probably be the same as the one projected for the European system, 400 GT) while the regional system would cover only the ships calling at the EU ports. They would have to surrender allowances for emissions on voyages to EU ports, defined as the distance from the port of loading for ships with a single bill of lading and distance from the last port call for ships with multiple bills of lading or non-cargo ships.

The cap for the cap-and-trade scheme has not been explicitly proposed in quantitative terms in any of the proposals. In CE et al. (2009) it is stated that most probably the cap would be based on historical emissions or would aim at maintaining a certain share of maritime emissions in overall emissions from all sectors. Lee et al. (2009) estimates that in this latter approach, if the share of shipping would be set equal to its current share in emissions, the global cap for the year 2030 would be in the range 765-815 Mt CO_2 and the EU cap would be in the range 158-169 Mt CO_2 (assuming a stabilisation scenario at 450 ppm CO_2).

The cap could also be estimated so that it would not significantly impact the prices in the EU ETS or simply as a political decision.

Regarding the allocation method, in the global system proposed by Norway, Great Britain and France, auctioning is recommended as the best way to allocate emissions. The same method is recommended for the regional system although CE et al. (2009) argues that there are three possible reasons to allocate the allowances (partly) for free:

1. Protect the participants from loosing market shares to competitors who are not participating in the scheme.
2. Ensure equal treatment of industries covered by the EU ETS.
3. Free allocation can be introduced temporarily in order to give the sector time to adjust to new circumstances.

Following these arguments, full financial responsibility for emissions could be introduced in the sector gradually, for example the ships would initially have to surrender allowances only equal to a certain portion of their emissions. Yet another way of gradual introduction of liability would be to recycle allowances. Ships could, during the first few years, be awarded some allowances free of charge based on the reported individual emissions of the previous year. The free allocation would never represent more than a certain percentage of the emissions caused during the year before. The first year of operation could be used as a trial when the ships have to report emissions but do not have to surrender any allowances.

With auctioning, which is generally recommended in both proposals, a question arises about the use of the revenues. As mentioned before in the part related to a tax, hypothecation of the revenues within the regional EU system may be problematic. From a legal perspective, it is argued that hypothecation of the EU ETS revenues breaches the principle of subsidiarity, a fundamental principle of EU law, enshrined in Article 5(2) EC Treaty, which says that the EU can act only if action of individual countries is insufficient. Any attempt to earmark the revenues, by transferring competence away from Member States to the EU level, could breach this principle. The issue has been, politically, highly controversial, most recently during the drafting of the Aviation Directive, due to the opposition of a number of Member States to any earmarking of revenues. It is very likely that any attempt to hypothecate revenues in relation to maritime emissions would meet the same opposition. We also understand that the hypothecation of revenues may be unconstitutional in certain Member States.

In the global proposal, the revenues would be used for three purposes: covering the administrative costs of the scheme, financing mitigation and adaptation efforts in developing countries and financing R&D and technology transfer in the maritime sector. Similar goals could be financed from the revenues generated in the regional system in the design where a central European authority rather than country-based structures would administer the scheme and if a special, joint EU fund gathering the revenues would be created. With such a setup, the problem with hypothecation would be significantly reduced.

6.3 Emissions tax

An emissions tax can be compared with the global GHG contribution as proposed in Cyprus et al. However, there are important differences in the choice of the responsible entity and the level of the tax.

The European tax cannot be levied on the fuel supplier, as this would lead to avoidance of the system by ships engaged in intercontinental transport. Hence, the ship owner would be responsible for paying the tax and the ship would be the accounting entity. The tax would be levied on emissions on voyages to EU ports, defined as the distance from the port of loading for ships with a single bill of lading and distance from the last port call for ships with multiple bills of lading or non-cargo ships.

As described in Section 3.2.1, the proposal of Cyprus et al. focuses on the use of the revenues rather than on the mechanism of creating incentives to reduce CO_2 emissions. The level of the contribution is determined by the price of offsets and the difference between actual emissions and the emission target. In contrast, the EU tax would be aimed at internalising external costs of CO_2

emissions and its primary goal would be to incentivise emission reductions in the maritime sector. The tax would be set at the level approximating the prices at the ETS market.

Generating the revenues and using them for further emission reductions via offsetting (e.g. through CDM) may increase the overall effect of CO_2 reduction related to this instrument. According to CE et al. (2009), because the anticipated effect of abatement measures and reduced demand to be achieved with a tax do not seem sufficient to reach the policy goals, a significant share of the environmental effect of an emissions tax would need to come from the use of the revenues. After assessment of different options, emission reductions in non-Annex 1 countries seem to be the best way to improve the environmental effectiveness of this instrument.

However it has to be noted that in the light of legal constraints existing in many countries, hypothecation (i.e. earmarking the revenues to a given goal/set of goals) may be problematic. Similar issues were raised in response to proposals to hypothecate revenues from auctioning of ETS allowances, where in some countries hypothecation of the revenues from auctioning is not allowed.

6.4 Baseline-and-Credit Scheme

Both the global Baseline-and-Credit Scheme as proposed by the United States and the regional scheme as proposed in CE et al. (2009) imply the same mechanism of trading. Within Baseline-and-Credit Schemes there is no absolute cap on emissions. Instead, a relative standard has to be defined. The US proposal at the moment does not elaborate on the type of a standard that could be taken as a baseline for such a system. In the regional proposal, two indexes have been considered as potential baselines: Energy Efficiency Operational Index (EEOI) and Energy Efficiency Design Index (EEDI), as developed within the IMO.

The EEOI is defined in terms of CO_2 emissions per unit of transportation work. Definition of EEDI is much more complicated and refers to technical characteristics of ships which influence their CO_2 emissions.

The most fundamental difference between EEDI and the EEOI is that the first one relates exclusively to the technical state of a vessel, while the EEOI covers also operational measures.

Both the EEDI and the EEOI in their current forms are applied to cargo ships, which accounted for 71% of emissions on ships sailing to EU harbours in 2006 and 84% of global CO_2 emissions from maritime transport in 2007 (Buhaug et al., 2009). Both indexes have been extensively debated in the IMO. In these debates, views on the applicability of both measures in a policy setting have been discussed.

In 2009, the IMO has issued Guidelines For Voluntary Use Of The Ship Energy Efficiency Operational Indicator (MEPC.1/Circ.684). As the title suggests, these guidelines exclusively mention the voluntary use of the EEOI. There is no consideration of a mandatory application and/or the use of the EEOI as a basis for a mandatory policy in these guidelines or in the report of the meeting in which they were adopted (MEPC 59/24). However, note that the first Intercessional Meeting of the Working Group on Greenhouse Gas Emissions from Ships concluded that 'the operational index should not be mandatory, but

recommendatory in nature, but this does not mean that it could not be made mandatory in the future' (MEPC 58/4)[5].

CE et al. (2009) review the use of the EEOI as an indicator for a ship's efficiency in a mandatory Baseline-and-Credit Trading Scheme. They conclude that currently, the EEOI is not fit as a basic parameter for a mandatory policy for the following reasons:

- The EEOI dos not take changes in efficiency due to the business cycle, the specific trade or the region where a ship operates into account and could therefore be considered to be inequitable.
- It is hard if not impossible to compare the EEOI across ship types, even across the most important ship types in terms of CO_2 emissions: bulkers, tankers, container ships and RoRo ships.
- The IMO has endorsed the use of the EEOI as a voluntary measure to evaluate the performance of ships by ship owners and operators, not as a metric for a ship's performance in a mandatory policy.

The EEDI may be developed into a good indicator for a ship's design efficiency. Currently, however, it is also not mature as the formula for the EEDI has only recently been established and is subject to trials at the moment. It should be kept in mind that there is no single baseline for the EEDI of the shipping sector, but a set of baselines for different vessel types. The number of vessel types with different baselines is still growing. At this point, we cannot assess where this process will end.

In Baseline-and-Credit Schemes, because the traded unit is not absolute quantities of actually emitted CO_2 but rather the amounts above or below the baseline, it would be difficult to link this scheme to cap-and-trade schemes like the EU ETS or even to flexible mechanisms under the Kyoto Protocol.

A major difference between a global and a European Baseline-and-Credit Trading Scheme would be that the latter can only be enforced on ships in EU ports. This opens up the possibility to avoid the system by employing ships with a low efficiency on routes outside Europe and using only highly fuel-efficient ships for voyages to EU ports. The scope for such avoidance is significant, potentially undermining the environmental effectiveness of the scheme.

[5] Currently MEPC is working on drafting text for mandatory of EEDI and SEEMP, where the EEOI will be part of the (mandatory) SEEMP.

7 Evaluation of European MBMs

The evaluation of the policy instruments described in Chapter 6 will be performed according to the criteria established during the MEPC 57, where it is stated that the instruments for curbing CO_2 emissions from maritime shipping should be:

1. Effective in contributing to the reduction of total global emissions of GHGs.
2. Binding and equally applicable to all Flag States, in order to avoid evasion;
3. Cost-effective.
4. Able to limit – or, effectively minimize – competitive distortion.
5. Based on sustainable environmental development without penalizing global trade and growth.
6. Based on a goal-based approach and not prescribing specific methods.
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.

In the following sections, we give a comparison of all the three selected instruments from the perspective of the criteria listed above. In this section we focus on comparison of the three regional instruments, however where applicable, we also give some assessment of the specific features of these instruments in comparison with the global instruments described in Chapter 4.

7.1 Environmental effectiveness

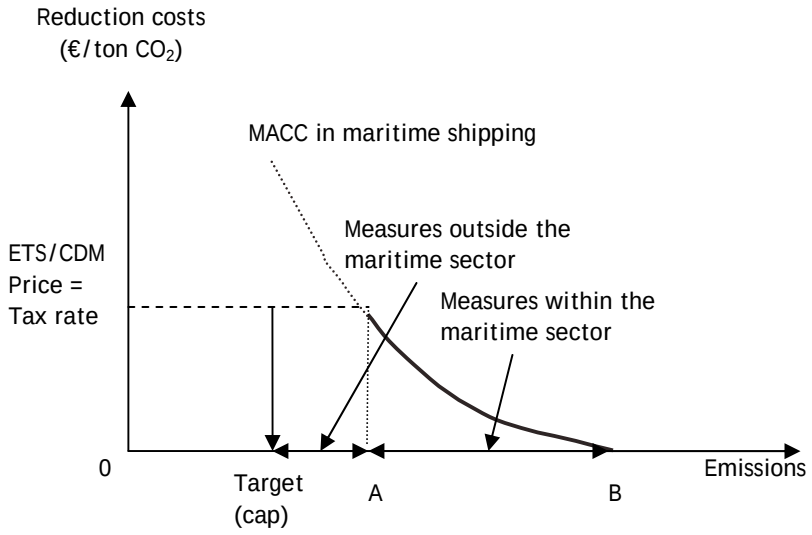
The environmental effectiveness of the regional policies would by definition be lower than the effectiveness of the global policies. The regional, EU-27 schemes envisaged for the ships which make port calls in the EU ports would cover at maximum around 208 Mt of CO_2 emissions annually (based on estimates for 2006), which would constitute around 20% of global emissions from the maritime shipping sector (CE et al., 2009).

Moreover, the environmental effectiveness can be undermined by possibilities to avoid the system. The scope for avoiding either an emissions tax or an emissions trading scheme depends on the definition of the route. We find that avoidance by making an additional port call becomes prohibitively expensive for ships with a single bill of lading if a voyage is defined as the route from the port of loading to the port of discharge. For ships with multiple bills of lading (container ships, general cargo ships), it is not possible to unequivocally determine a port of loading. Hence, for these ships, some avoidance will inevitably occur. In total, the avoidance is limited to about 15% of total emissions under the scope of the scheme.

For a European Baseline-and-Credit Scheme, avoidance is probably easier because it is possible to avoid the system by deploying ships with an EEDI over the baseline outside the EU, and deploy compliant ships in the EU. Such avoidance would relocate emissions, but would not significantly reduce them.

The environmental effectiveness of the three European instruments as proposed in CE et al. (2009) cannot be clearly compared without knowing the rate of the tax, the cap in the cap-and-trade and the standard adopted in the Baseline-and-Credit System. The hypothecated tax proposed and the cap-and-trade system can achieve exactly the same target, only approaching it differently (see below).

Figure 5 The mechanism of achieving the same effectiveness of emission reduction under the tax and ETS schemes



In Figure 5, a tax is set at the level approximating the ETS or CDM price. The effect on the maritime shipping emissions depends on the shape of the marginal abatement cost curve (MACC). The measures with the costs per ton CO_2 reduction below the tax level) will be implemented and the emission reduction equal to (B–A) at the picture will be achieved. Further reduction of emissions due to this policy, up to the target, can be achieved through buying offsets e.g. using the CDM mechanism (provided that hypothecation of tax revenues is legally feasible).

In the cap-and-trade scheme, the same target (cap) can be achieved. Emission reductions within the sector will be implemented at the increasing costs from point B up to the point A. Reductions going beyond this point would be more costly than buying offsets at the market so the reductions between point A and the level set as a cap will be achieved in other sectors and acquired by the maritime shipping sector through purchase of allowances at the market.

In theory, the same effect could be achieved with a Baseline-and-Credit Scheme imposing a sufficiently stringent baseline. However establishing such a baseline, especially in the proposed variant referring to the design index, would be very difficult if not impossible in practice. It has to be also noted that this instrument in its regional setup would be more susceptible to avoidance resulting in a sort of carbon leakage outside the region.
This would drive the effectiveness of the Baseline-and-Credit Scheme down.

Certainty and predictability of achieving a given target would be the highest with cap-and-trade, which establishes an absolute limit on emissions. Second best in this category would be the hypothecated emissions tax, and baseline-and-credit would come on the third place.

7.2 Equal applicability and limiting evasion

All the instruments analysed here would be designed is such a way that they would be equally applicable to all ships sailing to the EU ports, regardless of flag. The legal consequence of not complying with the prescribed scheme is envisaged to be the same for all policies: denying the access to any of the EU ports. In all the systems some evasion might occur, which is related to defining the geographical scope according to the routes and port calls that the ships make. Possibilities of avoidance have been estimated at the level of about 32 Mt of CO_2 per year, or about 15% of the total scope of emissions to be covered (CE et al., 2009).

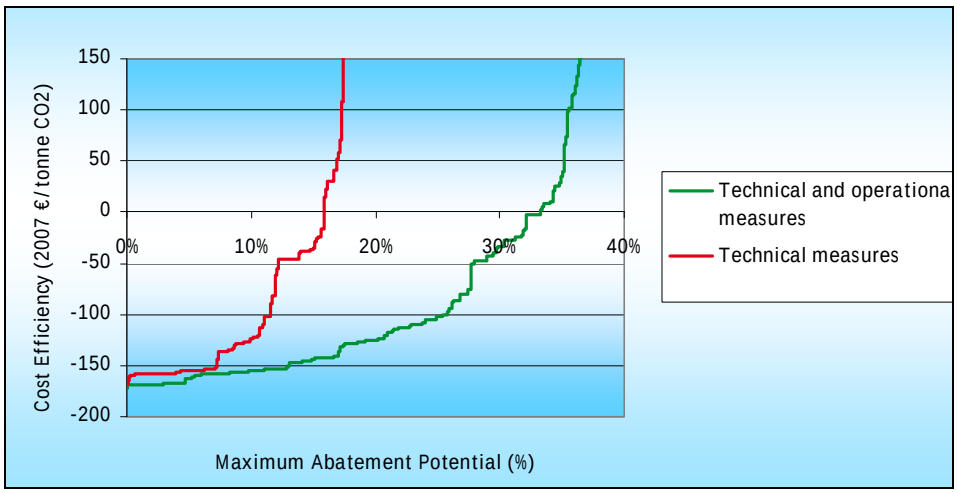
7.3 Cost-effectiveness

Among all the analysed options, the highest cost-effectiveness can be achieved with the cap-and-trade system in the design that is open for trading with other sectors (e.g. through ETS). As long as hypothecation of tax revenues is legally possible, the same cost-effectiveness can be achieved with the tax because a possibility of buying offsets at the market will be analogous to the possibility of trading with other sectors in the open ETS.

With the Baseline-and-Credit Scheme, this adjustment mechanism resulting from a possibility of trading with other sectors is absent. Therefore, this option comes as last in the ranking of the most cost-effective options.

In the Baseline-and-Credit System, internal cost-effectiveness of the system (i.e. the effectiveness within the maritime shipping sector) would be more or less the same as in case of cap-and-trade without the possibilities of trading with other sectors and as in the case of the tax, provided that all the measures (technical as well as operational) would be incentivised. Such a situation would occur if the operational index (EEOI) is taken as a basis for establishing the baseline. However in the currently discussed setup EEDI rather than EEOI has been recommended. This would mean including only technical options in a set of measures covered by the scheme. If we look at the marginal abatement cost curves (MACCs) for all measures and for technical measures only (see Figure 6 below), we can see that the MACC for technical measures only indicates much higher costs for the same levels of emission reductions.

Figure 6 **Maritime CO_2 abatement costs for all measures and for technical measures only, year 2030, $ 700/tonne fuel, interest rate 9%**



This drawback of the Baseline-and-Credit System based on the EEDI occurs both in comparison to the cap-and-trade and the tax schemes (both of which incentivise the whole range of measures).

Obviously with the global schemes, regardless of their type, cost-effectiveness is higher than with the regional schemes simply because cheaper reduction options may be available outside the regional scope. Also, the effective incentive level of the regional instruments is lower because many ships travel partly outside the scope of the policy. In addition, administrative costs of implementing the regional policies would be relatively higher than for global policies, which means that the overall costs of the policy per tonne of CO_2 reduced would also be higher in the regional setup.

7.4 Minimizing competitive distortions

All systems are designed to be applicable to all ships, regardless of flag, ship type and size (albeit above a certain threshold) in order to eliminate market distortions. The proposed size threshold of 400 GT constitutes a threshold for many environmental requirements and only excludes the smallest ships such as yachts and tugs. We do not expect a significant distortion from this threshold. A higher threshold could distort markets for e.g. short sea shipping.

There are three main issues involved regarding competitive distortion. First, MBMs are intended to offer financial incentives for emission abatement. Since larger and newer ships are more efficient than smaller and older ships this means that the latter face a financial disadvantage and therefore are at a competitive disadvantage. They will become less competitive because in order to recover the costs of operating the ships, they will have to charge higher prices for the same service. However, this disadvantage is an *intended* effect of the MBMs and could therefore hardly be called a *distortion*.

Second, the administrative burden of the MBMs may be relatively lower for large companies than for smaller companies, due to economies of scale. This may give larger companies a competitive advantage. Since the administrative burden is not an intended effect of the MBMs, this difference between large and smaller companies may be called a distortion. The larger the administrative burden, the larger the distortion. While the proposals lack specific details on the administrative burden, we assume that the costs for smaller companies would be relatively larger based on an analysis of emissions monitoring and reporting costs in the EU ETS (Jaraite et al., 2009). Also, costs for either engaging in trading or paying contributions are generally higher in relative terms for smaller companies.

Third, the introduction of MBMs in the maritime sector may raise the costs in comparison to other transport modes, such as aviation. However, it is assumed that other transport modes in Europe will face comparable emission abatement targets. In that sense, the introduction of MBMs in the maritime sector will *remove* competitive distortions.

7.5 Not penalizing global trade

The overall impact of climate policies on consumer prices of goods which are transported via sea is not expected to be significant. According to CE et al. (2009), import values are expected to increase within the range of approximately 0.4 to 2.7%. Assuming that other factors influencing consumer

prices along the chain between the producer and consumer would stay unchanged, consumer prices would be affected by the maritime shipping climate policy even to a lesser extent than import values. Such increase in prices could marginally influence the demand for maritime shipping transport, however at the moment it would be very difficult to estimate such a shift in demand because of lack of data on price elasticities.

It should be noted that limiting demand for maritime shipping is one of the measures for limiting CO_2 emissions from the sector. Therefore, this effect of policies may be viewed as positive, especially if we look at the whole wording of the criteria as formulated by IMO: 'based on sustainable environmental development without penalizing global trade and growth'. Sustainable environmental development can be interpreted as such a development where external costs are minimized, and reducing demand for maritime shipping transport is one of the measures promoting this goal.

The extent to which global trade could be limited due to the climate policies depends on the choice and the design of the instruments. The effect of the cap-and-trade and the hypothecated tax regimes would be more or less equal and relatively higher than the effect of the Baseline-and-Credit Scheme (see Section 5.2).

The regional instruments would definitely have less impact on the possibilities of growth of the maritime shipping sector than the global instruments with a comparable incentivising power. (one could imagine though for example a very low global GHG contribution with less impact on the sector than a very ambitious European tax-and-trade). Regional instruments affect only trade with Europe so maritime shipping trade in other regions would stay unaffected.

7.6 Goal-based

All the three regional policy instruments analysed in this section prescribe a goal-based approach without promoting specific measures for achieving emission reduction. However, while both the tax and the cap-and-trade systems include all the types of measures, both operational and technical, the Baseline-and-Credit System based on the design index (EEDI) does not take into account operational measures. Therefore, the scope of the measures that are incentivised by this latter system is relatively limited.

7.7 Promoting R&D

All the policy instruments considered promote indirectly R&D by incentivising fuel-efficient measures. The tax and the cap-and-trade schemes promote technical innovations in both technical and operational measures while the Baseline-and-Credit System based on the design index (EEDI) promotes only technical measures. Furthermore, in the Baseline-and-Credit Scheme only the measures which have impact on the index value are incentivised. Therefore, the potential of the tax and the cap-and-trade schemes are from this perspective higher, by covering a wider scope of innovations.

Promotion of R&D can be boosted via using (some of) the revenues from the instruments to support this sector. This would be possible both with the cap-and-trade and the hypothecated tax, at the extent depending on their design.

Only in the Baseline-and-Credit Scheme, expected to be revenue-neutral, there would be no such possibility.

7.8 Accommodating to leading energy efficiency technologies

All the policy instruments considered promote indirectly energy-efficient technologies by incentivising fuel-efficient measures. The tax and the cap-and-trade schemes promote technical innovations in both technical and operational measures while the Baseline-and-Credit System based on the design index (EEDI) promotes only technical measures. Furthermore, in the Baseline-and-Credit Scheme only the measures which have impact on the index value are incentivised. Therefore, the potential of the tax and the cap-and-trade schemes are from this perspective higher, by covering a wider scope of innovations.

Support for implementation of energy-efficient technologies can be boosted via using (some of) the revenues from the instruments to support this sector. This would be possible both with the cap-and-trade and the hypothecated tax, at the extent depending on their design. Only in the Baseline-and-Credit Scheme, expected to be revenue-neutral, there would be no such possibility.

7.9 Transparent and easy to administer

All the instruments discussed would be highly transparent by stating clearly who is eligible and in what form the compliance is to be executed. However, there are some features which make some of the instruments more susceptible to fraud or more complicated from an administrative point of view.

The tax, in the design where the existing national authorities are used, would be relatively easy to administer and would offer minimum possible opportunity of avoidance or fraud. One of the aspects related to administration would be related to the use of the revenues. Here, some problems might occur because hypothecation could in some countries be opposed or considered unconstitutional. The proposal by Cyprus et al. for a global fund discussed in Chapter 4 related to global instruments might be easier to implement and administer, as long as the process of finding a compromise among IMO Members regarding the use of the fund's revenues could be assumed to be less problematic than the analogous administrative process within the EU.

Cap-and-trade system with full auctioning would also be relatively easy to administer, by being able to use the procedures and even some structures created for the ETS. Hypothecation in the administrative option where the national institutional structures are used for administration might be opposed in some countries (in the same way as with the tax). However it has to be noted that CE et al. (2009) leaved two possible ways for administration of the ETS for maritime shipping: either using national structures or using a central European institution. In the latter case, the potential problems with hypothecation would be expected to be significantly reduced.

The Baseline-and-Credit Scheme seems to be the most complicated administratively because of the need to establish baselines for various ship types. A new administrative structure would have to be created especially for this system, there would be no possibility to use the existing ETS procedures and structures.

Because of the limited geographical scope of the regional instruments, their administration would be more complicated more susceptible to fraud and less transparent than administration of the global instruments. This would be related to the need of calculating and monitoring CO_2 emissions that would fall under the scope of the regional policies based on routes of ships, while with the global schemes, all emissions would be included.

7.10 Summary and conclusion

Table 2 below gives a summary of our evaluation of the three selected instruments, in the design recommended above, against these criteria.

Table 2 Summary of our evaluation of the three selected instruments

Instrument	Emissions tax	Cap-and-trade	Baseline-and-Credit
1. Effective	++	+++	+
2. Avoid evasion	++	++	+
3. Cost-effective	++	+++	+
4. Limit distortion	++	++	+
5. Not penalizing	++	++	++
6. Goal-based	++	+++	+
7. Promoting R&D	+++	+++	++
8. Leading technologies	+++	+++	++
9. Easy to administer	++/+	+	+/-
Comments	Second best	Best	Third option

+++ very good
++ good
+ fair
- bad

Among the analysed instruments, cap-and-trade is the most effective tool for achieving a given goal in emission reductions. It is also the most cost-effective because in the recommended design it is open for trade with other sectors. The same effectiveness and cost-effectiveness may be achieved with a hypothecated tax but this instrument is rated lower in both categories because of the expected problems with hypothecation of tax revenues in some countries. Cost-effectiveness of the Baseline-and-Credit Scheme based on EEDI would be lower because operational measures would be excluded. Also environmental effectiveness of this instrument is expected to be the lowest.

The possibilities for avoidance seem to be more-or-less the same in the cap-and-trade and the tax options. Baseline-and-Credit Scheme would offer more incentives for avoidance because the ship operators could choose to use the ships with worse environmental parameters outside the scope Setting the cap in absolute terms might cause a relatively high pressure on the future growth of the maritime shipping sector (that's why the criteria 5 is given a relatively low score).

All the instruments in their proposed design are aimed at limiting distortions in the sector, however it has to be kept in mind that if the scope of the scheme is regional, some competitive disadvantages may occur because the ships not covered by the scheme would not have to bear the costs of CO_2 emissions. Additional distortions may occur within the system, if the tax or allowances are set differently for different types (sizes) of ships. The risk of such distortions seems to be the highest with Baseline-and-Credit System.

All the instruments are in principle goal-based but the Baseline-and-Credit Scheme limits the incentivised measures to technical measures only, therefore it is given a relatively lower score.

Emissions tax would be relatively easy to administer, especially if the existing tax structures are used. Administrative complexity of cap-and-trade could be expected to be higher than for the tax in the design where a new central institution would have to be created and comparable with the tax if the existing national structures used for administration of the ETS would be used. The Baseline-and-Credit Scheme is the least transparent and easy to administer because of the need to establish baselines for all ship types and the need to perform calculations for the reporting period according to geographical scope. In addition, both EEOI and EEDI are currently not developed enough to provide the basis for such a system.

All the selected instruments promote R&D and leading technologies in the field of energy efficiency, however the Baseline-and-Credit Scheme scores the lowest because in the design based on EEDI the scope of promoting technological innovation is limited to technical options and only to these options which influence the value of the baseline index.

From this preliminary evaluation, cap-and-trade scheme seems to score the best among the instruments selected, with tax being on the second, and Baseline-and-Credit Scheme on the third place.

8 Conclusion

This report has evaluated three proposals for global MBMs to reduce emissions from shipping and three proposals to reduce emissions on European shipping.

The global MBMs are:

1. An Emission Trading Scheme for shipping. In this system, ships need to surrender emission allowances for the amount of CO_2 they emit. Ships would receive a number of allowances up to the cap for the sector. In addition, they would be able to buy additional allowances from other systems and/or use CDM or similar credits.
2. A GHG fund fed by hypothecated contributions based on emissions or fuel consumption. In this systems, ships or fuel suppliers would pay a contribution on each quantity of fuel consumed or sold. The contributions would feed into a fund, which would be used primarily to offset emissions by financing emission reductions in other sectors.
3. A Baseline-and-Credit Trading Scheme. In this scheme, the regulator sets a fuel efficiency target for ships, depending on ship type and size. Ships that are more efficient than the target receive credits while ships that are less efficient need to surrender credits in order to compensate for their inefficiency.

The European MBMs are:

- Inclusion of shipping emissions in the EU ETS.
- A European tax on shipping emissions.
- A Baseline-and-Credit System for ships in EU ports.

This chapter presents the conclusions on both sets of MBMs.

8.1 Global MBMs

Of the three proposals for global MBMs evaluated in this report, we find that the Maritime Emissions Trading scheme scores best on most of the nine criteria defined by MEPC 57:

- Its environmental effectiveness is most certain of the proposals evaluated since an absolute cap is put on the CO_2 emissions by the maritime sector.
- It can be designed – as all the other MBMs evaluated here – as binding and equally applicable to all Flag States. Thus, avoidance can be limited.
- From a social perspective, it is the most cost-effective proposal as it incentivises actors in the shipping sector to implement all measures that are more cost-effective than the global carbon price. Further reduction of emissions is achieved against the global carbon price. There are not more administrative tasks in an ETS than in any of the other proposals and consequently, to the extent that the other proposals are applied to ships, the administrative costs are likely to be similar. When the GHG fund would target fuel suppliers, not ships, its administrative costs are likely to be less because there are probably fewer fuel suppliers than shipping companies.
- It will not result in a distortion of competitive markets, as the system applies to all ships, regardless of type and size, and each unit of CO_2 has the same value.
- It is goal-based (limiting CO_2 emissions is its goal) and it does not prescribe specific abatement options, nor does it rule out certain categories of abatement options.

- It is supportive of promoting and facilitating technical innovation and R&D in the entire shipping sector as it improves the net present value of all technologies that reduce emissions. Its incentive to reduce emissions is higher than that of the GHG Fund, but lower than the incentive to reduce emissions by technical means of the Baseline-and-Credit Trading Scheme.
- It accommodates all leading technologies in the field of energy efficiency.

The other systems score less on one or more of the criteria above. The main differences between the GHG Fund and the ETS are:

- The environmental effectiveness of the GHG fund is less certain because it depends to a larger extent on offsets.
- The Funds cost-effectiveness is worse from a societal viewpoint, as it incentivises actors in the shipping sector to implement measures up to a price *lower* than the global carbon price. Further emission reduction is achieved against the global carbon price. Consequently, emissions are reduced against the global carbon price while cheaper options are unused within the maritime sector.
- The GHG fund provides a smaller incentive to reduce emissions and consequently exerts less pressure to perform R&D and innovate.

The main differences between the Baseline-and-Credit Trading Scheme and the ETS are:

- The Baseline-and-Credit Trading Scheme has a much lower certainty of reaching its environmental goals as has no absolute cap on emissions nor an offset mechanism to compensate for possible emissions growth.
- The Baseline-and-Credit Trading Schemes cost-effectiveness is reduced by the fact that it only incentivises technical options and not many of the cheap operational options to reduce emissions. Moreover, as it doesn't allow for the use of offsets at all, it may result in very high marginal abatement costs in the shipping sector, further diminishing the cost-effectiveness.
- The Baseline-and-Credit Scheme may have higher CO_2 prices and may hence exert a greater incentive to innovation and R&D.
- The Baseline-and-Credit Scheme does not accommodate operational technologies to reduce emissions.

8.2 European MBMs

The European MBMs are the mirror image of the global systems. Therefore, the conclusions regarding relative performance on environmental and cost-effectiveness are to a large extent the same. However, there are also major differences.

Since the system is regional (applying to shipments to and from EU ports), evasion is possible in principle. Consequently, some carbon leakage is inevitable:

- The possibility to bunker fuels outside the EU makes fuel taxes ineffective.
- The possibility to use inefficient ships outside the EU scheme makes a Baseline-and-Credit System ineffective.
- The possibility to make an additional port call by rerouting diminishes the effectiveness of an ETS.

However, avoidance of a European ETS by rerouting can be limited by defining a sea voyage as the voyage between loading and unloading all cargo or a major share of cargo on board. Using such a definition of a route, avoidance requires transhipment of cargo. As transhipment is costly, avoidance becomes unlikely.

Our analysis shows that within Europe only emission taxes and ETS are effective. Taxation, however, requires unanimity of the European Council. Therefore, inclusion of maritime transport in the EU ETS seems the most effective, efficient and politically feasible.

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