MARINE ENVIRONMENT PROTECTION COMMITTEE
60th session
Agenda item 4

MEPC 60/INF.21
15 January 2010
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# PREVENTION OF AIR POLLUTION FROM SHIPS

## Scientific study on international shipping and market-based instruments

### Note by the Secretariat


| SUMMARY | |
|---|---|
| ***Executive summary:*** | Based on the outcome of MEPC 59 and as a follow-up of *the Second IMO Study of Greenhouse Gas Emissions from Ships*, which was delivered in 2009, a scientific study has been carried out with the aim of illustrating the reduction potential and the financial benefits for developing countries that might be obtained by applying a market-based instrument (MBI) to international shipping. The annex to this document provides the full report of the Scientific Study on International Shipping and Market-based Instruments prepared on behalf of the IMO by an international consortium led by the University of Cambridge.<br><br>**Note: The views and conclusions drawn in this work are exclusively those of the scientists writing the report**. |
| ***Strategic direction:*** | 7.3 |
| ***High-level action:*** | 7.3.1 |
| ***Planned output:*** | 7.3.1.1 and 7.3.1.3 |
| ***Action to be taken:*** | Paragraph 5 |
| ***Related documents:*** | MEPC 59/4/5, MEPC 59/4/25, MEPC 59/4/26 and MEPC 59/INF.10 |


**Introduction**

1 The IMO Scientific Study on international shipping and market-based instruments set out in the annex was commissioned as a follow-up to *the Second IMO Study of Greenhouse Gas Emissions from Ships*, (the Second IMO GHG Study 2009), which was presented to MEPC 59. The Scientific Study has been prepared on behalf of IMO by an international consortium led by the University of Cambridge and was carried out in partnership with the following institutions: Cambridge Econometrics, MARINTEK, Manchester Metropolitan University, and Deutsches Zentrum für Luft-und Raumfahrt e.V. While the Study was originally submitted in December 2009, a number of subsequent iterations were necessary before the final product could be deemed acceptable by the Secretariat. It should also be noted that the views and conclusions drawn in this work are exclusively those of the scientists writing the report.

2 Based on the outcome of MEPC 59, the Study has been carried out with the aim of illustrating the reduction potential and financial benefits for developing countries that might be obtained by applying a market-based instrument (MBI), such as a fund for international shipping or emissions trading, to all ships while making every effort to accommodate the principle of common but differentiated responsibilities (CBDR). The Study is based on the methodology used in, and the outcomes of, the Second IMO GHG Study 2009. The Study has assessed the possible financial contribution by international shipping to combat climate change through two distinct market-based instruments, as well as their respective $CO_2$ emissions reduction potential (through direct reduction and offsetting), based on the information contained in the following documents submitted to MEPC 59:

.1 an International Fund for Greenhouse Gas Emissions from Ships, as proposed by Denmark in document MEPC 59/4/5 and related documents as appropriate;

.2 Global Emission Trading Scheme for International Shipping, as proposed by France, Germany and Norway in documents MEPC 59/4/25 and MEPC 59/4/26; and

.3 market-based measures, as considered and evaluated in the Second IMO GHG Study 2009 (MEPC 59/INF.10).

**Main objectives**

3 The main objectives of the study were to assess (i) the potential for reduction of $CO_2$ emissions through market-based instruments (through direct reduction and offsetting); and (ii) international shipping's possible financial contribution for mitigation of, and adaptation to, climate change in developing countries through two distinct market-based instruments proposed by Members to MEPC 59.

**Conclusions**

4 The following main conclusions may be drawn from the Study set out in the annex:

.1 mid-range emissions scenarios of the Second IMO GHG Study 2009 show that, by 2050, in the absence of appropriate policies, carbon dioxide emissions from international shipping may increase by a factor of 2 to 3 (compared to the emissions in 2007) as a result of the growth in world trade;

.2 it is assumed that 98% of all ships and ship operations are covered by the schemes (in line with the coverage of IMO's main treaties) either through the Flag State or Port State obligation (no more favourable treatment). Therefore the schemes under review cover both Annex I and non-Annex I countries;

.3 significant potential for reduction of $CO_2$ through MBI measures has been identified. The reductions can be achieved through direct reductions in the industry and through additional indirect reductions by offsetting;

.4 the UNFCCC principle of common but differentiated responsibilities (CBDR) can be satisfied through the appropriate distribution of revenues raised from the market-based instruments under consideration. A higher proportion of these revenues could be allocated to Least Developed Countries for adaptation and mitigation purposes;

.5 the level of reductions of $CO_2$ emissions by international shipping depends on the carbon price (contribution per tonne of bunker fuel). The higher the carbon price the more $CO_2$ emissions will be reduced. However, high carbon prices (nominal price of more than $1000 per tonne of $CO_2$) are required to reduce $CO_2$ emissions by 50% or more;

.6 revenues raised through a market-based instrument also depend on the carbon price per tonne of $CO_2$ and on the amount of emissions. Under the Fund all emissions covered by the scheme will raise revenues for a central governing body, while an ETS will raise revenues only from auctioned allowances below the cap;

.7 if a proportion of revenues are allocated to Least Developed Countries for adaptation and mitigation purposes, then a market-based instrument for international shipping can have a positive impact on the economies of these countries (up to 2.46% increase in GDP); and

.8 the Clean Development Mechanism credits that are used for offsetting would be purchased from Developing Countries. Therefore these countries would also benefit from a market-based instrument for international shipping.

**Action requested of the Committee**

5 The Committee is invited to note the attached scientific study on international shipping and market-based instruments and, in particular, the conclusions listed in paragraph 4 above.

***

**ANNEX**

# International Shipping and Market Based Instruments 2009

## Final Report

### 1. December 2009

Prepared for the International Maritime Organization (IMO) by:


- University of Cambridge, UK
- Cambridge Econometrics (CE), UK
- MARINTEK, Norway
- Manchester Metropolitan University, UK
- Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR), Germany

# Preface

This Study of international shipping and market-based instruments was commissioned as a follow-up of *the Second IMO Greenhouse Gas Study 2009*. This Study has been prepared on behalf of the IMO by an international consortium led by Annela Anger of the University of Cambridge. The study was carried out in partnership with the following institutions:

> Cambridge Econometrics, MARINTEK, Manchester Metropolitan University, and Deutsches Zentrum für Luft- und Raumfahrt e.V.

The following individuals were the main contributors to the report:

> Annela Anger (Coordinator), Terry Barker, Hector Pollitt, Håkon Lindstad, Veronika Eyring, David S. Lee.

In the course of their efforts, the research team has gratefully received input and comments from Gunnar Eskeland (NHH) and the IMO Secretariat.

The main objectives of the Study are to assess: (i) the potential for reduction of $CO_2$ emissions by market-based instruments (through direct reduction and offsetting); and (ii) international shipping's possible financial contribution for mitigation of and adaptation to climate change in developing countries through two different defined market-based instruments.

The views and conclusions drawn in this Study are those of the scientists writing the report.

Recommended citation: *International Shipping and Market Based Instruments 2009*; International Maritime Organization (IMO) London, UK, December 2009; Anger, A.; Barker, T.; Pollitt, H.; Lindstad, H.; Eyring, V.; Lee, D.S.

# List of abbreviations

| | |
|---|---|
| AAU | Assigned Amount Unit |
| CAC | Command and control regulation |
| CBA | Cost–benefit analysis |
| CER | Certified Emission Reduction Unit |
| CDM | Clean Development Mechanism |
| $CO_2$ | Carbon dioxide |
| COP15 | 15th United Nations Climate Change Conference in Copenhagen in December 2009 |
| EEDI | Energy Efficiency Design Index |
| EEOI | Energy Efficiency Operational Indicator |
| ETSIS | Emissions Trading Scheme for International Shipping |
| EUA | European Union Allowance Unit |
| EU ETS | European Union Emissions Trading Scheme |
| GDP | Gross domestic product |
| GHG | Greenhouse gas |
| GT | Gross tonnage |
| HFO | Heavy fuel oil |
| ICF | International Fund for GHG emissions from ships |
| IEA | International Energy Agency |
| IPCC | Intergovernmental Panel on Climate Change |
| JI | Joint Implementation |
| LRIT | Long range identification and tracking system |
| MARPOL | International Convention for the Prevention of Pollution from Ships |
| MBI | Market-based instrument |
| MEPC | Marine Environment Protection Committee |
| METS | Maritime emissions trading scheme |
| OECD | Organisation for Economic Co-operation and Development |
| IOPC Funds | International Oil Pollution Compensation Funds |
| SRES | Special Report on Emissions Scenarios (IPCC) |
| UNEP | United Nations Environment Programme |
| UNFCCC | United Nations Framework Convention on Climate Change |

# Definitions

| | |
|---|---|
| AAU | An AAU equals 1 tonne (metric ton) of $CO_2$-equivalent emissions calculated using the Global Warming Potential. (IPCC, 2007) |
| Annex I countries | The group of countries included in Annex I (as amended in 1998) to the UNFCCC, including all the OECD countries and economies in transition. Under Articles 4.2 (a) and 4.2 (b) of the Convention, Annex I countries committed themselves specifically to the aim of returning individually or jointly to their 1990 levels of greenhouse gas emissions by the year 2000. By default, the other countries are referred to as Non-Annex I countries (IPCC, 2007). For the full list see: http://unfccc.int/parties_and_observers/parties/annex_i/items/2774.php |
| Clean Development Mechanism (CDM) | Defined in Article 12 of the Kyoto Protocol, the CDM is intended to meet two objectives: (1) to assist parties not included in Annex I in achieving sustainable development and in contributing to the ultimate objective of the convention; and (2) to assist parties included in Annex I in achieving compliance with their quantified emission limitation and reduction commitments. Certified Emission Reduction Units from CDM projects undertaken in Non-Annex I countries that limit or reduce GHG emissions, when certified by operational entities designated by Conference of the Parties/Meeting of the Parties, can be accrued to the investor (government or industry) from parties in Annex B. A share of the proceeds from certified project activities is used to cover administrative expenses as well as to assist developing country parties that are particularly vulnerable to the adverse effects of climate change to meet the costs of adaptation (IPCC, 2007). |
| Certified Emission Reduction Unit (CER) | Certified Emission Reduction Unit is equal to 1 tonne (metric ton) of $CO_2$-equivalent emissions reduced or sequestered through a Clean Development Mechanism project, calculated using Global Warming Potentials (IPCC, 2007) |
| Developing Countries | Developing Countries in the UN list: http://www.unctad.org/en/docs/tdstat30_enfr.pdf |
| Domestic shipping | Shipping between ports of the same country, as opposed to *international shipping*. Domestic shipping excludes military and fishing vessels. By this definition, the same ship may frequently be engaged in both international and domestic shipping operations. This definition is consistent with IPCC 2006 Guidelines. |
| International shipping | Shipping between ports of different countries, as opposed to *domestic shipping*. International shipping excludes military and fishing vessels. By this definition, the same ship may frequently be engaged in both international and domestic shipping operations. This is consistent with IPCC 2006 Guidelines. |
| Joint Implementation | A market-based implementation mechanism defined in Article 6 of the *Kyoto Protocol*, allowing *Annex I countries* or companies from these countries to implement projects jointly that limit or reduce *emissions*, or enhance *sinks*, and to share the *Emissions Reduction Units*. JI activity is also permitted in Article 4.2(a) of the United Nations Framework Convention on Climate Change (IPCC, 2007). |
| Least Developed Countries (LDCs) | Least Developed Countries in the UN list. Defined in: http://www.unohrlls.org/en/ldc/related/62/ |
| Non Annex I countries | The countries that have ratified or acceded to the UNFCCC but are not included in Annex I (IPCC, 2007). For the full list see: http://unfccc.int/parties_and_observers/parties/non_annex_i/items/2833.php |
| Total shipping | This is defined in this report as international and domestic shipping plus fishing. It excludes military vessels. |

# Contents

# Chapter 1. Executive summary

**Conclusions**

- Mid-range emissions scenarios of the Second IMO GHG Study 2009 show that, by 2050, in the absence of policies, carbon dioxide emissions from international shipping may grow by a factor of 2 to 3 (compared to the emissions in 2007) as a result of the growth in world trade.

- A significant potential for reduction of $CO_2$ through MBI measures has been identified. The reductions can be achieved through direct reduction in the industry and through additional indirect reductions by offsetting.

- The amount of $CO_2$ emissions reduced by international shipping depends on the level of the carbon price (contribution per tonne of bunker fuel). The higher the carbon price (contribution per tonne of bunker fuel) the more $CO_2$ emissions will be reduced. However, high carbon price (nominal price of more than $1000 per tonne of $CO_2$) is required to lessen $CO_2$ emissions by 50% or more.

- It is assumed that 98% of all ships and ship operations are covered by the schemes (in line with the coverage of IMO's main treaties) either through the Flag State or Port State obligation (no more favourable treatment). Therefore the schemes under review cover both Annex I and Non-Annex I countries.

- The UNFCCC (Article 3, 1992) principle of common but differentiated responsibilities (CBDR) can be met through distribution of revenues raised from the market based instruments under consideration. A proportion of these revenues will be allocated to Least Developed Countries for adaptation and mitigation purposes.

- Revenues raised through a market-based instrument depend on the carbon price per tonne of $CO_2$ (or contribution per tonne of bunker fuel) and on the amount of emissions that raise revenues. Under the Fund all emissions covered by the scheme will raise revenues for the central governing body while an ETS will raise revenues only from auctioned allowances below the cap.

- If a proportion of revenues are allocated to Least Developed Countries for adaptation and mitigation purposes then a market-based instrument for international shipping can have positive impact on the economies of these countries (up to 2.46% increase in GDP).

- The Clean Development Mechanism credits that are used for offsetting will be purchased from Developing Countries. Therefore these countries are also likely to benefit from a market-based instrument for international shipping.

**Context and objectives**

1.1 IMO's work on greenhouse gases (GHG) contains three distinct components: the technical measures (mainly for new ships) and the operational measures (all ships in operation: new and existing) and the market-based reduction measures. Recognizing that technical and operational measures may not be sufficient to reduce the desired amount of GHG emissions from international shipping, market-based mechanisms have been considered over the recent years. A market-based mechanism can serve two main purposes:

.1 reducing and offsetting of growing GHG emissions from ships; and

.2 being an incentive for the industry to invest in more fuel efficient ships and to operate ships more energy efficiently.

1.2 In July 2009 MEPC 59 adopted a work plan that contains, *inter alia*, consideration of market-based methods for regulating GHG emissions from ships in international trade (international shipping).

1.3 The main objectives of the Study are to assess:

.1 the potential for reduction (through direct reduction and offsetting) of $CO_2$ emissions through market-based instruments for international shipping; and

.2 international shipping's possible financial contribution for mitigation of and adaptation to climate change in developing countries through two different defined market-based instruments.

**Approach adopted and key assumptions**

1.4 The two possible hypothetical market-based instruments considered in this study are:

.1 A fund for greenhouse gas emissions from international shipping (Fund) which is represented by an International Fund for Greenhouse Gas Emissions from Ships (ICF) that is based on contributions that are paid per tonne of bunker fuel, as proposed by Denmark in document MEPC 59/4/5 and related documents; and

.2 An emissions trading scheme for international shipping (ETSIS) that is outlined as a Maritime Emissions Trading Scheme (METS) by France, Germany and Norway in documents MEPC 59/4/25 and MEPC 59/4/26 and related documents.

1.5 It is assumed that 98% of all ships and ship operations are covered by the schemes (in line with the coverage of IMO's main treaties) either through flag State or port State obligation (no more favourable treatment). Any market-based instrument to address GHG emissions from ships which does not respect these specificities could be easily avoided and so would therefore be environmentally ineffective. The scheme covers both Annex I and Non-Annex I countries.

1.6 The UNFCCC (Article 3, 1992) principle of common but differentiated responsibilities (CBDR) can be met through redistribution of revenues raised through the market based instruments under consideration. A proportion of these revenues will be allocated to Least Developed Countries for adaptation and mitigation purposes.

1.7 The only GHG considered in the schemes is $CO_2$. The Second IMO GHG study 2009 (MEPC 59/INF.10) showed that carbon dioxide is the most important GHG emission from shipping, and the potential benefits from reducing emissions of the other GHG are small in comparison.

1.8 A new central international body under the auspices of IMO and outside national control is established to manage and govern either of the schemes. The body will need to originate an effective monitoring, reporting and verification system to ensure compliance.

1.9 This study adopts a baseline scenario for international shipping $CO_2$ emissions based on the Second IMO GHG study 2009 (MEPC 59/INF.10, Chapter 7) A2 scenario (Figure 1-1). The baseline scenario reflects projected business as usual international shipping emissions. Scenario A2 was chosen as it represents one of the middle scenarios of the international shipping emissions.

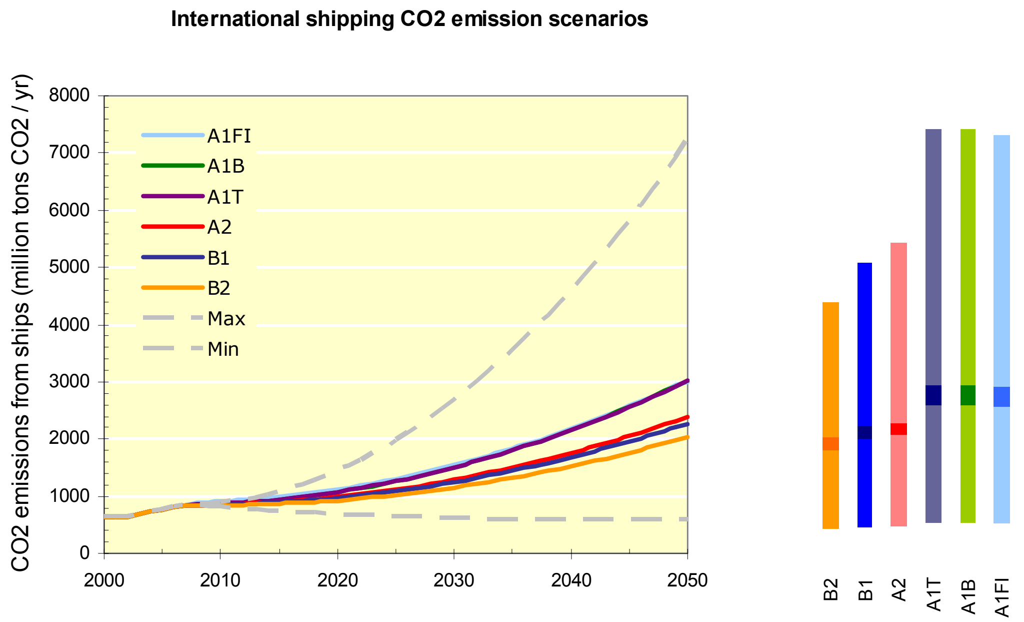


**Figure 1-1. Trajectories of the emissions from international shipping. Columns on the right-hand side indicate the range of results for the scenarios within individual scenario families.** Source: document MEPC 59/INF.10 p. 134**.**

1.10 Scenarios in the Second IMO GHG Study 2009 are based on the framework for global development and storylines that have been developed by the Intergovernmental Panel on Climate Change (IPCC) in the Special Report on Emission Scenarios (SRES), and are named according to IPCC SRES terminology. Scenario SRES A2 was chosen as it represents one of the middle scenarios for international shipping emissions.

1.11 Based on the Second IMO GHG Study 2009 the baseline scenario A2 for international shipping emissions adopted for this study assumes following levels of $CO_2$ emissions from international shipping:

.1 468 Mt$CO_2$ in 1990;

.2 795 Mt$CO_2$ in 2005;

.3 982 Mt$CO_2$ in 2020; and

.4 2194 Mt$CO_2$ in 2050.

1.12 In the baseline scenario for this study, it is further assumed that Annex I countries adopt additional policies to impose carbon prices on energy intensive sectors including aviation (international and domestic) and excluding shipping. In this study the carbon price is imposed through a hypothetical Annex I carbon trading scheme.

1.13 It is assumed that the MBI will be implemented in 2015 and be in place until 2050. Thereafter the regulation can be extended or a new instrument can be adopted.

1.14 Both schemes adopt a target (cap) on international shipping emissions that will be set at 2005 levels in 2015. The target (cap) will decrease gradually and reach 20% below 2005 levels by 2020, and thereafter continue decreasing and will be 50% below 2005 levels in 2050 (this is about 15% below 1990 levels).

1.15 All results and conclusions presented in this study are based on the SRES A2 international shipping $CO_2$ scenario of the Second IMO GHG Study 2009 with the hypothetical Annex I carbon trading scheme. If another scenario were adopted as a baseline then the results differ.

1.16 Revenues raised through contribution on bunker fuel sales (Fund) or via auctioning the allowances (ETSIS) will be distributed as following:

.1 The administration costs for the two schemes are assumed to be two per cent. Both schemes will need to set up a new administrative system and therefore it is assumed that the administrative costs of these two schemes are going to be the same;

.2 Three per cent of the total revenues collected or generated through auctioning will be used for energy efficiency R&D purposes within the shipping industry under the control of IMO;

.3 The remainder of the total revenues is assumed to be used to fund climate change adaptation and mitigation in the UN-defined group of Least Developed Countries (LDCs), the small island developing states (SIDS) and the landlocked developing countries (LLDC);[1] and

1 This group of counties are called LDCs in this study.

.4 The revenues raised in the Fund that cover the emissions above the adopted target line will be used for offsetting through buying CDM credits from developing countries.

1.17 The amount of revenues raised is heavily dependent on the carbon price (auctioning price and contribution rate) and on the amount of $CO_2$ emissions covered (auctioned or covered by contribution).

**Summary of findings**

**The Fund**

1.18 A range of contribution rates (all in 2015 US dollars) from MEPC 59/4/5 was used for the four Fund scenarios:

.1 $7.5 per tonne of bunker fuel (i.e. $2.4 per tonne of $CO_2$);

.2 $15 per tonne of bunker fuel (i.e. $4.7 per tonne of $CO_2$);

.3 $30 per tonne of bunker fuel (i.e. $9.5 per tonne of $CO_2$); and

.4 $45 per tonne of bunker fuel (i.e. $14.2 per tonne of $CO_2$).

These prices are assumed to start in 2015 and to increase in line with annual inflation of 3% from 2015 to 2050.

1.19 The revenues of the Fund are assumed to be generated by the contributions on bunker fuel in each Fund scenario and being applied to the amount of bunker fuels sold. Emissions exceeding the target line emissions need to be offset. The amount of $CO_2$ emissions is limited by the revenues raised and the cost of purchased credits, so if the price of the credits is higher than the carbon price (derived from the contribution on bunker fuel) in the Fund scenarios, the emissions above the target line will not be 100% offset.

1.20 In the Fund there will be uncertainty about the amount of offsets used as this will depend on the market price and availability of CDM credits. Table 1-1.gives an overview of the $CO_2$ reductions under the Fund with a contribution rate of $45 per tonne of bunker fuel (i.e. $14.2 per tonne of $CO_2$) identified in this Study.

1.21 If the contribution rate is $45 per tonne of bunker fuel (i.e. $14.2 per tonne of $CO_2$) that increases 3% (inflation rate) per annum then international shipping reduces its emissions by 11% in 2020 and 5% in 2050 as direct response to this price.

**Table 1-1. Emissions reduced through direct reductions in the international shipping industry and through offsetting relative to the baseline under the Fund Scheme with a contribution rate of $45 per tonne of $CO_2$ (in millions tonnes of $CO_2$ and as % of the baseline).** *The price of one* ***Certified Emission Reduction Unit*** *(CER) is $49.8/t$CO_2$ in 2020 and $919.5/t$CO_2$ in 2050.*

| Scenario | Fund $45 per tonne of bunker fuel | |
|---|---|---|
| | **2020** | **2050** |
| **Baseline emissions** | 981 (100%) | 2181 (100%) |
| **Target line** | 636 (65%) | 398 (18%) |
| **Direct reduction** | 111 (11%) | 119 (5%) |
| **Offsetting – indirect reductions** | 63 (6%) | 72 (3%) |
| **Not offset** | 171 (18%) | 1592 (73%) |

1.22 Developing countries and Least Developed countries (LDC) will benefit under the Fund scenarios. Advance developing countries (for example India and China) will receive payments for the CDM credits that the international shipping industry uses for compliance purposes. Least developed countries will benefit from additional direct investments from the revenues raised under the Fund that will be used for helping these countries to adapt to climate change.

1.23 Under the Fund impacts on trade in LDCs are estimated to be positive but very small (a maximum of 0.01%). These increases stem from the proportion of Fund revenues that are allocated to these countries. There will be almost no impact on import prices of food and agricultural products for LDCs. Under all price scenarios in the Fund the increase in these prices was close to zero.

1.24 The overall reduction in global $CO_2$ from the Fund with a carbon price of $14.2 per tonne of $CO_2$ (i.e. $45 per tonne of bunker fuel) is very small, 0.2% by 2020 rising to 0.4% by 2050 below baseline (A2 scenario of Second IMO GHG Study 2009).

1.25 The conclusion is that all carbon price scenarios under the Fund are sufficient to achieve the target on their own through direct $CO_2$ emissions reductions in international shipping. The contribution scenarios will have to be complemented to by offsetting and regulation for enhanced energy efficiency in the shipping sector to achieve the target.

1.26 The major uncertainty related to the outcome of this Study is related to unknown future carbon prices and the existence of future carbon markets. If a Fund is adopted, then the contribution per tonne of fuel is known. Even if the contribution per tonne of fuel will be changed over time, it is likely to be announced before adoption.

1.27 Uncertainties related to future CDM markets suggest that the MBI system planned has to be designed in an adjustable manner to allow incorporation of CDM market changes without compromising transparency and predictability throughout the compliance period. Predictability and transparency encourage long-term investments to low-carbon technology by the shipping industry.

**ETSIS**

1.28 For the ETSIS a carbon price is adopted based on PointCarbon (2009) forecasts for the European Emissions Trading scheme starting with $28 per tonne of $CO_2$ in 2013 increasing thereafter to $56 per tonne of $CO_2$ in 2020 and thereafter continuing to rise by 7% each year. These prices are also adjusted to an annual inflation of 3%. An open trading scheme is considered meaning that international shipping can buy allowances from other regulated carbon markets in Annex I countries and from Kyoto Protocol's Clean Development Mechanism's projects.

1.29 For the emission trading scheme (ETSIS) all emissions from international shipping are covered by allowances. Initial allocation of allowances is bought through auctions up to the target levels (cap). $CO_2$ emissions that exceed the target level (cap) will have to be covered by purchases of allowances from an international emission trading scheme (Annex I ETS) covering many energy intensive sectors and aviation plus offsetting through CDM up to 15% of target levels is allowed.

1.30 Table 1-4 shows direct and indirect reductions of $CO_2$ emissions from international shipping under ETSIS identified in this Study. An open emissions trading scheme (such as ETSIS) for international shipping will lead to a certain environmental outcome since all emissions above the target line will be either reduced directly by the industry or offset by purchasing carbon allowances from other industries and CDM credits from Developing countries (indirect reductions).

1.31 Under the ETSIS with a carbon price as it is defined in 1.27 international shipping will reduce its $CO_2$ emissions by 29% in 2020 and by 52% in 2050. Additional reductions of 6% in 2020 and 30% in 2050 are needed to reach the cap and this will be achieved through offsetting by buying CDM and/or by purchasing carbon allowances from the Annex I carbon trading scheme (Table 1-4).

**Table 1-4. Emissions reduced through direct reductions in the international shipping industry and through offsetting (in millions tonnes of $CO_2$ and as % of the baseline).** ***Allowance price in the ETSIS is \$56/t$CO_2$ (\$176.96 per tonne of bunker fuel) in 2020 and \$1022/t$CO_2$ (\$3229 per tonne of bunker fuel) in 2050. The price of one Certified Emission Reduction Unit (CER) is 10% less respectively.***

| **Scenario** | **ETSIS** | |
|---|---|---|
| | **2020** | **2050** |
| **Baseline emissions** | 981 (100%) | 2181 (100%) |
| **Cap** | 636 (65%) | 398 (18%) |
| **Direct reduction** | 287 (29%) | 1126 (52%) |
| **Offsetting – indirect reduction** | 58 (6%) | 60 (3%) |
| **Allowances from the market – indirect reduction** | 0 (0%) | 597 (27%) |
| **Emissions not offset under the scheme** | 0 (0%) | 0 (0%) |

1.32 If international shipping is included in an international carbon trading scheme with sufficiently high carbon prices, then this inclusion is likely to drive innovation that leads to larger direct $CO_2$ reduction in the industry.

1.33 Developing countries and Least Developed countries (LDC) will benefit from direct transfers for financing adaptation and mitigation under the ETSIS depending on the design and on the distribution key. Developing countries (for example India and China) will receive payments for the CDM credits that the international shipping industry uses for compliance purposes. Least Developed countries will benefit from additional direct investments from the revenues raised under the fund that will be mainly used for helping these countries to adapt to climate change.

1.34 Under ETSIS impacts on trade in LDCs are estimated to be positive but small. These increases stem from allocated auctioning revenues (increased investments) to these countries. The maximum increase in export volumes is likely to be 0.01% in 2050. Import volumes in the LDCs may increase by up to 0.6% in 2050. There will be almost no impact on import prices of food and agricultural products for LDCs. Under ETSIS the maximum increase in these prices was 0.08% in 2020.

1.35 The proportion of international shipping $CO_2$ emissions in global total is relatively small and therefore the overall reduction in total global $CO_2$ from the ETSIS is very small, 0.7% by 2020, rising to 2.8% by 2050 below baseline (A2 scenario of Second IMO GHG study 2009).

1.36 The major uncertainty related to the outcome of this Study is related to unknown future carbon prices and the existence of future carbon markets. These suggest that the carbon reduction system planned has to be designed in an adjustable manner to allow incorporation of changes in carbon markets. On the other hand the designed scheme has to be transparent and predictable throughout the applicability period to enable long-term investments to low-carbon technology by the industry.

# Chapter 2. Introduction to Market-Based Instruments for shipping

**Market-based instruments in theory**

2.1 This chapter gives a theoretical explanation of policy options for reducing the negative environmental impacts from human behaviour. The discussion is illustrated with examples from existing policies.

2.2 Options for regulating undesirable environmental impacts of human behaviour can be broadly divided into three categories:

.1 command-and-control (CAC) measures;

.2 market-based instruments (MBI); and

.3 voluntary measures.

Out of these three, CAC is used most frequently (for example, fuel sulphur emission limits in the revised MARPOL Annex VI). An example of voluntary measures is voluntary carbon offsetting and the Energy Efficiency Design Index (EEDI) and Energy Efficiency Operational Indicator (EEOI) that are developed by the IMO are likely to become CAC measures.

2.3 This study focuses on MBIs. The idea of an MBI is to give polluters an economic incentive to reduce their emissions. Three main types of MBIs are:

.1 environmental fees (contribution);

.2 tradable permit (allowance) schemes; and

.3 liability rules.

Different combinations of these types (so-called hybrid schemes) are also possible and frequently used.

2.4 An environmental fee imposed on a unit of pollution gives the polluter an incentive to reduce the amount of pollution in order to pay less fees. However, if a fee is set too low compared with the cost needed to reduce a unit of pollution, the polluter may simply pay and continue polluting (pay and pollute). Fees are argued to be easier to administer (mainly because there is usually no need to establish new tax authorities) and the transaction costs (for example, costs associated with finding a trading partner) are lower than those in tradable permit schemes. Examples of environmental fees are the Italian carbon tax on the consumption of energy products introduced in 1998 (Tiezzi, 2004) and the Danish carbon dioxide tax introduced in 1992 (OECD, 1994). If a fee is chosen as an MBI then the revenues raised are more certain and depend on the level the fee is set at, as well as the compliance regime and any penalties.

2.5 In an emissions trading scheme (ETS), the aggregate amount of emissions by market participants is limited to, or capped at, a certain level. Allowances are issued corresponding to the cap and distributed to the participants, and the trading of these allowances in the market creates a price for a unit of emissions. An ETS encourages those with lower marginal abatement costs to abate and to sell their allowances to those with higher abatement costs. This approach is especially suitable for uniformly distributed greenhouse gases, such as $CO_2$, where the location of emission reductions does not matter in terms of climate impacts.

2.6 An emissions trading scheme is assumed to have higher administrative cost (usually there is a need to establish a new administrative body) and transaction costs (for example, costs associated with finding a suitable counterpart in trade) compared to other MBIs. Since the aggregate amount of emissions allowed is defined in an ETS the environmental outcome is more certain. The European Emissions Trading Scheme (EU ETS) and GHG emissions trading (trading with Assigned Amount Units (AAUs)) under the Kyoto Protocol are examples of emissions trading schemes.

2.7 The EU ETS is currently the world's largest ETS and the first that crosses country borders. It came into operation on 1 January 2005 and is the centrepiece of the current European climate change policy. Its second phase started in 2008. Phase 1, from 2005 to 2007, failed to deliver a substantial carbon price – the price of a European Union Allowance Unit (EUA) was close to zero in 2007 as the drop in price was created by an over distribution of allowances. However, it can be seen as a learning period for the EU ETS. The EU ETS includes $CO_2$ emissions from energy intensive industries in the European Union (Directive 2003/87/EC, 2003). Companies, that belong to these industries (currently about 10,000 entities), trade among themselves. The design of the third phase EU ETS (2013–2020) is currently under review. Aviation (all flights departing from and arriving at the EU) will be included in the EU ETS from 2012.

2.8 Emissions trading under the Kyoto Protocol is now in its first phase (2008-2012). The Annex B countries of the protocol have committed themselves to reduce GHG emissions 5% below 1990 levels. Under the Kyoto Protocol country governments trade Assigned Amount Units (AAUs). The Kyoto Protocol allows Clean Development Mechanism (CDM) and Joint Implementation (JI) projects to be carried out and emissions reductions gained through these projects be used for compliance purposes.

2.9 Emissions of $CO_2$ from international shipping are excluded from the Kyoto Protocol targets for Annex I countries. Owing to difficulties in allocating these emissions to parties, under Article 2.2, Annex I countries have an obligation to reduce these emissions working through the IMO.

**Market-based instruments for international shipping**

2.10 Mid-range emissions scenarios of the Second IMO GHG study 2009 (MEPC 59/INF.10) show that, by 2050, in the absence of policies, carbon dioxide emissions from international shipping may grow by a factor of 2 to 3 (compared to the emissions in 2007) as a result of the growth in shipping.

2.11 IMO's GHG work contains three distinct components: the technical measures (mainly for new ships) the operational measures (all ships in operation: new and existing) and the market-based reduction measures. Recognizing that technical and operational measures may not be sufficient to reduce the desired amount of GHG emissions from international shipping, market-based mechanisms have been considered by IMO (MEPC) in recent years. A market-based mechanism can serve two main purposes:

.1 offsetting of growing GHG emissions from ships; and

.2 being an incentive for the industry to invest in more fuel-efficient ships and to operate ships more energy efficiently.

2.12 In July 2009 MEPC 59 adopted a work plan for further consideration of market-based methods for regulating GHG emissions from ships in international trade.

2.13 The Second IMO GHG Study (MEPC/59/INF-10) outlines policy options for regulating GHG emissions from international shipping. MBIs are discussed and evaluated, in particular in Chapter 6.

2.14 The two MBIs that have received most attention are:

.1 A fund for GHG emissions from international shipping (the Fund) which is represented by an International Fund for Greenhouse Gas Emissions from Ships (ICF) that is based on contributions that are paid per tonne of bunker fuel, as proposed by Denmark in document MEPC 59/4/5. By nature this scheme belongs to the first category of MBIs – environmental fees. However from the way it is proposed it also consists of elements of voluntary offsetting; and

.2 An emissions trading scheme for international shipping (ETSIS), that is outlined as a Maritime Emissions Trading Scheme (METS) by France, Germany and Norway in documents MEPC 59/4/25 and MEPC 59/4/26. This proposed scheme belongs to the second category of MBIs – tradable permit schemes.

2.15 There are other types of market based instruments discussed for shipping. Some of these are voluntary and some are hybrid schemes (for more discussion please see MEPC 59/INF.9 and Stochniol, 2008)

# Chapter 3. Description of the schemes and assumptions

3.1 The two hypothetical market-based instruments considered in this study are an emissions trading scheme for international shipping (ETSIS) and a fund for greenhouse gas emissions from international shipping (Fund). The assumptions used for these instruments build largely on existing proposals (MEPC 59/4/25, MEPC 59/4/26 and MEPC 59/4/5, and related documents as appropriate). However some additional assumptions are made to allow examination of the two MBIs for shipping. The assumptions are outlined below.

**Technical assumptions applicable to both schemes**

3.2 The only GHG considered in the schemes under consideration is $CO_2$. The Second IMO GHG study 2009 (MEPC 59/INF.10) showed that carbon dioxide is the most important GHG emission from shipping, and the potential benefits from reducing emissions of the other GHG are small in comparison.

3.3 It is assumed that the MBI under consideration will be implemented in 2015 and that the scheme will be operational be operational until 2050. Thereafter the regulation can be extended or a new instrument can be adopted.

3.4 Both schemes under review face the need to create an effective management system to govern the schemes: assessment and distribution of contributions of individual ships in the Fund and auctioning of allowances and distribution of auctioning revenues under the ETSIS. A central international body under the auspices of IMO and outside national control is established to fulfil this role.

3.5 Both schemes face the need for efficient monitoring of ship activities for verification of compliance of individual ships and it is assumed that this is solved by international agreements that may include utilization of IMO's long range identification and tracking system (LRIT).

3.6 The monitoring of fuel oil suppliers, if involved in operation of the scheme under review, will be a Party obligation based on agreed guidelines and it is assumed that the Parties have established the needed framework and practices to that effect.

3.7 The need for the monitoring of all financial transactions and efficient monitoring, reporting and verification of compliance are equal for both schemes. A central database functioning as an electronic exchange (similar to The Community Independent Transaction Log (CITL) of the EU) where all participating ships have a dedicated account will be established and used.

3.8 The enforcement of the new GHG mitigation regime for shipping will follow the usual structure of mandatory IMO instruments, namely: flag State obligations and port State rights and obligations. The central international body will monitor all financial transactions (related to each bunkering operation) and ship movements by using a combination of software and manual control, and will thereby be able to assess if the data received from a ship on its emissions (fuel consumption) and distance sailed are correct. Comparison of the ships' own data on fuel consumption (which may be found in the EEDI data or as part of the ships' particular in the ship register data) and the ship movements data, which for example could be derived from LRIT, will be sufficient to determine compliance.

3.9 If a ship is found not to be in compliance, it is assumed that the Port State has the power to detain ships that are found not to be in compliance based on information obtained from the central international body, until the matter is satisfactorily resolved (any outstanding debt is settled).

3.10 Both schemes face the need for either a new treaty instrument or inclusion in an existing IMO instrument. It is assumed that the schemes will be in effect from 1 January 2015 supported by an IMO treaty.

3.11 Both schemes face the possibility of avoidance (carbon leakage) by ships flying the flag of non-parties trading between non-parties. Therefore it is assumed that 98% of all ships and ship operations are covered by the schemes (in line with the coverage of IMO's main treaties) either through flag State or port State obligation (no more favourable treatment).

3.12 Both schemes will be applicable to all ships above 400 GT and there will be no large-scale deviations from the general trend in the energy-efficiency improvements for smaller ships.

3.13 There will be no major shift from international shipping to domestic shipping and the proportion of international shipping to total shipping will remain the same as it was in 2007. GHG emissions from domestic shipping will be included in national climate change policies.

3.14 The administration costs for the two schemes are set to two per cent of the total amount revenues collected through the Fund or generated through auctioning in ETSIS. The 2% used in this study is in line with administrative costs of existing funds and schemes. The administration cost of the IOPC Funds is about 5% of revenues raised through the fund (IOPC, 2008) and the Australian government has estimated the administrative costs of their ETS to be about 1.7%. Tax administrative costs are typically one percent of tax revenue (Pope and Owen, 2009). Tax administrative costs are usually lower because they build on existing institutions.

3.15 Both schemes will need to set up a new administrative system and therefore it is assumed that the administrative costs of these schemes are going to be the same. In the modelling these costs have been allocated region by region according to the regional revenues raised by the schemes. The revenues have been assumed to be all spent on administration by the central administrative body.

3.16 Three per cent of the total revenues collected or generated through auctioning will be used for energy-efficiency R&D purposes within the shipping industry under the control of IMO. In order to quantify this effect in the scenarios, the R&D spending has been assumed to be 3% of the carbon revenues collected or generated by region from international shipping and then spread equally as extra investment across three production sectors: 1) shipbuilding, 2) water transport and associated services and 3) the R&D sector (Professional Services).

3.17 The remainder of the total revenues (excluding any revenues used for offsetting under Fund option) is assumed to be used to fund climate change adaptation and mitigation in the UN-defined group of Least Developing Countries (LDCs), the Small Island Developing States (SIDS) and the Land-locked Developing Countries (LLDS). All these countries are in one region in the E3MG model used for the study (the Rest-of-World region 20). The revenues have been converted into extra investment for the region, which has then been allocated for adaptation purposes as 90% to investment by Public Administration and Defence and as 10% to investment in the government sector Health and Social Security.

3.18 According to the UNEP Risoe Institute (2009) the availability of CDM credits is predicted to be 5542 million CER from 2013 to 2020 (this makes 693 million CER per annum). The vast majority (very likely more than 50%) of the CDM projects will be carried out in China. India will provide about 30% of CERs followed by Brazil (about 10%) and Mexico (about 5%). Reminding CDM credits are provided by the rest of the Non-Annex I countries. This study assumes that when international shipping purchases credits for offsetting then the same proportions are used.

**Baseline scenario**

3.19 This study adopts a baseline scenario for international shipping based on the Second IMO GHG study 2009 (MEPC 59/INF.10, Chapter 7) A2 (Figure 3-1). Scenarios in the Second IMO GHG Study 2009 are based on the framework for global development and storylines that have been developed by the Intergovernmental Panel on Climate Change (IPCC) in the Special Report on Emission Scenarios (SRES), and are named according to IPCC SRES terminology. The baseline scenario reflects projected business as usual international shipping emissions under the IPCC A2 GHG scenario.

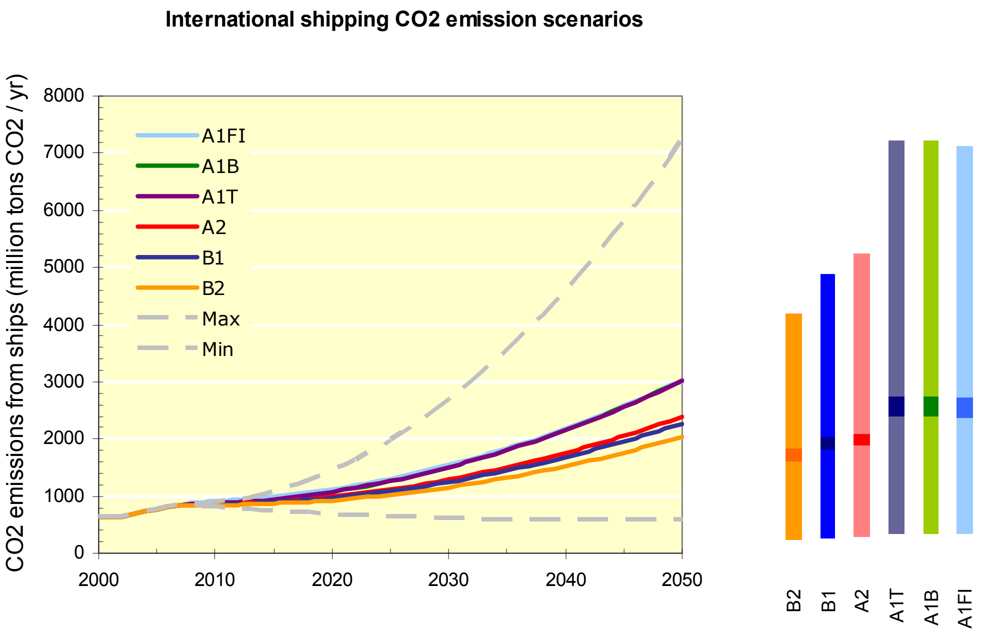


**Figure 3-1. Trajectories of the emissions from international shipping (2000–2050). Columns on the right-hand side indicate the range of results for the scenarios within individual scenario families. Source: MEPC 59/INF.10 p. 134.**

3.20 Scenario A2 as developed by the Second IMO GHG Study 2009 was chosen as it represents one of the middle scenarios of the international shipping emissions. This scenario assumes as an input a 39% improvement in efficiency in fuel use by 2050 compared to 2007 and a 12% improvement by 2020 compared to 2007. Assumptions of these aggregate improvements in transport efficiency are shown in table 3-1. These values are derived in (MEPC 59/INF.10, Chapter 7) from the discussion of voluntary and mandatory (CAC) policy instruments in Chapter 6 based on either the EEDI or the EEOI, acknowledging that different pathways could lead to similar reductions. The aggregate values for 2050 also account for structural changes to the fleet that could occur in the period beyond 2020.

**Table 3-1. Inputs to the scenarios: aggregate improvements in efficiency (fleet average values) compared to efficiencies in 2007 as the base year**

| **2050** | **All scenario families** | | |
|---|---|---|---|
| | **Base** | **High** | **Low** |
| **Ocean-going shipping** | −39% | −58% | −5% |
| **Coastwise shipping** | −39% | −65% | −5% |
| **Container** | −39% | −75% | −5% |
| **2020** | **All scenario families** | | |
| | **Base** | **High** | **Low** |
| **Ocean-going shipping** | −12% | −22% | 0% |
| **Coastwise shipping** | −12% | −22% | 0% |
| **Container** | −12% | −39% | 0% |

Source: Document MEPC 59/INF.10, p. 134.

3.21 The scenario was derived from the annual economic growth rate of 2.4% for the period 2000 to 2050 in the IPCC A2 scenario. The IPCC SRES A2 storyline and scenario family describes a very heterogeneous world. The underlying theme is self reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in continuously increasing global population. Economic development is primarily regionally oriented whereas per capita economic growth and technological change are more fragmented and slower than in other storylines.

3.22 Based on the Second IMO GHG Study 2009 the baseline scenario A2 for international shipping emissions adopted for this study assumes following levels of $CO_2$ emissions from international shipping:

.1 468 $MtCO_2$ in 1990;

.2 795 $MtCO_2$ in 2005;

.3 982 $MtCO_2$ in 2020; and

.4 2194 $MtCO_2$ in 2050.

**Model and modelling assumptions**

3.23 The hybrid model, E3MG, is a 20-region, structural, annual, dynamic, econometric simulation model based on data covering the period 1970–2006, and projected forward annually to 2020 then every 10 years to 2050 or 2100 (see Annex II). Each sector in each region is assumed to follow a different pattern of behaviour within an overall theoretical structure. The model covers in principle emissions of the six Kyoto GHGs ($CO_2$, $CH_4$, $N_2O$, PFCs, HFCs, $SF_6$) and other atmospheric pollutants from 28 emission sources, but is restricted to $CO_2$ for the assessment of the impacts of an emission trading scheme.

3.24 The E3MG industrial and energy/emissions database[2] covering the years 1970–2006 is drawn from OECD, IEA, GTAP, RIVM, EDGAR and other national and international sources, processed to provide comprehensive and consistent time-series of varying quality and reliability across regions and sectors. It contains information about historic changes by region and sector in emissions, energy use, energy prices and taxes, input–output coefficients, and industries' output, trade, investment and employment. This is supplemented by data on macroeconomic behaviour from the IMF and the World Bank. However, the data are far from comprehensive, especially for developing countries. Therefore there are large uncertainties in the estimates for some regions and variables, which must be taken into account in the econometric estimation and in interpreting the results. Furthermore, the parameters based on 33-year historical data may not be appropriate for solutions that cover a period of 100 years.

3.25 The E3MG modelling approach assumes that understanding the future is best done by first understanding the past; hence the econometric basis of the model. E3MG represents a novel approach to the modelling of technological change and economic growth in the literature on the costs of climate stabilization. Growth in this approach is dependent on waves of investment and as a macroeconomic phenomenon arising out of increasing returns, which lead to technological change and diffusion. Other features of the model include: varying returns to scale (which are derived from estimation), non-equilibrium, not assuming full employment, varying degrees of competition, industries acting as social groups and not as a group of individual firms (i.e. no optimization is assumed but bounded rationality is implied), and the grouping of countries and regions based on political criteria.

3.26 E3MG incorporates a special subroutine to assess the impacts of an emission trading scheme. $CO_2$ (as the tradable gas under the ETSIS) is the only GHG included in the subroutine. For this study, the emissions trading subroutine was revised and developed, and international shipping was added as one of the trading sectors in the sub-model. A specific code that allows an assessment of the impact of use of CDM credits (CERs) was also developed and added to the subroutine. Exogenous carbon allowance and CDM credit prices and the industry specific allowance allocations were included in the model through specific input files – scenario files. The scenario file structure was also amended to allow the inclusion of shipping at different time points and to make use of CDM credits and to allow for an exogenous price for these credits.

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2 The database was constructed by teams at Cambridge Econometrics (see www.camecon.com/).

3.27 The $CO_2$ emissions and corresponding fuel uses are calibrated in the E3MG baseline to the figures estimated in the Second IMO GHG study 2009 for the A2 scenario over the whole period 2005 to 2050. The estimates of fuel use by region in the model are derived from the International Energy Agency's data on bunker fuel use for international shipping. The IEA-based data are scaled to match the totals of A2 scenario.

3.28 In the baseline scenario, it is further assumed that Annex I countries adopt policies to impose carbon prices on energy intensive sectors at levels similar to those in the ETSIS. These carbon prices are assumed for an Annex I ETS on the electricity and energy-intensive sectors (including aviation) covering all of Annex I, with 100% auctioning.

3.29 The revenues from the auctions of the Annex I ETS are assumed to be spent by governments on reducing their employers' social security payments. This has the effect of keeping the ETS revenue neutral so that all revenues from auctions are recycled via reductions in the cost of labour to employers. The Annex I ETS reduces $CO_2$ emissions by 24% by 2020 and 45% by 2050, each below 2005 levels in Annex I countries. These reductions are adopted to give an indication of the effects of the Fund and ETSIS in the context of some action by Annex I countries.

3.30 The baseline scenario A2, without Fund or ETSIS, is used in the E3MG model and the modelling results for shipping emissions 2015 to 2050 are presented relative to the baseline scenario.

3.31 In this study, allowances allocated to the international shipping industry in the ETSIS are auctioned. It is assumed that the cost of auctioned and purchased carbon allowances from the market as well as the contributions paid on bunker fuel in the Fund is fully passed on to consumers by increasing prices for water transport services. In the model, these costs are added to fuel costs: increasing fuel costs impacts the industry's fuel demand through an econometric fuel demand equation (the average long-term price elasticity of fuel demand is estimated to be -0.3). $CO_2$ emissions are estimated from fuel use with the help of a conversion factor.

# Chapter 4. Fund for Greenhouse Gas Emissions from International Shipping (Fund)

**Assumptions**

4.1 In addition to the assumptions in Chapter 3 and the proposed details provided by Denmark in document MEPC 59/4/5, the following assumptions were made when the Fund was assessed.

4.2 A range of contribution rates (all in 2015 US dollars) was considered for the four Fund scenarios:

.1 $7.5 per tonne of bunker fuel (i.e. $2.4 per tonne of $CO_2$);

.2 $15 per tonne of bunker fuel (i.e. $4.7 per tonne of $CO_2$);

.3 $30 per tonne of bunker fuel (i.e. $9.5 per tonne of $CO_2$); and

.4 $45 per tonne of bunker fuel (i.e. $14.2 per tonne of $CO_2$).

These prices start in 2015 and increase by 3% per annum in line with average global inflation (Figure 4-1).

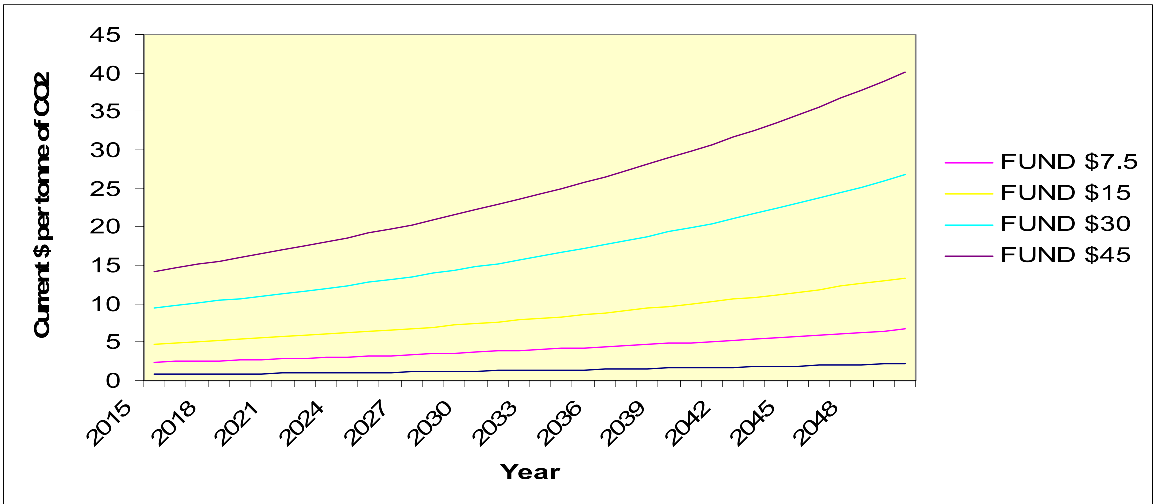


**Figure 4-1. Carbon prices in current dollars per tonne of $CO_2$ under the Fund from 2015 to 2050.**

4.3 The spot price of carbon in the European carbon market was about $20/t$CO_2$ ($62 per tonne of bunker fuel) in November 2009 (PointCarbon) exceeding the highest contribution per tonne of bunker fuel proposed in Fund.

4.4 A target line for $CO_2$ emissions is set at 2005 levels for 2015 decreasing to 20% below 2005 levels by year 2020 and thereafter to 50% below 2005 levels by 2050. The revenues corresponding to the target levels of emissions are used for administration, R&D and adaptation and mitigation purposes in LDCs (as specified in 3.11-3.14). The revenues corresponding to the emissions exceeding this baseline are used for offsetting. Offsetting here means purchasing credits from outside the shipping industry to allow carbon emissions being reduced elsewhere by using the shipping industries' additional payments to buy the credits for the reductions. The credits can be purchased from the Kyoto project's Clean Development Mechanism.

**Results**

**Reductions in $CO_2$ emissions**

4.5 Table 4-1 shows the absolute and relative reductions in $CO_2$ emissions from international shipping required to achieve the target line as defined in the study in 2020 and 2050 both as difference from 2005 levels and differences from the SRES A2 international shipping scenario of the Second IMO GHG study 2009 for 2020 and 2050.

**Table 4-1. Absolute and relative differences in $CO_2$ emissions from international shipping between the target line and 2005 levels and between the target line and the reference case scenario A2.**

| | Mt (%) below 2005 levels | | Mt (%) below A2 projections | |
|---|---|---|---|---|
| | 2020 | 2050 | 2020 | 2050 |
| **Target line** | 159 (-20) | 397 (-50) | 346 (-35) | 1796 (-82) |

4.6 In the Fund scenario, the $CO_2$ emissions from international shipping fall by 11.3% below baseline by 2020 for the highest contribution of $45 per tonne of bunker fuel (14.2/t$CO_2$) (see Table 4-2), implying that the target line is not reached even in the highest price scenario. The reduction by 2050 is 5.4%. The $CO_2$ response is reduced after 2030 because the underlying real price of oil is assumed to rise by 1% a year, so that the relative increase in costs from the carbon price, which is constant in real terms, gradually falls. None of the Fund scenarios comes close to achieving the targets without offsetting (Figure 4-2).

**Table 4-2. $CO_2$ reductions from international shipping (% difference from baseline) in 2020 and 2050 under the Fund.**

| Scenario | 2020 | 2050 |
|---|---|---|
| **Fund $7.5 per tonne of bunker fuel** | **-2.2** | **-0.5** |
| **Fund $15 per tonne of bunker fuel** | **-4.3** | **-1.2** |
| **Fund $30 per tonne of bunker fuel** | **-8.0** | **-3.2** |
| **Fund $45 per tonne of bunker fuel** | **-11.3** | **-5.4** |

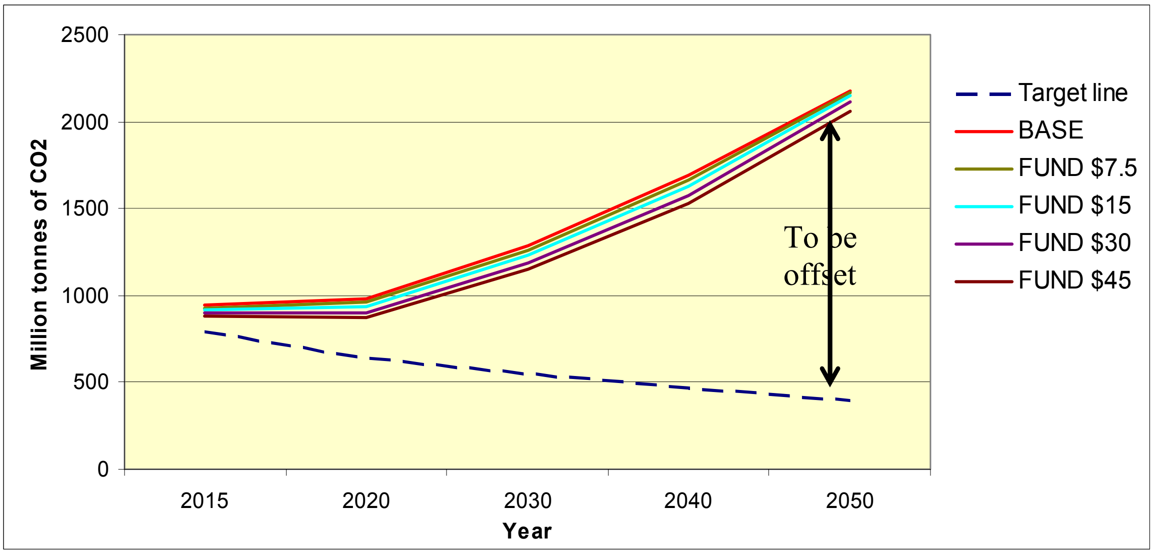


**Figure 4-2. Reductions in $CO_2$ emissions from international shipping 2015-2050 in the Fund.**

4.7 Table 4-3 below shows the reductions in total global $CO_2$ emissions from energy use for the different Fund scenarios. Since emissions from international shipping are likely to be about 5.8% of the total global baseline emissions in 2050, these total reductions are very small, at most 0.4 % by 2050 for the high contribution scenario.

**Table 4-3. Reductions in total global $CO_2$ from energy use (% difference from baseline) in 2020 and 2050 under the Fund.**

| Scenario | 2020 | 2050 |
|---|---|---|
| **Fund $7.5 per tonne of bunker fuel** | 0.0 | 0.0 |
| **Fund $15 per tonne of bunker fuel** | -0.1 | -0.1 |
| **Fund $30 per tonne of bunker fuel** | -0.2 | -0.2 |
| **Fund $45 per tonne of bunker fuel** | -0.2 | -0.4 |

**Effects on global GDP, regional exports and imports**

4.8 The scenarios all show slight increases in global GDP arising from the transfer of revenues to the LDCs' investment in adaptation and mitigation projects (Table 4-4). These expenditures raise LDCs' construction, equipment and vehicle output, hence the incomes of these sectors and hence general incomes and expenditures, including imports. There are also very slight increases in expenditures in many regions from the extra spending on administration and R&D.

**Table 4-4. Changes in GDP (% difference from baseline) in 2020 and 2050 under the Fund.**

| Scenario | Annex I | | Non-Annex I | | Least Developed Countries | | World | |
|---|---|---|---|---|---|---|---|---|
| | 2020 | 2050 | 2020 | 2050 | 2020 | 2050 | 2020 | 2050 |
| Fund $7.5 per tonne of bunker fuel | 0.00 | 0.00 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| Fund $15 per tonne of bunker fuel | 0.00 | 0.00 | 0.02 | 0.03 | 0.01 | 0.00 | 0.00 | 0.01 |
| Fund $30 per tonne of bunker fuel | 0.00 | 0.00 | 0.04 | 0.06 | 0.02 | 0.00 | 0.01 | 0.01 |
| Fund $45 per tonne of bunker fuel | 0.00 | 0.00 | 0.06 | 0.08 | 0.03 | 0.00 | 0.01 | 0.02 |

4.9 Impacts on export and import volumes (Annex I of this study) in developing countries and least developed countries are small -- in most scenarios close to zero for both 2020 and 2050. Impacts on import prices of food and drink and agricultural products are negligible.

**Table 4-5. Relative changes in import prices in LDCs in 2020 and 2050 under the Fund scenarios (% change from baseline).**

| Products imported | Food and drink | | Agricultural products | |
|---|---|---|---|---|
| Scenario | 2020 | 2050 | 2020 | 2050 |
| Fund $7.5 per tonne of bunker fuel | 0.00 | 0.00 | 0.00 | 0.00 |
| Fund $15 per tonne of bunker fuel | 0.00 | 0.00 | 0.00 | 0.00 |
| Fund $30 per tonne of bunker fuel | 0.00 | 0.00 | 0.00 | 0.00 |
| Fund $45 per tonne of bunker fuel | 0.00 | 0.00 | 0.00 | 0.00 |

## Revenues raised by the central international governing body

4.10 Table 4-6 shows the transfers in billion US dollars (in current prices) from the Fund to Administration (2%), R&D (3%), as a contribution to climate change adaptation and mitigation in developing countries and LDCs and revenues allocated for offsetting. The scale of the transfers follows the $CO_2$ emissions from international shipping, so that as the contribution increases so does the transfer.

**Table 4-6. Results of scenarios: Annual revenues from MBIs $bn (current prices) in 2020 and 2050 under the Fund.**

| Scenario | Administration (2%) | | International shipping R&D (3%) | | Adaptation Fund for Least Developed Countries | | Offsetting by purchasing CDM credits | | Total (100%) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2020 | 2050 | 2020 | 2050 | 2020 | 2050 | 2020 | 2050 | 2020 | 2050 |
| **Fund $7.5 per tonne of bunker fuel** | 0.05 | 0.29 | 0.08 | 0.43 | 1.75 | 2.53 | 0.76 | 11.15 | 2.64 | 14.40 |
| **Fund $15 per tonne of bunker fuel** | 0.10 | 0.57 | 0.16 | 0.86 | 3.50 | 3.89 | 1.41 | 23.24 | 5.17 | 28.56 |
| **Fund $30 per tonne of bunker fuel** | 0.20 | 1.12 | 0.30 | 1.68 | 7.00 | 7.83 | 2.44 | 45.37 | 9.94 | 56.00 |
| **Fund $45 per tonne of bunker fuel** | 0.29 | 1.64 | 0.43 | 2.46 | 10.50 | 11.85 | 3.14 | 66.05 | 14.36 | 82.00 |

4.11 If the Fund is chosen to regulate $CO_2$ emissions from international shipping then the central governing body receives contributions for every tonne of $CO_2$ emitted by the industry assuming 100% of compliance (Figure 4-2). The transfers as shown in Table 4-6 will all be done through the central governing body and this includes offsetting of $CO_2$ emissions from international shipping.

4.12 The effects of the fund on LDCs revenues for climate change investments is of the order of $10bn by 2020 rising to $12bn by 2050 (in current prices) for the $14.2/t$CO_2$ carbon price ($45 per tonne of bunker fuel). The revenues allocated to the LDCs in the Fund depend on the target line set since the revenues from emissions exceeding the target line will be used to purchase CDM credits. Therefore only the revenues from emissions under the target line less the allocation to administration and R&D can be used to raise funds for LDCs.

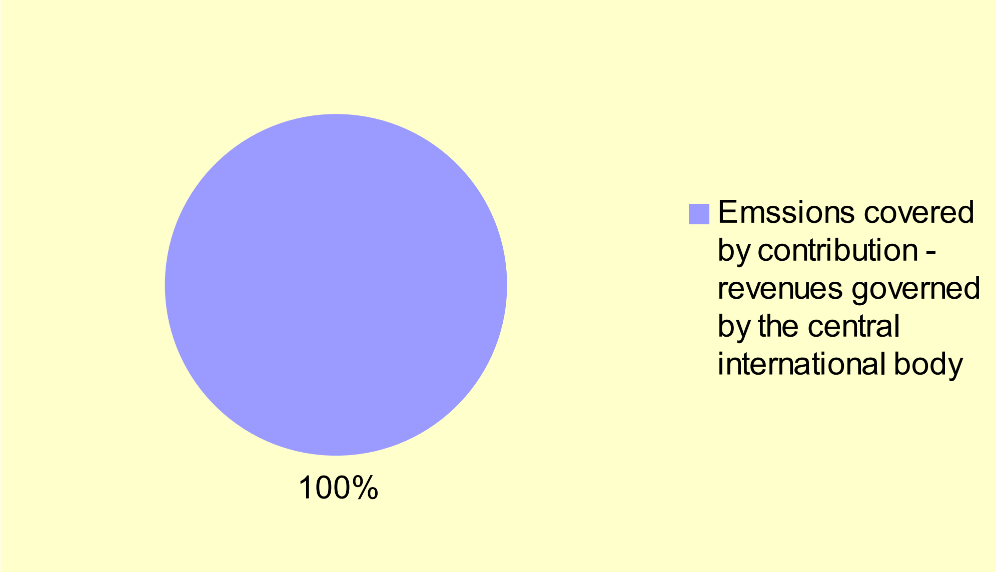


**Figure 4-2. Revenues governed by the central international body in the Fund.**

4.13 Table 4-7 shows the amounts of CDM credits purchased by international shipping under the Fund. CDM credits are used in both schemes. The price of one credit (CER) has historically been 10% less then the price of a European Union allowance (EUA). In this study it is assumed that the price of a CER is $49.8 per tonne of $CO_2$ in 2020 and $919.5 in 2050 (in current dollars) and that CERs in Fund are purchased at this price.

**Table 4-7. CDM credits (CERs) purchased by international shipping (in millions CERs and as % of the baseline emissions) in 2020 and 2050.**

| **Price of a CER in current $** | **49.8** | **919.5** | **20.0** | **20.0** |
|---|---|---|---|---|
| **Scenario** | **2020** | **2050** | **2020** | **2050** |
| **Fund $7.5 per tonne of bunker fuel** | 15.3 (2%) | 12.1 (1%) | 38.0 (4%) | 557.5 (26%) |
| **Fund $15 per tonne of bunker fuel** | 28.3 (3%) | 25.3 (1%) | 70.5 (7%) | 1162.0 (53%) |
| **Fund $30 per tonne of bunker fuel** | 49.0 (5%) | 49.3 (2%) | 122.0 (12%) | 2268.5 (104%) |
| **Fund $45 per tonne of bunker fuel** | 63.1 (6%) | 71.8 (3%) | 157.0 (16%) | 3302.5 (151%) |

4.14 CDM credits (CERs) purchased in Fund are to cover the $CO_2$ emissions above the target line from international shipping that will be offset. The amount of CERs bought in Fund depends on revenues raised. The higher the contribution per tonne of bunker fuel the more credits can be purchased from developing countries. The majority of these credits will be purchased from China and India. UNEP Risoe Institute estimates the availability of CDM credits to be 5542 million CER for the period 2013 - 2020 (this makes 693 million CER per annum). The international shipping industry is likely to take up 9% of global annual provision of CERs at the Fund with the highest contribution per tonne ($45 per tonne of bunker fuel) of bunker fuel in 2020.

4.15 However if the price of a CER will be lower, for example at the level of current carbon price in the EU ETS (i.e. \$20 per CER), then more credits can be bought using the revenues raised under the Fund. In 2050 the revenues from Fund corresponding to the prices \$30 and \$45 per tonne of bunker fuel will allow offsetting more emissions than is needed to reach the target line i.e. more than 1796 million tonnes of $CO_2$ (Table 4-7).

**Table 4-8. Emissions reduced through direct reductions in the international shipping industry and through offsetting relative to the baseline under the Fund Scheme with a contribution rate of \$45 per tonne of $CO_2$ (in millions tonnes of $CO_2$ and as % of the baseline).** ***The price of one Certified Emission Reduction Unit (CER) is \$49.8/t$CO_2$ in 2020 and \$919.5/t$CO_2$ in 2050***

| Scenario | Fund \$45 per tonne of bunker fuel | |
|---|---|---|
| | 2020 | 2050 |
| **Baseline emissions** | **981 (100%)** | **2181 (100%)** |
| **Direct reduction** | **111 (11%)** | **119 (5%)** |
| **Offsetting – indirect reductions** | **63 (6%)** | **72 (3%)** |
| **Target line emissions** | **636 (65%)** | **398 (18%)** |
| **Not covered** | **171 (18%)** | **1592 (73%)** |

4.16 The table 4-8 above shows direct and indirect reductions in $CO_2$ emissions for the Fund scenario with a contribution rate of \$45 per tonne of bunker fuel. However if the price of a CER would be lower then it would allow more emissions to be offset in the Fund (see table 4-7). In this case the offsetting could cover more emissions than international shipping will emit in the baseline scenario. Another question is whether in 2050 the amount of CERs available at \$20 price level (if the project based mechanisms will continue beyond 2020) is enough to cover the shipping industry's demand. Looking at current market projections this seems to be unlikely.

4.17 The major uncertainty related to the outcome of this study is the one related to unknown future carbon prices and the existence of future carbon markets (Table 4-8). If a Fund is adopted then contribution per tonne of fuel is known (even if the contribution per tonne of fuel will be changed over time it is likely to be announced before adoption). For this study there were assumptions made regarding the levels of carbon prices and existence of carbon markets.

**Table 4-8. Main current uncertainties related to Fund (2015- 2050)**
Legend: Not known: **-**, Known: + . Not applicable: **n.a.**

| For the period of 2015-2050 | FUND |
|---|---|
| **Existence of Annex I carbon trading scheme** | **n.a.** |
| **Allowance price on the Annex I carbon market** | **n.a.** |
| **Existence of CDM markets** | **-** |
| **Availability of CERs** | **-** |
| **Price of CERs** | **-** |
| **Contribution rate** | + |

4.18 These uncertainties suggest that the carbon reduction system planned has to be designed in an adjustable manner to allow incorporation of carbon market changes. On the other hand the designed scheme has to be transparent and predictable to enable long-term investments to low-carbon technology by the industry.

# Chapter 5. Emission Trading Scheme for International Shipping (ETSIS)

**Assumptions**

5.1 In addition to the proposed details provided by France, Germany and Norway in documents MEPC 59/4/25 and MEPC 59/4/26 and related documents, the following assumptions were used when assessing the ETSIS.

5.2 There are two options related to the openness to the emissions trading scheme. The scheme for international shipping could be an open trading scheme meaning that allowances can be bought from or/and sold to other industries that are part of the same trading scheme. If a closed scheme is considered then emissions trading is only allowed inside the shipping sector and the $CO_2$ emissions from international shipping cannot exceed the defined cap. The latter also means that no offsetting through Kyoto flexible mechanisms is allowed and no purchasing of credits is allowed from other emission trading schemes.

5.3 International shipping could be linked to one of the major emissions schemes that will be in force in 2015. It would be preferable to link it to a global emissions trading scheme allowing reductions to be achieved at the lowest possible cost. The ETSIS considered in this study is an **open** emissions trading scheme, in which the shipping industry can buy allowances from and sell allowances to other market participants (energy-intensive industries) in a hypothetical emissions trading scheme for all Annex I countries. In 2015 international shipping would account for about 8.5% of this market. This means that the carbon price for international shipping in this trading scheme will be largely defined by the other market participants that have larger market shares.

5.4 In 2015 annual international shipping emissions will be capped at 2005 levels. The cap (Figure 5-1) will decrease gradually and will reach 20% below 2005 levels by 2020, and thereafter continue decreasing and will be 50% below 2005 levels in 2050 (about 15% below 1990 levels). 100% of allowances under the annual cap (target line) for international shipping will be allocated through auctioning that takes place once a year during the trading period from 2015 to 2050. The auctioning revenues will go to the central international body. The revenues will be allocated to LCDs, R&D and administration as specified in 3.11 – 3.14. No revenues will be allocated to cover the carbon emissions that exceed the initial allocation. Purchasing allowances and credits will be done by the trading entities under the scheme.

5.5 In the ETSIS, emissions exceeding the target line (cap) will be either reduced by the international shipping industry or offset through buying allowances from the market and CDM credits.

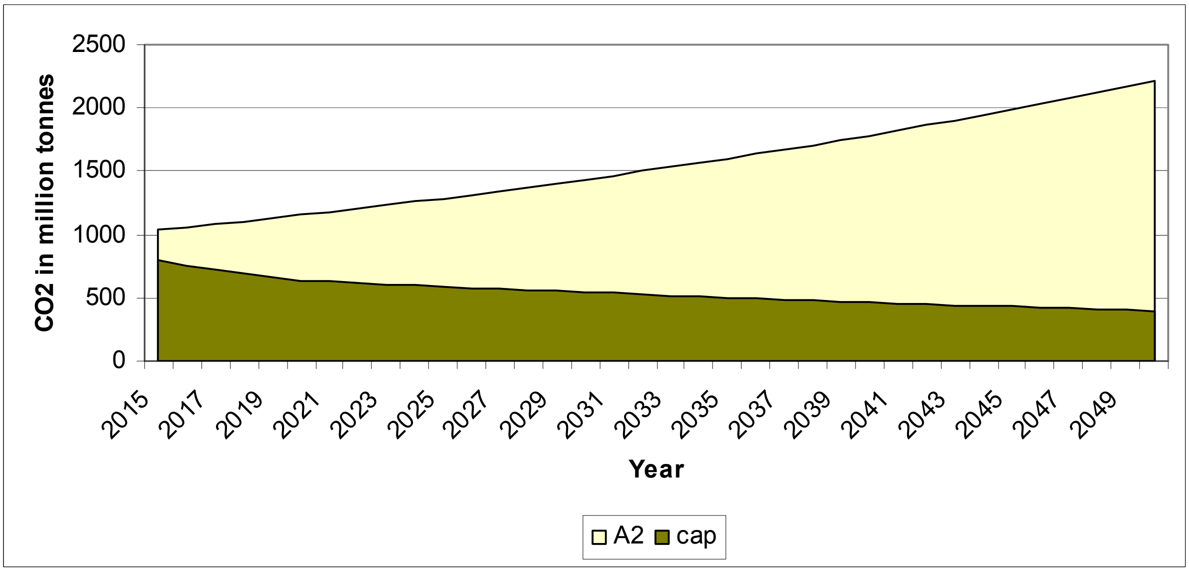


**Figure 5-1. Comparison of projected $CO_2$ emissions (A2) and annual allowances auctioned (up to the target line i.e. cap) for the international shipping industry.**

5.6 An introduction period may be used, e.g., that only a certain part (10%) of a ship's emissions needs to be covered in the first year, gradually increasing to 100% over some few (three) years. The aim of this introduction period is to introduce the industry to carbon trading and allowing gradual adjustment to the new policy. If an introduction period is used then it should be seen as separate trading period carried out before the MBI comes into force.

5.7 Credits from Clean Development Mechanism (CERs) under the Kyoto Protocol (CDM) or its successor instrument can be used to cover the demand for extra allowances. These credits can account for up to 15% of the initial allocation in the ETSIS and are supplementary to the original allocation.

5.8 For the ETSIS a carbon price is adopted based on PointCarbon (2009) forecasts for the European Emissions Trading scheme starting with $28 per tonne of $CO_2$ in 2013 increasing thereafter to $56 per tonne of $CO_2$ in 2020 and continuing to rise by 7% year. These prices are adjusted to an annual inflation of 3% (Figure 5-2).

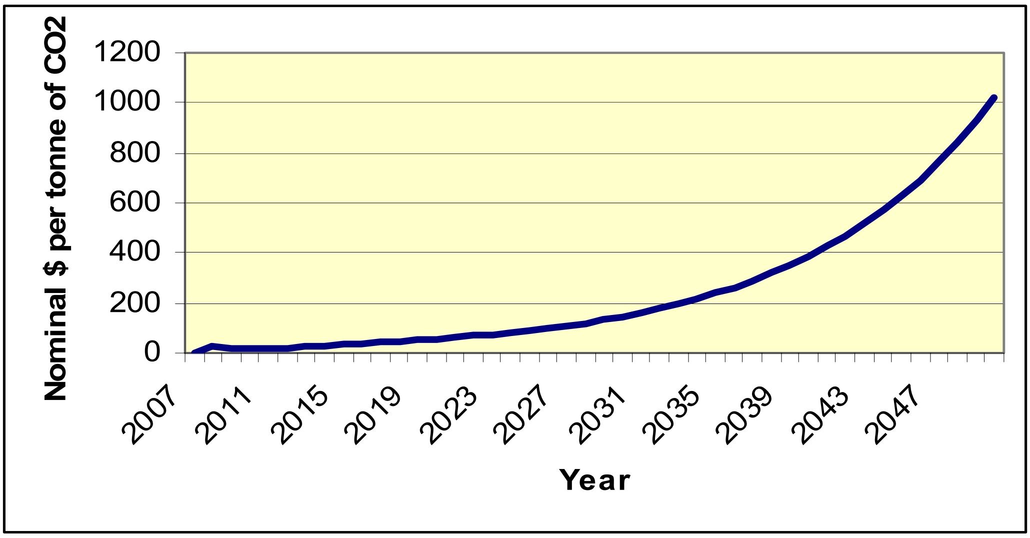


**Figure 5-2. Carbon price in the ETSIS: based on market price (2007-2009) and PointCarbon estimates for 2012 and 2020. After 2020 the price is extrapolated up to 2050.**

**Results**

**Reductions in $CO_2$ emissions**

5.9 Table 5-1 shows the absolute and relative reductions in $CO_2$ emissions from international shipping required to achieve the caps as defined in the study in 2020 and 2050 both as difference from 2005 levels and differences from the SRES A2 international shipping scenario of the Second IMO GHG study 2009 for 2020 and 2050.

**Table 5-1. Absolute and relative differences in $CO_2$ emissions from international shipping between the caps and 2005 levels and between the caps and the reference case scenario A2.**

| | Mt (%) below 2005 levels | | Mt (%) below A2 projections | |
|---|---|---|---|---|
| | **2020** | **2050** | **2020** | **2050** |
| **Target line** | 159 (-20) | 397 (-50) | 346 (-35) | 1796 (-82) |

5.10 In the ETSIS open scenario, the nominal carbon price from the other emission trading schemes is assumed to be $34/t$CO_2$ in 2015 rising to $56/t$CO_2$ in 2020 and thereafter, using the same price growth rate, rising to $1022/t$CO_2$ in 2050 (see Section 5.7 and Figure 5-2 ). These prices give reductions of 29.3% below baseline by 2020 and 51.7% by 2050 in shipping $CO_2$ emissions (Table 5-2). These reductions are insufficient to achieve the targets, implying that the additional reductions must come from purchases of CER from CDM projects and/or allowances from the open carbon market (Figure 5-3).

**Table 5-2. $CO_2$ from international shipping % difference from base in 2020 and 2050**

| **Scenario** | **2020** | **2050** |
|---|---|---|
| **ETSIS** | **-29.3** | **-51.7** |

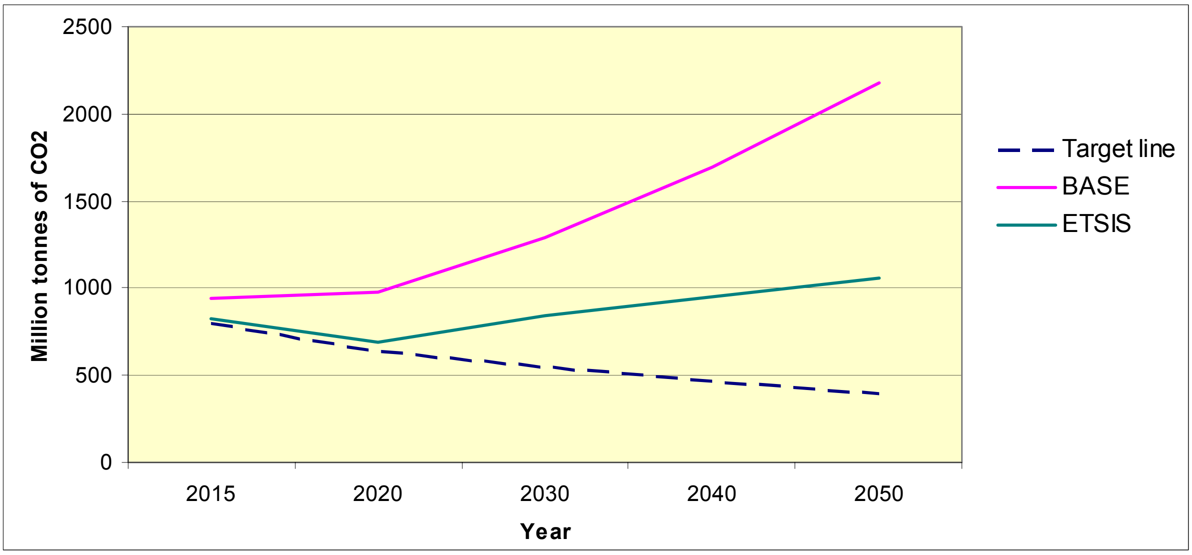


**Figure 5-2. Reductions in $CO_2$ emissions for international shipping 2015-2050 in ETSIS**

5.11 The 2020 result from the E3MG modelling is consistent with the Central Estimate in the Second IMO GHG study 2009 Figure (MEPC 59/INF.10, p. 76) of the 2020 Marginal $CO_2$ Abatement Cost Curve, although the result is derived from econometric estimates. It is shown by the block arrow in Figure 5-3. These estimates come from an explanation of the regional fuel demand by international shipping in terms of total exports and imports carried, prices of the fuels used relative to a general index of prices and; for some regions, technical progress. The estimates do not allow for alternative technologies to conventional technologies using fossil fuels. The carbon content of the fuel mix is derived from historical data.

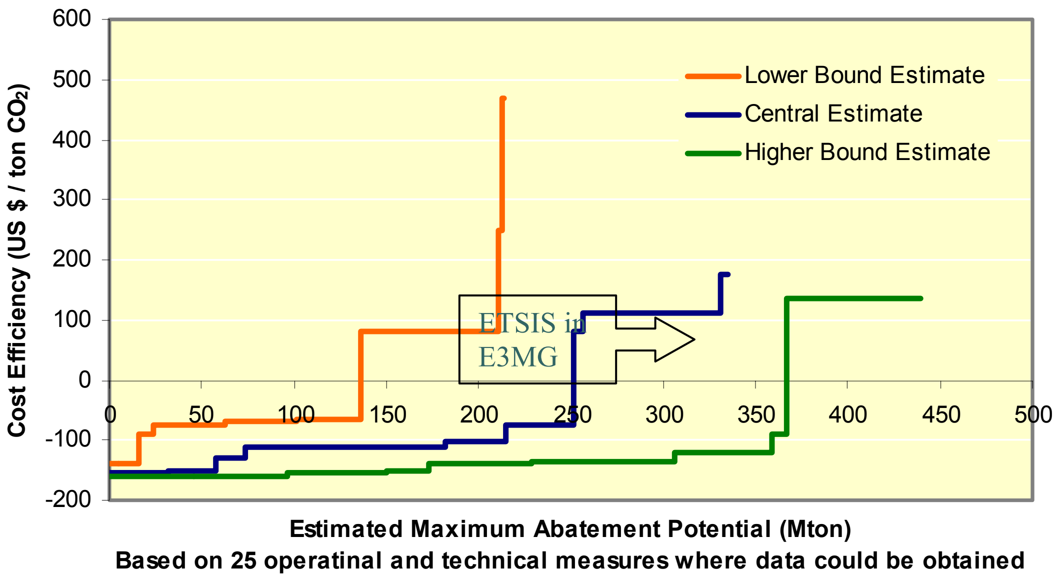


**Figure 5-3. Marginal $CO_2$ Abatement cost curve for 2020 (Fuel price \$500 per tonne)**
Source: Document MEPC 59/INF.10, p. 76 and E3MG

5.12 It was not possible to achieve the reductions in $CO_2$ implied by the 2050 cap at carbon prices in the ranges shown in Figure 5-1. Note that abatement required by 2020 to achieve the cap is about 350mt $CO_2$, but that for 2050 is much larger about 1800mt $CO_2$ (Table 5-1), well above the top of the range of reductions of 500mt shown in the Figure 5-3.

5.13 Table 5-3 below shows the reductions in total global $CO_2$ emissions from energy use for the ETSIS. Since emissions from international shipping are likely to be about 5.8% of the total baseline emissions in 2050, these total global reductions are small, at most 2.9 % by 2050.

**Table 5-3. Change in global total $CO_2$ from energy use under the ETSIS (% difference from baseline) in 2020 and 2050**

| Scenario | 2020 | 2050 |
|---|---|---|
| ETSIS | -0.7 | -2.9 |

**Effects on global GDP, regional exports and imports**

5.14 The scenarios all show slight increases in global GDP arising from the transfer of revenues to the LDCs' investment in adaptation and mitigation projects (Table 5-4). These expenditures raise LDCs' construction, equipment and vehicle output, hence the incomes of these sectors and hence general incomes and expenditures, including imports. There are also very slight increases in expenditures in many regions from the extra spending on administration and R&D.

**Table 5-4. Changes in GDP (% difference from baseline) in 2020 and 2050 under the ETSIS.**

| Scenario | Annex I | | Non-Annex I | | Least Developed Countries | | World | |
|---|---|---|---|---|---|---|---|---|
| | 2020 | 2050 | 2020 | 2050 | 2020 | 2050 | 2020 | 2050 |
| ETSIS | 0.00 | 0.02 | 0.20 | 0.38 | 1.34 | 2.46 | 0.06 | 0.14 |

5.15 The effects of the ETSIS on GDP are small, but positive. The Least Developing Countries' GDP increases the most through the spending of the funds on adaptation and mitigation projects. Here GDP is 1.34% above baseline by 2020 and 2.46% by 2050. Overall global GDP is less than 0.15% above base for the ETSIS.

5.16 Impacts on export and import volumes (Annex I of this study) in developing countries and LDCs are small; in most scenarios close to zero for both 2020 and 2050. ETSIS has impact on import volumes in LDC by increasing import volumes 0.3% in 2020 and 0.6% in 2050. Impacts on import prices of food and drink and agricultural products are very small. Only in 2020 there is small increase (0.08%) in import prices of food and drink.

**Table 5-5. Relative changes in import prices in LDCs under the ETSIS (% of baseline).**

| Products imported | Food and drink | | Agricultural products | |
|---|---|---|---|---|
| **Scenario** | **2020** | **2050** | **2020** | **2050** |
| **ETSIS** | 0.08 | 0.00 | 0.00 | 0.00 |

5.17 CE Delft (2008), quoted by Lockley (2008) submitted to IMO as document MEPC 58/4/39 provide estimates for different carbon prices of the implicit increase in the costs of food imports to selected LDCs. They conclude that for a carbon price of $30/t$CO_2$, food import prices would rise by little more than 0.5%. These numbers are calculating without taking into account economy wide interactions such as the impact of additional investments from the ETSIS revenues. However, the data is poor quality for import prices of food and agricultural products and this adds uncertainties to the estimates. But the impact is still likely to be very small.

**Revenues raised by the central international governing body**

5.18 Table 5-6 shows the transfers in billion US dollars (in current prices) from the Fund and ETSIS to Administration (2%), R&D (3%), as a contribution to climate change adaptation and mitigation in developing countries and LDCs and revenues allocated for offsetting. The scale of the transfers follows the $CO_2$ emissions from international shipping, so that as the allowance price and carbon emissions increase so does the transfer.

**Table 5-6. Annual revenues from the ETSIS $bn (current prices) in 2020 and 2050.**

| Scenario | Administration (2%) | | International shipping R&D (3%) | | Adaptation Fund for Least Developed Countries | | Offsetting by purchasing CDM credits | | Total (100%) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **2020** | **2050** | **2020** | **2050** | **2020** | **2050** | **2020** | **2050** | **2020** | **2050** |
| **ETSIS** | 0.81 | 9.40 | 1.22 | 14.11 | 38.65 | 446.72 | 0.00 | 0.00 | 40.73 | 470.23 |

5.19 Under the ETSIS the central governing body receives revenues from auctioning that covers only the $CO_2$ emissions under the target line (Figure 5-4). The amount of revenues raised in the ETSIS depends also on the target line set and the carbon price in the scheme.

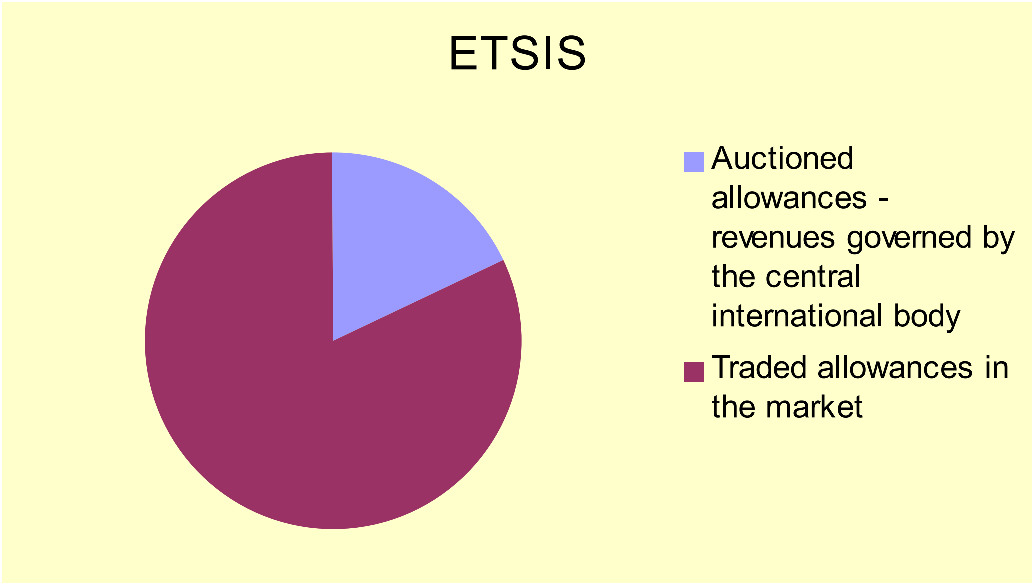


**Figure 5-4. Revenues governed by the central international body in the ETSIS.**

5.20 Table 5-7 shows the amounts of CDM credits purchased by international shipping under the ETSIS. CDM credits are used in both schemes. The price of one credit (CER) has historically been 10% less then the price of a European allowance. In this study it is assumed that the price of a CER is 90% of the ETSIS price and that CERs in ETSIS are purchased at this price.

**Table 5-7. CDM credits (CERs) purchased by international shipping (in millions and as % of the baseline) in 2020 and 2050.**

| **Price of a CER (in current $)** | **49.8** | **919.5** | **20.0** | **20.0** |
|---|---|---|---|---|
| **Scenario** | **2020** | **2050** | **2020** | **2050** |
| **ETSIS** | 58.4 (6%) | 59.7 (3%) | 58.4 (6%) | 59.7 (3%) |

5.21 In the ETSIS all $CO_2$ emissions are offset by market participants by purchasing allowances from other industries and CDM credits in amount that is equivalent up to 15% (fixed in the assumptions) of emissions under the target line. Since the target line diminishes over time then also fewer credits will be purchased in ETSIS in 2050.

5.22 The majority of these credits will be purchased from China and India. UNEP Risoe Institute estimates the availability of CDM credits to be 5542 million CER for the period 2013-2020 (this makes 693 million CER per annum). The international shipping industry is likely to take up 14% of global annual provision of CERs under ETSIS in 2020.

**Table 5-8. Emissions reduced through direct reductions in the international shipping industry and through offsetting (in millions tonnes of $CO_2$ and as % of the baseline).** *Allowance price in the ETSIS is \$56/t$CO_2$ (\$176.96 per tonne of bunker fuel) in 2020 and \$1022/t$CO_2$ (\$3229 per tonne of bunker fuel) in 2050. The price of one* ***Certified Emission Reduction Unit*** *(CER) is 10% less respectively.*

| Scenario | ETSIS | |
|---|---|---|
| | 2020 | 2050 |
| **Baseline** | 981 (100%) | 2181 (100%) |
| **Direct reductions by international shipping** | 287 (29%) | 1126 (52%) |
| **Offsetting (CERs)** | 58 (6%) | 60 (3%) |
| **Allowances from Annex I trading scheme** | 0 (0%) | 597 (27%) |
| **Target line** | 636 (65%) | 398 (18%) |
| **Not covered** | 0 (0%) | 0 (0%) |

5.23 The table 5-8 above supports the theory by showing that under an emissions trading scheme *the environmental goal is always achieved*. The results for exports and imports and import prices at a global and country level are similar to the overall GDP effect. They are extremely small, confirming results from other studies.

5.24 The major uncertainty related to the outcome of this study is the one related to unknown future carbon prices and the existence of future carbon markets (Table 1-2) For this study there were assumptions made regarding the levels of carbon prices and existence of carbon markets.

**Table 1-2. Main current uncertainties related to the ETSIS (2015- 2050)**
Legend - Not known: **-**, Known: + . Not applicable: **n.a.**

| Market-based instrument for the period of 2015-2050 | ETSIS |
|---|---|
| **Existence of Annex I carbon trading scheme** | **-** |
| **Allowance price in the carbon market** | **-** |
| **Existence of CDM markets** | **-** |
| **Availability of CERs** | **-** |
| **Price of CERs** | **-** |
| **Contribution rate** | **n.a.** |

5.25 These uncertainties suggest that the carbon reduction system planned has to be designed in an adjustable manner to allow incorporation of carbon market changes. On the other hand the designed scheme has to be transparent and predictable to enable long-term investments to low-carbon technology by the industry.

5.26 Kågeson (2007) has a thorough discussion of Maritime Emissions Trading Scheme (METS) as described in documents MEPC 59/4/25 and MEPC 59/4/26 and related documents, although without any detailed modelling of the effects, but covering the technical detail and institutional aspects of the scheme. Kågeson (2009) finds that a METS, covering emissions from shipping from and within the industrialised countries, would allow the shipping industry to respond by technical measures, by purchasing of allowances or credits and thereby supporting the carbon price and by funding of mitigation and adaptation options in developing countries.

5.27 The modelling estimates derived from this study provide support to Kågeson (2007) and (2009) and show that an emissions trading scheme for international trading can be implemented in line with the coverage of IMO's main treaties (no more favourable treatment) covering both Annex I and Non-Annex I countries. At the same time the scheme can meet the UNFCCC (Article 3, 1992) principle of common but differentiated responsibilities (CBDR) through distribution of revenues raised from the ETSIS. A proportion of revenues will be allocated to LDCs for adaptation and mitigation purposes. This revenue allocation will help LDCs to cope with climate change impact by supporting their economic growth.

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APPENDIX 1

## ETSIS and Fund impacts on export and import volumes

### Table AI-1. Changes in exports (in 2000 prices), % difference from baseline in 2020 and 2050.

| Scenario | Annex I | | Non-Annex I | | Least Developing Countries | | World | |
|---|---|---|---|---|---|---|---|---|
| | 2020 | 2050 | 2020 | 2050 | 2020 | 2050 | 2020 | 2050 |
| Fund $7.5 per tonne of bunker fuel | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Fund $15 per tonne of bunker fuel | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 |
| Fund $30 per tonne of bunker fuel | 0.01 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 |
| Fund $45 per tonne of bunker fuel | 0.01 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.02 |
| ETSIS – open | 0.02 | 0.05 | 0.01 | 0.00 | 0.00 | 0.01 | 0.02 | 0.03 |

### Table AI-2. Changes in imports (in 2000 prices), % difference from base in 2020 and 2050.

| Scenario | Annex I | | Non-Annex I | | Least Developing Countries | | World | |
|---|---|---|---|---|---|---|---|---|
| | 2020 | 2050 | 2020 | 2050 | 2020 | 2050 | 2020 | 2050 |
| Fund $7.5 per tonne of bunker fuel | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Fund $15 per tonne of bunker fuel | 0.00 | 0.01 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 0.01 |
| Fund $30 per tonne of bunker fuel | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.00 | 0.01 |
| Fund $45 per tonne of bunker fuel | 0.00 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.02 |
| ETSIS – open | 0.01 | 0.03 | 0.03 | 0.04 | 0.28 | 0.60 | 0.02 | 0.3 |

APPENDIX 2

**Description of E3MG**

**Introduction**

The E3MG model (An Energy-Environment-Economy Model at the Global level) has been constructed by international teams led by 4CMR[3] and Cambridge Econometrics[4]. It is an econometric model for the world capable of addressing issues that link developments and policies in the areas of energy, the environment and the economy. The essential purpose of the model is to provide a framework for evaluating different policies, particularly those aimed at achieving sustainable energy use over the long term, while also giving an indication of short-term transition effects. For example, the model is expected to contribute to the evaluation of policies to reduce anthropogenic emissions of greenhouse gases in G8 countries by 60% over the next 50 years.

E3MG is the latest in a succession of models developed for energy-economy and, later, E3 interactions at the international level. It is very similar in structure to the E3ME model (see www.e3me.com), which follows from EXPLOR, built in the 1970s, then HERMES in the 1980s. Each model has required substantial resources from international teams and each model has learned from earlier problems and developed new techniques.

E3MG is designed from the outset to remove one of these problems, that of linkage, by encompassing E3 interactions in a single global model. New techniques have been developed to estimate, interpret and present the equations of the model, while keeping its structure simple and understandable.

E3MG is an estimated model, based on OECD, UN, IMF and IEA data; it encompasses both long-term behaviour and dynamic year-to-year fluctuations, so that it can be used for dynamic policy simulation and for forecasting and projecting over the medium and long terms. As such, it is a valuable additional tool available for E3 policy analysis at the global level.

The model is constructed, estimated and solved on a personal computer: the construction and solution use the software package IDIOM[5], while the stochastic parameters of the model are estimated using an econometrics package, Ox (see Doornik, 2007). The estimation methods are for the most part instrumental variables, making use of error-correction methodology where applicable. Communication between Ox and IDIOM is generally via databank stores. For a general discussion of the principles of the software system, see Peterson, Barker and van der Ploeg (1983).

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3 www.4cmr.org.
4 www.camecon.com.
5 See http://www.camecon.com/suite_economic_models/idiom.htm.

**Summary design of E3MG**

E3MG is intended to meet an expressed need by researchers and policy makers for a framework for analysing the implications of long-term E3 policies, especially those concerning R&D and environmental taxation and regulation. The model is capable of addressing the short-term and medium-term economic effects as well as, more broadly, the long-term effects of such policies.

Most conventional macroeconomic models which are operational in government describe short and medium-term economic consequences of policies but with a limited treatment of long-term effects, such as those from the supply side of the labour market, and this limits their ability to analyse long-term policies. In contrast, Computable General Equilibrium (CGE) models have been widely used to analyse long-term E3 policies. CGE models specify explicit demand and supply relationships and enforce market clearing, and are therefore seen as better characterisations of long-term outcomes in which markets are assumed to be in equilibrium; for this reason they have been developed particularly in the US for the analysis of environmental regulation. However, CGE models are not generally estimated by time-series econometric methods and so have not typically been subjected to historical validation, either in terms of the values of the model's parameters or, more broadly, the underlying assumptions with respect to economic behaviour. They also have no treatment of the dynamics of model solution, and so cannot be used for historical validation of the overall model or for analysing the short- and medium-term impacts of policy changes. Their use in forecasting is limited.

E3MG, like the E3ME model, combines the features of an annual short- and medium-term sectoral model estimated by formal econometric methods with the detail and some of the methods of the CGE models, providing analysis of the movement of the long-term outcomes for key E3 indicators in response to policy changes. It is essentially a dynamic simulation model estimated by econometric methods.

In contrast with some macroeconomic models currently in operation, E3MG has a complete specification of the long-term solution in the form of an estimated equation which has long-term restrictions imposed on its parameters. Economic theory, for example the recent theories of endogenous growth, informs the specification of the long-term equations and hence properties of the model; dynamic equations which embody these long-term properties are estimated by econometric methods to allow the model to provide forecasts. The method utilises developments in time-series econometrics, with the specification of dynamic relationships in terms of error correction models (ECM) which allow dynamic convergence to a long-term outcome.

E3MG is therefore a relatively ambitious modelling project which expands the methodology of long-term modelling to incorporate developments both in economic theory and in applied econometrics, while at the same time maintaining flexibility and ensuring that the model is operational.

**The Model and the research strategy**

E3MG is a detailed model of over 40 sectors, compatible with ESA95 (Eurostat, 1995) accounting classifications, and with the disaggregation of energy and environment industries, in which the energy-environment-economy interactions are central. The model is designed to be estimated and solved for 20 regions of the world, although single-region solutions are also possible.

This one-model approach is distinguished from the multi-model approach, which was a feature of earlier model-based research. In principle, linked models -such as the DRI or the HERMES-MIDAS system of models (Barker et al, 1993) - could be estimated and solved consistently for all the economies involved. However, in practice, this often proves difficult, if not impossible, and considerable resources have to go into linking. Even if the consistency problem in linkage can be solved by successive iterative solutions of the component models, as reported in the DRI study (1991, 1992), there remains a more basic problem with the multi-model approach if it attempts to combine macroeconomic models with detailed industry or energy models. This problem is that the system cannot adequately tackle the simulation of 'bottom-up' policies. Normally these systems are first solved at the macroeconomic level and then the results for the macroeconomic variables are disaggregated by an industry model. However if the policy is directed at the detailed industry level (say, a tax on the carbon content of energy use), it is very difficult (without substantial intervention by the model operator) to ensure that the implicit results for macroeconomic variables from the industry model are consistent with the explicit results from the macro model. As an example, it is difficult to use a macro-industry two-model system to simulate the effect of exempting selective energy-intensive industries from the carbon/energy tax.

Compared to other models in existence targeted at achieving the same goals, E3MG has the following advantages:

- Model disaggregation: The detailed nature of the model allows it to represent fairly complex scenarios, in particular scenarios which are differentiated according to sector and to country. Similarly, the impact of any measure can be represented in a detailed way.

- Econometric pedigree: The econometric grounding of the models gives it a better capability in representing and forecasting performance in the short to medium run. It therefore provides information which is closer to the time horizon of many policy makers than pure CGE models.

- E3 linkages: An interaction (two-way feedback) between the economy, energy demand/supply and environmental emissions is an undoubted advantage over other models which may either ignore the interaction completely or only assume a one-way causation.

In summary, the characteristics of E3MG are such that the model is:

- elaborated at the global level rather than at a national level, with the national economies of several developed and developing countries being treated as regions of the world
- dealing with energy, the environment, population and the economy in one modelling framework
- designed from the outset to address issues of central importance for economic, energy and environmental policy at the global level
- capable of providing short- and medium-term economic and industrial forecasts for business and government
- based on a system of dynamic equations estimated on annual data and calibrated to recent outcomes and short-term forecasts
- capable of analysing long-term structural change in energy demand and supply and in the economy
- focused on the contribution of research and development, and associated technological innovation, on the dynamics of growth and change.

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