TEXTE
48/2016

Analyse und Weiterentwicklung von Klimaschutzmaßnahmen im Seeschiffsverkehr unter Berücksichtigung der aktuellen Entwicklungen auf internationaler und europäischer Ebene

6 Diskussionspapiere in englischer Sprache

Für Mensch & Umwelt

Umwelt Bundesamt

TEXTE 48/2016

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6 Diskussionspapiere in englischer Sprache

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Das diesem Bericht zu Grunde liegende Vorhaben wurde mit Mitteln des Bundesministeriums für Umwelt, Naturschutz, Bau und Reaktorsicherheit unter der Forschungskennzahl 3711 45 104 gefördert. Die Verantwortung für den Inhalt dieser Veröffentlichung liegt bei den Autorinnen und Autoren.

Kurzbeschreibung

Der jüngste Bericht des Weltklimarats (IPCC) legt nahe, dass im Jahr 2050 die globalen Treibhausgasemissionen um 40% bis 70% unter dem Niveau von 2010 liegen müssen um einen globalen Temperaturanstieg von mehr als 2°C gegenüber dem vorindustriellen Niveau zu verhindern. Laut der 3. Treibhausgas-Studie der internationalen Schifffahrtsorganisation (IMO) werden die Emissionen des Schiffsverkehrs bis 2050 jedoch um 50% bis 250% steigen. Wenn der Rest der Welt auf dem Weg in Richtung des 2-Grad-Ziels ist, würde dies zu einer Erhöhung des Anteils an den weltweiten Emissionen vom derzeitigen Niveau von 2 auf 10% führen. Bislang gibt es jedoch weder auf EU-, noch auf globaler Ebene ein System, das die Höhe der Treibhausgasemissionen des Schiffsverkehrs reguliert.

Vor diesen Hintergrund wurde diese sechs Diskussionspapiere in englischer Sprache für das Forschungsvorhaben „Analyse und Weiterentwicklung von Klimaschutzmaßnahmen im Seeschiffsverkehr unter Berücksichtigung der aktuellen Entwicklungen auf internationaler und europäischer Ebene“ verfasst. Jedes einzelne Papier enthält eine deutsche und englische Zusammenfassung.

Der Inhalt der Papiere gibt nicht unbedingt die offizielle Meinung des Umweltbundesamtes wieder.

Abstract

The latest report of the Intergovernmental Panel on Climate Change suggests that in 2050 global greenhouse gas emissions need to be 40% to 70% below their 2010 levels in order to prevent a global temperature increase of more than 2°C compared to pre-industrial levels. However, the third greenhouse gas study of the International Maritime Organization (IMO) projects that shipping emissions will increase by 50% to 250% by 2050. This would result in an increase in the share in global emissions from the current level of 2% to 10% if the rest of the world is on a path towards the 2°C target. However, there is no system in place – either on EU or global level – that regulates the level of its greenhouse gas (GHG) emissions.

Against this background, these six discussion papers were written for the German Federal Environment Agency (UBA) as part of the project entitled “Analysis and further development of climate protection measures of sea shipping taking into account current developments at European and international level”.

The contents of these publications do not necessarily reflect the official opinions of the German Federal Environment Agency.

Inhaltsverzeichnis

Abkürzungsverzeichnis

CBDR	Common but differentiated responsibilities (gemeinsamen aber unterschiedlichen Verantwortlichkeiten)
EEOI	Annual Energy Efficiency Operational Index
ETS	Emissions Trading Scheme
EHS	Emissionshandelssystem
FORS	Fuel Oil Reduction Strategy
GHG	Greenhouse gas
IMO	Internationale Schifffahrtsorganisation (International Maritime Organization)
IPCC	Weltklimarat
ISPI	Individual Ship Performance Indicator
MRV	Monitoring, Verification und Reporting

Zusammenfassungen

Diese sechs Diskussionspapiere wurden in englischer Sprache für das Forschungsvorhaben „Analyse und Weiterentwicklung von Klimaschutzmaßnahmen im Seeschiffsverkehr unter Berücksichtigung der aktuellen Entwicklungen auf internationaler und europäischer Ebene“ verfasst. Jedes einzelne Papier enthält eine deutsche und englische Zusammenfassung.

Der Inhalt der Papiere gibt nicht unbedingt die offizielle Meinung des Umweltbundesamtes wieder.

1 Greenhouse gas emission reduction targets for international shipping

Der jüngste Bericht des Weltklimarats (IPCC) legt nahe, dass im Jahr 2050 die globalen Treibhausgasemissionen um 40 bis 70% unter dem Niveau von 2010 liegen müssen um einen globalen Temperaturanstieg von mehr als 2°C gegenüber dem vorindustriellen Niveau zu verhindern. Laut der 3. Treibhausgas-Studie der internationalen Schifffahrtsorganisation (IMO) werden die Emissionen des Schiffsverkehrs bis 2050 jedoch um 50 bis 250% steigen. Wenn der Rest der Welt auf dem Weg in Richtung des 2-Grad-Ziels ist, würde dies zu einer Erhöhung des Anteils an den weltweiten Emissionen vom derzeitigen Niveau von 2 auf 10% führen. Vor dem Hintergrund, dass die globale Emissionsminderung kostengünstiger ist, wenn alle Sektoren beitragen und dass die Schifffahrt erhebliches technisches und operatives Potenzial zur Emissionsverringerung hat, analysieren wir potenzielle Minderungsziele für Treibhausgasemissionen in der internationalen Schifffahrt und in welchem Umfang diese Ziele durch Effizienzsteigerungen alleine erreicht werden können.

Diskussionspapier vom 19. März 2015, Seite 13ff. des PDF-Dokuments.

2 Further technical and operational measures for enhancing the energy efficiency of international shipping – Environmental Aspects

In der International Maritime Organization (IMO) stehen derzeit vier Maßnahmen zur Verbesserung der Energieeffizienz beziehungsweise zur Verringerung des Kraftstoffverbrauchs von Schiffen zur Diskussion: der US Vorschlag, der Annual Energy Efficiency Operational Index (EEOI), der Individual Ship Performance Indicator (ISPI) und die Fuel Oil Reduction Strategy (FORS). In dem Diskussionspapier werden diese vier Maßnahmen beschrieben und analysiert, wobei der Schwerpunkt auf den jeweils zu erwartenden CO_2-Emissionsminderungen sowie auf einer Wechselwirkung mit potentiellen zukünftigen marktbasierten Maßnahmen liegt. Um die Unterschiede zwischen den vier Maßnahmen zu veranschaulichen, werden schließlich für drei fiktive Schiffe quantitative Beispiele präsentiert.

Diskussionspapier vom 7. Juli 2014, Seite 34ff. des PDF-Dokuments.

3 Monitoring, Reporting and Verification of CO_2 emissions from ships – Design options, their feasibility and implications

Die Europäische Kommission plant die Einführung eines Monitoring-Systems für Seeschiffe als einen wichtigen Teilschritt hin zu globalen oder regionalen Politikmaßnahmen zur Minderung der Treibhausgasemissionen der Seeschifffahrt. In dem vorliegenden Diskussionspapier werden Optionen zur Gestaltung eines Monitoring-Systems für Treibhausgasemissionen der Seeschifffahrt analysiert und in den Zusammenhang mit den verschiedenen Politikmaßnahmen zur Begrenzung der Treibhausgase gestellt. Zusätzlich werden detaillierte Aspekte zu Monitoring, Verification und Reporting behandelt. Das Diskussionspapier diskutiert die Vor- und Nachteile der Optionen insbesondere im Hinblick auf zukünftige Politikentscheidungen.

Diskussionspapier vom 26. September 2013, Seite 64ff. des PDF-Dokuments.

4 Comparison of GHG contribution for a climate fund and an Emissions Trading Scheme in the shipping sector

Verschiedene marktbasierte Maßnahmen wurden vorgeschlagen, um die Treibhausgasemissionen der internationalen Seeschifffahrt zu reduzieren. Zwei werden im vorliegenden Papier vorgestellt und verglichen: ein Emissionshandelssystem (EHS) und ein Treibhausgasfond, der durch eine Abgabe auf Schiffstreibstoffe gespeist wird. Der Vergleich zeigt, dass die Vorschläge sich in vielen Aspekten ähneln wie dem Anwendungsbereich, der Gleichbehandlung aller Schiffe, Verwaltungsaufwand, der Notwendigkeit Qualitätskriterien für Kompensationsgeschäfte zu definieren und dass nur Unterzeichnerländer der Konvention Mittel aus den jeweiligen Fonds beantragen können. Ein wesentlicher Unterschied ist jedoch, dass im Fall des Treibhausgasfonds wesentlich weniger Einnahmen erzielt werden als beim Emissionshandel. Solange die Finanzierung von Kompensationsgeschäften für die Emissionen oberhalb der Ziellinie das Hauptziel des Fonds ist, kann das Prinzip der „gemeinsamen aber unterschiedlichen Verantwortlichkeiten“ (CBDR) nicht erfüllt werden. Zudem sind die Anreize im Schiffssektor, selber Emissionen zu mindern, im Falle des Emissionshandels höher.

Diskussionspapier vom 26. September 2013, Seite 98ff. des PDF-Dokuments.

5 The GHG fund and the ETS: finding common ground

Zwei marktbasierte Mechanismen zu Emissionsreduktion im Schiffssektor wurden von EU-Ländern vorgeschlagen, die dem Prinzip der gemeinsamen aber unterschiedlichen Verantwortung Rechnung tragen: ein Treibhausgasfond und ein Emissionshandelssystem (EHS). Dieses Diskussionspapier arbeitet heraus, dass die Unterschiede zwischen den beiden Ansätzen vor allem im Design und nicht in den Grundsätzen liegen. Beide Systeme können so ausgestaltet werden, dass sie ähnliche Kosten (inklusive Verwaltungskosten) für die Industrie verursachen, eine vergleichbare Umweltwirkung haben und eine ähnliche Menge an Einnahmen für Zwecke über die Kompensation von Schiffsemissionen hinaus generieren. Unterschiede bleiben jedoch in der kurzfristigen Preisvolatilität bestehen.

Diskussionspapier vom 29. August 2013, Seite 114ff. des PDF-Dokuments.

6 EU policies to address maritime GHG emissions – Analysis of the impacts on GHG emissions

Die EU will die Treibhausgasemissionen des internationalen Seeverkehrs senken und lässt deshalb verschiedene marktwirtschaftliche Instrumente für ein regionales System prüfen. CE Delft und Öko-Institut haben im Auftrag des UBA ein Diskussionspapier erstellt, um die Vorschläge zu analysieren. Ergebnis: Für die Umwelt wäre ein Emissionshandelssystem die beste Lösung.

Diskussionspapier von 17. Juli 2012, Seite 136ff. des PDF-Dokuments.

Summaries

These six discussion papers were written for the German Federal Environment Agency (UBA) as part of the project entitled "Analysis and further development of climate protection measures of sea shipping taking into account current developments at European and international level".

The contents of these publications do not necessarily reflect the official opinions of the German Federal Environment Agency.

1 Greenhouse gas emission reduction targets for international shipping

The latest report of the Intergovernmental Panel on Climate Change suggests that in 2050 global greenhouse gas emissions need to be 40 to 70% below their 2010 levels in order to prevent a global temperature increase of more than 2°C compared to pre-industrial levels. However, the third greenhouse gas study of the International Maritime Organization projects shipping emissions to increase by 50 to 250% by 2050. This would result in an increase in the share in global emissions from the current level of 2 to 10% if the rest of the world is on a path towards the 2°C target. Taking into account that reducing emissions globally is more cost-effective when all sectors contribute and that shipping has significant technical and operational potential to reduce emissions, we analyse potential greenhouse gas mitigation targets for the shipping sector and the extent to which these targets can be achieved by efficiency improvements only.

Discussion paper, 19 March 2015, page 13ff. of the PDF document.

2 Further technical and operational measures for enhancing the energy efficiency of international shipping – Environmental Aspects

Four measures to enhance energy efficiency and to reduce fuel consumption of ships are currently under discussion in the International Maritime Organization (IMO): the US proposal, the Annual Energy Efficiency Operational Index (EEOI) proposal, the Individual Ship Performance Indicator (ISPI) and the Fuel Oil Reduction Strategy (FORS). This paper describes the four measures and analyses them, focusing on their expected environmental impact in terms of CO_2 emission reduction as well as their interaction with potential future market-based measures. To illustrate the differences between the four measures, quantitative examples for three virtual ships are presented.

Discussion paper, 7 July 2014, page 34ff. of the PDF document.

3 Monitoring, Reporting and Verification of CO_2 emissions from ships. Design options, their feasibility and implications

The European Commission plans to introduce a monitoring, reporting and verification system for marine vessels as an initial step towards global or regional policies that would limit greenhouse gas emissions from maritime shipping. The discussion paper analyses the relationship between monitoring options and the possible policy measures. Additionally, different aspects of the monitoring, verification and reporting procedures are discussed in detail. The paper presents the advantages and disadvantages of monitoring options in particular with regard to the future development of policy instruments.

Discussion paper, 26 September 2013, page 64ff. of the PDF document.

4 Comparison of GHG contribution for a climate fund and an Emissions Trading Scheme in the shipping sector

Several options for market-based mechanisms were proposed to reduce emissions from international shipping. Two of them are presented and compared in this paper: an Emissions Trading Scheme (ETS) and a GHG fund generated by a GHG contribution on bunker fuels. The authors find that both proposals are similar in many aspects, such as coverage, equal treatment of all ships, eligibility to receive funding from the revenues generated only to Parties of the scheme, administrative efforts and the need to define quality requirements for offset credits. A major difference, though, is the amount of revenues generated and their envisaged uses. The amount of revenues generated by the GHG contribution is substantially lower than the revenues generated by the ETS. As long as the funding of offset projects is the predominant use of the GHG fund, the principle of "common but differentiated responsibilities" (CBDR) cannot be addressed. Furthermore the incentives to reduce emissions in the international shipping sector itself are higher in the ETS case.

Discussion paper, 26 September 2013, page 98ff. of the PDF document.

5 The GHG fund and the ETS: finding common ground

Two market based mechanisms have been proposed by EU countries to address the climate impacts and reflect the principle of common but differentiated responsibilities: a GHG Fund and an Emissions Trading Scheme (ETS).This discussion paper concludes that the differences between the two are primarily due to differences in design, and not to differences in principle. Both systems can be designed to have similar costs to industry, including administrative costs, similar environmental effectiveness, and yield a similar amount of revenue for other purposes than offsetting shipping emissions. Differences remain in short term price volatility.

Discussion paper, 29 August 2013, page 114ff. of the PDF document.

6 EU policies to address maritime GHG emissions – Analysis of the impacts on GHG emissions

The EU Commission committed itself to include emissions from shipping into the existing EU reduction commitment if no international agreement was achieved on a global level. To this aim the EU Commission is currently considering different regional policy options in an impact assessment. In this paper the impact of these policy options on GHG emissions has been analysed. We conclude that a carefully designed emissions trading scheme (ETS) is the best option from an environmental point of view, mainly because of an overall emission cap.

Discussion paper, 17 July 2012, page 136ff. of the PDF document.

Environmental Research
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Nature Conservation, Building and Nuclear Safety

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Greenhouse gas emission reduction targets for international shipping

DISCUSSION PAPER

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ON BEHALF OF THE
FEDERAL ENVIRONMENT AGENCY

19 March 2015

This paper was written for the German Federal Environment Agency (UBA) as part of the project entitled “Analysis and further development of climate protection measures of sea shipping taking into account current developments at European and international level” (FKZ 3711 45 104). This project is being carried out by Öko-Institut (coordination), CE Delft and Tim Bäuerle LL. M.

Summary

The latest report of the Intergovernmental Panel on Climate Change suggests that in 2050 global greenhouse gas emissions need to be 40 to 70% below their 2010 levels in order to prevent a global temperature increase of more than 2°C compared to pre-industrial levels. However, the third greenhouse gas study of the International Maritime Organization projects shipping emissions to increase by 50 to 250% by 2050. This would result in an increase in the share in global emissions from the current level of 2 to 10% if the rest of the world is on a path towards the 2°C target. Taking into account that reducing emissions globally is more cost-effective when all sectors contribute and that shipping has significant technical and operational potential to reduce emissions, we analyze potential greenhouse gas mitigation targets for the shipping sector and the extent to which these targets can be achieved by efficiency improvements only. We conclude that all considered targets would require shipping emissions to stay well below the business-as-usual projections and that achieving these targets would, despite efficiency improvements, require instruments that aim at reducing the absolute emissions of the sector or at offsetting emissions by financing emission reductions in other sectors.

Zusammenfassung

Der jüngste Bericht des Weltklimarats (IPCC) legt nahe, dass im Jahr 2050 die globalen Treibhausgasemissionen um 40 bis 70% unter dem Niveau von 2010 liegen müssen um einen globalen Temperaturanstieg von mehr als 2°C gegenüber dem vorindustriellen Niveau zu verhindern. Laut der 3. Treibhausgas-Studie der internationalen Schifffahrtsorganisation (IMO) werden die Emissionen des Schiffsverkehrs bis 2050 jedoch um 50 bis 250% steigen. Wenn der Rest der Welt auf dem Weg in Richtung des 2-Grad-Ziels ist, würde dies zu einer Erhöhung des Anteils an den weltweiten Emissionen vom derzeitigen Niveau von 2 auf 10% führen. Vor dem Hintergrund, dass die globale Emissionsminderung kostengünstiger ist, wenn alle Sektoren beitragen und dass die Schifffahrt erhebliches technisches und operatives Potenzial zur Emissionsverringerung hat, analysieren wir potenzielle Minderungsziele für Treibhausgasemissionen in der internationalen Schifffahrt und in welchem Umfang diese Ziele durch Effizienzsteigerungen alleine erreicht werden können. Wir schlussfolgern, dass die Schiffsemissionen bei allen betrachteten Zielen weit unter den Business-as-usual-Projektionen bleiben müssen und dass zur Erreichung dieser Ziele trotz Effizienzsteigerungen Instrumente erforderlich sind, die auf eine Verringerung der absoluten Emissionen des Sektors oder eine Kompensation der Emissionen durch die Finanzierung von Emissionsreduktionen in anderen Sektoren abzielen.

Table of Contents

1 Introduction

In 1997, when the Kyoto Protocol was adopted under the United Nations Framework Convention on Climate Change (UNFCCC), the implementation of measures to reduce greenhouse gas (GHG) emissions from international shipping was left to industrialised countries (Annex I Parties) working through the International Maritime Organization (IMO). IMO has not been able to agree on measures or instruments that would limit absolute emissions since then. The UNFCCC included bunker fuels in the agenda of the Ad hoc Working Group on Long-term Cooperative Action (AWG-LCA) in 2008, but the agenda item was closed without conclusions having been reached four years later. The major reason why GHG emissions from maritime shipping have been left unregulated is the existence of several dilemmas which have not been reconciled so far:

- Countries have not been able to agree on ways to allocate emissions to countries, which could then assume responsibility to reduce them in line with their commitments under the UNFCCC and its Kyoto Protocol.
- The different principles of policymaking in the IMO and the UNFCCC. IMO policies are based on equal treatment of all ships, regardless of their nationality. IMO has regionally differentiated policies but even these apply to all ships in the specified regions. In contrast, the UNFCCC is based on the principle of Common but Differentiated Responsibilities (CBDR). Under this principle, industrialised countries (Annex I) have to limit their emissions while developing countries (non-Annex I) do not. Simply applying this principle to shipping, e.g. by specifying that ships flying an Annex I flag would have to reduce their emissions while other ships would not, is widely agreed to be ineffectual as ships can easily change flag.

So far IMO has adopted two efficiency measures – the Energy Efficiency Design Index (EEDI), which sets compulsory energy efficiency standards for new ships, and the Ship Energy Efficiency Management Plan (SEEMP), which requires ships to develop a plan to monitor and possibly improve the energy efficiency – but no other instruments to address GHG emissions. Despite efficiency improvements brought about by these measures and by market forces, emissions are projected to increase by 50% to 250% in the period up to 2050. This trend risks undermining the efforts that are being made in order to stay on a trajectory that will keep the average global temperature increase below 2°C compared to pre-industrial levels.

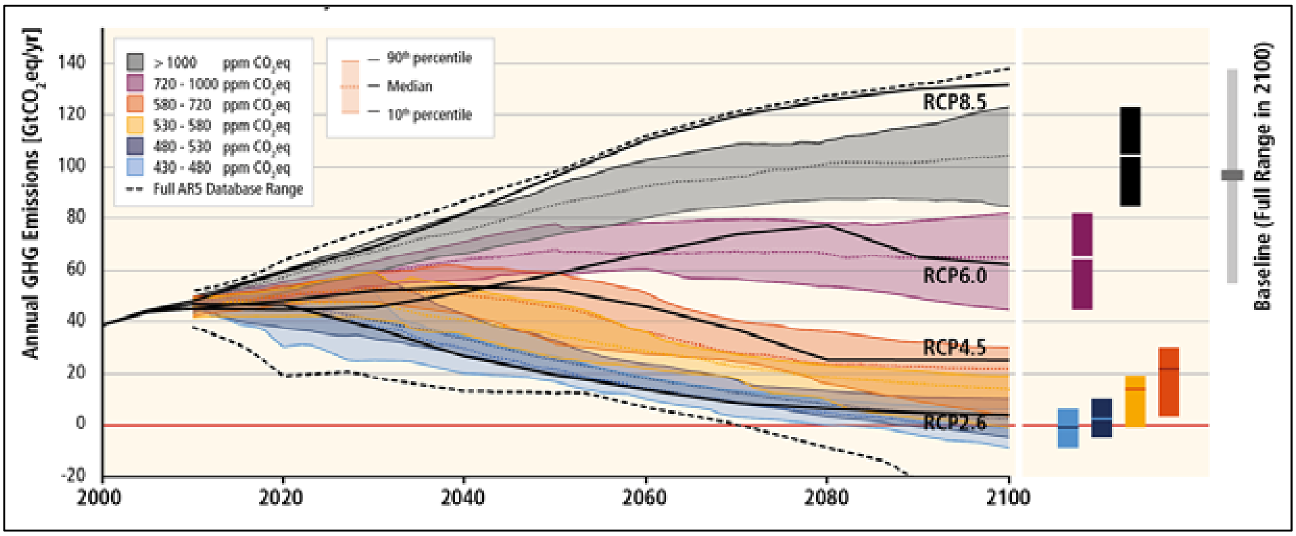
Taking into account that reducing emissions globally is more cost-effective when all sectors contribute and that shipping has significant technical and operational potential to reduce emissions, we analyze the possibility of setting GHG mitigation targets for the shipping sector. The paper starts with a presentation of the projected *global* emissions and the pathways required to achieve a range of average global temperature increases. Section 2 then presents emission projections for the *shipping* sector. Section 3 presents various methods for setting targets. It quantifies the targets for shipping for each of these methods and analyses the *required* efficiency improvements to meet these targets. We finish the paper with an analysis of the extent to which the potential targets could likely be achieved through *realistic* assumptions of future efficiency improvements (Section 4) and draw a number of conclusions from the previous analyses (Section 5).

2 Mitigation pathways and the shipping sector

2.1 Global mitigation pathways

According to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC 2014), global GHG emissions are expected to continue to grow due to population and economic growth if, on top of the current efforts, no extra efforts are made to reduce GHG emissions. Until 2100, the global mean surface temperature could increase by 3.7 to 4.8˚C compared to pre-industrial levels. The GHG concentration could reach a level of between 750 and more than 1,300 ppm CO_2 equivalents (CO_2e). This is similar to the range in atmospheric concentration levels between the Representative Concentration Pathways (RCPs) 6.0 and 8.5 (Figure 1 and Table 1).[1]

Figure 1 GHG emission pathways 2000-2100 from the IPCC Fifth Assessment Report (AR5)



Sources: IPCC 2014

For the temperature to likely stay below 2˚C (3˚C) above pre-industrial levels during the 21st century, the concentration of greenhouse gases in the atmosphere should not exceed 430 to 530 (580-650) ppm CO_2e. This would require a change in emission of at least -40 to -70% (-38 to +24%) in 2050, relative to the 2010 emission level (Table 1, rows 1 and 6).

[1] Baseline scenarios fall into the > 1,000 and 720 – 1,000 ppm CO_2e categories (rows 8 and 9 in Table 1). The latter category also includes mitigation scenarios. The baseline scenarios in the latter category reach a temperature change of 2.5 – 5.8˚C above pre-industrial levels in 2100. Together with the baseline scenarios in the > 1,000 ppm CO_2e category, this leads to an overall 2100 temperature range of 2.5 – 7.8˚C (median: 3.7 – 4.8˚C) for baseline scenarios across both concentration categories.

Table 1 Key characteristics of the scenarios collected and assessed for the Work Group III AR5

	CO_2e concentration ranges in 2100	Subcategories	Relative position of the RCPs	Temperature change relative to pre-industrial levels			Change of CO_2e emissions in 2050 compared to 2010 [%]
				2100 temperature change*	Likelihood of staying below temperature level during the 21st century		
					2.0°C	3.0°C	
1	430 – 480		RCP 2.6	1.5 – 1.7 (1.0 – 2.8)	Likely	Likely	- 72 to - 41
2	480 – 530	No overshoot of 530 ppm CO_2e		1.7 – 1.9 (1.2 – 2.9)	More likely than not		- 57 to - 42
3		Overshoot of 530 ppm CO_2e		1.8 – 2.0 (1.2 – 3.3)	About as likely as not		- 55 to - 25
4	530 – 580	No overshoot of 580 ppm CO_2e		2.0 – 2.2 (1.4 – 3.6)	More unlikely than likely		- 47 to - 19
5		Overshoot of 580 ppm CO_2e		2.1 – 2.3 (1.4 – 3.6)			- 16 to + 7
6	580 – 650		RCP 4.5	2.3 – 2.6 (1.5 – 4.2)			- 38 to +24
7	650 – 720			2.6 – 2.9 (1.8 – 4.5)	Unlikely	More likely than not	- 11 to + 17
8	720 – 1,000		RCP 6.0	3.1 – 3.7 (2.1 – 5.8)		More unlikely than likely	+ 18 to + 54
9	> 1,000		RCP 8.5	4.1 – 4.8 (2.8 – 7.8)	Unlikely	Unlikely	+ 52 to + 95

* The range of temperature change in the parentheses includes the carbon cycle and climate system uncertainties.

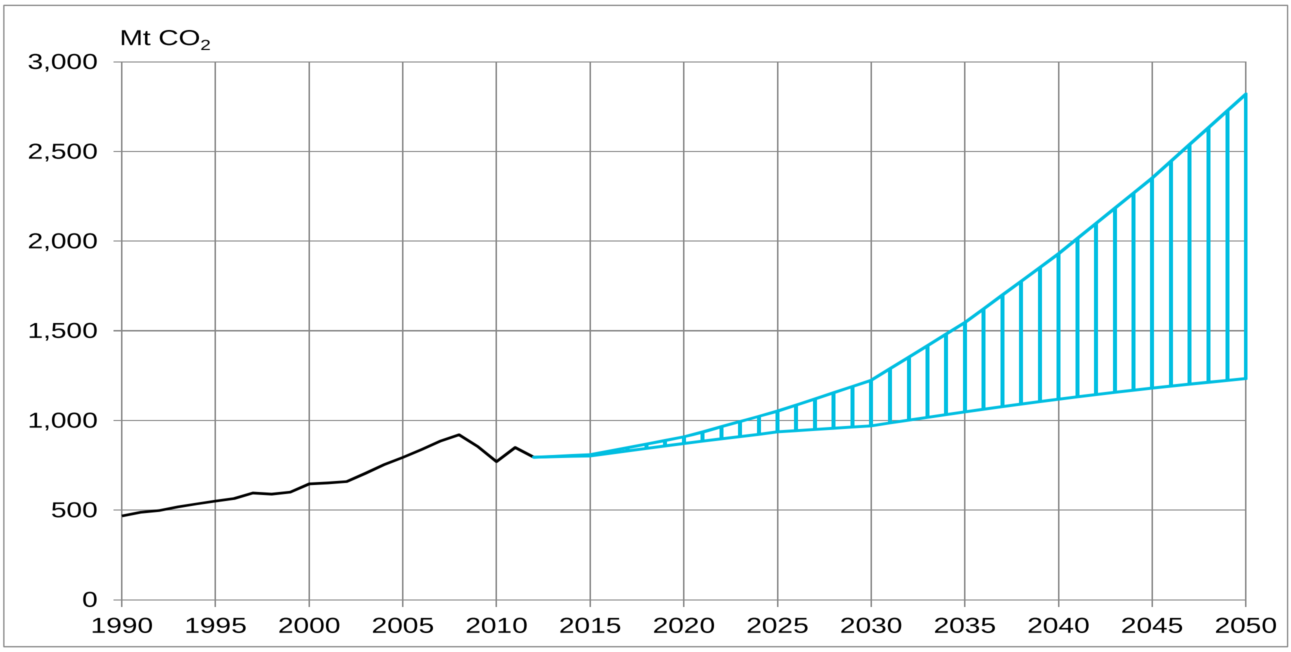
Sources: IPCC 2014

Regarding the transport sector, the IPCC finds that the growth of global transport demand could pose a significant challenge to the achievement of potential emission reduction goals (Sims et al. 2014). Transport-related CO_2 emissions could, compared to 2010, without policy interventions and with a continuation of the current demand trend, double by 2050 and more than treble by 2100 in the highest scenario projections. In mitigation scenarios aiming to keep the global concentration of greenhouse gases around 450 ppm or 550 ppm, all transport modes would be required to improve their fuel efficiency considerably, use more low carbon fuels and adopt behavioural measures that reduce transport demand and emissions (Sims et al. 2014).

2.2 Maritime transport emission projections

In 2012, international shipping emitted just over 800 Mt CO_2, which accounted for approximately 2.1% of global greenhouse gas emissions (IMO 2014). The emissions are projected to increase significantly: According to the third IMO GHG study (IMO 2014), the emissions are expected to increase by 50 to 250% in the business-as-usual (BAU) scenarios in the period up to 2050 compared to 2012 level, depending on the future economic and energy developments (Figure 2). The four BAU scenarios differ in their macro-economic and energy transition outlook, leading to different levels and compositions of transport demand, but all assume no additional policies addressing the efficiency of ships, ship fuels or shipping emissions. They do, however, take the impact of current efficiency policies into account, such as the EEDI and the SEEMP, as well as market-driven efficiency improvements. In each of the four BAU scenarios the fuel-efficiency of the fleet improves with 40% by 2050 compared to 2012.

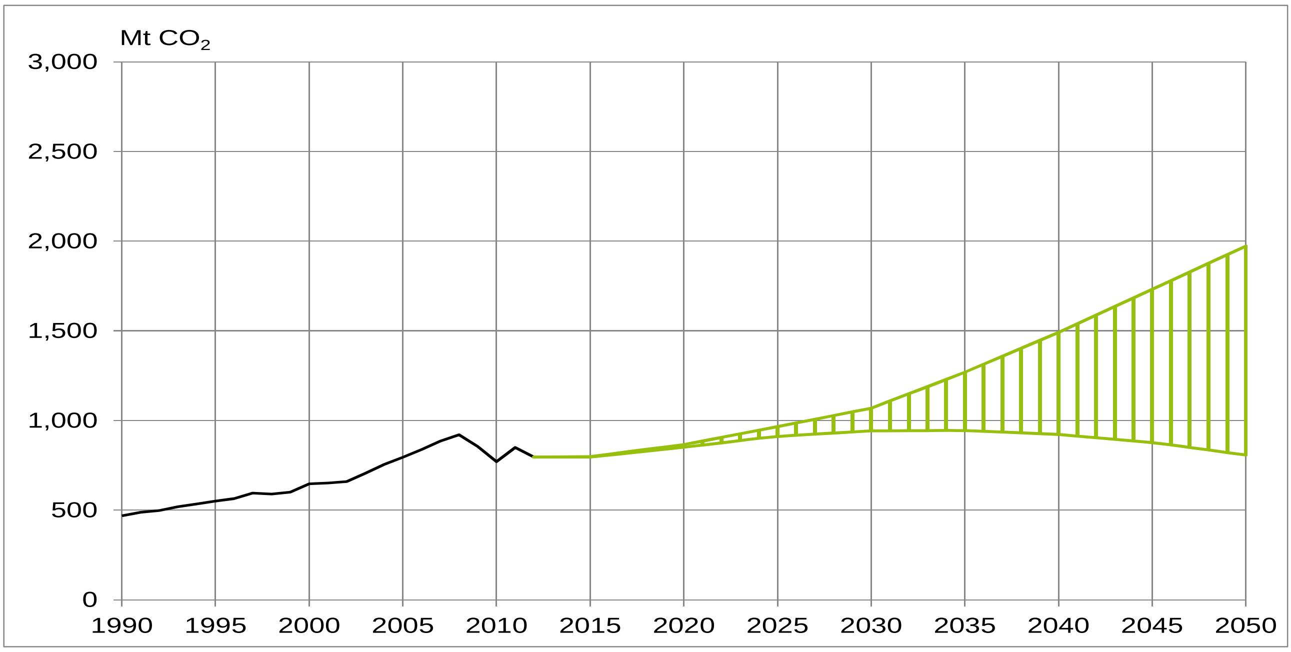
Figure 2 Range of CO_2 emissions in the business-as-usual scenarios



Sources: IMO 2014, authors' own illustration

If additional/stricter regulation was implemented (e.g. stricter EEDI requirements, operational efficiency standards, fuel standards or market-based measures, or a combination of those), the projected emissions will be lower than in the respective business-as-usual scenarios. Figure 2 shows the range of emission projections of the mitigation scenarios from the third IMO GHG study (IMO 2014), in which regulatory drivers are assumed to lead to higher efficiency improvements and/or to a higher share of low carbon fuels. Regarding the long-term (2030-2050) efficiency improvements, two scenarios are thereby differentiated. Based on estimations of the emission abatement potential in the literature (IMO, MEPC 2009, Eide/Chryssiakis/Endresen 2013), it is thereby assumed that the fuel-efficiency will have improved with either 40% or 60% in 2050 compared to 2012. In four mitigation scenarios, including the upper bound scenario given in Figure 2, the fuel-efficiency of the fleet is assumed to improve to the same extent as in the baseline scenarios (40% by 2050 compared to 2012), and in eight mitigation scenarios, including the lower bound scenario given in Figure 2, the fuel-efficiency of the fleet is assumed to improve by 60% by 2050 compared to 2012. Most of the policy scenarios show an increase in emissions in the period to 2050. Only one scenario sees emissions return to 2012 levels by 2050; a reduction below that level is not foreseen in any scenario.

Figure 3 Range of CO_2 emissions in the mitigation scenarios



Sources: IMO 2014, authors' own illustration

The projected growth of shipping emissions, even with increasingly stringent efficiency measures, means that the share of shipping emissions in total emissions will increase if global mitigation scenarios are to become reality. Shipping currently accounts for 2.2% of man-made CO_2 emissions.[2] When global emissions are reduced in line with a 2°C target, but shipping emissions are allowed to follow a BAU scenario, shipping emissions may increase to 10% of global emissions in 2050.

2.3 The benefits of reducing shipping GHG emissions

In general, climate mitigation policies are cheaper when more countries and more sectors contribute than when the effort is made by a selection of countries and sectors (IPCC 2014). In theory, the most cost-effective way to reduce global emissions would be to have a global policy instrument encompassing all sectors and countries. However, the institutions to design, implement and enforce such an instrument do not exist. Still, many studies have found that the smaller the proportion of total global emissions included in a climate regime, the higher the costs and the more challenging it becomes to meet any long-term goal, even in the absence of a single policy instrument (IPCC 2014). The reason is that most sectors and countries have cost-effective options to reduce emissions. The more sectors and countries that participate in the global effort to reduce emissions, the larger the pool of cost-effective options that can be used. Therefore, when the shipping sector emissions are not addressed, the burden on the other sectors and countries would become higher. Especially as the emissions from shipping are not insignificant, the cost increase to other sectors could be large.

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2 Note: 2.2% is the share in terms of CO_2, whereas the above-mentioned 2.1% is the share in terms of greenhouse gas emissions (CO_2e).

The shipping sector has a significant and cost-effective potential to increase the efficiency of ships beyond business as usual (MEPC 2011). Eide/Chryssiakis/Endresen (2013) and MEPC (2009) show that efficiency improvements of 50% or more per tonne mile are feasible. The third IMO GHG study presents mitigation scenarios where the emissions per tonne mile are reduced by 60% in the period from 2012 to 2050 as a result of increased operational and design efficiency and low carbon fuels (IMO 2014). The range given in Figure 3 comprises twelve mitigation scenarios. For eight of these scenarios, a 60% fuel efficiency improvement is assumed in 2050, with absolute emissions in 2050 ranging from around 800 to 1,900 Mt CO_2.

3 How to derive a target for the shipping sector?

In order to determine potential options for GHG mitigation targets for international shipping, we firstly look at the targets that have been suggested or agreed upon in similar contexts and secondly how they could be applied to international maritime transport. We conclude these considerations with an overview of the philosophies underlying these different approaches and by drawing recommendations for the international shipping.

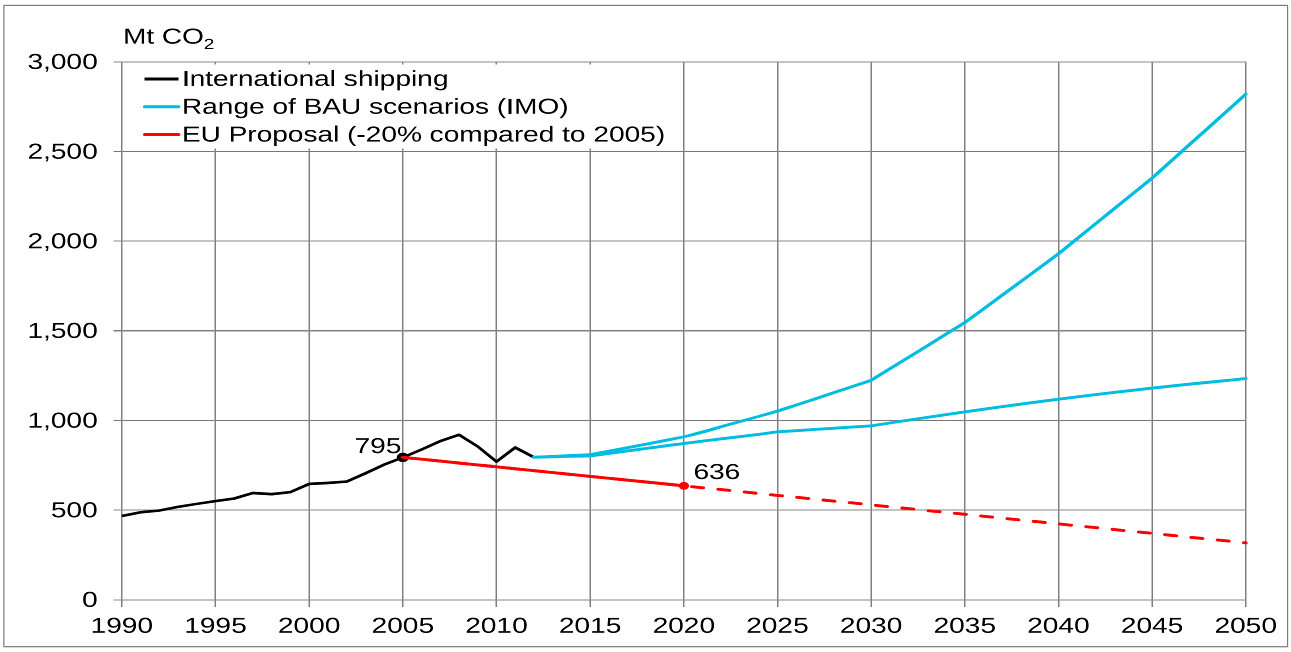
3.1 Targets suggested for international shipping and in similar contexts

So far the European Union (EU) and Norway have suggested GHG targets for international shipping (3.1.1, 3.1.2). Furthermore, the targets set by the International Air Transport Association (IATA) and the International Civil Aviation Organization (ICAO) for international aviation are presented below (3.1.3, 3.1.4). International aviation is a sector that faces similar challenges concerning the reconciliation of the conflicting principles of CBDR and equal treatment as international shipping. Finally, overarching targets such as the Cancun pledges (3.1.5) UNFCCC Parties made under the so-called Copenhagen Accord and the carbon budget approach (3.1.6) suggested by Tyndall Centre are translated into targets for the shipping sector.

3.1.1 EU target proposal for international shipping

In its Council Conclusions before the Copenhagen climate conference, the European Union (EU) suggested a -20% reduction compared to 2005 for international shipping (CEU 2009). This target was not considered as carved in stone but as a starting point for negotiations. It clearly indicated that the sector should contribute to absolute GHG reductions, be it within the sector or outside of the sector by means of offsets. The final figure is a result of political bargaining process taking into account both requirements for global GHG reduction, efforts undertaken by other sectors and reduction potential within the sectors rather than being based on a scientific justification.

Figure 4 European Union



Sources: CEU 2009, IMO 2014, authors' own calculations

In Figure 4 above, the EU proposal of -20% below the 2005 level by 2020 is compared to the development of historic emissions (black line) and the range of projected business-as-usual (BAU) emission trends (blue lines, as given in Figure 2) of the third IMO GHG study (IMO 2014). Applying the reduction goal results in a target of 636 Mt CO_2 in 2020. The EU did not agree on a target for 2050. However, extending the trend of its 2020 goal linearly until 2050 seems to be largely in line with the EU's long-term reduction policy expressed in the White Paper on Transport: "[O]verall, the EU CO_2 emissions from maritime transport should be cut by 40% (if feasible 50%) by 2050 compared to 2005 levels" (EC 2011). The drop of emissions in 2010 due to the global financial and economic crisis brought the shipping sector near to the target line. For 2020 and 2050, further action would be needed to reduce the projected emissions in order to meet the target line.

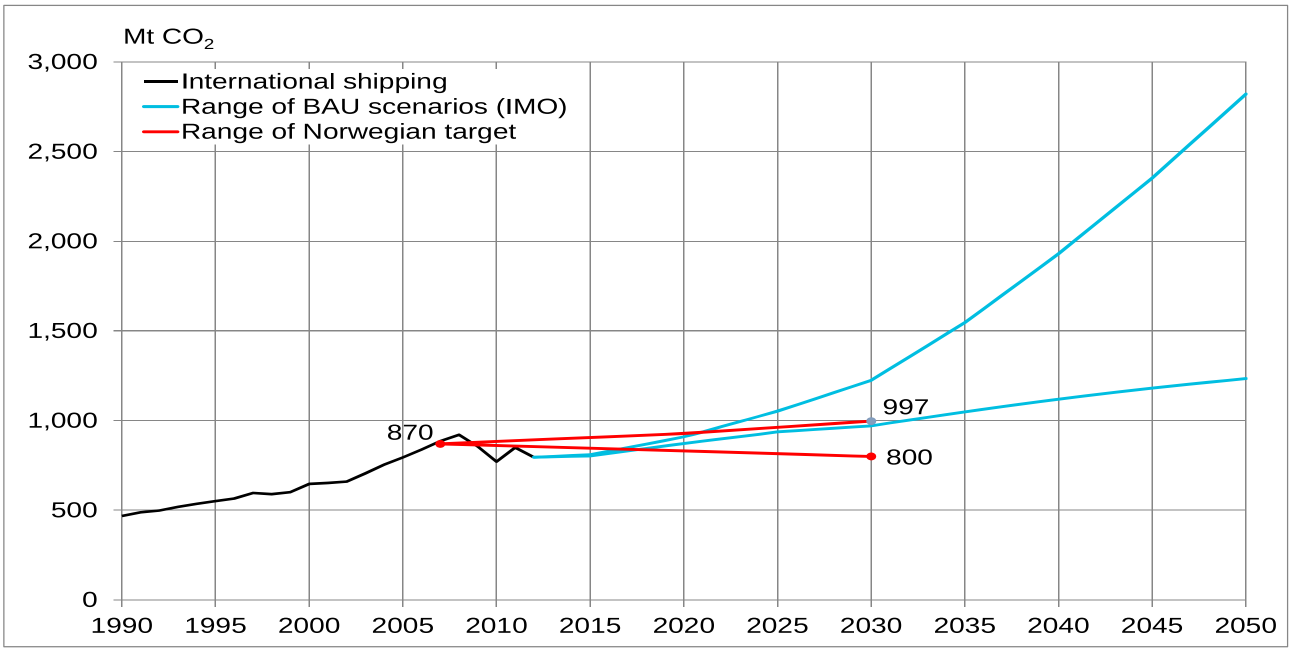
3.1.2 Norwegian target proposal for international shipping

In January 2010 at the 60th Maritime Environment Protection Committee (MEPC), Norway suggested two targets for international shipping (MEPC 2010). The targets are based on the philosophy that the economic effort to reduce emissions (marginal cost) in the shipping sector should be the same as in other sectors (equivalence of the carbon price between shipping and other sectors). Therefore, Marginal Abatement Cost Curves (MACC) for shipping were determined for the years 2020 and 2030.[3] Shipping targets were derived by comparing these shipping-sector MACC with MACC of the global economy as a whole. Marginal abatement costs required to achieve the global target level were estimated at 132 USD/t CO_2 in 2020 and at 200 USD/t CO_2

3 MACC summarize the estimated mitigation potentials of GHG mitigation measures and the estimated marginal abatement costs or revenues of each measure (MEPC 2011). In a way, they are the GHG mitigation supply curve of a country or a sector. From an economic perspective, GHG mitigation is considered to be most efficient if the marginal abatement costs are equivalent in all covered areas.

in 2030. These values were applied to the shipping sector MACC in order to determine the mitigation potential which can be achieved in the shipping sector at these price levels. These potentials were then deducted again from the BAU projection for the shipping sector to arrive at the absolute targets for international shipping.

Figure 5 Norway



Sources: MEPC 2010, IMO 2014, authors' own calculations

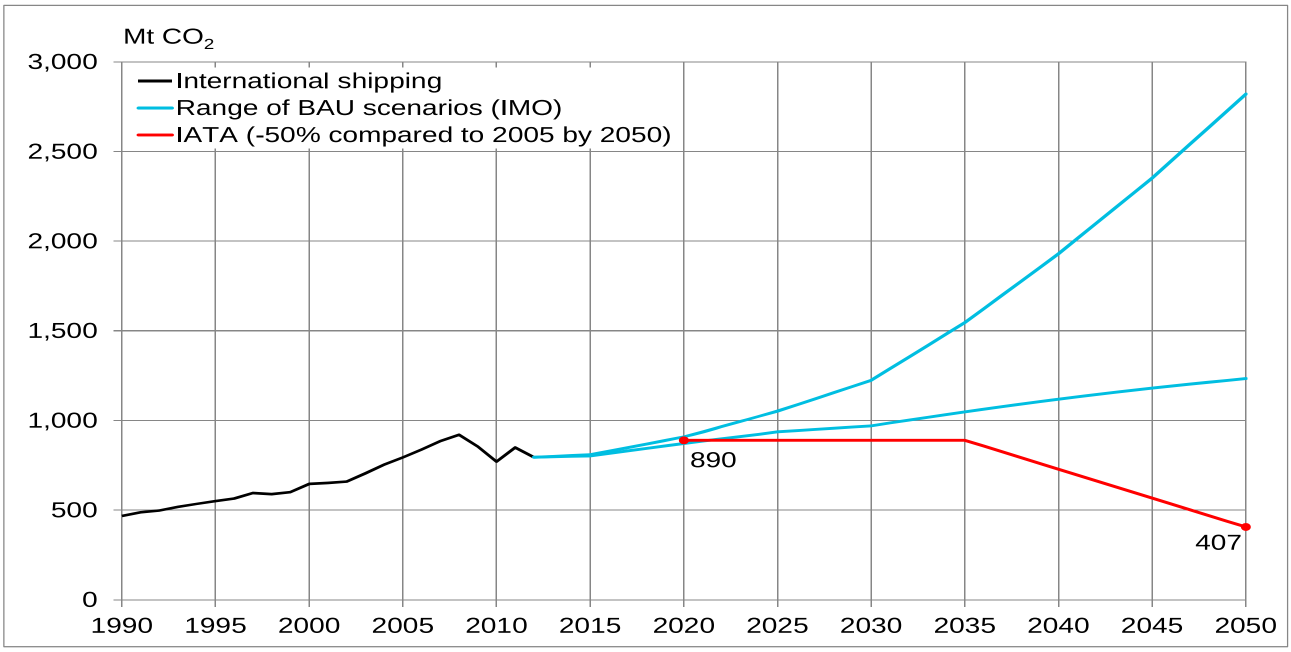
Similar to the IMO's BAU projection, the range of Norwegian targets (red lines) reflects the different assumptions in terms of future economic development (Figure 5). Currently, actual emissions are below the target range. This is because in 2010 it was not yet possible to take into account in the BAU projections the impact of the global financial crisis which started in 2008/2009. Therefore, if this approach is selected, the calculation would need to be updated to reflect most recent emission developments and current expectations.

3.1.3 IATA target for international aviation

In June 2013, IATA agreed to a target of keeping CO_2 emissions of international aviation from 2020 to 2035 at the level of 2020 and to reduce emissions by 50% compared to 2005 from 2035 to 2050 (IATA 2013). This should be achieved through technical and operational measures, within the sector including the increased use of biofuels as well as by purchasing offsets from other sectors.

This target setting approach can also be applied to the shipping sector; the results are shown in Figure 6 below: emissions shall stabilize at 2020 levels up to 2035 at around 890 Mt of CO_2 and drop by 50% to 407 Mt CO_2 in 2050 compared to 2005. Until 2020, the resulting trajectory would be slightly below BAU emissions but would, from 2035 onwards, require additional effort by the shipping sector.

Figure 6 International Air Transport Association

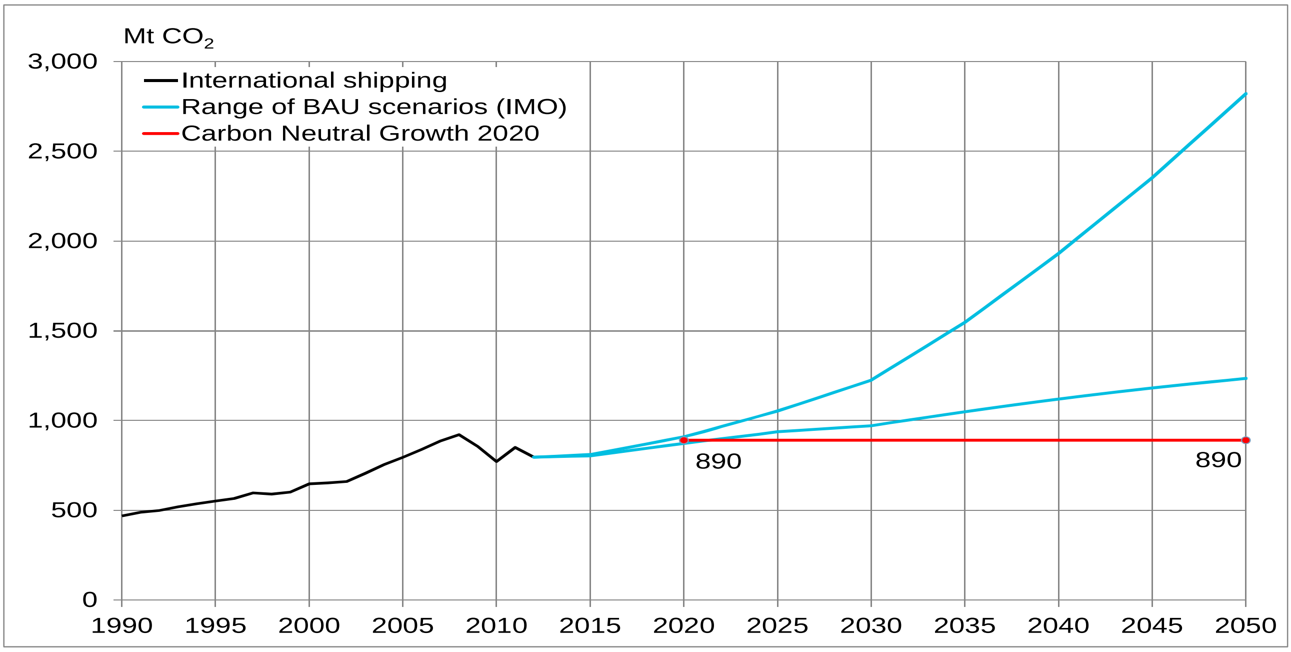


Sources: IATA 2013, IMO 2014, authors' own calculations

3.1.4 ICAO target for international aviation

The International Civil Aviation Organization (ICAO) agreed at its 37th Assembly to freeze the sector's CO_2 emissions at its 2020 level and to accommodate further growth by means of technical and operational measures as well as by extending the use of biofuels (ICAO 2010). The emission reduction which cannot be achieved by measures within the sector should be addressed by the purchase of offsets from other sectors in order to achieve carbon neutral growth.

Figure 7 International Civil Aviation Organization



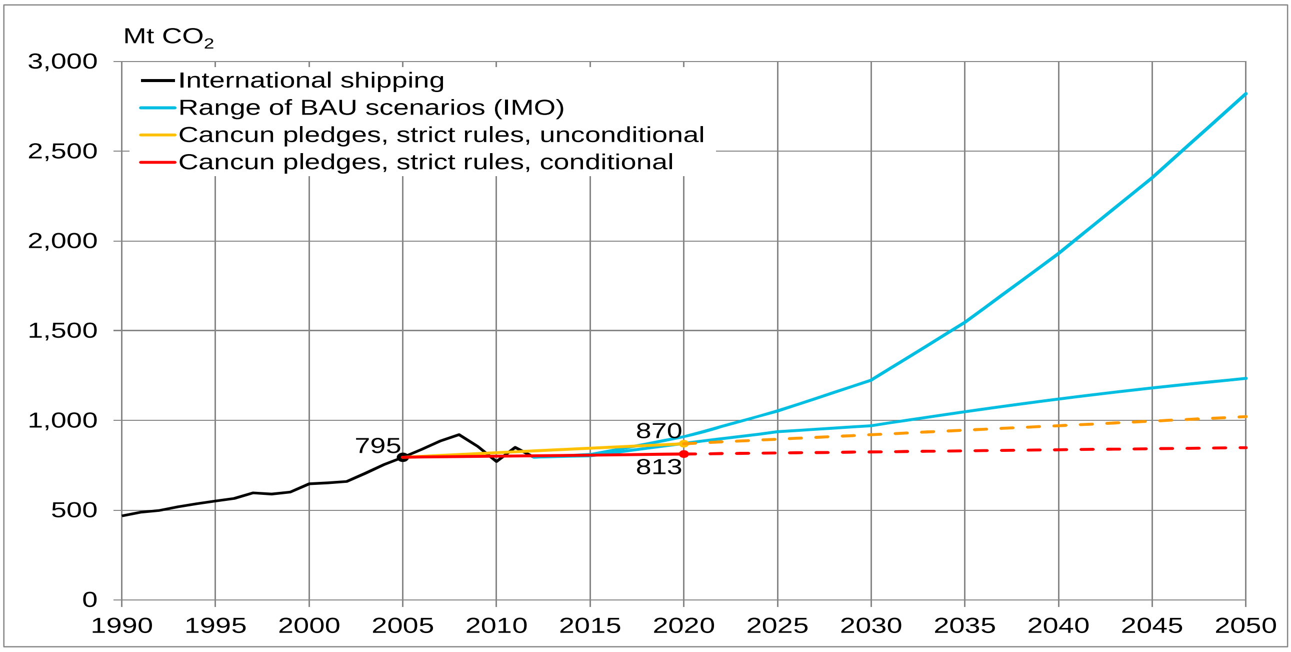
Sources: ICAO 2010, IMO 2014, authors' own calculations

Up to 2035, ICAO's target is similar to the one put forward by IATA. However, the IATA approach envisages a further decline of the target line beyond 2035. Under the ICAO approach, efforts beyond 2035 are limited to the extent that they are sufficient to compensate a growth in activity, whereas the IATA approach requires additional emission reductions by 2050. Both approaches intend in the first place to reduce emissions within the sector and, if necessary, to purchase offsets from other sectors to achieve the targets.

3.1.5 Cancun pledges under UNFCCC Copenhagen Accord

In line with the so-called Copenhagen Accord (UNFCCC 2009), Parties to the UNFCCC made GHG emission reductions pledges compared to 2005 levels. The aggregate of these pledges can be considered as a global GHG reduction effort. This effort can be transferred to international shipping: the shipping sector should basically agree to the same reduction effort as the world at large.

Figure 8 Cancun pledges



Sources: PBL 2012, IMO 2014, authors' own calculations

In total, the Cancun pledges roughly result in a stabilization of emissions at 2005 levels (including conditional pledges) or a slight increase of emissions (unconditional pledges only).[4] For the shipping industry this would mean that up to 2020 projected emissions are in a similar range than the target path, so that no additional actions to reduce emissions from shipping would be needed. However, if it is assumed that the target trends are continued until 2050, even the most optimistic BAU emissions would be some 20% to 50% above these targets.

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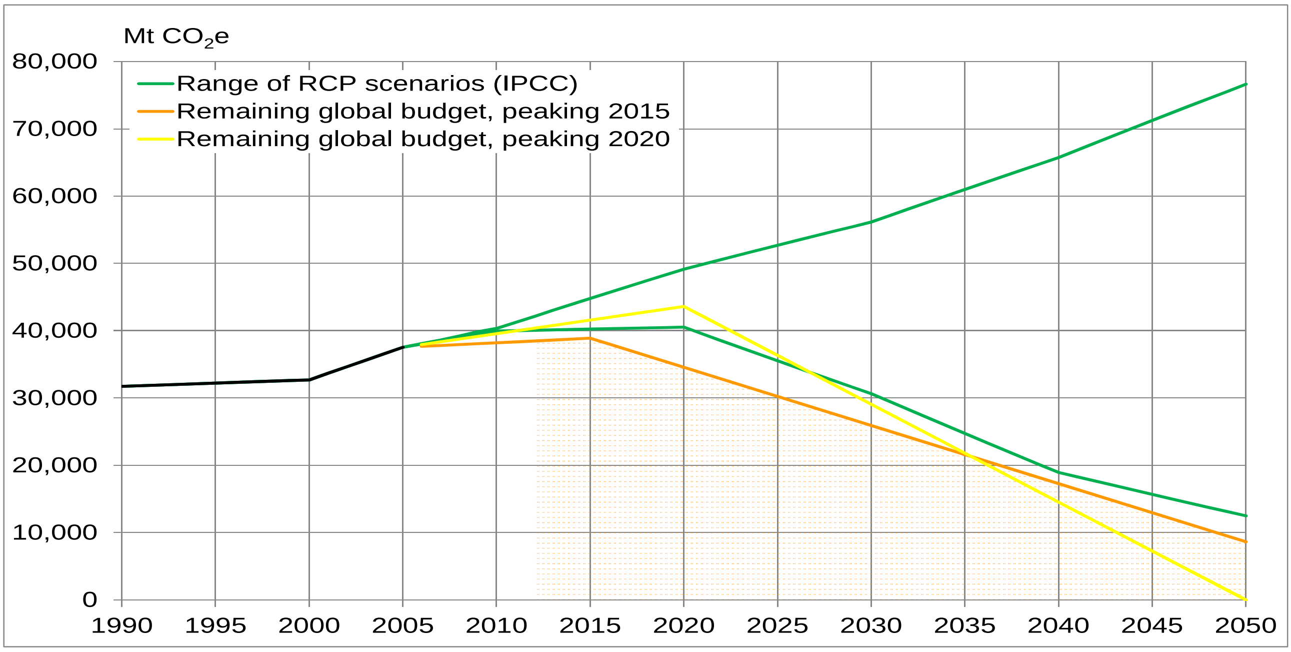
4 The EU and a few other UNFCCC Parties submitted pledges, which actually included two separate pledges: one pledge was unconditional and would be applied in any case while the other would have been applied only if other developed countries submitted pledges with a comparable level of ambition.

3.1.6 Carbon Budget approach

The results of the most recent assessment report of the IPCC (2014) suggest that for keeping global temperature below a 2°C increase compared to pre-industrial levels, a global cumulative budget of some 1,000 Gt of CO_2e emissions remains.[5] Figure 9 compares this budget approach with the range of the Representative Carbon Pathways (RPC), which the IPCC had used to analyse impacts of climate change and policy options to limit the impacts. Only the lower bound of that range, which is based on assumptions that GHG emissions peak in 2020, is somewhat in line with the remaining budget approach. The figure also illustrates that, assuming a fixed carbon budget, the slope of the declining emissions trend needs to be the steeper the later global GHG emissions peak.

Figure 9 Representative Carbon Pathways and remaining budgets

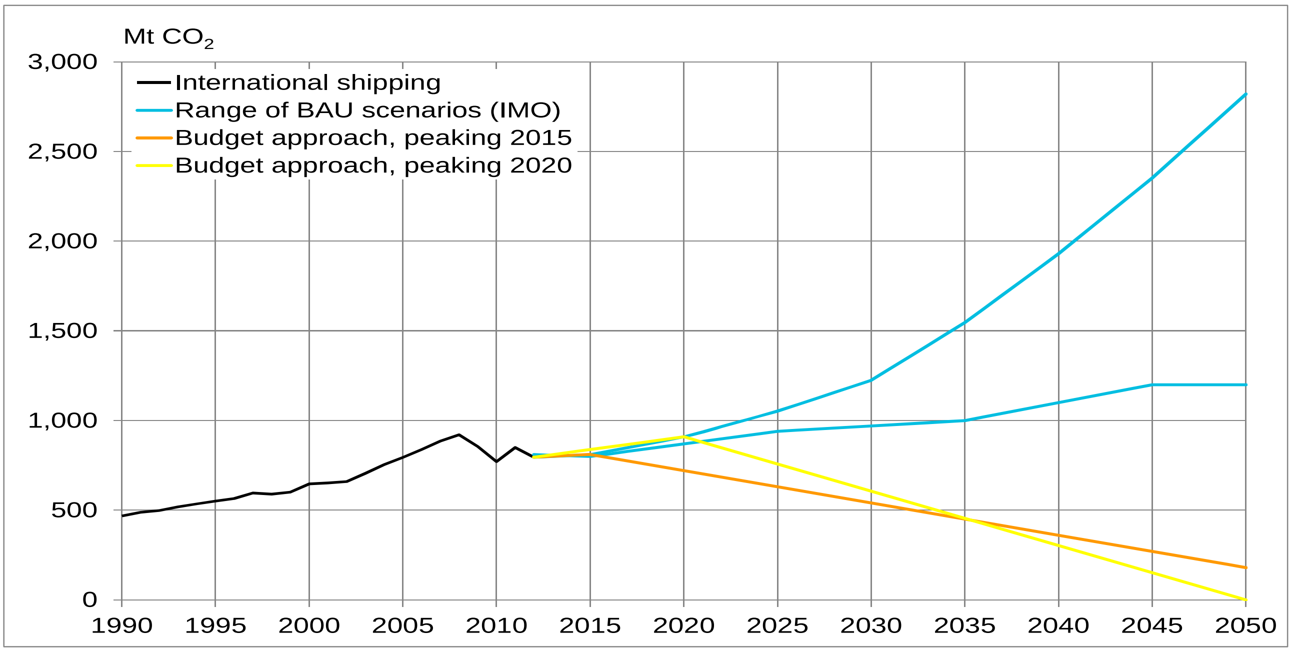


Source: IIASA 2009, Tyndall Centre 2014, authors' own calculations

Based on the assumption that the shipping sector's current share in global GHG emissions remains constant, an emission budget for the shipping sector can be determined. In Figure 10 the resulting shipping sector budgets are compared with the range of BAU projections from the third IMO GHG study. Depending on when the emissions from international shipping peak, the full phase-out of GHG emissions has to be achieved earlier or later.

5 To stay below an increase of 2°C, the all-time aggregated GHG emissions should not exceed 2,900 Gt CO_2e (Tyndall Centre 2014). To date, some 1,800 Gt CO_2e have already been emitted, with the result that a budget of some 1,000 Gt CO_2e can still be emitted before the 2°C threshold will be exceeded.

Figure 10 Shipping sector emission budget



Source: IMO 2014, authors' own calculations

3.2 Philosophies applied to the setting of targets

To limit the impacts of climate change, GHG emissions need to be reduced. However, how can the individual contribution of the shipping sector to that global goal be determined? In the above sections we have outlined two targets which have been proposed for the shipping sector as well as different approaches how targets could be derive from other areas for international shipping.

All approaches represent efforts to determine an appropriate share for the shipping sector. Based on the philosophies applied to determine the target, they can be categorised into four groups:

- Carbon budget (section 3.1.6): This approach is based on a scientifically estimated remaining emission budget; to determine the shipping sector's mitigation contribution it is assumed that the sector's share in global GHG emissions remains unchanged; in the longer term it results in the most stringent mitigation targets.
- Similar emission reduction (section 3.1.5): For this approach it is assumed that the GHG emissions of the shipping sector develop at the same pace as the world at large; it is somewhat similar to the carbon budget approach although no clear date for phasing out GHG emissions from fossil fuels is determined.
- Similar economic effort (section 3.1.2): Under this approach more emphasis is put on the economic mitigation potential of different areas, such as countries or sectors; it requires an overall mitigation target and focuses more on how this can be allocated to entities covered.
- Political decision (sections 3.1.1, 3.1.3, 3.1.4): While the previous categories are based on a clear philosophy, this last category includes the examples which are the result of polit-

ical bargaining processes; usually they take into account aspects from the previous categories but do not follow one of them strictly. As the number of examples falling into this category already shows, it seems to be the most widely used approach to determine targets.

The approaches mainly differ in the criteria which they prioritize: The budget approach is strictly derived from the environmental requirements while the similar economic effort approach puts more emphasis on economic efficiency and viability. The similar reduction approach is in a way a hybrid approach because it neither emphasises environmental nor economic requirements but focuses on the feasibility of implementation.

In absolute terms the spectrums of the potential targets are quite large. They range from about 900 to 636 Mt of CO_2 in 2020 and from 890 to 0 Mt of CO_2 in 2050. These ranges illustrate that there is no single objective way to determine the adequate contribution of international shipping to global GHG reduction efforts. However, the approaches can inform the political discussion and if there is a political momentum, as shown by the aviation sector, targets can be formulated.

4 Can the targets be achieved by efficiency improvements?

With one exception, the targets presented in Section 3.1 are lower than even the lowest BAU emission projection, which is based on the most modest assumptions on the growth of the global economy. Under more optimistic growth assumptions, the difference between the targets and the emissions will likely increase.

As discussed in Section 1, the IMO has currently implemented two instruments that address the efficiency of ships: an efficiency standard (EEDI) for new ships and a compulsory energy efficiency management plan (SEEMP) for all ships, albeit the latter does not require any compulsory efficiency improvements. The MEPC is therefore currently discussing further technical and operational measures for enhancing energy efficiency of international shipping. Other types of regulation – such as market-based instruments or fuel standards – are not being discussed at the moment.

The question discussed in this section is whether the targets identified in the previous sections can be met by means of the current set of efficiency instruments. To answer this question we compare the fleet efficiency improvements that would be needed to meet the potential 2020 and 2050 targets with the efficiency improvements of the fleet in the BAU scenarios – the scenarios for which it is assumed that the current set of efficiency instruments are applied.

Working with efficiency in terms of the average CO_2 emissions per tonne-mile of the world fleet engaged in maritime transport work, we determine

- the 2020 and 2050 efficiency of the fleet in the BAU scenarios by dividing the 2020 and 2050 BAU emissions (in Mt CO_2) by the 2020 and 2050 maritime transport demand (in tonne-miles) as projected in the third IMO GHG study; and
- the 2020 and 2050 efficiency that would be needed to meet the potential targets by dividing the 2020 and 2050 emission targets (in Mt CO_2) by the 2020 and 2050 maritime transport demand (in tonne-miles) as projected in the third IMO GHG study.

The according efficiency *improvements*, presented in Table 2, are determined by comparing the 2020 and 2050 efficiencies with the efficiency of the fleet in 2012, also measured in terms of the average CO_2 emissions per tonne-mile.

Note that in the third IMO GHG study, there is not one projection of the maritime transport demand for 2020 and 2050, but a range of projections, reflecting the fact that different economic scenarios project different amounts of transport work. For this reason, not only one efficiency improvement value but rather an efficiency improvement range is given in Table 2.

Table 2 Efficiency improvements in BAU scenarios and efficiency improvements required to meet the potential emission targets, both compared to the fleet's 2012 efficiency

	Target or source	Description of target or scenario	2020	2050
1	Third IMO GHG study	BAU scenarios	15% - 19%	33% - 37%
2	EU target 2009 (3.2.1)	-20% by 2020	27% - 34%	n.s.
3	IATA target (3.2.3)	-50% by 2050	15% - 19%	78% - 91%
4	ICAO target (3.2.4)	CNG2020	15% - 19%	52% - 79%
5	Cancun (3.2.5)	Unconditional	2% - 8%	n.s.
6	Cancun (3.2.5)	Conditional	8% - 14%	n.s.
7	Remaining Carbon Budget (3.2.6)	Peaking 2015	18% - 24%	90% - 94%
8	Remaining Carbon Budget (3.2.6)	Peaking 2020	6% - -5%	100%
9	Third IMO GHG study	Mitigation scenarios with max. efficiency improvements	15% - 21%	56% - 63%
n.s.: Target not specified for this year.				

Sources: Authors' own calculations

A comparison of the efficiency improvements in the BAU scenarios (Table 2, row 1) with the required efficiency improvements under the various caps (rows 2-8) shows that two of the seven potential 2020 targets, i.e. the 20% emission reduction in 2020 compared to 1990 levels (row 2) and the target based on the remaining carbon budget approach with the emissions peaking in 2015 (row 7), and all 2050 targets require efficiency improvements beyond BAU efficiency improvements. A comparison with the mitigation scenarios (row 9) shows that the required efficiency improvements are even beyond the efficiency improvements of the mitigation scenarios with maximum efficiency improvements.

This implies that, at least for the long run, not only the stringency of the existing efficiency measures would need to be increased and possibly further efficiency measures for existing ships would need to be developed, but also that instruments would probably need to be considered that aim at reducing the absolute emissions of the sector or that the sector would need to buy offsets, thus financing emission reductions in other sectors.

5 Conclusions

The stated goal of global climate policy is to limit the average global temperature increase to 2°C above pre-industrial levels, as agreed at the 16th Conference of Parties of the UNFCCC (2010) in Cancun. To reach that goal, emissions need to start decreasing sooner rather than later and continue on a downward path. This would require an emission reduction of approximately 40 to 70% in 2050, relative to their 2010 level. Even to stay below +3°C would require a 20 to 50% decrease in global GHG emissions in the period to 2050.

The third IMO GHG study projects shipping emissions to increase by 50 to 250% by 2050 (IMO 2014). This would result in an increase in the share in total global emissions from the current level of 2 to 10% if the rest of the world is on a path towards the 2°C target. Although there is no single objective way to determine the appropriate contribution of shipping to the global effort to reduce emissions, it is clear that an increase in emissions would be counterproductive.

The costs of climate policy can be reduced by including as many emissions, sectors and countries as possible and by starting early, as the Fifth Assessment Report of the IPCC unequivocally shows. Hence, an appropriate contribution of the shipping sector to global emission reductions would decrease the overall macro-economic costs of climate policy.

In this paper we quantified various potential emission reduction targets for international shipping for the period up to 2050. The targets were transferred from other sectors or from country pledges, were suggested specifically for the shipping sector or were derived from environmental requirements. Some targets are based on a proportional contribution of shipping to the global mitigation effort; others are modelled after targets for other sectors or countries, are based on economic considerations or are the result of political negotiations. However, all potential targets analysed here would require shipping emissions to stay well below the business-as-usual projections presented in the third IMO GHG study.

Targets can be useful in several ways. For example, since they define the contribution of the shipping sector to the global climate policy goal, they facilitate setting targets and developing policy instruments in other sectors. In addition, they can help to track the progress of the shipping sector towards achieving its contribution. They can also help in the development of policy instruments for the shipping sector and the assessment of their contribution to reaching the targets. This paper presents an example of the latter.

The shipping sector currently has two policy instruments at its disposal that address emissions: the EEDI, which sets efficiency standards for new ships, and the SEEMP, which requires ships to have an energy efficiency management plan. In addition, it is discussing further technical and operational measures for enhancing the energy efficiency of international shipping. Hence, all instruments are aimed at improving efficiency.

In this paper we have analysed the extent to which efficiency instruments can be expected to achieve the various emissions targets. To this end, we have compared the efficiency improvements theoretically required to reach the targets with the projected efficiency in the high efficiency scenarios of the third IMO GHG study. These efficiency scenarios assume that the efficiency of ships improves by 60% compared to current levels through increased stringency of existing instruments, new instruments, or market forces. The comparison shows that up to 2020, some of the potential emissions targets are achievable, provided that appropriate action is taken. Beyond 2020, most targets would require efficiency improvements that are much larger than considered possible in the third IMO GHG study. These targets would require other types of policy instruments that aim at reducing the absolute emissions of the sector or at offsetting emissions by financing emission reductions in other sectors.

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Further technical and operational measures for enhancing the energy efficiency of international shipping Environmental Aspects

DISCUSSION PAPER

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ON BEHALF OF THE

FEDERAL ENVIRONMENT AGENCY

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This paper was written for the German Federal Environment Agency (UBA) as part of the project titled “Analysis and further development of climate protection measures of sea shipping taking into account current developments at European and international level” (FKZ 3711 45 104). This project is being carried out by Öko-Institut (coordination), CE Delft and Tim Bäuerle LL. M.

Summary

In the International Maritime Organization (IMO) there are currently four measures under discussion that aim to enhance the energy efficiency and to reduce the fuel consumption of ships:

- the US proposal, which aims to reduce the energy used per hour in service;
- the Annual EEOI proposal, which aims to reduce CO_2 emissions per dwt-mile;
- the Individual Ship Performance Indicator (ISPI), which aims to reduce CO_2 emissions per mile; and
- the Fuel Oil Reduction Strategy (FORS), which aims to reduce CO_2 emissions by reducing fuel consumption.

This paper describes the four measures and analyses them, focusing on their expected environmental impact in terms of CO_2 emission reduction as well as their interaction with potential future market-based measures. To illustrate the differences between the four measures, quantitative examples for three virtual ships are presented.

The expected impact of the measures on the CO_2 emissions will greatly depend on their respective stringency. However, no targets have been determined yet, which is why the paper discusses design elements that have an impact on the environmental effect of the measures: the potential scope of the measures, their expected implementation time, the abatement measures they incentivise, whether they can be expected to remove barriers that prevent ship owners to take abatement measures as well as their expected environmental effectiveness, e.g. whether a measure limits total fleet emissions.

Analysing the elements, the following conclusions can be drawn:

- Both the US proposal and FORS can be applied in principle to all ship types and thus have the highest potential coverage of the fleet. The other measures are more suitable for cargo ships.
- The quicker a measure can be implemented, the sooner CO_2 can be reduced. Of the four measures, FORS can be expected to be implemented the quickest since it does not call for a data collection phase and works with a readily available baseline.
- All four measures do, in principle, incentivise the adoption of operational as well as technical emission abatement measures. However, only FORS incentivises slow steaming in a technology-neutral way. The other measures either reward it more than other options to reduce a similar amount of emissions (the US proposal) or less (the Annual EEOI and ISPI). Fuel switching is not rewarded in the US proposal, even when it reduces emissions.
- By rewarding lower capacity utilisation, the US proposal and the ISPI give an incentive that is not desirable from an environmental point of view.
- All four measures contribute to a removal of the barriers that prevent ship owners investing in CO_2 abatement reduction measures; all measures require ship owners to take CO_2 abatement measures. Thus, on the one hand, the measures help to overcome the split incentive problem between ship owners and charterers. On the other hand, the lack of transparency in the market can be reduced by prompting the ship owners that have invested in emission abatement to credibly show that the energy efficiency of their ships has improved to be able to earn back their investment via higher charter rates.

- None of the measures limits the total CO_2 emissions of the fleet since new ships may be added to the fleet and increase the total emissions. Regarding the emissions of the baseline fleet, i.e. the existing fleet at the time at which a measure is implemented, only FORS will ensure with certainty that these emissions will decline. This does not necessarily hold for the other measures as the activity (distance covered, hours in service or transport work in tonne miles) of the ships may increase.
- Progress indicated by each of the measures does not reflect reductions of CO_2 emissions of the fleet. All measures allow for an increase of emissions as a result of the addition of new ships to the fleet. Furthermore, the Annual EEOI, ISPI and the US proposal allow for a growth in emissions due to an increase of transport work, distance sailed or time in service, respectively. When slow steaming results in additional ships being added to the fleet, FORS and the US proposal do not take the emissions of additional ships into account, whereas the Annual EEOI and ISPI do.

Regarding the interaction of the measures with potential future market-based instruments, it can be concluded that there are two ways in which a measure to improve efficiency and reduce fuel use could co-exist with a Market-Based Measure (MBM) that also caps emissions. The first way would be to use the monitoring, reporting and verification requirements in the MBM. This could be combined with any of the proposed measures. The second way would be to introduce an MBM as a flexibility mechanism in FORS.

Zusammenfassung

In der International Maritime Organization (IMO) stehen derzeit vier Maßnahmen zur Verbesserung der Energieeffizienz beziehungsweise zur Verringerung des Kraftstoffverbrauchs von Schiffen zur Diskussion:

- der US Vorschlag zielt darauf ab, den Energieverbrauch je Nutzungsstunde zu verringern;
- der *Annual Energy Efficiency Operational Index (EEOI)* Vorschlag hat zum Ziel die CO_2 Emissionen je *DWT*-Meile zu verringern;
- der *Individual Ship Performance Indicator (ISPI)* soll eine Minderung der CO_2-Emissionen je zurückgelegter Meile bewirken;
- die *Fuel Oil Reduction Strategy* (*FORS*) möchte eine Reduktion der CO_2-Emissionen mittels Verringerung des Kraftstoffverbrauchs erwirken.

Im folgenden Diskussionspapier werden diese vier Maßnahmen beschrieben und analysiert, wobei der Schwerpunkt auf den jeweils zu erwartenden CO_2-Emissionsminderungen sowie auf einer Wechselwirkung mit potentiellen zukünftigen marktbasierten Maßnahmen liegt. Um die Unterschiede zwischen den vier Maßnahmen zu veranschaulichen, werden schließlich für drei fiktive Schiffe quantitative Beispiele präsentiert.

Der CO_2-Effekt der Maßnahmen wird weitgehend davon abhängen, wie streng die jeweilige Norm angesetzt werden wird. Da jedoch noch keine Reduktionsziele festgelegt worden sind, können die jeweiligen CO_2-Minderungspotentiale in dieser Studie nicht als solche quantifiziert werden, vielmehr werden die Ausgestaltungselemente der Maßnahmen analysiert, die einen Einfluss auf die CO_2-Emissionen haben werden. Die folgenden Elemente werden dabei berücksichtigt:

- der potentielle Deckungsgrad,
- die zu erwartende Dauer der Implementierung,
- die Anreizstruktur hinsichtlich der verschiedenen Emissionsminderungsmaßnahmen,
- der Beitrag zum Abbau von Barrieren hinsichtlich der Investition in die Minderungsmaßnahmen sowie
- die Umwelteffektivität der Maßnahme.

Folgende Schlussfolgerungen werden aus dieser Analyse gezogen:

- Grundsätzlich können sowohl der US-Vorschlag als auch *FORS* auf alle Schiffstypen angewendet werden und haben somit den größten potentiellen Deckungsgrad. Die anderen Maßnahmen sind vor allem zur Regulierung von Frachtschiffen geeignet.
- Je schneller eine Maßnahme implementiert werden kann, desto eher können CO_2-Emissionen gemindert werden. Es ist zu erwarten, dass *FORS* am schnellsten implementiert werden kann, da keine Datensammlung erforderlich ist und da diese Maßnahme eine bereits vorliegende Baseline nutzen würde.
- Prinzipiell setzen alle vier Maβnahmen den Anreiz sowohl operative als auch technische Emissionsminderungsmaßnahmen zu implementieren. Was *Slow Steaming* betrifft, setzt *FORS* jedoch den neutralsten Anreiz: Die anderen Maßnahmen belohnen *Slow Steaming* entweder mehr (US-Vorschlag) oder weniger (*Annual EEOI*, *ISPI*) als andere Minderungsmaßnahmen; darüber hinaus wird durch den US-Vorschlag ein

Kraftstoffwechsel nicht belohnt, selbst wenn dieser zu Emissionsminderungen führen würde.

- Sowohl der US-Vorschlag als auch der *ISPI* begünstigen eine geringere Kapazitätsauslastung und geben somit einen Anreiz, der aus Umweltperspektive nicht wünschenswert ist.
- Alle vier Maβnahmen tragen zu einem Abbau von Investitionshemmnissen für Emissionsminderungsmaßnahmen bei: Alle Maβnahmen erfordern, dass der Schiffseigner Minderungsmaßnahmen durchführt. Somit kann einerseits das *Split-Incentive*-Problem zwischen Schiffseigner und Charterer überwunden werden. Andererseits kann die Intransparenz im Markt abgebaut werden, da der Schiffseigner einen Anreiz hat, die Verbesserung der Energieeffizienz des Schiffes glaubwürdig nachzuweisen, um seine Investition mittels höherer Charterraten zurückzuverdienen.
- Keine der Maßnahmen begrenzt die CO_2-Emissionen der gesamten Flotte, da neue Schiffe zur Flotte hinzugefügt werden und die Gesamtemissionen dadurch steigen könnten. Was die Baselineflotte, d.h. die Flotte, die zum Zeitpunkt des Inkrafttretens einer Maßnahme besteht, betrifft, so kann nur unter *FORS* mit Sicherheit davon ausgegangen werden, dass deren Emissionen sinken werden. Bei den anderen Maßnahmen kann es sein, dass die jeweilige Aktivität (zurückgelegte Entfernung, Nutzungsstunden, Meilen und Tragfähigkeit) sich erhöht und die Effizienzverbesserung überkompensiert.
- Der Fortschritt, der durch die Maßnahmen aufgezeigt wird, reflektiert nicht die CO_2-Minderung der Gesamtflotte. Bei jeder der vier Maßnahmen kann es sein, dass die Gesamtemissionen durch ein Wachstum der Flotte steigen. Ferner können bei dem *Annual EEOI*, bei *ISPI* und dem US Vorschlag die Emissionen aufgrund erhöhter Transportleistung, längerer Transportabstände oder mehr Nutzungsstunden steigen. Wenn *Slow Steaming* zum Einsatz zusätzlicher Schiffe führen sollte, so reflektieren *FORS* und der US Vorschlag, im Gegensatz zu dem *Annual EEOI* und *ISPI,* die Emissionen der zusätzlichen Schiffe nicht.

Bezüglich der Wechselwirkung der vier Maßnahmen mit potentiellen zukünftigen marktbasierten Maßnahmen, gibt es grundsätzlich zwei Kombinationsmöglichkeiten. Zum einen könnten die Anforderungen hinsichtlich *Monitoring*, *Reporting* und *Verification* bei der Implementierung einer marktbasierten Maßnahme übernommen werden. Dies ist für alle vier Maßnahmen möglich. Zum anderen könnte *FORS*, durch einen Flexibilitätsmechanismus erweitert, als eine marktbasierte Maßnahme implementiert werden.

Table of Contents

1 Introduction

1.1 Background

MEPC 66 discussed further technical and operational measures for enhancing the energy efficiency of international shipping in a working group. The group discussed in detail four proposals made by various parties on this subject:

- A proposal by the US to enhance the energy efficiency of international shipping defined as energy used per hour in service (MEPC 65/4/19);
- A proposal to enhance the energy efficiency of shipping defined as CO_2 per deadweight mile, called 'Annual EEOI' (MEPC 66/4/6);
- A proposal to enhance the energy efficiency of shipping defined as CO_2 per mile, under which less efficient ships would need to do more, called Individual Ship Performance Indicator (ISPI) (MEPC 66/4/6);
- A proposal to enhance the energy efficiency by limiting the amount of fuel used per year, called FORS (MEPC 66/4/6).

The group concluded that further work was needed on all the metrics proposed so far and that no metric should be excluded at this point in time.

1.2 Aim of Report

The aim of the report is twofold:

The first aim of the report is to compare the expected environmental impact of the efficiency indicator as proposed by the US (65/4/19) with the expected environmental impact of the three alternative metrics as specified in the commenting paper (MEPC 65/4/30).

The second aim of the report is to develop ideas on how the standard proposed by the US as well as the three alternative standards could evolve into a market-based measure with an overall emissions cap.

1.3 Outline

In chapter 2 we first briefly describe the four proposed standards and subsequently analyse these standards in chapter 3. The phased implementation of the standard as proposed by the US is described in greater detail and the four proposals are compared with regards to their environmental impact based on a set of criteria. In chapter 4 the potential evolution of the four proposals is discussed. Chapter 5 concludes and provides an overview table of the outcomes of chapters 3 and 4. In the Annex the differences between the metrics underlying the four standards are illustrated with calculations carried out for three exemplary ship types.

2 Brief description of the proposed measures

2.1 US proposal

The US submission to MEPC 65 (MEPC 65/4/19) presents a phased approach to the implementation of an efficiency standard and proposes an efficiency metric; this is one of the four metrics currently under discussion at the IMO.

The phased implementation approach comprises three phases:

- Phase I: Data collection and analysis phase.
  In this first phase, relevant data will be collected centrally for two years and will subsequently be analysed by an expert group. Based on the analysis, baseline curves will be established per ship type. If possible energy efficiency standards, expressed as a function of dwt, will be derived from the baseline curves or, if the data does not support this, ship-specific standards could be developed.
- Phase II: Pilot phase.
  In this phase, ships will be evaluated against the standards but are not required to meet them. The purpose of the pilot phase is to gain experience with the system.
- Phase III: Full implementation.
  In this phase, ships will be required to comply with the applicable efficiency standards.

The different phases will be discussed in greater detail in section 3.1.

The phased approach in the US proposal can use different efficiency metrics. The efficiency metric that takes the most prominent role in the US proposal is 'Joules of fuel energy consumed/hours in service', with hours in service being defined as the hours a ship is underway. The US also recommends careful consideration of working with distance or other alternatives instead of working with hours in service. In this paper, however, we will focus on the indicator 'Joules of fuel energy consumed/hours in service' and will refer to it as the US proposal.

2.2 Alternative metrics

In the commenting paper (MEPC 65/4/30) on the US proposal (MEPC 65/4/19), three alternative metrics have been proposed, which have been elaborated in a submission by Japan and Germany (MEPC 66/4/6). These metrics will be described in more detail below.

2.2.1 Annual Energy Efficiency Operational Index (EEOI)

The Annual EEOI is an efficiency indicator that presents a ship's efficiency in terms of CO_2 emitted per unit of transport work. Two alternative definitions of transport work have thereby been proposed: one that relates the real cargo volume and the other that relates the nominal cargo volume (e.g. dwt or a share thereof) to the distance covered. Due to potential difficulties with the collection of reliable cargo volume data, MEPC 66/4/6 puts the nominal cargo option forward as an appropriate proxy to be considered by the Commission. Since the efficiency of a ship in terms of 'CO_2/tonne nautical mile' can be expected to fluctuate highly between voyages, it is proposed that annual averages are used. Regarding the baseline, three options are mentioned in the proposal: a ship-specific reference value, an average reference value per ship type/size category or a combination of both.

2.2.2 Individual Ship Performance Indicator (ISPI)

The Individual Ship Performance Indicator (ISPI) measures the efficiency of ships in terms of CO_2 emitted per nautical mile. It is proposed that the corresponding reference values are ship-specific and a data collection phase would be necessary for determining these reference values.

It is proposed that the emission reduction target is differentiated according to the initial technical efficiency of the ships. The initial technical efficiency of the ships would be measured by a 'design efficiency factor' (DF) that relates the ships' Estimated Index Value (EIV) to the baseline EIV of the relevant ship category and size. The Estimated Index Value is calculated by means of the simplified formula of the EEDI that has been used by the IMO to develop the EEDI reference lines (see Guidelines for calculation of reference lines for use with the EEDI, MEPC.215(63)). The design efficiency factors could be determined without a data collection phase.

The formula implies that a ship with a less fuel-efficient design will have to improve its efficiency more than a ship with a more efficient design.

2.2.3 Fuel oil reduction strategy (FORS)

FORS aims at reducing the fuel oil consumption of each individual ship by means of a fuel oil consumption standard. FORS thereby combines ship-specific reference values with a uniform percentage reduction target for all ships. No data collection phase is needed to determine the ship-specific reference values under FORS; instead, readily available data is used: The average 2007 operational profiles of a ship's type/size category (i.e. average days at sea, average specific fuel oil consumption (SFOC), average engine load), as given in the Second IMO Greenhouse Gas Study, is combined with the ship's actual engine power as given in the IHS Fairplay database to determine the ship's reference fuel oil consumption.

3 Analysis of the proposed measures

3.1 The phased implementation as proposed by the US

The US has developed a phased implementation approach for their proposed efficiency measure (MEPC 65/4/19). In Table 1 a detailed overview of the different intended steps per phase and the intended responsibilities is provided.

Table 1: Overview of the phased implementation as proposed by the US (MEPC 65/4/19)

Phase I **Data collection and analysis phase**	Central database	Centralised database is set up.
	MRV	- Ships collect data (joules of fuel energy used, hours in service) - 'Hours in service' need to be attested by ship master for verification purpose. - Ships have to report (collected data, attained efficiency, basic ship data) to a centralised database on annual basis and compile data in annual report. - In statutory survey flag administration or recognized organisations (RO) verifies data in report and submits verification notice together with attained energy efficiency to centralized database.
	Baseline	After 2 years MEPC expert group establishes baseline curves for different ship

		types.
	Standard(s)	If possible MEPC sets standards on the basis of baseline curves. Alternatively, MEPC develops ship-specific standards.
Phase II **Pilot Phase**	MRV	- Ships collect data (joules of fuel energy used, hours in service) - 'Hours in service' are attested by ship master for verification purpose. - Ships have to report (collected data, attained efficiency, basic ship data) to a centralised database on annual basis and compile data in annual report. - In statutory survey flag administration or RO verifies data in report and submits verification notice together with attained energy efficiency to centralised database. - Compliance periods are no less than two and no more than five years. - Ships are evaluated against the standard by Flag States per compliance period but ships do not have to comply with standard in the pilot phase.
	Flexibility	Need for (initial) flexibility measures for non-compliant ships can be established.
	Adjustments	MEPC may consider recalculation of baseline curves and adjustment of standards.
	Labels	Option: MEPC could develop ship efficiency labels.
Phase III **Full implementation**	MRV	- Ships collect data (joules of fuel energy used, hours in service) - 'Hours in service' need to be attested by ship master for verification purpose. - Ships report data to a centralised database on annual basis and compile data in annual report. - Flag States/RO verify data in report during statutory surveys, submits verification notice together with attained energy efficiency to centralised database and notes the attained efficiency in the ship's International Energy Efficiency Certificate (IEEC). - Compliance periods are no less than two and no more than five years. - Ships are evaluated against the standard by Flag States per compliance period.
	Stringency	Stringency of standards is revised at no less than five-year intervals.

An implementation in the three proposed phases has the advantage that due to the data collection phase, current CO_2 emissions can be estimated more precisely. As a consequence, the environmental and economic impacts of alternative targets can be assessed more precisely ex ante, facilitating a goal-oriented choice of a target. However, working with a data collection phase as well as with a pilot phase has the major disadvantage that full implementation with mandatory efficiency improvements will only occur four to seven years after adoption of the proposal. Note, therefore, that the data collection phase is inherent to the US proposal as well as to the Annual EEOI and ISPI since data has to be collected for the establishment of a baseline.

3.2 Comparison of expected environmental impact of the different measures

The expected impact of the measures to enhance the energy efficiency and reduce fuel consumption on the CO_2 emissions of maritime shipping can only be analysed to a limited extent at this stage since their overall impact will strongly depend on their stringency of targets which have not been determined yet. At this stage we can only discuss the following elements that have an impact on the environmental effect of the measures:

1. Scope:

   Which part of the fleet will be covered by the proposed measure?

2. Implementation time:
   a. What is the scheduled time for the proposed measure to become effective?
   b. Which factors could turn out to be problematic and could delay implementation?

3. Incentivised abatement measures:
   a. Are both technical and operational CO_2 abatement measures in principle incentivised?
   b. Are there useful, specific abatement measures which are not incentivised?
   c. Are there specific, unwanted abatement measures incentivised?

4. Removal of barriers to taking CO_2 abatement measures:
   a. Can the measure contribute to a reduction of the split incentive between ship owners and charterers?
   b. Can the measure take away the lack of transparency and enable charterers to choose ships on the basis of their energy efficiency?

5. Environmental effectiveness of the measure:
   a. Are the CO_2 emissions of the baseline fleet[1] reduced if the fleet is compliant with the standard?
   b. Are the CO_2 emissions of the total fleet reduced if all ships are compliant?
   c. Are the ships more carbon-efficient if they comply with the standard?
   d. Are there any design elements of the measure that may lead to an overestimation of the expected environmental impact?

Note that in section 5 an overview table is given with a comparison of the different measures in which the findings of this section are also included.

3.2.1 US proposal

The US proposes to apply a standard on the efficiency of ships in terms of 'Joules of fuel energy consumed/hours in service', with the hours in service being defined as the hours a ship is underway.

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[1] By "baseline fleet" we mean the existing fleet by the time the measure is implemented.

1. Scope

A maximum share of the fleet is covered by this standard since the standard is in principle applicable to all ship types.

2. Implementation time

The standard proposed by the US cannot become effective at short notice: a data collection phase is necessary to determine the baselines (2 years proposed); and after the baselines and standards have been determined, there is a pilot phase (with a proposed length of 2 to 5 years).

Before the data collection phase could start, a common definition of all the relevant parameters, including the as yet undefined 'hours in service', would need to be agreed upon. After the data collection phase, the establishment of the baselines and standards could turn out to be difficult and time consuming.

3. Incentivized abatement measures

Both technical and operational measures can, in principle, be used to comply with the standard, which has a positive effect on the maximum abatement potential of the standard.

However, higher capacity utilisation is not encouraged by the measure. In fact, ballast voyages contribute to a reduction of the average efficiency in terms of 'Joules of energy used/hours in service' because the energy use per hour in service is, all else being equal, lower for ballast voyages than for laden voyages (ships in ballast have a lower draft and consequently less friction).

Fuel switching is not incentivised by an efficiency measure that works with 'Joule of energy used' in the numerator since the energy consumption of vessels is not reduced by fuel switching. Switching to a fuel type that is associated with less CO_2 per unit of energy could, however, be desirable from an environmental point of view.[2]

4. Removal of barriers for taking CO_2 abatement measures

If a standard was implemented as proposed by the US, the split incentive problem between ship owners and charterers would be reduced since ship owners would be required to take CO_2 abatement measures regardless of whether they can subsequently profit from the charterer's reduced fuel bill or not.

[2] MDO/MGO (˜75 gCO_2/MJ) and LNG (˜57 gCO_2/MJ) are associated with less CO_2 emissions per energy unit than HFO (˜78 gCO_2/MJ). The climate benefits of LNG depend crucially on methane slip because methane is a more powerful greenhouse gas than CO_2. Methane slip depends, amongst other things, on the engine technology. Some engine types do not have methane slip while in other engine types, methane slip may be 2%-4%. Methane is not only emitted as an exhaust gas, but also at different upstream points in the LNG supply chain. The climate benefits of switching to biofuels depend on emissions associated with the production of biofuel over the lifecycle (growing feedstock, transport and conversion into liquid fuel).

If this data/information became available for shippers as well, it would enable them to select a ship on the basis of the energy efficiency, which may trigger a competition between ship owners on environmental grounds.

5. **Environmental effectiveness of the measure**

If the ships of baseline fleet[3] are compliant with the standard, this would not necessarily mean that the CO_2 emissions of these ships would have been reduced; an increase of the fleet's 'hours in service' might counteract the reduction of the energy used per hour in service.

Regarding the CO_2 emissions of the total fleet, these may not only increase due to an increase of the 'hours in service' of the baseline fleet but also due to a growing fleet. The relative standard proposed by the US is not accompanied by an absolute emissions cap and thus allows for unlimited growth of the total emissions of the fleet.

Due to the standard, the efficiency of a ship in terms of 'Joules of fuel energy consumed/hours in service' has to be improved. Complying with the standard, however, does not necessarily mean that the transport efficiency actually has been improved: the ship may, for example, have had longer queuing times in front of ports, lower cargo load factors or have been transporting cargo with a lower density within the compliance period.

The efficiency metric proposed by the US favours slow steaming in the sense that if slow steaming is applied, the CO_2 emissions will have to be reduced to a lesser extent to comply with the standard than if another abatement measure was applied: slow steaming not only reduces fuel energy consumption (numerator of the indicator) but also leads to an increase in the hours in which a ship is in service (denominator of indicator), at least if the maximum amount of hours in service per year has not yet been reached. The standard may thus be less stringent than expected. From an environmental perspective, there is no benefit in favouring one particular emission reduction option over others.

'Hours in service' is a new concept for which no common definition currently exists. The verification of the reported 'hours in service' could thus be difficult, leading to an uncertainty regarding the actual target achievement.

3.2.2 Annual Energy Efficiency Operational Index

If the Annual Energy Efficiency Operational Index (EEOI) was used as a metric in a measure to improve the efficiency and reduce fuel use, a standard would be set on the ships' annual average CO_2 emissions per tonne nautical mile[4]. In the following, we discuss the different determinants of the environmental effect of this metric as listed above. Since working with nominal cargo volume of the ships (e.g. ships' dwt) is brought forward as an alternative for working

[3] By "baseline fleet" we mean the existing fleet by the time the measure is implemented.

[4] In the EEOI Guidelines (MEPC.1/Circ.684) the proposal is to use either mass of cargo or number of TEU's for cargo ships and to work with the number of passengers or the gross tonnage of the ship for passenger ships.

with the real cargo volume (actual mass of the cargo carried), we subsequently discuss the advantages and disadvantage of this alternative.

1. **Scope**

   In principle, the Annual EEOI can be applied to all ships whose primary purpose is to transport cargo and/or passengers. Ships that serve other purposes such as dredgers, fishing vessels, research vessels, etc. would thus not be covered. Non cargo/non-passenger ships accounted for 15% of emissions in 2007 (Buhaug et al., 2009).

2. **Implementation time**

   Just as for the implementation of the standard proposed by the US, a data collection phase is necessary to determine the baselines for the Annual EEOI. It can nevertheless be expected that the implementation of the Annual EEOI would be less time-consuming than the implementation of the US proposal since the EEOI has already been adopted as the primary monitoring tool for the Ship Energy Efficiency Management Plan and is thus an instrument adopted by the IMO and accepted by the international community of States. Some ship operators are also already monitoring the efficiency of their ships by means of the EEOI, a pilot phase will not be necessary.

   What could constitute a problem in the implementation phase is the fact that some ship owners/operators have reservations about reporting real cargo loads, considering these as business sensitive data. Reporting the EEOI on an annual basis, which would be the case for the Annual EEOI, or publishing the data with a time delay could help to overcome these reservations.

3. **Incentivised abatement measures**

   The Annual EEOI incentivises both the adoption of technical and operational CO_2 abatement measures, leading to a high maximum abatement potential. Regarding the operational measures, there is also an incentive to switch to alternative fuels[5] and to increase the capacity utilisation rate – in contrast to the measure proposed by the US. Since the real cargo load is often not under the control of the vessel operator and also influenced by global economic developments, the actual abatement potential of logistic measures may, however, turn out to be low.

   The Annual EEOI would disincentivise slow steaming in the sense that if slow steaming is applied, the EEOI is reduced to a lesser extent than CO_2 emissions. In contrast, if CO_2 is reduced through other measures, the EEOI and emissions are reduced by the same percentage. This difference occurs because slow steaming not only reduces the annual CO_2 emissions (numerator of indicator) but also results in a decrease in the distance covered in that year (part of the denominator of the indicator), if it is assumed that the time per port call remains constant. This does not mean, however, that slow steaming will consequently not be applied under the Annual EEOI; it only means that other abatement measure might be preferred.

[5] The Annual EEOI gives an incentive to switch to fuel types that are associated with less CO_2 emission per energy unit, which can be desirable from an environmental point of view. See footnote 2 for a discussion of the climate benefits of a fuel switch.

4. Removal of barriers to taking CO_2 abatement measures

The EEOI of a ship can greatly differ between voyages. These fluctuations can have different reasons such as different weather conditions, different routes, different types of cargo, the economic cycle, which has an impact on cargo load factors, etc. The explanatory power of the EEOI of a ship measured per voyage is thus very limited. This is the reason why the Annual EEOI works with an annual average in the first place. The question remains, however, whether an annual average provides relevant information for a potential charterer given that its utilisation profile could highly differ from that of the previous charterers of the ship. Nevertheless, the Annual EEOI will help to reduce the split incentive problem between ship owners and charterers. Just as the standard proposed by the US (see 3.2.1, point 4) the relative measure will require ship owners to invest into CO_2 abatement measures and therefore give ship owners the incentive to show credibly that the efficiency of their ship has improved. If this data/information becomes available for shippers as well, this would enable them to choose a ship on the basis of the energy efficiency, which in turn may trigger a competition between ship owners on energy efficiency grounds.

5. Environmental effectiveness of the measure

The emissions of the baseline fleet[6] are not necessarily reduced if the ships of the baseline fleet are compliant with the standard since the activity of the fleet in terms of tonne nautical miles may be increased. This is inherent to a relative standard.

The Annual EEOI does not set a cap on the fleet's CO_2 emissions. The total CO_2 emissions of the sector may thus increase not only due to a higher activity of the baseline fleet but also due to a growing fleet.

Discussion: nominal versus real cargo

Since some ship operators have reservations about reporting real cargo loads, considering these business sensitive data, it is proposed that nominal cargo data are used instead. Most probably this would mean that it is worked with (a certain share of) the deadweight tonnage of a ship.

Working with nominal instead of real load would have the advantages that:

- the standard would, due to less resistance from the sector, probably be implemented quicker and thus would become effective earlier,
- all ships could be covered by the Annual EEOI,
- the indicator is less volatile since it does not depend on economic circumstances.

On the other hand, working with nominal load would involve several disadvantages:

- An optimisation of the utilisation rate can no longer contribute to the compliance with the standard.
- The marine transport efficiency can no longer be compared with that of other transport modes.

[6] By "baseline fleet" we mean the existing fleet by the time the measure is implemented.

3.2.3 Individual Ship Performance Indicator (ISPI)

With ISPI a standard would be set on a ship's CO_2 emissions per unit of distance (nautical mile). The relative emission reduction target is thereby differentiated: Ships with a relative high initial technical efficiency have a lower reduction target than ships with a relative low initial technical efficiency.

1. Scope

   In principle, ISPI can be applied to all ship types. The application to certain ship types which typically consume fuel while covering little or no distance (e.g. dredging vessels) may, however, not be constructive.

   It is proposed that the relative emission reduction targets vary according to the ships' initial efficiencies: A design efficiency factor (DF) is applied to the default relative emission target (e.g. 20%), with the DF being the ratio of the ship's specific Estimated Index Value and the according industry average. The Estimated Index Value has been used by the IMO to determine the reference values for the Energy Efficiency Design Index but has not been calculated for all ship types by the IMO yet. Application to all ship types is thus not straight-forward.

2. Implementation time

   Like the US proposal and the Annual EEOI, ISPI necessitates a data collection phase for the determination of the baselines. In addition, for some ship types, the Estimated Index Values would have to be determined to be able to differentiate the emission reduction target of all ships.

   Relating the CO_2 emissions to the distance sailed is not an established concept under the IMO, but since distance data cannot be considered business-sensitive and can be measured precisely, distance as such will probably not be an obstacle in the implementation process.

   Rewarding early movers by differentiating the relative emission targets could enhance the acceptability and thus the time before ISPI is implemented.

3. Incentivised abatement measures

   ISPI would incentivise the same measures as the Annual EEOI with nominal cargo capacities. Ships can thus apply both technical and operational abatement measures to improve their efficiency; fuel switching is incentivised, whereas higher capacity utilisation is not. In fact, ballast voyages will contribute to a lower (better) annual average of the indicator because the fuel consumption on a ballast voyage is less than on a laden voyage, while the distance is the same. As with the Annual EEOI, slow steaming would reduce both the amount of fuel energy and the distance sailed per annum, at least if a ship is not able to operate enough extra days at sea and therefore could have a comparatively smaller impact on the indicator than other measures that reduce emissions or fuel energy by the same amount. This could make slow steaming less attractive.

4. Removal of barriers for taking CO_2 abatement measures

   Like the Annual EEOI, ISPI can be expected to fluctuate due to non-efficiency related factors like the density of the cargo. Although the ISPI can be expected to fluctuate less than the Annual EEOI, it is still questionable inasmuch the market will find it a useful measure for overcoming the split incentive problem and the lack of transparency on the side of the shippers.

However, as for all four standards under consideration here, ISPI will help to overcome the split incentive problem between ship owners and charterers by requiring ship owners to take CO_2 abatement measures. As a consequence the lack of transparency might also be solved because ship owners will have an incentive to credibly show that they have improved the energy efficiency of their ships and might want to make this data/information available for shippers, too.

5. Environmental effectiveness of the measure

ISPI works with a relative standard. This means that even if the baseline fleet[7] was compliant with the standard, its CO_2 emissions might increase due to longer distances covered in that year.

Since ISPI does not provide for a cap of the total fleet's CO_2 emissions, total CO_2 emissions of the sector can grow unlimited, not only due to longer distances covered but also due to a growing fleet.

If a ship is compliant with the relative standard, this does not necessarily mean that the ship's carbon efficiency is improved. ISPI may fluctuate less than the Annual EEOI but there are nevertheless non-efficiency related factors that have an impact on ISPI, e.g. cargo with varying density.

3.2.4 Fuel oil reduction strategy (FORS)

In contrast to the other proposed measures, the fuel oil reduction strategy works with an absolute and not with a relative standard: FORS obliges each ship to limit its annual fuel oil consumption. The ship-specific target is thereby determined on the basis of a ship-specific reference value and a relative target, which is the same for all ships. The ship-specific reference value reflects both the ship-type average operational profile of 2007 and the ship-specific engine power.

1. Scope

FORS sets an absolute standard on the ship's fuel consumption and can thus be applied to all ship types.

2. Implementation time

FORS can be implemented and become effective at short notice: Since the ship-specific reference values are determined on the basis of data that already is available, there is no need for a data collection phase. The calculation of the reference values is not expected to be time-consuming. FORS also does not envisage a pilot phase, which seems appropriate since ship owners can more easily anticipate the effort that is needed for the compliance with an absolute standard (FORS) than with a relative standard (the other proposals).

[7] By "baseline fleet" we mean the existing fleet by the time the measure is implemented.

The fact that under FORS ship operators will not have to report data that could be regarded as business-sensitive and that early movers are rewarded by working with a 2007 baseline could contribute to quick implementation.

3. Incentivised abatement measures

Ships can apply both technical and operational abatement measures to comply with FORS leading to a high maximum abatement potential.

Fuel switching, the optimisation of the capacity utilisation and slow steaming are specific operational measures. Regarding these measures, the following holds for FORS:

- FORS gives an incentive to switch to a fuel type with a higher calorific value – a fuel type that enables the same transport work to be carried out with a reduced amount of fuel. This fuel switch can be desirable from an environmental point of view.[8]
- FORS gives ships the incentive to use their 'fuel consumption budget' efficiently, so that an optimisation of the capacity utilisation is incentivised too.
- In contrast to the other proposed measures, FORS incentivises all measures to reduce emissions – be it slow steaming, technical or operational measures, to the same extent.

4. Removal of barriers for taking CO_2 abatement measures

If FORS was implemented, ship owners would be obliged to monitor and report the annual fuel oil consumption and the annual CO_2 emissions of their ships. These data however are not specific enough to take away the split incentive between ship owners and operators or to eliminate the lack of transparency regarding the energy efficiency of the ships on the part of shippers. This is because they cannot provide an indication of the fuel consumption/CO_2 emissions for a specific utilisation of the ship (e.g. fuel consumption for a specific cargo and route combination) that a charterer or shipper might be interested in. Nevertheless, in good economic times, FORS will prompt ship owners to improve the energy efficiency of their ships, which means that the split incentive problem is overcome. As a result ship owners have an incentive to credibly show that the energy efficiency of their ships has improved in order to earn back their investment expenditures via higher charter rates. If this information became available for shippers too, they would be able to select a ship on the basis on its energy efficiency and ship owners might compete based on the energy efficiency of their ships, too.

5. Environmental effectiveness of the measure

In contrast to the other three proposed measures, FORS works with an absolute and not with a relative standard. This means that if the baseline fleet[9] is compliant with the standard set under FORS, total CO_2 emissions of the baseline fleet are definitely reduced.

As with the other three measures, FORS does not limit total CO_2 emissions of the total fleet; it limits fuel consumption per ship whereas the growth of the fleet is not limited.

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[8] See footnote 2 for a discussion of the climate benefits of a fuel switch.

[9] By "baseline fleet" we mean the existing fleet by the time the measure is implemented.

Whether FORS will lead to an improvement of transport efficiency will depend on the economic situation. In good economic times ships will have to improve their efficiency to be able to meet their fuel oil consumption limit, whereas in times of economic downturn ships can probably meet their limit without improving their efficiency.

4 Interaction with a potential future MBM

4.1 Why could there be a need for an MBM to complement a measure to improve efficiency and reduce fuel use?

All proposed measures to improve efficiency and reduce fuel use contain a reference to flexibility mechanisms that allow ships for which efficiency improvements are infeasible or very costly to comply at a lower cost. Market-Based Measures (MBM) may be helpful in creating flexibility. They may allow shipping companies for which meeting the standard would be very costly to contribute to efficiency improvements of others, for example, thus reducing the overall costs of meeting the target.

A measure to improve efficiency and reduce fuel use would improve the efficiency of the fleet and thereby reduce emissions relative to a situation without the measure. However, even with efficiency improvements in the order of 40% up to 2050, Buhaug et al. (2009) project shipping emissions to increase. For the medium term (2020), UNEP (2011) finds that emission reductions relative to 2005 are only possible with the most stringent efficiency standards, under which the sector would incur high costs. The reason why shipping emissions are projected to increase is that activity and transport work will increase.

Hence, it is unlikely that the proposed measures alone will help the shipping sector to contribute to the overall emission reductions that are necessary to fulfil the 2°C target. For a reduction of (net) emissions of shipping, an MBM would be required that sets a cap on the total amount of emissions and allows for the use of offsets.

4.2 Potential synergies between measures to improve efficiency and reduce fuel use and MBMs

In principle, all proposed measures to improve efficiency and reduce fuel use could be supplemented with an MBM.

MBMs could be introduced in order to accommodate non-compliance with the standard for ships for which this would be costly or otherwise infeasible. The US proposal proposes ‘flexibility mechanisms’ for ships that are not in compliance, such as allowing them extra time to comply or exemptions. One could also imagine other flexibility mechanisms, such as pooling the obligations of groups of ships, or, to go one step further, efficiency credit trading between ships, which is the MBM previously proposed by the US (see, for example, MEPC 59/4/48, 60/4/12, and 61/5/16). Efficiency credit trading would be a suitable flexibility mechanism for the US metric, the Annual EEOI and the ISPI. A suitable flexibility mechanism for FORS would be emissions trading or offsetting.

Efficiency credit trading could be effective in reducing the costs of meeting an efficiency target, as ships for which meeting the target would be costly or otherwise infeasible could finance the efficiency improvements of other ships. However, efficiency credit trading would not limit the aggregate emissions of the fleet. Emissions could still increase because of an increase in the number of ships or in their activity, whether this is defined as hours at sea, miles sailed or tonne-miles covered.

Offsetting would be an obvious flexibility mechanism for ships failing to meet their target under FORS. For each tonne of CO_2 that they emit over their target, they could surrender an offset for an equal amount. In order to be environmentally effective, the quality of the offsets would thereby need to be guaranteed so that they are really worth a tonne of CO_2. Emissions could still increase because of an increase of the fleet, but other increases in activity (e.g. increasing the speed and/or the amount of miles sailed) would not lead to higher aggregate emissions. A next step towards an MBM could then be to relate the emissions target for individual ships under FORS to the emissions of the entire shipping sector so that when the fleet size increases, the target for individual ships becomes more stringent. This, in combination with offsetting, would effectively limit the emissions of the shipping sector. By also allowing ships that stay below their FORS target to generate offsets, one would arrive at a system that resembles emissions trading.

Alternatively, MBMs could be introduced independent of the measure decided upon. The argument for their introduction would then be that other goals than efficiency need to be met, e.g. reducing CO_2 emissions. MBMs aimed at reducing or capping CO_2 emissions would be an ETS or a GHG Fund. These MBMs could use the monitoring, reporting and verification systems developed as part of the measure. Which measure is chosen is perhaps not so important since all require monitoring fuel consumption.

In summary, there are two ways in which a measure to improve efficiency and reduce fuel use could co-exist with an MBM that also caps emissions. The first way would be to use the monitoring, reporting and verification requirements in the MBM. This could be combined with any of the proposed measures. The second way would be to introduce an MBM as a flexibility mechanism in FORS.

5 Conclusions

In the IMO there are currently four measures under discussion that aim to enhance the energy efficiency and to reduce the fuel consumption of ships:

- the US proposal, aiming to reduce the energy used per hour in service;
- the Annual EEOI proposal, aiming to reduce CO_2 emissions per tonne-mile of transport work or dwt-mile;
- the Individual Ship Performance Indicator (ISPI), aiming to reduce CO_2 emissions per mile;
- the Fuel Oil Reduction Strategy (FORS), aiming to reduce CO_2 emissions.

Several elements that will have an impact on the environmental effect of these measures have been analysed in this study and the following can be concluded in this regard:

- Both the US proposal and FORS can, in principle, be applied to all ship types and thus have the highest potential coverage of the fleet.
- The quicker a measure can be implemented, the sooner CO_2 can be reduced. From the four measures, FORS can be expected to be implemented the quickest since it does not call for a data collection phase and works with a readily available baseline.
- All four measures do in principle incentivise the adoption of operational as well as technical emission abatement measures; however, only FORS does so in a technology-neutral way. The other measures either reward slow steaming more than other options to reduce a similar amount of emissions (the US proposal) or less (the EEOI and the efficiency indicator). Fuel switching is not rewarded in the US proposal, even when it reduces emissions.
- By rewarding lower capacity utilisation, the US proposal and the ISPI give an incentive that is not desirable from an environmental point of view.
- For all four measures it holds that they contribute to a removal of the barriers that prevent ship owners investing in CO_2 abatement reduction measures: All measures require ship owners to take CO_2 abatement measures. Thus, on the one hand, the measures help to overcome the split incentive problem between ship owners and charterers. On the other hand, the lack of transparency in the market can be reduced by prompting the ship owners that have invested in emission abatement to credibly show that the energy efficiency of their ships has improved in order to earn back their investment via higher charter rates.
- None of the measures limits the total CO_2 emissions of the fleet. Regarding the emissions of the baseline fleet, i.e. the existing fleet by the time a measure is implemented, only FORS will ensure with certainty that these emissions will decline. This does not necessarily hold for the other measures as activity (distance covered, hours in service or transport work in tonne miles) of the ships may increase.
- Two design elements of the US proposal make the achievement of an environmental target uncertain: Firstly, if slow steaming was applied, CO_2 would have to be reduced less than if another measure was applied since the metric rewards slow steaming more than the actual emission reduction, and secondly, since the verification of 'hours in service' could turn out to be difficult, the actual 'hours in service' may deviate from the reported 'hours in service'.

There are two ways in which a measure to improve efficiency and reduce fuel use could co-exist with an MBM that also caps emissions. The first would be to use the monitoring, reporting and verification requirements in the MBM. This could be combined with any of the proposed measures. The second would be to introduce an MBM as a flexibility mechanism in FORS.

Table 2: Overview of the findings regarding the expected environmental impacts of the proposed measures and their potential evolution towards an MBM

		US proposal	Annual EEOI (real cargo load)	ISPI	FORS
Scope	Which part of fleet is covered?	Can be applied to all ships.	Can be applied to all ships whose primary purpose is to transport cargo and/or passengers.	Application to ship types that typically consume fuel whilst covering little/no distance (e.g. dredging vessels) may not be sensible. The Estimated Index Value is used for calculating a target correction factor but has not been calculated for all ship types by the IMO yet. Application to all ship types is thus not straight forward.	Can be applied to all ships.
Implementation time	Scheduled time	Data collection phase and pilot phase scheduled.	Data collection phase necessary.	Data collection phase necessary.	No data collection phase needed.
	Potential factors for delays/quick implementation	Commonly accepted definition of 'hours in service' and a baseline have to be established.	EEOI is an established metric within IMO. Baseline has to be established. Reservations about reporting real cargo loads.	Estimated Index Values have to be determined for some ship types. Baseline has to be established. Rewarding early movers enhances acceptability.	Rewarding early movers enhances acceptability. Baseline is readily available.

		US proposal	Annual EEOI (real cargo load)	ISPI	FORS
Incentivised measures	Are both types of measures (technical and operational) incentivised?	In principle, both technical and operational measures are incentivised.			
	Specific useful measures not/less incentivised	Fuel switching is not incentivised.[10]	Slow steaming could be less rewarded than other abatement measures if days at sea cannot be expanded sufficiently.	Slow steaming could be less rewarded than other abatement measures if days at sea cannot be expanded sufficiently.	
	Specific unwanted measures incentivised	Lower capacity utilisation is rewarded.		Lower capacity utilisation is rewarded.	
Removal of barriers	Split incentive	All proposed measures require ship owners to take CO_2 abatement measures and thus help to overcome the split incentive problem between ship owners and charterers.			
	Lack of transparency	Ship owners are required to take CO_2 abatement measures and thus have incentive to credibly show that energy efficiency has improved to earn back investment via higher charter rates.			

[10] See footnote 2 for a discussion of the climate benefits of a fuel switch.

		US proposal	Annual EEOI (real cargo load)	Efficiency Indicator	FORS
Environmental effectiveness	Is CO_2 of baseline fleet reduced if it complies with standard?	Not necessarily.	Not necessarily.	Not necessarily.	Yes.
	Is CO_2 of total fleet reduced?	None of the four proposed measures limits the total CO_2 emissions of the fleet. The annual EEOI and ISPI take into account that slow steaming may result in emissions of ships that are added to the fleet to make up for the lower transport work, whereas the US proposal and FORS do not.			
	Design elements that might give uncertainty whether environmental target is achieved.	If slow steaming is applied, CO_2 has to be reduced less than if another measure is applied. Environ. achievement ex ante thus unclear. Verification of 'hours in service' may be difficult; target achievement thus not clear.			
Interaction with a potential future Market-Based Measure (MBM)	Supplementary MBM	MBM without a cap on total fleet emissions: Efficiency credit trading.			MBM with cap: Emissions trading or offsetting.
	MBM independent of measure	MBM only makes use of the monitoring, reporting and verification requirements of the proposed measures.			

6 Illustrative Examples

In order to illustrate our findings on the environmental impacts of the four proposed measures under discussion (see section 3.2), we have calculated for three exemplary ships the indicators to which a standard would be applied per measure, as well as the impact that different CO_2 abatement measures would have on these indicators.

These calculations have been carried out for vessel types that reflect three different types of transport service, i.e. a large crude oil tanker, a medium size container vessel and a medium sized RoPax vessel.

The data used for the calculations stems from the Second IMO GHG Study. The data is therefore related to the year 2007 and do not represent the characteristics and activity of specific ships but of an average ship of a specific ship type/size category.

In the following table the characteristics and activities that have been used for the calculation are given.

Table 3: Characteristics and activities of exemplary ships

(rounded figures)	Crude oil tanker	Container vessel	Ferry
IMO size category	200,000+ dwt	5-7,999 TEU	RoPax, <25 kn
Average GT	155,700	70,300	4,700
Average cargo capacity (tonnes)	295,250	40,350	Not known.
Average capacity utilisation	48%	70%	Not known.
Average service speed (knots)	15.4	25.3	20
Distance covered per year (nm)	100,200	149,900	122,100
Transport work per year (million tonne-nm)	14,200	4,200	Not known.
Fuel type consumed	HFO	HFO	MDO
Fuel consumption per year (kt)	24.3	42.1	5.2
CO_2 emissions per year (kt)	77.0	133.7	16.3

Source: Second IMO GHG Study

Given these characteristics and activities of the three ship types, the following indicators can be derived for the different proposed measures:

Table 4: Indicator per proposed measure for exemplary ship types

(rounded figures)	Crude oil tanker	Container vessel	Ferry
US proposal (GJ/hour in service)	150	290	35
Annual EEOI (gCO2/tonne-nm)	5	32	28
ISPI (kgCO2/nm)	768	892	134

FORS (kt fuel)	24	42	5

According to the EEOI Guideline of the IMO, the transport work carried out by passenger ships, including RoRo passenger ships, should be calculated using the number of passengers or the GT. We have calculated the Annual EEOI.

If on the three ships a CO_2 abatement measure was applied that had no impact on the hours in which a ship is in service per year and also no impact on the cargo carried and the distance sailed by the ship per year, the application of such a measure would lead to the same relative change of the indicators per ship.

In the following, we will analyse the impact on the indicators of three CO_2 abatement measures where this is/could not be the case, i.e. where a CO_2 abatement measure does/could lead to a different relative change of the indicators for the very same ship and discuss the consequences.

Speed reduction

We assume the three ships reduce their average speed by 10% and the time per port call remains the same, with the result that each ship has a lower number of voyages per year, but each voyage takes longer, and the total time at sea per year increases. This has the following effects:

- Main engine fuel consumption is reduced by 19%;
- The hours at sea per annum increases because there are fewer port calls and less time is spent in port;
- The transport work and miles sailed decreases because there are fewer voyages per annum.

As a result, the US proposal will reward slow steaming more than FORS, and the other two indicators less. FORS is the only indicator that shows the same improvement in the indicator as the reduction in fuel consumption and CO_2 emissions:

Table 5: Relative impact of a 10% speed reduction on indicators

(rounded figures)	Crude oil tanker	Container vessel	Ferry
US proposal (GJ/hour in service)	-21%	-21%	-21%
Annual EEOI (gCO_2/tonne-nm)	-12%	-12%	-12%
ISPI ($kgCO_2$/nm)	-12%	-12%	-12%
FORS (kt fuel)	-19%	-19%	-19%

*Note that this is a rough calculation, for which the fuel consumption of the auxiliary engines and the boiler has been kept constant.

Lower capacity utilisation

A useful indicator should not reward a lower capacity utilisation of the ships.

Table 6: Relative impact on indicators if ships transport 10% less (assuming a 1% CO_2 emission reduction)

(rounded figures)	Crude oil tanker	Container vessel	Ferry
US proposal (GJ/hour in service)	-1%	-1%	-1%
Annual EEOI (gCO_2/tonne-nm)	+10%	+10%	-1%
ISPI ($kgCO_2$/nm)	-1%	-1%	-1%
FORS (kt fuel)	-1%	-1%	-1%

As Table 6 reveals, only the Annual EEOI penalises lower capacity utilisation, at least if the Annual EEOI is calculated by means of the real cargo carried. If the Annual EEOI of the ferry is calculated using the ship's nominal cargo (GT), the lower capacity utilisation is also not penalised by the Annual EEOI.

Fuel switching

A ship could decide to switch from, for example, Heavy Fuel Oil to Marine Diesel Oil in order to reduce its CO_2 emissions. Whereas the carbon content of MDO only differs slightly from the carbon content of HFO, the calorific value of MDO is higher for MDO, thus leading to a reduced amount of fuel that is needed to carry out the same transport work.

Table 7: Relative impact on indicators if ships switched from Heavy Fuel to Marine Diesel Oil

(rounded figures)	Crude oil tanker	Container vessel	Ferry
US proposal (GJ/hour in service)	0%	0%	0%
Annual EEOI (gCO_2/tonne-nm)	-4%	-4%	-4%
ISPI ($kgCO_2$/nm)	-4%	-4%	-4%
FORS (kt fuel)	-3%	-3%	-3%

As Table 7 reveals, a switch from HFO to MDO does not have an impact on the indicator of the US proposal; it does not incentivise fuel switching.

The impact on the indicator of the Annual EEOI and the ISPI is the same whereas the impact on the FORS indicator is lower. This can be explained by the fact that the FORS indicator is, in terms of fuel and not in terms of CO_2, the same as for the two other indicators.

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Monitoring, Reporting and Verification of CO_2 emissions from ships
Design options, their feasibility and implications

DISCUSSION PAPER

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Summary

The European Commission is currently working on a regional Monitoring, Reporting and Verification (MRV) system as an intermediary step towards a regional or a global regulation of the GHG emissions of maritime shipping. In this paper we discuss the implications and the feasibility of different design options of such a regional MRV system.

The European Commission has short-listed several regional market-based measures aimed at reducing the greenhouse gas emissions from maritime shipping for a stakeholder consultation and an impact assessment. These market-based measures differ with respect to the data that are needed for their implementation and the data that are needed post implementation. These data needs should be taken into account when choosing the parameters that would need to be monitored under an MRV regulation.

Assuming that ships have an incentive to improve the monitored elements over time, the direct effect of a stand-alone MRV system for CO_2 emissions would depend on the parameters to be monitored and on the options that are available to the ships to improve the monitored elements. If, for example, the operational efficiency of ships was monitored, a ship could apply technical as well as operational reduction measures to improve its operational efficiency, whereas if the technical efficiency of ships was monitored, a ship could only apply technical measures to improve its technical efficiency. The direct effect of an MRV system on CO_2 emissions would thus potentially be lower if the technical and not the operational efficiency of ships was monitored. However, independent of the parameters that are monitored, a direct effect of a stand-alone MRV system on CO_2 emissions can only be expected if the MRV system will provide additional insight to the actor that is actually paying for the fuel consumption of the ship.

There are certain mandatory documentation and reporting requirements in place that may offer useful data for an MRV system and thus could limit the additional costs of an MRV system.

Vessels of 400 GT and above have to record their fuel uptakes and have to keep Bunker Fuel Delivery Notes on board for a period of not less than 3 years according to Regulation 18 of MARPOL Annex VI. However, there are no legal requirements to measure and report fuel consumption of vessels. Nonetheless, fuel consumption is monitored on board of vessels for several purposes and will not require additional data collection. However, for some ships (mainly smaller and older ones), the accuracy of the data may be limited and only sufficient if measured over a longer period of time.

Monitoring the vessels' operational efficiencies requires the monitoring of distance sailed and cargo loads, too. Distance sailed data is readily available. Cargo load is also known to the ship operators, but the shipping industry prefers the cargo load to be derived through a formula based on the nominal load instead of working with the actual load per voyage.

If Europe required vessel operators to use technical installations on board ships for monitoring and reporting purposes or if new installations were required, it would likely create a conflict with the IMO and would need to be adopted by the IMO. However, if the monitoring and reporting mandates did not mandate particular technical installations on ships and are built around existing ones, no juridical conflicts would result and the system could benefit from the use of the existing technical monitoring and communication options.

Monitoring, reporting and verification of marine vessels for environmental purposes would not require additional institutions besides those already in existence for safety purposes. However, their legal mandate as well as their personnel and technical capacity may need to be expanded.

Since data monitored under the Ship Energy Efficiency Management Plan (SEEMP) do not have to be reported and verified, verification could be the value added of an MRV system, at least if it leads to an enhancement of the accuracy of the data monitored and thus to more transparency for the ship owner/charterer and shipper. At the same time, verification is associated with extra administration and thus extra administrative costs for both the reporting entity and public (national) administrations.

Regarding the format in which to monitor and report, the EEDI politically does not provide a suitable format, since the IMO has stated that it is not acceptable that the EEDI is applied to the existing fleet.

The EEOI is linked to the SEEMP and may be further developed. Both EEOI and EEDI offer valuable templates for designing an index to be used in an MRV system. In order to avoid political stalemate, an MRV system may identify its own index, for which both IMO indices offer good templates. The *Existing Vessel Design Index* is another example of an index system.

Zusammenfassung

Die Europäische Kommission arbeitet derzeit an einem regionalen MRV (*Monitoring, Reporting and Verification*) System zur Überwachung von, Berichterstattung über und Prüfung von Kohlendioxidemissionen aus dem Seeverkehr als einem Zwischenschritt hin zu einer regionaler oder globalen Regulierung von Treibhausgasemissionen der Seeschifffahrt. Im vorliegenden Papier diskutieren wir die Implikationen und die Durchführbarkeit verschiedener Ausgestaltungsoptionen eines solchen regionalen MRV Systems.

Die Europäische Kommission hat verschiedene regionale marktbasierte Maßnahmen zur Verringerung der Treibhausgasemissionen der Seeschifffahrt zum Zwecke der Befragung von Stakeholdern und der Folgenabschätzung in eine engere Auswahl genommen. Diese marktbasierten Instrumente unterscheiden sich darin, dass sie unterschiedliche Daten sowohl für ihre Implementierung als auch nach ihrer Implementierung benötigen. Diese unterschiedlichen Datenanforderungen sollten bei der Entscheidung der in einem MRV System zu überwachenden Parameter berücksichtigt werden.

Davon ausgehend, dass Schiffe einen Anreiz haben, die überwachten Parameter mit der Zeit zu verbessern, hängt der Effekt, den ein reines MRV System auf die Kohlendioxidemissionen der Schifffahrt haben würde, davon ab, welche Parameter überwacht werden und welche Möglichkeiten dem Schiff überhaupt zur Verfügung stehen, um die überwachten Parameter zu verbessern. Wenn beispielsweise die betriebliche Effizienz eines Schiffes überwacht würde, könnte ein Schiff sowohl technische als auch betriebliche Reduktionsmaßnahmen treffen, wenn hingegen die technische Effizienz eines Schiffes überwacht würde, könnte es nur technische Reduktionsmaßnahmen treffen, um seine durch das System erfasste Effizienz zu verbessern. Der potentielle CO_2-Reduktioneseffekt eines reinen MRV Systems ist dann erwartungsgemäß auch geringer falls die technische und nicht die betriebliche Effizienz der Schiffe überwacht würde. Unabhängig davon, welche Parameter überwacht werden, kann aber nur dann überhaupt ein direkter Effekt eines reinen MRV Systems erwartet werden, wenn das System demjenigen, der für den Kraftstoffverbrauch des Schiffes aufkommt, auch neue Einsichten liefert.

Es gibt derzeit schon bestimmte Überwachungs- und Berichterstattungsverpflichtungen, die nützliche Daten für ein MRV System liefern und somit die zusätzlichen Kosten eines MRV Systems beschränken könnten.

Was den Kraftstoffaufnahme betrifft, so müssen Schiffe mit 400 GT und größer gemäß Verordnung 18 von MARPOL Annex VI Bunker Fuel Delivery Notes für mindestens 3 Jahre an Bord bewahren, jedoch bestehen derzeit keine rechtlichen Verpflichtungen den Kraftstoffverbrauch zu messen und zu rapportieren. Nichtsdestotrotz wird der Kraftstoffverbrauch der Schiffe zu verschiedenen Zwecken an Bord erfasst und es wäre somit keine zusätzliche Datenerfassung erforderlich. Allerdings könnte die Genauigkeit der Daten, insbesondere bei kleinen und alten Schiffen, beschränkt und nur bei langfristigen Messungen ausreichend sein.

Das Überwachen der betrieblichen Effizienz der Schiffe erfordert die Erfassung der zurückgelegten Strecken und der jeweiligen Ladungen. Entfernungsdaten liegen hier vor. Zwar kennen die Reeder die Beladungen, doch würden sie es bevorzugen, wenn nicht mit der tatsächlichen Beladung, sondern mit einer Abschätzung mittels der nominalen Beladung gearbeitet würde.

Wenn Europa die Reeder verpflichten würde, technische Installationen zu Überwachungs- und Berichterstattungszwecken an Bord zu verwenden, so könnte dies zu einem Konflikt mit der IMO führen und müsste die Verpflichtung von der IMO angenommen werden. Falls eine MRV Verordnung aber keine spezifischen technischen Installationen vorschriebe sondern vielmehr bei den bestehenden Verpflichtungen anschlösse, sind keine juristischen Konflikte zu erwarten und könnte sich das System trotzdem der vorhandenen technischen Überwachungs- und Kommunikationsmöglichkeiten bedienen

Um zu Umweltzwecken ein MRV System für die Seeschifffahrt einzurichten, müssten neben den bestehenden Institutionen, die Sicherheitszwecken dienen, keine zusätzlichen Institutionen geschaffen werden. Allerdings müssten deren rechtliches Mandat, deren technische Kapazität und Personalbestand wohl aufgestockt werden.

Da die Daten, die im Zuge des *Ship Energy Efficiency Management Plan* (SEEMP) erfasst werden, nicht rapportiert und überprüft werden müssen, könnte die Überprüfung der Daten einen Mehrwehrt des MRV Systems darstellen, zumindest wenn die Überprüfung die Genauigkeit der Daten verbesserte und somit den Schiffseignern, Charterern und Verladern mehr Transparenz verschaffte. Andererseits ist eine Verifizierung der Daten mit einem zusätzlichen administrativen Aufwand und somit auch mit zusätzlichen Kosten für die rapportierende Instanz und die öffentliche Hand verbunden.

Was das Maß betrifft, in der es zu rapportieren gelte, so scheint der *Energy Efficiency Design Index* (EEDI) politisch gesehen nicht geeignet zu sein, da die IMO eine Verwendung des EEDI für bestehende Schiffe als nicht akzeptabel eingestuft hat. Der *Energy Efficiency Operational Index* (EEOI) steht im Zusammenhang mit dem SEEMP und könnte noch weiterentwickelt werden. EEOI und EEDI stellen wertvolle Ausgangspunkte für einen Index dar, der bei einem MRV System verwendet werden könnte. Um einen politischen Stillstand zu vermeiden, könnte ein MRV System mit einem eigenen Index arbeiten. Ein weiteres Beispiel für einen Index ist der *Existing Vessel Design Index*.

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1. Introduction

At the beginning of October 2012, the Vice-President of the European Commission and the EU Commissioner for Climate Action stated that it is their joint intention to pursue a monitoring, reporting and verification (MRV) system based on fuel consumption at EU level in early 2013. This MRV system would be a necessary starting point for intermediary steps towards further global measures next to the EEDI. Market-based mechanisms at EU level could thereby be an intermediary step.

This paper analyses the possible designs of MRV regulation, and specifically discusses how MRV regulation can be used as a first step towards an MBM and how MRV could be designed to have an effect on emissions itself. It starts with an analysis of the relation between MRV and MBMs in Section 2. Section 3 describes the availability of data and the additional monitoring requirements. Reporting is discussed in Section 4 in connection with existing reporting requirements. Section 5 discusses verification and Section 6 the potential metric of an MRV system.

The paper focuses on monitoring, reporting and verification of ship emissions. It does not discuss in detail *who* should be reporting and which entity would be the best recipient of the data.

Note that the different design elements as specified by the European Commission in its proposal for a regulation on the monitoring, reporting and verification of CO_2 emissions from maritime transport as published at the end of June 2013 are not discussed in this paper.

2. MRV and MBMs

The choice of the data that would need to be monitored and reported by the maritime shipping sector under a mandatory MRV system is crucial for two reasons: Firstly, it can have an impact on the feasibility of the future implementation of specific market-based instruments and, secondly, it will have an impact on whether and to what extent the MRV system as such can prompt the sector to take measures to reduce GHG emissions.

In this chapter we will therefore first analyse the data needs of the different market-based measures that had been short listed by the European Commission.

The data that could be gathered with an MRV system will depend on the geographic scope to which it will be applied. In the second section of this chapter we therefore relate the data needs of the different market-based measures and the data that could be gathered under an MRV system, depending on the scope of implementation.

In the third section of this chapter we analyse how an MRV system should be set up to be most effective in terms of CO_2 emission reductions.

2.1. Data needs stemming from different MBM options

The following nine types of market-based measures had been shortlisted by the European Commission for an impact assessment and stakeholder consultation (EC, 2012):

- Compensation fund:

    - contribution-based,
    - target-based:
        - overall target based on historical transport performance,
        - overall target based on historical emissions,
- Emissions trading scheme (ETS),
- Bunker fuel tax,
- Emissions tax (ET),
- Mandatory emission reduction per ship:
    - with a target related a historical emission baseline,
    - with a target related to:
        - an operational efficiency index,
        - a technical efficiency index.

These market-based measures differ with respect to the data that is needed for their implementation and with respect to the data needed after the measures have been implemented. Seven main categories of data can thereby be differentiated:

Depending on the choice of market-based measure, the following data may be needed prior to the implementation of measures:

1) CO_2 emissions of the fleet.
2) CO_2 emissions per ship.
3) Activity of the fleet.
4) Activity per ship.

Again, depending on the choice of instrument, the following data may be needed after implementation of measures:

5) CO_2 emissions per ship.
6) Activity per ship.
7) Fuel purchased in the EU.

The activity of a ship or the fleet could thereby mean different things, e.g. nautical miles sailed or nautical tonne/TEU miles or nautical dwt/GT miles.

In Table 1 an overview is given on the different market-based measures under consideration at EU level and their data needs concerning the seven data categories.

Table 1: Data needs of market-based measures under consideration at EU level

		Contribution based comp. Fund	Target-based comp. fund; overall target based on historical transport performance	Target-based comp. fund; overall target based on historical emissions	ETS	Bunker fuel tax	Emissions Tax	Mandatory emission reduction per ship (target related to historical baseline)	Mandatory emission reduction per ship (target related to operat. eff. index)	Mandatory emission reduction per ship (target related to techn. eff. index)
Data needs for implementation	CO_2 emissions of fleet			For determining overall target.	To determine baseline/cap.					
	CO_2 emissions per ship		For dividing target between funds.	For dividing target between funds.	If allowances allocated on basis of historical emissions.			To determine baseline/cap.	To determine baseline index.	Under standard conditions.
	Activity of fleet		For determining overall target.							
	Activity per ship				If allowances allocated on basis of output benchmark.				To determine baseline index.	
Data needs after implementation	CO_2 emissions per ship	To control contribution payments	To control whether target is met.	To control whether target is met.	To determine amount of allowances to be submitted.		To determine tax debt.	To control whether target is met.	To control whether target is met.	To control whether target is met (under standard conditions).
	Activity per ship								To control whether target is met.	
	Fuel purchased in EU					To determine tax debt.				

From Table 1 it becomes clear that for three policy options, neither emissions nor activity data are a necessary condition for implementation:

- A contribution-based compensation fund,
- A bunker fuel tax,
- An emissions tax,

since the minimum fee that the EU will prescribe the contribution fund(s) and the tax rate of a bunker fuel/emissions tax can be decided on politically.

For two instruments both emissions and activity data are a necessary condition for implementation:

- An ETS with the allowances allocated on the grounds of an output benchmark, and
- a mandatory emission reduction per ship with a target related to an operational efficiency index.

For four instruments only emissions data are a necessary condition for implementation:

- A target-based compensation fund with an overall target based on emissions,
- An ETS with the allowances not allocated on the grounds of an output benchmark,
- A mandatory emission reduction per ship with a target related to a historical baseline,
- Mandatory emission reduction per ship with a target related to a technical efficiency index (where the emissions are measured under standard conditions).

And finally, for one instrument only activity data are a necessary condition for implementation, i.e. for a target-based compensation fund with an overall target based on historical transport performance.

Note that the aggregation level of the data that is needed for implementation differs between instruments. For an Emissions Trading Scheme with allowances that are auctioned, emissions data on *flee*t level are sufficient for implementation and for a target-based compensation fund for which the overall target is based on historical transport performance activity data on *fleet* level are sufficient for implementation.

Also the meaning of activity of a ship/fleet differs between the policy measures. In the IMO proposal of the US for an operational efficiency standard (MEPC 64-5-6) distance sailed, cargo mass carried or work done per tonne mile are specified. When the EEOI would be used under a SEEMP, the distance sailed and the cargo mass carried per tonne mile would have to be monitored on a route basis.

After implementation of the measures, for all measures, except a bunker fuel tax, CO_2 emissions data per ship are needed. Under a technical emission standard, these data stem from a test per “rating cycle”.

2.2. MRV system and data needs of MBMs

An MRV system could be implemented at EU level in four different ways. An obligation to monitor and report data could be imposed

- on all ships in EU ports

  a. on routes to/from EU ports,
  b. on all routes;

- on EU-flagged ships:

  a. on routes to/from EU ports,
  b. on all routes.

It can be expected that a market-based measure will be implemented flag-neutrally and on routes to/from EU ports. Therefore, only when using the first option (1.a.) the data necessary for the implementation of measures with an overall emission target, i.e. an emissions trading scheme and a target based compensation fund, could be gathered.

Data relevant for a ship specific emissions cap would be gathered under options 1.a. and 2.a., whereby under the second option (2.a.) a smaller share of the ships that would fall under the market-based measures would be covered. But also for the first option (1.a.) it holds that ships that start to sail on routes to/from Europe at a later point in time would not be covered in the MRV system phase; this is inherent to this market-based measure.

Since the monitoring of data of EU-flagged ships is probably easier to implement, it is a conceivable option, too. Data gathered from EU-flagged ships only could, independent of whether the third or the fourth option is applied, be used to determine the average operational efficiency of ship types, which could be used to determine a baseline for an operational efficiency standard.

2.3. How to get maximum effect from MRV system?

In Figure 1 a stylised representation of the factors that determine total maritime CO_2 emissions is given. It also allows the factors to be identified that determine CO_2 emissions on ship level.

The CO_2 emissions of a ship are, in the first instance, determined by the ship's operational CO_2 efficiency (CO_2 emissions per unit of transport work) and the transport work that is carried out by the ship (e.g. in terms of tonne miles).

A ship's operational CO_2 efficiency depends on three main factors: the technical energy efficiency of the ship, the carbon content of the fuel used, and on different operational factors, such as the speed at which the ship is sailed, how well the ship is maintained or the route that is chosen.

Total transport demand, ship size, the ship's relative transport price (compared to other ships and other transport modes) together with logistic factors (determining, for example, the ship's load factor) and the speed determine its transport work. The ship's operational CO_2 efficiency thereby has, via fuel costs, an impact on the ship's relative transport price.

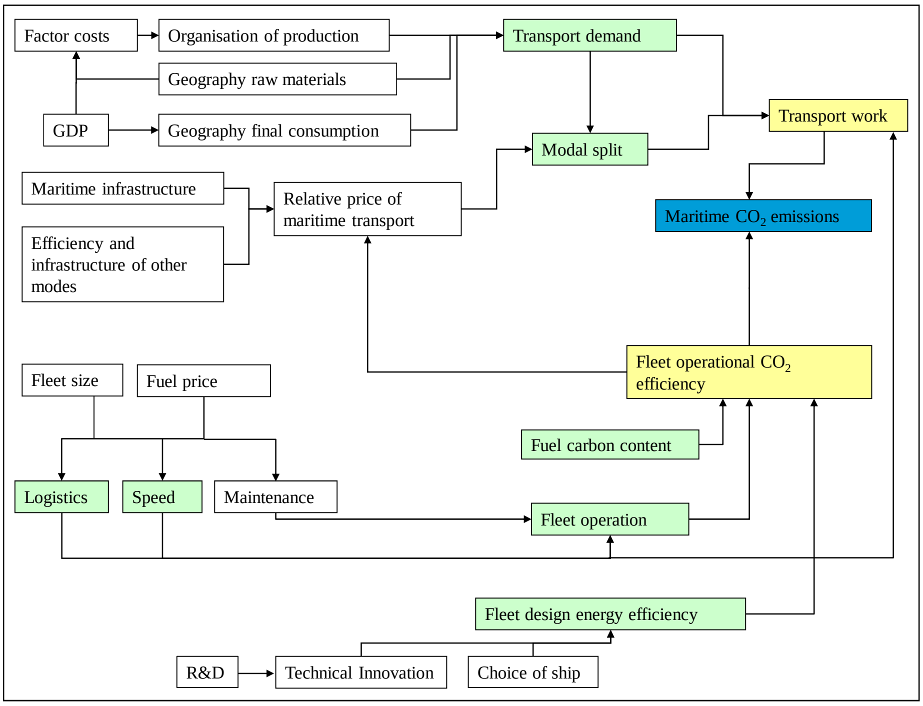

Figure 1: Stylised representation of factors that determine total maritime CO_2 emissions.

From Figure 1 it becomes clear that the effect of the MRV system on CO_2 emissions will differ depending on the data that is monitored, simply because the number of options to bring about an improvement of the data monitored differs:

If CO_2 emissions are monitored (e.g. from fuel consumption in combination with carbon content), then the maximal number of options can be used to effect an improvement of the data monitored, whereas monitoring of the technical efficiency of a ship will only incentivise the adoption of technical measures.

However, if operational CO_2 emissions are the only value monitored, this would probably not give enough transparency, since a reduction of CO_2 emissions does not necessarily mean that the operational CO_2 efficiency of a ship has been improved. It could simply be brought about by less transport work having been carried out.

Monitoring operational CO_2 efficiency, i.e. monitoring both operational CO_2 emissions and the transport work carried out thus seems to be the better option. This still gives the opportunity to effect an improvement of CO_2 emissions in all possible ways but at the same time gives transparency too.

If both CO_2 emissions and transport work are to be monitored, the question remains on what level of aggregation and using what values this would be carried out. Ideally one would like to know the emissions, the cargo mass transported and the distance sailed per voyage, just as under the EEOI. However, the sector may be reluctant to report data like the cargo mass transported per route, since this may be business-sensitive information (for detailed information on the EEOI and its appraisal by stakeholders see 6.2). The use of an alternative approach may therefore be necessary:

- CO_2 emissions and transport work could be monitored per voyage as described above, but only total CO_2 emissions and the efficiency index (total CO_2/total tonne nautical miles) could be reported.
- When determining the transport work an average load factor (including empty voyages) could be applied to the cargo capacity of a ship. In this case total CO_2, total relevant nautical miles and maximum cargo capacity would have to be reported.
- Instead of working with the transport work, the tonnage of a ship could be used so that total CO_2, total relevant nautical miles and dwt/GT would have to be reported.

The first alternative approach is still the most accurate; it has, however, the disadvantage that verification of the data is restricted.

The advantage of the second and the third alternative is that no data needs to be monitored and verified that may be business-sensitive and that less data needs to be monitored and verified. This however comes at the cost of less transparency. An MRV system making use of the second and third alternative approach still incentivizes the use of all possible CO_2 reduction measures (numerator of index will decline) but this may be rewarded less than optimally. When increasing the load factor, the denominator of the index (transport work done) will not adjust accordingly.

The impact of an MRV system on the CO_2 emissions of ships will not only depend on the data that will be monitored. For an MRV system to have an impact on a ship's CO_2 emissions, it also has to give additional insight to the party that is paying for the fuel consumption of the ship and this party should be able to take measures to bring about an improvement of the data monitored.

If the data to be monitored under an MRV system are already being monitored for internal purposes or will be monitored after implementation of the Ship Energy Efficiency Plan (see 6.1.1 for more information), it is very likely that the additional effect on CO_2 emissions will be rather small. An additional effect could stem from the verification of the reported data under an MRV system which is not being carried out under the SEEMP, assuming that verification leads to a higher accuracy of the data monitored and thus to a higher transparency. Only if the sector is provided with feedback e.g. by giving information on averages to provide the sector with a kind of benchmark and/or if the reported data would be published, to give the shippers the opportunity to choose a relative clean ship, can a significant additional emission reduction be expected from an MRV system. The latter, i.e. the publication of the data, may however lessen the acceptance of an MRV system.

Independent of whether an MRV system will have an additional CO_2 emission reduction effect, it will provide data that is necessary for the implementation of market-based measures. Three market-based measures have been identified, for the implementation of which activity data is necessary and for which the choice of the data to be monitored is thus crucial:

- A target-based compensation fund with an overall target based on historical transport performance,
- An emissions trading scheme where the allocation of the allowances is based on an output benchmark,

- Mandatory emission reduction per ship with a target related to an operational efficiency index.

For the target-based compensation fund and for the emissions trading scheme this could mean that an alternative design could be preferred, i.e. a target-based compensation fund with an overall target based on emissions and an ETS where the allocation of allowances is not based on an output benchmark (e.g. auctioning) or that the definition of activity is selected according to the definition chosen under the MRV system. The latter would probably be the case for the mandatory emission reduction per ship with a target related to an operational efficiency index.

2.4. Conclusion

The market-based measures (MBMs) that had been shortlisted by the European Commission for a stakeholder consultation and an impact assessment differ with respect to the data that are needed for their implementation and the data that are needed after their implementation.

A Monitoring, Reporting and Verification (MRV) system can be implemented on different levels. If all ships sailing to/from EU ports have to use an MRV system, the data collected with the MRV system are most suitable for a later implementation of a MBM. The monitoring of data of EU-flagged ships might, however, be easier to implement. Data gathered from EU-flagged ships could be used to determine the average operational efficiency of ship types, which could be used to determine a baseline for an operational efficiency standard.

The effect of the MRV system on CO_2 emissions will differ depending on the data that is monitored, because the number of options to effect an improvement of the data monitored differs respectively. From this point of view the monitoring of operational CO_2 emissions would be the best option, however, limiting monitoring to this would probably not give enough transparency, since a reduction of CO_2 emissions does not necessarily mean that the operational CO_2 efficiency of a ship has been improved. Monitoring both operational CO_2 emissions and the transport work carried out thus seems to be the best option. Working therefore with an index that is comparable to the EEOI, seems only to be an option when, due to business sensitivity, not all data that is needed for the calculation of the index would have to be reported. Alternatively, the transport work incorporated in the index could be determined by applying an average load factor to the cargo capacity of a ship or, instead of working with the transport work, the tonnage of a ship could be utilized.

The effect of the MRV system on CO_2 emissions will also depend on whether it will give additional insight to the party that is paying for the fuel consumption of the ship and this party should be able to take measures to bring about an improvement of the data monitored.

If the data to be monitored under an MRV system are already being monitored for internal purposes or will be monitored after implementation of the Ship Energy Efficiency Plan (SEEMP), it is very likely that the additional effect on CO_2 emissions will be rather small. An additional effect could stem from the verification of the reported data which is not being done under the SEEMP, assuming that verification leads to a higher accuracy of the data monitored and thus to a higher transparency. Only if the sector is provided with feedback, e.g. by giving information on averages to provide the sector with a kind of benchmark and/or if the reported data would be published, to give the shippers the opportunity to choose a relative clean ship, can a significant additional emissions reduction be expected from an MRV system. The latter, i.e. the publication of the data, may however lessen the acceptance of an MRV system.

Independent of whether an MRV system will have an additional CO_2 emission reduction effect, it will provide data that is necessary for the implementation of market-based measures. The choice of the data that needs to be monitored and reported under an MRV system can thereby have an impact on the market-based measure that could be implemented at a later stage, since for the implementation of some MBMs activity data are a necessary condition. For the target-based compensation fund and for the emissions trading scheme this could mean that an alternative design could be preferred, i.e. a target-based compensation fund with an overall target based on emissions and an ETS where the allocation of allowances is not based on an output benchmark or that the definition of activity is selected according to the definition chosen under the MRV system. The latter would probably be the case for the mandatory emission reduction per ship with a target related to an operational efficiency index.

3. Monitoring

3.1. Discussion of availability of data on board ships / in shipping companies

There are certain mandatory documentation and reporting requirements that may offer useful information for MRV:

- Bunker Fuel Delivery Notes (MARPOL Annex VI Reg. 14 & 18)
- Devices that measure and indicate operational parameters, such as speed (vessels >300 GT), heading, propeller revolution, force and direction of trust etc. (vessels >500 GT). (SOLAS Chapter V Regulation 19)
- Automated signals that provide information including position, course and speed. (SOLAS Chapter V Regulation 19)
- Pre-port-arrival notification requirement and list of ten last port calls. (Directive 2010/65/EU)
- Vessel registration, IHS Fairplay, formerly Lloyds Register Fairplay.

MARPOL Annex VI Regulations 14 and 18 require vessel operators to document certain information with regard to fuels and make them available to the responsible authorities. Regulation 14 covers aspects with regard to fuel sulphur levels and regulation 18 with regard to fuel quality. One part of the documentation and reporting are the Bunker Fuel Delivery Notes (BDN). The BDN provide details on the amount, quality, date, time and location of fuel uptakes. Details have to be recorded in a logbook – either a separate logbook, the official logbook or other specific logbooks.

SOLAS V, Regulation 19 sets high standards for internationally travelling vessels of 300 GT and upwards and all passenger ships. The purpose of SOLAS V Reg. 19 is to enhance safety at sea. It establishes the construction, design, equipment, and manning standard on board vessels that must be implemented. Furthermore, it establishes the Automated Information System (AIS), which offers the ability to track the position and heading of ships.

With Directive 2010/65/EU, the European Parliament and Council establishes the reporting requirements for safety and security purposes for vessels bound to a European port. Vessels have to report certain information, including a list of the past ten ports, 24 hours ahead of arrival or at least upon departure of a port if less than 24 hours away.

The mandatory vessel identification and technical vessel information, such as installed power, is stored in the IHS Fairplay database. This data can provide a sound basis for verifying fuel consumption through modelling.[1]

However, besides BDN information, there are no legal requirements to measure and report fuel consumption of vessels. Nonetheless, fuel consumption is monitored on board of vessels for several purposes.

International marine shipping has become an advanced competitive industry and plays a vital role in the global economy. As such, modern vessels that are engaged in international trade[2] are high tech products. Marine engineers seek solutions to accommodate today's needs of marine vessel operators and charterers, for example to accurately determine fuel consumption for chartered vessels (CE Delft 2009). Technical innovation has influenced the management on board ships and determines the data available on board as well as the capabilities of data transfers.

There are two parameters of significant importance for monitoring the environmental performance of ocean going vessels, i.e. the emissions of greenhouse gases and airborne toxics: the amount of fuel burned and the amount of energy generated. The first directly correlates with the greenhouse gases released. It also indicates the emissions of sulphur oxides and particulate matters in relationship to the fuel quantity and quality. The second, in combination with technical engine data, in particular indicates the emissions of nitrogen oxides and hydro carbons. Thus the monitoring of fuel and energy are the two prime parameters to be measured for environmental management purposes.[3]

The cost of fuel plays a significant role with regard to the overall cost for the operators. It influences the freight rates and the profitability of ocean shipping. However, the impact of fuel cost differs with the marine service types, in particular between liner services and bulk services

1 IMO has agreed to use IHS Fairplay database for calculating the EEDI of new ships. It should be noted that the privatization of the vessel registration data, including data on the technical setting of the ship and its cargo capacity, makes vessel analysis for scientific purposes difficult and at least very expensive. In the past, many inventory analysis where based on the former version, the Lloyds Register Fairplay, which was publicly available in libraries up to 2009/2010 edition. Today, this officially collected data can only be obtained electronically and for very high fees. The monopole of IHS on the vessel data may create barriers for using it for verification purposes in the future.

2 Internationally travelling cargo vessels account for approximately 45 % of the number of ships, while they represent about 90 % of the marine gross tonnage (IMO 2009).

3 The measurement of airborne emissions in the stacks of ocean ships is not a proven technology. Besides technical difficulties (e.g. large air flow volume, heterogeneous exhaust flows), exhaust gas monitoring would need to prove viable in the extreme conditions at sea.

(UNCTAD 2010). Nonetheless, optimizing fuel consumed per transport work is one mechanism to improve profitability and is thus in the interest of vessel operators (or charterer if they are obliged to pay the fuel bills[4]).

However, monitoring fuel consumption and other parameters also serve other needs, such as scheduling of hull maintenance. The amount of fuel used per transport work is determined by several key performance indicators:

- Fuel used per shaft energy output; indicates for example engine maintenance needs.
- Energy per log of the ship (speed relative to the water); indicates for example level of hull and propeller fouling.
- Speed over ground, distance sailed and ahead; can be optimized according to planned arrivals.
- Wind and ocean currents; necessary information to evaluate engine and ship performance data.

Modern ship management focuses on those key performance indicators to improve overall vessel efficiency. Several marine service firms offer vessel management solutions that include technical components (i.e. fuel flow meters), hard and software components as well as onshore management components. The (voluntary) Ship Energy Efficiency Management Plan as adopted by the IMO creates additional incentive to implement advanced and real time monitoring on board of vessels. Chartered vessels report in so-called noon reports the fuel levels ones per day.

The fuel storage and flow system on large ocean going vessels, provide the setting that offers several methods of fuel monitoring on ships. In order to assess the technical options for fuel monitoring, it is important to understand the technical principles of vessel's fuelling systems.

The vast majority of ocean vessels operate on heavy fuel oil (HFO). HFO need to be heated to become pumpable and purified to avoid damage of the injection system and the engine. The fuel is stored at around 40 °C in the main tanks (usually multiple), from which they are pumped to settling tanks. Here they are heated to about 70 °C and some water and solids are separated. From the settling tanks the fuel is processed in separators, which are heated centrifuges. The impurities are collected and withdrawn as sludge and the fuel is pumped in day tanks. From here the fuel is processed in boilers and brought to 7 to 10 bar pressure and 130 °C. The fuel is then filtered and pumped to the injection pumps that take up the fuel needed. The rest fuel is circulated back to the day tank or settling tank, after being cooled down. In addition, marine vessels may contain tanks for different fuel types, for example Marine Diesel Oils that may be blended with HFO or used in certain locations.

At the minimum a vessel master tracks its fuel consumed over a period of time in order to plan fuel uptakes. This may be done by measuring the main tank fuel levels (tank sounding), or by

[4] It is common practice that charterers pay for the fuel consumed. Therefore, charter contracts include provisions to determine the fuel on board at the beginning and at the end of charter contracts as well as for measuring and reporting fuel per voyage. Hereby, speed data are used to check the plausibility of fuel consumption data, taking weather conditions into account. Fuel consumption data are usually verified at the end of the charter by third party verifiers.

measuring the fuel inflow in the day tanks via flow through meters or calibration tanks (see CE Delft 2009, Oeko-Institut et al. 2011). The vessel master may then determine the times and amount of fuel uptakes that are necessary. However, those simple fuel measurements are not sufficient to manage a vessel by using the above key performance indicators.

The vessel management with key performance indicators requires a more detailed monitoring of fuel flow, energy output and speed. For this purpose fuel flow meters are placed at the inflow and outflow of the fuel injectors. The delta then provides the amount of fuel burned at any given time[5]. This fuel consumption provides valid information for the vessel operator, when analysing it against energy output and speed data.

This advanced vessel monitoring is often paired with knowledge, monitoring and forecast information of the weather and the ocean currents on the route. Today, many vessels are being managed from shore based stations that bundle and process a large amount of vessel monitoring, weather and ocean current data.[6]

Thus it can be concluded that fuel consumption data exists on board of all vessels. The vast majority of large vessels likely have technical installations that provide highly accurate real-time fuel consumption figures, while smaller and older vessels may only have capabilities to measure fuel consumption in longer time periods. The fuel consumption information may be stored and processed electronically or manually in log-book entries.

3.2. Monitoring vessel efficiency

One stated goal of a European MRV system is to improve the vessel's efficiency. Thus, vessel efficiency itself may be monitored. A similar effort is made through the SEEMP, which is a voluntary management plan to improve the vessel's fuel efficiency.

Determining the vessels' efficiencies is based on

fuel consumed divided by distance sailed and cargo loaded

It is apparent that efficiency factors are most sound if they are based on primary measured data. Thus the above on fuel measurement also applies.

The additionally challenging aspects are distance monitoring and cargo load monitoring. Here too, it would be most accurate to base it on real data.

For a detailed discussion on distance monitoring see Oeko-Institut (2011). In short, automated distance monitoring would need to rely on existing equipment on ships, which would be technically sufficient to do so. However, currently the AIS signals are not captured sufficiently by satellites in order to provide a near global coverage. Furthermore, it is questionable whether AIS data captured by private satellite organisations can legally be used for regulatory purposes. LRIT signals are dedicated signals sent by ships to authorized States that requested it. Thus, to

5 Normalized to the fuel's density and carbon content.

6 Companies that offer vessel management solutions including technical fuel and engine monitoring include Kongsberg Maritime, ABB Marine, KRAL and Krill Systems. Integrated vessel and fleet management is offered by many service firms and the marine classification societies.

date, LRIT signals may be used for communications, but do not provide the basis for continuous distance monitoring.

However, the distances sailed are known to the Master of the vessel and information is kept in the official logbook. Furthermore, some data, i.e. the last ten ports, already have to be reported to European Port State authorities. Thus distance sailed data is easily available and could be requested for any time in the past in order to be used to calculate the vessel's efficiencies. The question is who is demanding it, how is the information being communicated (transmitted), and who is processing the data. In Oeko-Institut (2011) it is concluded that Port States would have the authority to demand it; that it would be best left up to the vessel master whether to use LRIT, fax or online forms to submit the data; and that a European centralized processing would reduce double data acquisition and burdens for the vessel operators.

The other challenging aspect is the real cargo load. Cargo load on vessels is a competitive aspect and it is unlikely that vessel operators are willing to disclose this information easily. From experience gathered managing the Clean Cargo Working Group, it is a fact that information on vessel utilization, empty voyages etc. is used to negotiate freight rates. Vessel operators happily overbook vessel spaces and then find solutions through freight sharing in alliances and additional charter. However, they do not want to be known to have “empty” spaces on vessels because it immediately would be used by customers to negotiate for lower rates. Thus, it is unlikely that cargo load information would be provided to national authorities.

At the same time, cargo information may be obtained through the bill of ladings. Theoretically, Port States could withdraw the information of the cargo unloaded and loaded in their ports. However, to determine cargo load on voyages is tedious and probably unfeasible for vessels in liner services that often also unload and load cargo in ports of States not part of the same regulation.

A third option to the cargo load determination may be the use of the nominal capacity and pre-defined cargo utilization factors. This approach is used in modelling vessel emissions for geographic inventories (IMO GHG Study, US port studies). The nominal vessel capacity is part of the vessel information in the IHS Fairplay database or could be demanded as a data point by a MRV scheme. Average utilization factors could be derived through trade and cargo analysis for different type of vessels. The resulting cargo load figures would be less accurate than those based on prime data, but would offer a fair manner for vessel operators to assess their vessels' efficiencies. Moreover, using real cargo load data might be even unfair, because it would make the vessel's efficiencies dependent on aspects of cargo flows, for which the vessel operators have no control. For example, if an economic downturn reduces the capacity utilization, the vessel efficiency would decrease as well.

Monitoring the vessel efficiencies is principally possible by using fuel consumption data and records about the distances sailed. Cargo load should be derived through a formula based on the nominal load. A vessel efficiency monitoring would be close to the approach of the EEOI, but should be named and designed specifically for the MRV purpose. Using the EEOI term may create friction with the stakeholders at the IMO that do not want the EEOI to be used for regulatory purposes (for detailed information on the EEOI and its appraisal by stakeholders see 6.2.2).

3.3. Discussion of relationship between monitoring needs and "scope", i.e. geographical scope

One variable of the proposed European MBM and MRV for marine shipping is the geographical scope. While stakeholders in Europe have emphasized that a global system, implemented through the IMO, would be preferred, Europe may go ahead with a regional system. With regard to the geographical scope of a regional system, three concepts have been elaborated so far:

- Covering all ships within the territorial waters or EEZ.
- Covering all distances of ships voyages with destination at a European port and leaving a European port.
- Covering all vessel activities within a given time frame, e.g. one year.

As we have discussed previously vessels may, as a minimum, collect information of fuel consumed in a period of time in order to plan fuel uptakes and at maximum conduct real time key performance parameter monitoring, potentially combined with shore-based vessel and fleet management. Those two levels of sophistication have ample influence on the feasibility of monitoring requests and result in different additional burden depending on the mandated monitoring information.

Example: vessel that measures fuel in time intervals through tank soundings:

- The vessel could relatively easy report on the fuel consumed over a period of time (e.g. one year). BFDN and voyage data could serve as verification data.
- Fuel consumed for particular voyages could also be monitored with a degree of accuracy, by measuring the tank levels at the beginning and at the end of the voyage.
- The determination of fuel consumed on parts of particular voyages (e.g. EEZ) is rather difficult because tank soundings at sea are challenging and inaccurate. Options would include determining the overall vessel efficiency (based on past period's reporting) and using those factors for the distances sailed.

Example: vessel that continuously measures and monitors key performance parameters including fuel consumption:

- The vessel could easily report on the fuel consumed over a period of time (e.g. one year). BFDN and voyage data could serve as verification data.
- The vessel could relatively easily supply parallel data on fuel consumption and distance sailed. Therefore, it also could start reporting its fuel consumption at any given point during a voyage up to an ending point. The reporting would create little additional burden for the vessel's crew.

For verification purposes the vessel's log-books, the BFDN and other information (such as port of calls, distance information, AIS observations, etc.) could be used by the adequate authorities (CE Delft 2009, Oeko-Institut 2011). While the IMO stated that the EEOI should not be used for regulatory purposes, it is nevertheless technically and legally feasible for authorities in the EU to apply similar modelling of vessel performances in order to check the plausibility of reported data[7].

4. Reporting

4.1. Comparison of communication / surveillance options ship to shore.

The question of using existing installations for communication and surveillance is rather a question of communication than of monitoring. If Europe required vessel operators to use technical installations on board of ships for monitoring purposes, it could create a conflict with other States that could only be avoided by adopting IMO regulations on monitoring equipment. However, if the monitoring requirements can be met using existing installations on ships, they could still benefit from the technical capabilities of communication options. For example, a MRV could mandate the fuel to be monitored and reported but leave the monitoring techniques to the ship operators. Technical data and distance data could be used to check occasionally for plausibility, similar to the reporting between vessel operator and charterer. The data could be requested by the Port State, conditionally upon calling at a port, but the means of transmission could be left open. Vessel operators could then choose those means that create the least additional burden, which might, for example, be LRIT signals. Therefore, the following only lists vessel-to-shore communications and surveillance options without suggesting using those directly for monitoring purposes.

System	Type	Prime Purpose	Receptor	Data Processor
AIS	VHF signal sender - receiver	Safety	Ship to ship; onshore antenna	Ships; Marine safety organisations
AIS	VHF signal satellite receiver[8]	Private vessel tracking	Ship to shore by satellite	Corporate
LRIT	Satellite communication; Inmarsat	Safety, national security	Data Center Port State	Maritime Administration
Text messaging	Satellite communication; Inmarsat	Communication, fleet management	Ship to Corporate and other recipients	Corporate, Maritime Administration
Email	Like text messaging	Communication	Crew to recipients	NA
Fax	Like text messaging	Communication	Like text messaging	Like text messaging

7 The monitoring of vessels' fuel consumption would not require information on the transport work of the vessel, which is part of the EEOI. Since transport work information, such as cargo utilization, is sensitive corporate data, modelling without this information may increase the acceptance by vessel operators.

8 As mentioned above, most vessels in commercial transport are equipped with AIS. The World's Radio Communication Conference allows the two AIS frequencies AIS-1 and AIS-2 to be picked up by satellites. Thus AIS signals received by satellites expand the geographic reach of AIS coverage. However, its legal use for regulatory purposes is not yet determined.

Marine communications can be differentiated into short range and long range communications. Short range communications use very high frequency (vhf) signals similar to radar signals. The Automatic Identification System (AIS) uses vhf signals. Its range is similar to the range of sight and dependent on the height of the antenna.

Long range communications rely on satellite receptors, i.e. the Inmarsat system, a private organisation under the host of the International Mobile Satellite Organisation (IMSO). Inmarsat was launched in 1979 by the IMO to enhance vessel safety at sea. Satellites today can receive Long Range Identification and Tracking (LRIT) signals, as well as regular text, email and fax messages. The Inmarsat system has a near global coverage, except pole ward of 70° North and South.

4.2. Institutional requirements for European port States and non-Port States

Maritime administrations for communicating with vessels and for observing territorial waters already exist in all Port States. Furthermore, a dense network of AIS shore receivers is installed along the European coast. The data of the AIS network is processed by the maritime administrations.

LRIT data has to be submitted to Port States, once the ship has indicated a port arrival or if it is within 1000 nautical miles off shore and not within the jurisdiction of another State. The receptors are also the maritime administrations.

The European Council of Ministers adopted in October 2007 a Council Resolution that established the European LRIT Data Centre. The LRIT data centre is housed at the European Marine Safety Agency (EMSA). EMSA is also the centralized data centre for AIS data of EU Member States. The network of AIS data and its exchange is called SafeSeaNet (SSN), operated for EU Member States as well as Norway and Iceland (EMSA 2010). (For further discussion on AIS, LRIT and SSN see Oeko-Institut 2011).

The monitoring of marine vessels for environmental purposes would not require additional institutions besides those already in existence for safety purposes. However, their legal mandate as well as their personnel and technical capacity may need to be expanded. It seems beneficial to further strengthen European Institutions and centralize the data processing, considering that many vessels call at European ports of different Nation States. (For further discussion of options see CE Delft 2009 and Oeko-Institut 2011)

The enforcement of a mandatory monitoring system may be more challenging to European institutions than the processing of monitoring information itself. Any European system would be bound to international law and therefore any enforcement measure would need to be based on the principle of proportionality. Non-compliance with mandatory reporting could be punished with fines, for which the US ballast water reporting provides a template, which has established criminal charges in cases on non-compliance. Another option would be to categorize vessels that participate and those that do not participate in the monitoring of fuel consumed. Those that participate may be rewarded by conducting fewer Port State inspections.

The US Maritime Information Services of North America (MISNA) offers an example of a cooperative approach to vessel monitoring, although it tracks and monitors AIS signals and does not monitor the vessels' fuel consumption. However, run as a non-profit organisation, it shares particular information from participating vessels with the US Coast Guard and the port authorities, while it disseminates particular information to the vessel operating companies that can use this information for better vessel and fleet management. While the participation in the MISNA reporting is voluntary, participating vessels are being regarded as "low risk vessels" aiding their port clearance and inspection decision processes (Page, E. 2011). "Several in the marine industry (...) finding ways to accelerate an industry developed vessel tracking solution that meets the needs of governments while also aiding commercial interests".

One open question is the use of the potentially raised funds through an MBM. Options are to circle the funds fully or partially back to the industry or to provide financing for other greenhouse gas reducing initiatives. A question also remains as to what extent non-Port States, which some of the seaborne cargo is headed to or originates from, may participate in a monitoring system and may benefit from funds available through an MBM system.

5. Verification

As discussed in section 2, verification could play a crucial role regarding the impact of an MRV system on CO_2 emissions. Since data monitored under the SEEMP do not have to be reported and verified, verification could be the value added by an MRV system, at least if it leads to an enhancement of the accuracy of the data monitored and thus to more transparency for the ship owner/charterer and shipper.

At the same time, verification is associated with extra administration and thus extra administrative costs for both the reporting entity and public administrations.

What could nevertheless be a good reason for verification under an MRV system is the fact that most market-based measures, with the exception of a bunker fuel tax collected from the bunker fuel supplier, will need verification of vessel-related data. It could therefore be very useful to gain experience on verification under an MRV system. In addition, if the data that is monitored under an MRV system is used for the implementation of a market-based measure, acceptance could be higher due to a better quality of verified monitored data.

Regarding verification there should be a distinction between verification of the data that is monitored before it is reported and a verification of the reported data.

Verification of the data that is monitored before it is reported would have to be carried out by a recognized third party. Verification on this level could involve the certification of monitoring equipment, control of on-board documentations (e.g. deck-log books) and cross-checking of data with other business data. Verification guidelines would have to be established to this end.

For enforcement purposes, verification of the reported data would have to be carried out by a public entity. This could be done by carrying out plausibility tests on the data reported. Since data can better be tested on plausibility if you have a larger data sample, public verification could probably be more easily carried out by one central European entity to which the data then would have to be reported too.

On-site controls that would have to be carried out by State Port Control could then be confined to ships for which implausible data have been reported and to ships that are being controlled for other reasons and/or to random extra controls. Hereby bunker delivery notes, deck-log book, and bill of lading are relevant documents.

6. Potential metric of an MRV system

6.1. Institutional aspects

6.1.1. IMO conclusions on use of EEDI and EEOI

In July 2011 during MEPC 62, amendments to MARPOL Annex VI were adopted, adding a new chapter 4 to Annex VI on *Regulations on energy efficiency for ships* to make mandatory the Energy Efficiency Design Index (EEDI) for new ships, and the Ship Energy Efficiency Management Plan (SEEMP). The regulations apply to all ships of 400 GT and above and are expected to enter into force 1 January 2013.

EEDI

The EEDI requires new ships to comply with a minimum design energy efficiency that varies over ship type and size. The reference energy efficiency equates to the average efficiency for ships built between 1999 and 2009 (for further details see IMO(2012b)).The reduction level in the first phase is set to 10% and will be tightened every five years with reduction rates being, at least for the bigger ship sizes, 30% in 2025.

Administrations may waive the requirements, though the waiver cannot be applied to ships for which the building contract is placed four years after the EEDI regulation enters into force.

Under the EEDI the attained energy efficiency of a new ship is determined by the EEDI formula that relates the ships' CO_2 emissions to its transport work. CO_2 emissions are determined on the grounds of technical design parameters of the ship, taking into account the carbon content of the fuel used and specific technical CO_2 reduction measures applied. Transport work is calculated by multiplying the ship's capacity as designed with the ship's design speed. (For further details see IMO (2012c)).

The IMO recognizes that the EEDI formula is not suitable for all ship types, particularly not for ships that are *not* designed to transport cargo, and also not suitable for all types of propulsion systems, e.g. not for hybrid propulsion systems. Ship types covered by the EEDI formula are: oil and gas tankers, bulk carriers, general cargo ships, refrigerated cargo carriers and container ships. For the other ship types formulas will be developed.

The design "[s]peed is the most essential factor in the formula and may be reduced to achieve the required index" (IMO, 2011). Concerns have been raised that when ships reduce their installed propulsion power to reduce the design speed that the manoeuvrability under adverse conditions may not be sufficient enough. MEPC therefore has acknowledged the need for a minimum speed to be incorporated into the EEDI formula (IMO, 2011).

A ship's attained EEDI needs verification. The IMO has set up a guideline regarding the verification procedure (IMO, 2012d).

As to a possible use of the EEDI to the existing fleet, the outcome of MEPC 63 is unambiguous: "The Committee having considered the above views, agreed that the EEDI had been developed as a regulatory tool for new ships only and, as a design index, it was inappropriate to extending its application to the existing fleet. Proponents of MBM proposals which rely on design benchmarks/parameters were invited to clarify in their proposals the relation between such design benchmarks/parameters and the EEDI set out in the new chapter 4 to MARPOL Annex VI" (IMO, 2012a).

EEOI

The voluntary Energy Efficiency Operational Indicator (EEOI) was introduced by the IMO as one element to manage the vessels' greenhouse gas emissions (MEPC 1/Circ.684) in addition to the mandatory Energy Efficiency Design Index (EEDI for new ships) and Ship Energy Efficiency Management Plan (SEEMP). The introduction of the EEOI was motivated by findings of the second IMO GHG study (IMO 2009) that identified multiple operational options to reduce a vessel's greenhouse gas emissions. Operational improvement measures are documented in the ship's SEEMP and it was envisioned that the EEOI would be used to monitor the success of SEEMP measures and to provide benchmarks for the industry.

The principle formula of the EEOI is the amount of fuel used - at a specific voyage or during a time period - divided by the performed transport work. Transport work might be transported tonnes of cargo, numbers of containers or passengers, etc. Several studies and submission to the IMO have analysed the results of applying the EEOI to existing vessels. While the discussions in the IMO focus on the EEDI, the general perception of the EEOI is that it is not suitable to provide comparable benchmarks or to monitor a vessel's performance over time (VDR [BMVBS 2012], Hapag Lloyd [Guntermann 2012] and several submissions to the MEPC by, for example. Germany, Denmark and Japan). The critique of the EEOI focuses on technical aspects of the index-value calculation. However, it must be assumed that there are economic reasons for rejecting the EEOI as an appropriate tool.

6.1.2. Monitoring Mechanism Decision

The "Monitoring Mechanism Decision" (Decision No 280/2004/EC) that covers the reporting from the EU and its Member States required under the UNFCCC and the Kyoto Protocol is currently under revision. According to the European Commission (EC, 2011), the aim of the revision is, among other things, to

- facilitate development of new *Union* climate change mitigation and adaptation instruments, and
- provide legal basis for the implementation of future reporting requirements and guidelines pursuant to Union legislation or international agreements decisions.

In the Proposal for a Regulation from November 2011[9] the maritime transport sector was identified as a sector of great significance in reducing GHG emissions and taking action at EU level, where currently no or insufficient data was collected to underpin effective policy design and implementation.

It was stressed that since policy discussions within the Union and internationally are ongoing the proposal would take a prudent approach to reporting on emissions from international

9 Proposal for a Regulation of the European Parliament and of the Council on a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other information at national and Union level relevant to climate change, 2011/0372 (COD) from 23.11.2011.

maritime transport. Therefore the proposal would ensure that the monitoring mechanism provides an adequate framework for setting detailed reporting requirements at a larger stage when a concrete policy outcome would be reached, be it at international or EU level. This would ensure coherence with a future policy framework, avoid duplicating efforts and ensure that the Union is able to implement detailed requirements most efficiently.

According to the proposal, requirements for the monitoring and reporting of emissions from maritime transport by Member States should be adopted in a manner which is complementary and consistent with any requirements agreed at the UNFCCC or, to the extent possible, with requirements applied to vessels as determined in the extent of the IMO or through an EU measure addressing GHG emissions from maritime transport.

In Article 10 of the proposal it was constituted that the Commission would be empowered to adopt a delegated act to specify the requirements for monitoring and reporting of CO_2 emissions from maritime transport relating to marine vessels calling at Member States' seaports and that emissions should be reported on a yearly basis whereas the emissions reported in a specific year are the emissions of the year before the previous year.

Regarding the Proposal for Regulation from November 2011 opinions were, however, divided.

The proposed amendment of the European Parliament regarding Article 10 aimed at monitoring and reporting of all climate-relevant data, at the extension of the European Emissions Trading Scheme to also cover the maritime transport sector, to let the Member States report the data gathered to EMSA which would analyse these data to determine the overall impact of the sector on global climate, including non-CO_2 impacts. The ship types that, taking a size and traffic threshold into account, in any case should be covered by the mechanism are also specified (see the Annex for the EP's exact proposal).

The European Council of Ministers however had removed the entire article.

The arguments tabled against the mandatory monitoring/reporting of the maritime transport sector were the expected high administrative costs for the Member States and that the regulation would get ahead of European and international legislation.

As a result of a compromise reached between the European Parliament and the Council, the European Parliament adopted a legislative resolution on the proposal for a Regulation of the European Parliament and of the Council in March 2013. This proposal does not contain provisions for maritime transport anymore: "[S]ince the Commission has announced that it intends to propose new monitoring and reporting requirements for emissions from maritime transport, a recital underlines that such provisions should not be included in this Regulation at this time" (EP, 2013).

6.2. EEOI as potential metric

The Energy Efficiency Operational Index (EEOI) is a potential index to be used in an MRV system. In this section the critique of the EEOI and counter-arguments as well as the Existing Vessel Design Index and other viable alternatives are presented.

6.2.1. Critique of EEOI

The critique of technical aspects is based mainly on findings of large spreads and fluctuations in test runs of the EEOI. Reasons for large variations in different test runs are for example the consideration of real load (which differs largely from zero in ballast voyages to near full capacity on some routes of bulk carriers), differences in the voyage definitions and variations in ship and service types. Some causes for the spreading results are summarized below:

- Definition of voyage: The voyages used in test runs include single-loaded trips from port A to port B up to the recognition of entire return voyages. Mathematically, the IMO guidelines for the EEOI include a potential error by defining the denominator as cargo times distance. If cargo is zero, the denominator becomes zero.
- Fuel consumption and greenhouse gas emissions occur during loaded, partially loaded and empty (ballast) voyages and during the times in port. A voyage might be defined as a loaded trip from port A to port B, a voyage A to B including the port time in port B or as a round trip starting in port A and ending when the vessel returns to port A. The EEOI under each definition differs greatly.
- Seasonal variabilities: some services, in particular liner services, show seasonal variabilities in their cargo utilization. A RoRo vessel for example might show a wide spread of EEOI values in different times of the year due to a fluctuating pattern of cargo and passenger space utilization.
- Effects of cargo density: low density cargo, for example liquified natural gas, result in larger EEOI values compared to high density cargo, for example crude oil.
- Variations within sister ships: technically similar sister ships may show a spread of EEOI values depending on the variability of the services they are operating in.

All aspects above were reasons for the high variability of EEOI values within vessel categories, which in turn has been used by governments and industry to argue against the EEOI as an instrument to assess the operational efficiency of vessels. However, as we argue below, these technical arguments are not sufficient to explain the denial of the EEOI as an instrument for GHG monitoring.

One argument that may be more important for the rejection is economic in nature. Vessel operators and shipping companies are reluctant to disclose information on the cargo load of their ships, because cargo utilization information may be used by their customers to negotiate lower freight rates. Freight rates are freely negotiable between shipping companies and customers. Once the customers know of free capacities on particular routes, they would aim to lower the price of transport. This is of particular importance for all vessels in liner services, where the customer only pays for the carriage of their cargo from A to B. Lowering freight rates on routes with empty cargo capacity (e.g. westbound trade from the US to Asia) is a common practice in order to increase the capacity utilization and thus the profitability of the necessary return run. However, concrete knowledge on empty spaces will be used by customers in price negotiations. Thus the shipping industry is reluctant to discuss any aspect that would point to under utilized service routes and thus reluctant to disclose information on their vessel`s EEOI.

Bookers of cargo operations with bulk cargo are, on the other side, aware that the freight rate also includes the ballast voyage back to the next loading port. Therefore, bulk shipping would be less affected by those dynamics.

6.2.2. Countering the critique of the EEOI

The critique of the technical aspects of the EEOI can be countered with technical solutions or better definitions of terms and references. However, the motivation of the shipping industry to keep secret real cargo loads on particular routes is a valid concern on economic ramifications. Therefore, any wide dissemination of the EEOI or any other operational indicator must seriously take those concerns into account.

Some counter-arguments to the technical critique are given below:

- Definition of voyage: the EEOI itself offers the option to build rolling averages, which would level the variabilities, or to use a period of time instead of a voyage for calculating EEOI values. However, both “voyage” and “period” would need a clear definition in order to lead to sound results. The draft European Norm “Methodology for calculation and declaration of energy consumption and GHG emissions of transport services (freight and passengers)” (prEN 16258) provides some guidance. According to the norm:
    - All empty voyages and fuel consumed in ports must be included, for example the idle time and ballast voyages returning to the original departure port A.
    - The transport performance of liner services equals the average utilization over the entire trip returning to the departure port A, regardless of the port to port segment in between.
    - A representative period therefore needs to include entire operational cycles of ships, representing their common economic dedication.

Solid EEOI values without emission gaps can be expected to be achieved if EEOI calculations adhere to sound definitions of “voyage” and “period” as outlined above.

- Seasonal variabilities: The choice of a representative period of time would also level seasonal variabilities. Thus for services with significant seasonal variabilities a representative period of time would result in sound values.
- Cargo density: the effects of different cargo density may be overcome by defining normalization units other than tonnage of cargo. Those may be, for example, cubic meter (of gas), number of container units (TEU), lane meter (potentially weighted according to bearing capacity) and numbers of passengers. Since vessels may be benchmarked only within their respective categories, the effects of different cargo densities matter mostly for container carriers, RoRo vessels, ferries and passenger ships that may carry different cargo within the same category.
- Variations between sister ships: variations of EEOI values between sister ships are not sufficient to argue against the validity of EEOI values because the EEOI particularly aims to identify operational parameters that have an influence on GHG emissions. However, EEOI values should always be interpreted with care, recognizing that reasons outside the responsibility of the vessel operator (e.g. weather, routes) will influence the vessels' performance.

6.3. Existing Vessel Design Index and other viable alternatives

One option to overcome the economic concerns of the maritime industry might be to use the DWT of a ship (or TEU capacity, lane meter, volume, etc.) together with average cargo utilization factors. This would avoid the need to disclose business-sensitive information and it would withdraw the cargo aspect, over which the vessel operator has only limited control, from the EEOI equation.

There are ample examples of the application of average utilization factors and knowledge on average utilization is relatively firm. Recent inventories of marine emissions have usually used a bottom-up modelling approach. This bottom-up methodology also uses average utilization factors in order to estimate the transport activity to accomplish certain transport needs. For example, the following utilization rates were used in the 2009 IMO GHG study: crude oil tanker 48%, chemical tanker 64%, general cargo vessels 60% and container vessels 70%.

Determining the average cargo load is most challenging for vessels in liner service, i.e. container vessels, RoRo vessels and full car carriers. In contrast to bulk carriers, which in simple terms run an empty return trip for each loaded trip and thus have utilizations of below 50%, liner services operate in circular patterns with multiple loading and discharging ports. The overall capacity utilization thus depends on the loading and unloading patterns as well as on aspects such as international trade imbalances. However, the methodology in EcoTransIT World showed the possibility of calculating more detailed, trade-route dependent, utilization factors using assumptions and trade data [IFEU et al. 2011, Appendix 6.3 page 90). Industry representatives have verbally confirmed the relative accuracy of these utilization figures.

One methodology that also uses average utilization rates is the Existing Vessel Design Index (EVDI) by the Rightship organisation (www.shippingefficiency.org). This organisation aims to benchmark existing vessels' CO_2 performance by using a derivation of the EEDI. It is supported by large players of the maritime industry, including Maersk Line, TK Shipping, Star Bulk, ABB and others. The Clean Cargo Working Group (www.bsr.org) urges to treat each vessel equally and applies the vessels' nominal capacity or in other words a 100% cargo utilization. An homogeneously applied lower utilization rate (e.g. 70%) may satisfy the desire for equal treatment as well. Therefore, it can be concluded that the maritime industry would be open to a system that uses realistic average utilization rates instead of disclosing real cargo loads.

7. Conclusions

This paper has analysed how MRV regulation can be used as a first step towards an MBM. All MBMs require MRV, but the requirements of what needs to be monitored and how differs. Moreover, there are often different requirements prior to the implementation of an MBM, when MRV is used to establish essential MBM design parameters, and after the first implementation, when MRV is meant to ensure compliance with the MBM.

For example, an ETS or a target-based compensation fund requires establishing a cap or a target. As current emission estimates have a considerable uncertainty range, a period in which emissions in the relevant scope are monitored and reported can inform the policy choice of setting the cap or target. Once such an MBM is implemented, these systems require ships to monitor and report verified emissions when surrendering allowances or paying a contribution to the fund.

While monitoring emissions prior to implementation can help with setting design parameters in many MBMs, the level of aggregation differs. For an ETS and many variants of the fund, total emissions of the fleet are sufficient. Other MBMs require ship emissions. Some MBMs also require transport data, such as the efficiency-based MBMs.

Almost all MBMs require monitoring and reporting ship emissions once implemented. The only exception is the bunker fuel tax. In addition, the efficiency-based MBMs require monitoring and reporting ship activity data.

MRV may have a small effect on emissions if some type of efficiency metric is monitored and if the results are published. In that case, this information may help charterers, shippers and other stakeholders select the most efficient ship available. It is unlikely that monitoring emissions or fuel-efficiency without publishing the data will have an impact on emissions, as such monitoring is already a legal requirement under MARPOL Annex VI and hence shipping companies will already collect such data.

Monitoring fuel and/or emissions does not require additional data collection, as it is common practice to monitor the fuel consumption of ships. However, for some ships the accuracy of the data may not be very high.

There are several ways in which ships and shipping companies currently communicate with port states that can be used to facilitate the reporting of emissions.

Shipping companies have several sources of information that can be used to verify monitored emissions. For example, fuel consumption data recorded on board ships can be compared with bunker fuel delivery notes, financial data on fuel sales, fuel bills (if a ship is chartered), etc.

While shipping companies would probably not incur significant costs for monitoring and reporting, verification may be more costly. Hence, it should be contemplated at which stage of the policy cycle verification becomes a necessity.

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9. Annex

Proposal of the European Parliament for amendment of a Regulation of the European Parliament and of the Council on a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other information at national and Union level relevant to climate change, 2011/0372 (COD) from 23.11.2011(EP, 2012):

Article 10

Reporting ***climate-relevant information relating to*** *maritime transport*

1. The Commission shall *[…]* adopt a delegated act in accordance with Article 29 of this Regulation ***by the date mentioned in Recital 3 of Directive 2009/29/EC of the European Parliament and the Council of 23 April 2009 amending Directive 2003/87/EC so as to improve and extend the greenhouse gas emission allowance trading scheme of the Community***[10]to specify requirements for the monitoring and reporting of ***climate-relevant information relating*** **to** maritime transport relating to marine vessels calling at Member States' seaports. The monitoring and reporting requirements adopted shall be consistent with ***methodologies*** agreed at the UNFCCC and with ***methodologies*** applied to vessels in the context of the IMO or ***requirements*** through Union legislation addressing GHG emissions from maritime transport. To the extent possible, monitoring and reporting requirements shall minimise Member States' workload including through the use of centralised data collection**,** maintenance ***and publication.***

The requirements shall cover ships responsible for significant emissions, including at least tankers, bulker, general cargo and container ships, subject to appropriate de minimis size and traffic thresholds.

2. ***Following the adoption of a delegated act pursuant to paragraph 1,*** Member States shall determine and ***gather*** to the Commission ***and the European Maritime Safety Agency (EMSA)*** by 15 January each year ('year X') for the year X-2, ***the climate-relevant information relating to maritime transport, and shall make that information available to the public. That information shall be made available in a manner that is useful to the charterers or users of such ships.***

(2a)The EMSA shall provide analysis inter alia of maritime transport's overall impact on the global climate, based on the information provided pursuant to paragraph 2, including on non-CO_2 impacts such as from black carbon, and effects of aerosols, and establish forecasts including through modelling and traffic data where relevant. The EMSA shall regularly review the modelling by reference to scientific advances.

The EMSA shall also present options for establishing performance labelling.

[10] *OJ L140, 5.6.2009, p. 63.*

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Comparison of a GHG contribution for a climate fund and an Emissions Trading Scheme in the shipping sector

DISCUSSION PAPER

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The contents of this publication do not necessarily reflect the official opinions of the German Federal Environment Agency.

Summary

The International Maritime Organization (IMO) has endorsed a number of technical and operational measures in order to reduce the greenhouse gas (GHG) emissions from international shipping. The Marine Environment Protection Committee (MEPC) agreed at its 59th meeting in July 2009 that those measures alone would not be sufficient to reduce emissions in the growing shipping sector and that a market-based mechanism is needed. Of the several options for market-based mechanisms proposed by different parties two are presented and compared in this paper: an Emissions Trading Scheme (ETS) and a GHG fund generated by a GHG contribution on bunker fuels. Many details of the proposed schemes, for instance the target line/cap for shipping emissions, still remain to be defined; the comparison draws therefore on generic differences.

The goal of the ETS proposal is to set a price on each ton of carbon emitted by international shipping. A cap on emissions would be defined and an amount of emission rights (allowances) equal to the cap sold/auctioned. The revenues generated by selling/auctioning the allowances are to be spent in line with priorities established under the United Nations Framework Convention on Climate Change (UNFCCC) for adaptation, mitigation, capacity building, technology development and transfer, as well as for research and development in the shipping sector. At the end of each compliance period the ship owner would have to report his emissions and surrender a corresponding number of allowances, either shipping allowances or units from linked schemes such as the Clean Development Mechanism (CDM).

The GHG contribution would be charged on bunker fuel sales and generate revenues for a GHG fund. The tariff of the GHG contribution would be set in a way to enable the fund to offset the emissions of the shipping sector above (and only above) an agreed target line. Other potential uses of revenues are adaptation, research and development, technical cooperation within the IMO framework and administrative costs of the fund administrator. These uses would have to be reflected in the determination of the tariff of the GHG contribution.

The authors find that both proposals are similar in many aspects, such as coverage, equal treatment of all ships, eligibility to receive funding from the revenues generated only to Parties of the scheme, administrative efforts and the need to define quality requirements for offset credits. A major difference, though, is the amount of revenues generated and their envisaged uses. The amount of revenues generated by the GHG contribution is substantially lower than the revenues generated by the ETS. As long as the funding of offset projects is the predominant use of the GHG fund, the principle of “common but differentiated responsibilities” (CBDR) cannot be addressed. In the ETS case, private parties (ship owners) are additionally expected to purchase an amount of offsets which is comparable to the one to be acquired by the GHG fund, while the revenues generated through selling/auctioning can be spent in a way reflecting the CBDR principle. Furthermore the incentives to reduce emissions in the international shipping sector itself are higher in the ETS case as the price per ton of CO_2 is envisaged to be higher than the tariff per ton of CO_2 under the GHG contribution enabling offsets of emissions above the target line only.

Zusammenfassung

Die Internationale Seeschifffahrts-Organisation (International Maritime Organization – IMO) hat eine Reihe technischer und betrieblicher Maßnahmen eingeführt, um die Treibhausgasemissionen der internationalen Seeschifffahrt zu reduzieren. Das Meeres-Umweltschutzkomitee (Marine Environment Protection Committee – MEPC) hat bei seiner 59. Sitzung im Juli 2009 beschlossen, dass zusätzlich eine marktbasierte Maßnahme (MBM) nötig ist, um die Emissionen im Wachstumssektor Schiffsverkehr zu reduzieren. Hierzu wurden verschiedene marktbasierte Maßnahmen vorgeschlagen, zwei werden im vorliegenden Papier vorgestellt und verglichen: ein Emissionshandelssystem (EHS) und ein Treibhausgasfond, der durch eine Abgabe auf Schiffstreibstoffe gespeist wird. Viele Einzelheiten der vorgeschlagenen Maßnahmen müssen noch definiert werden, zum Beispiel die Emissionsziellinie/das Cap für durch den Schiffsverkehr verursachte Emissionen. Der Vergleich basiert auf den grundlegenden Unterschieden.

Das Ziel des Emissionshandelsvorschlages ist es, jeder Tonne CO_2-Emissionen der internationalen Seeschifffahrt einen Preis zu geben. Eine Obergrenze für die Emissionen (das Cap) würde festgelegt und eine Anzahl von Emissionsberechtigungen, die dem Cap entsprechen, verkauft oder auktioniert. Die Einnahmen daraus sollen gemäß den Prioritäten der Klimarahmenkonvention (United Nations Framework Convention on Climate Change – UNFCCC) für Anpassung an den Klimawandel, Vermeidung von Emissionen, Weiterbildung, Technologieentwicklung und -transfer sowie für Forschung und Entwicklung im Schiffssektor ausgegeben werden. Am Ende jeder Verpflichtungsperiode müsste der Schiffseigner seine Emissionen berichten und eine entsprechende Anzahl von Emissionsberechtigungen abgeben. Dies könnten entweder Emissionsberechtigungen des Schiffssektors oder von verbundenen Programmen wie des Mechanismus für umweltverträgliche Entwicklung (Clean Development Mechanism – CDM) sein.

Die Abgabe würde auf Treibstoffverkäufe erhoben und so Einkünfte für einen Treibhausgasfond generieren. Ihre Höhe würde so gewählt, dass Emissionen der internationalen Schifffahrt, die oberhalb ihres Treibhausgaszieles liegen, durch Emissionseinsparungen in anderen Sektoren ausgeglichen werden. Als weitere Verwendungszwecke des Fonds wurden Anpassung, Forschung und Entwicklung, technische Zusammenarbeit unter dem Dach der IMO und Verwaltungskosten für den Fond genannt. Diese Ziele müssten ebenfalls in die Ermittlung der Höhe der Abgabe einfließen.

Die Vorschläge ähneln sich in vielen Aspekten wie dem Anwendungsbereich, die Gleichbehandlung aller Schiffe, Verwaltungsaufwand, der Notwendigkeit Qualitätskriterien für Kompensationsgeschäfte zu definieren und dass nur Unterzeichnerländer der Konvention Mittel aus den jeweiligen Fonds beantragen können. Ein wesentlicher Unterschied ist jedoch, dass im Fall des Treibhausgasfonds wesentlich weniger Einnahmen erzielt werden als beim Emissionshandel. Solange die Finanzierung von Kompensationsgeschäften für die Emissionen oberhalb der Ziellinie das Hauptziel des Fonds ist, kann das Prinzip der „gemeinsamen aber unterschiedlichen Verantwortlichkeiten“ (CBDR) nicht erfüllt werden. Im Emissionshandel kann davon ausgegangen werden, dass die Schiffseigener eine vergleichbare Anzahl an Kompensationsgeschäften tätigen werden und die Einnahmen durch den Verkauf/die Auktion der Emissionsberechtigungen gemäß dem CBDR-Prinzip erfolgen können. Zudem sind die Anreize im Schiffssektor, selber Emissionen zu mindern, im Falle des Emissionshandels höher, da der Preis pro Tonne CO_2 höher sein wird als im Falle eines Treibhausgasfonds, der lediglich zur Finanzierung von Kompensationsgeschäften der Emissionen oberhalb der Ziellinie vorgesehen ist.

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1 Introduction

The International Maritime Organization (IMO) has endorsed a number of technical and operational measures in order to reduce the greenhouse gas (GHG) emissions from international shipping. In July 2011 a new chapter on energy efficiency was added to MARPOL Annex VI and is expected to enter into force in 2013. The Energy Efficiency Design Index (EEDI) was made mandatory for new ships and the Ship Energy Efficiency Management Plan (SEEMP) for all ships in operation (IMO 2011).

The Marine Environment Protection Committee (MEPC) had already agreed at its 59th meeting in July 2009 that technical and operational measures alone would not be sufficient to reduce emissions in the growing shipping sector and that a market-based mechanism (MBM) is needed.[1] Two main purposes shall be reached by putting a price on GHG emissions:

1. To reduce emissions from international shipping by providing the maritime industries with an economic incentive to reduce its fuel consumption (both by investing in more fuel efficient technologies and by improved operation); and
2. To offset growing emissions from international shipping by reduction in other sectors.

Furthermore, market-based mechanisms can generate funds for climate-related purposes, e.g. for adaption or technology transfer.

Several options for market-based mechanisms were proposed by different parties; two of them will be assessed further in this discussion paper: an Emissions Trading System (ETS) for international shipping and an international fund for Greenhouse Gas Emissions (GHG fund) from ships. These will be briefly introduced in chapter 2 and compared concerning their expected environmental effectiveness, the amount of revenues to be generated, the incentives for emission reduction in the shipping sector itself, the impact on developing countries and the administrative effort involved in their implementation in chapter 3. In many aspects the two proposals for market-based measures were, at the time of writing, not specified in enough detail to enable a quantitative comparison. Therefore the analysis draws on the generic differences. The conclusions are to be found in chapter 4.

2 Short profiles of the policy options compared

2.1 Global Emissions Trading System for international shipping

A global Emissions Trading Scheme for international shipping was brought forward by Norway, France, Germany and the UK (MEPC 59/4/25, MEPC 59/4/26, MEPC 60/4/22 and MEPC 60/4/26). The cap and trade scheme would cover emissions from all ships engaged in international voyages over a size that is yet to be defined. The threshold chosen should “seek to maximize cov-

[1] IMO homepage on market-based measures accessed on 28th August 2013: http://www.imo.org/OurWork/Environment/PollutionPrevention/AirPollution/Pages/Market-Based-Measures.aspx.

erage of emissions while minimizing administrative burden" (MEPC 60/4/26). The point of regulation would be individual vessels as identified by their IMO number.

An emission limit, the cap, would be defined and emission rights (allowances) sold/auctioned. At the end of the compliance period every ship owner will have to report his emissions and surrender an amount of allowances equal to these. It is foreseen that credits from other compatible trading schemes and project based credits such as the Clean Development Mechanism (CDM) are eligible without quantitative limit. Ship owners can therefore acquire allowances and credits from within the sector or buy them from other sectors. Therefore, the cap will not install an absolute emission limit on the shipping sector and not limit growth in the shipping sector.

To enable additional flexibility banking and borrowing could be introduced as proposed by proposal MEPC 60/4/22 brought forward by Norway. If emission allowances are not used in a certain year they can be banked and used for compliance in a future year/commitment period and thus cater for unexpected fluctuation in emissions or to enable ship owners to buy allowances for future use, e.g. for reasons of risk management. Ship owners may also borrow allowances from future auctions but would then have to surrender allowances corresponding to a certain amount above the verified emissions to discourage extensive borrowing. A disadvantage of borrowing is that it "raises issues with respect to the liability and credibility of future emission reductions" (ZEW/Fraunhofer ISI 2011). Banking (and borrowing) can act as a price stabilization mechanism and equalize price fluctuation in years with exceptionally low or high emissions and add to cross-sectoral cost-efficiency effect of linking the ETS with other schemes.

The original proposal does not foresee that allowances are allocated for free. It is argued that free allocation would require data which is currently not available, thus give rise to substantial administrative efforts and may in addition cause competitive distortions amongst sector participants. Therefore it is suggested that in an introduction period only a certain percentage of the emissions need to be covered and that this percentage can gradually be stepped up to 100% (MEPC 59/4/25).

The revenues should be used primarily to fund:

1. "projects, programmes, policies and other activities in developing countries related to mitigation including REDD-plus, adaptation, capacity-building, technology development and transfer in line with priorities established for funding mechanisms under the UN-FCCC; and
2. research and development activities within the maritime sector with a view to support the objective of this Convention" (MEPC 60/4/22, p.31).[2]

The exact uses of revenues are deemed to need further discussion among all states at the IMO. Only countries who are parties to the shipping ETS would be eligible for revenues from the fund.

An exemption clause is foreseen which can be used to cater for voyages to and from small island developing states (SIDS) and least developed countries (LDCs). Exemptions would have to be approved by the IMO on the condition that they do not lead to carbon leakage.

2.2 International fund for GHG emissions from ships (or GHG contribution)

An International Fund for GHG emissions from ships was proposed by Cyprus, Denmark, the Marshall Islands, Nigeria and the International Parcel Tankers Association (IPTA) (MEPC 60/4/8; MEPC 59/4/5). The fund is envisaged to be filled by a GHG contribution to be paid on every ton of bunker fuel purchased by all party ships engaged in international trade. The GHG contribution would either be collected by the bunker fuel supplier or directly paid by the ship owner to the International GHG fund. If bunker fuel suppliers collect the GHG contribution, they would be required to register to be eligible to sell bunker fuels in compliance with the scheme. All ships flying the flag of a Party to the suggested Convention must buy fuels at registered bunker fuel suppliers and keep the documentation on board of the ship as evidence.

A global reduction target for international shipping would be set either by the UNFCCC or the IMO. The purpose of the fund is to offset shipping emissions above (and only above) this target line, "a significant reduction of GHG emissions from international shipping in absolute terms is not foreseen" (MEPC 60/4/8). To meet this goal offset units may be purchased from other sectors, e.g. CDM credits or units from other mechanisms established under the United Nations Framework Convention on Climate Change (UNFCCC).

The tariff of the GHG contribution will be determined based on the expected cost of purchasing enough credits to cover shipping emissions below the target line. To judge the amount of revenues required; the following parameters would need to be estimated for the period for which the contribution level is defined:

- expected amount of emissions to be offset (difference between projected shipping emissions and target line); and
- expected price for offsets per ton of CO_2.

[2] REDD+: Reducing Emissions from Deforestation and Forest Degradation.

The amount of revenues required is calculated by multiplying the expected amount of emissions to be offset with the corresponding price for offsets. To determine the GHG contribution per ton of bunker fuel the amount of revenues required is divided by the projected shipping emissions resulting in a contribution per t of CO_2 which can be converted to contribution per t of bunker fuel based on the CO_2 emissions caused by one ton of bunker fuel.

$$GHG\ contribution = \frac{(projected\ emissions - target\ line) * carbon\ price}{projected\ emissions} * emissions\ per\ t\ fuel$$

Regular adjustments are needed to ensure that an adequate amount of credits can be purchased. An interval for those updates should be set in the new IMO convention; the initial proposal (MEPC 59/4/5) suggests a time span of four years to provide predictability and certainty to the shipping industry on the one hand and reflect deviations from emissions and market prices projections for carbon units on the other hand. There have been substantial fluctuations in the market price for Certified Emission Reductions (CER, i.e. units issued under the CDM) over the past four years (Figure 2 in chapter 3.2).

Alongside offsetting shipping emissions above the target line the proposal (MEPC 60/4/8) also lists other purposes for the allocation of revenues from the GHG fund. These include adaptation (especially in the most vulnerable developing countries), research and development, technical cooperation within the IMO framework and administrative costs of the Fund Administrator. The resulting financing needs of these additional purposes are not included in the example calculation for the tariff of the GHG contribution (MEPC 60/4/8, p.10).[3] The receipt of revenues for mitigation and adaptation purposes would be limited to those countries which are parties to the new convention in order to incentivise participation in the scheme.

The proposal assumed that the additional costs occurring to the shipping industry is negligible and can be passed on to the consumers due to the predominance of shipping as a transport means in world trade.

3 Comparison of policy option

3.1 Environmental effectiveness

The environmental effectiveness of the schemes depends on the coverage, the stringency of the target and the incentives provided to the shipping industries. In terms of coverage the two approaches are very similar. The proposal for an ETS foresees exclusion of smaller ships below a certain size threshold whereas the GHG fund proposal includes all ships as long as the bunker fuel suppliers collect the GHG contribution. In the case that ship owners pay the contribution directly, a minimum size limit may also apply for the GHG fund proposal. For both MBMs a

3 It is assumed that the support of the Adaptation Fund will include but not be limited to the 2% share of proceeds applied to credits issued for a CDM project going to the Adaptation Fund.

threshold chosen in a way which does not exclude a large share of emissions, is expected not to hamper the environmental effectiveness while reducing the administrative burden.

For both proposals the target line/cap has not yet been defined and therefore cannot be compared at this stage. Different options are assessed in, for example, the Norwegian submission on alternative caps (MEPC 60/4/23) and the example calculations included in the GHG fund proposal (60/40/8). In both policy options the base year should be chosen with care as shipping emissions fluctuate with economic cycles. A base period which covers several years might be preferable to choosing a single year that might not be representative.

Both proposals allow for unlimited use of offsets from other sectors. This is an option to cater for the concerns of shipping industry that their growth might be hampered and offers the opportunity to tap low cost emission reductions in other sectors and thus act as a cost-reducing mechanism. The environmental integrity is not affected as long as emissions are effectively reduced in other sectors. High quality standards for allowable credits are therefore essential. In the case of other schemes with an absolute limit on emissions (e.g. the EU ETS) emission reduction can be assumed safely to occur as long as the absolute limit (or cap) does not exceed business as usual (BAU) emissions. In the case of project-based mechanisms (e.g. the CDM) no quantitative limit exists, the reduction is estimated by comparing the actual emissions of a CDM project with a baseline which is inevitably a hypothetical reference scenario. If those units are recognized in the shipping sector, the question of whether the project would have been carried out also without the CDM or not (additionality) is crucial to the integrity of the project-based credits and thus to the environmental integrity of the market-based instrument in the shipping sector. An option could be to exclude certain project types where there are severe doubts on the environmental integrity.

A generic difference between an ETS and a GHG contribution (that acts in a comparable way to a tax or levy) is that in the trading scheme a quantitative limit is set and the price will adapt to it. In the case of a tax, the price is set politically and the emissions will adapt to it. Whereas in the first case there is certainty on the emissions level, in the latter case there is certainty on the price. The differences between the two instruments are somewhat blurred in the present proposals. In the case of the ETS, the certainty on the emissions level in the shipping sector is reduced by allowing an unlimited use of offset units. In the case of the GHG contribution it is envisaged that the price per ton of emissions is set in a way that reflects the target line and enables the offsetting of the excess emissions. Therefore, the certainty of the price is reduced compared to a conventional environmental tax but the probability of archiving the target improved. The total level of emissions in the shipping sector may exceed the target line as the goal is only to offset the emissions above them, not to set the tariff of the GHG contribution in a way that the target line is met exactly.

3.2 Generation of revenues and incentives in the shipping sector

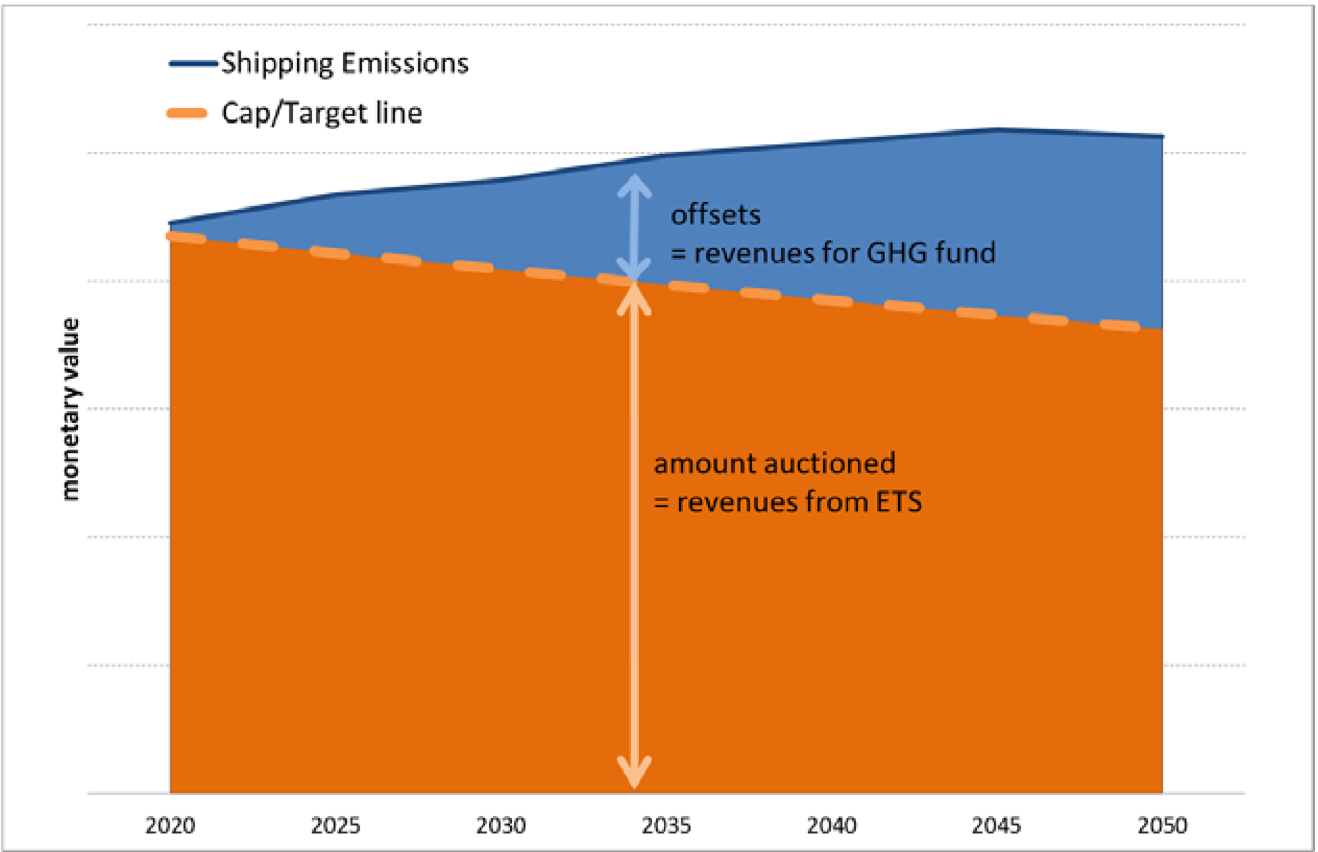
In both MBMs analysed revenues are generated. In the case of the proposed ETS all certificates are envisaged to be auctioned or sold. The price for allowances will be determined by the marginal abatement cost in the shipping sector or by the price of offset units (e.g. CDM), whichever is lower.

The revenues of a GHG contribution would be similar if the aim were to offset all shipping emissions – then the price for offsets would determine the GHG contribution per ton of emissions. As offsets are likely to be cheaper than the marginal abatement cost in the shipping sector, the resulting price would be of a similar level. The GHG fund proposed by Denmark, though, aims at offsetting only emissions above the target line. The amount of revenues available for other purposes will thus be substantially lower if not negligible.

Figure 1 illustrates exemplarily the order of magnitude of revenues generated. For the example it was assumed that the emissions in the shipping sector would be higher than the cap or target line.

- ETS:
  The revenues generated in an ETS equal the proceeds from the auctioning of allowances; the number of allowances that can be sold/auctioned depends on the cap defined. In case the ETS starts with an introductory phase in which allowances surrendered would only have to cover a certain share of the total emissions reported, the revenues generated would be lower in the first years. Emissions above the cap would have to be covered by certificates from linked schemes such as the CDM or other mechanisms. These certificates would be purchased additionally by the ship owners. The total amount available for climate action would therefore be the sum of the two areas.

Figure 1 Illustrative example of revenues generated

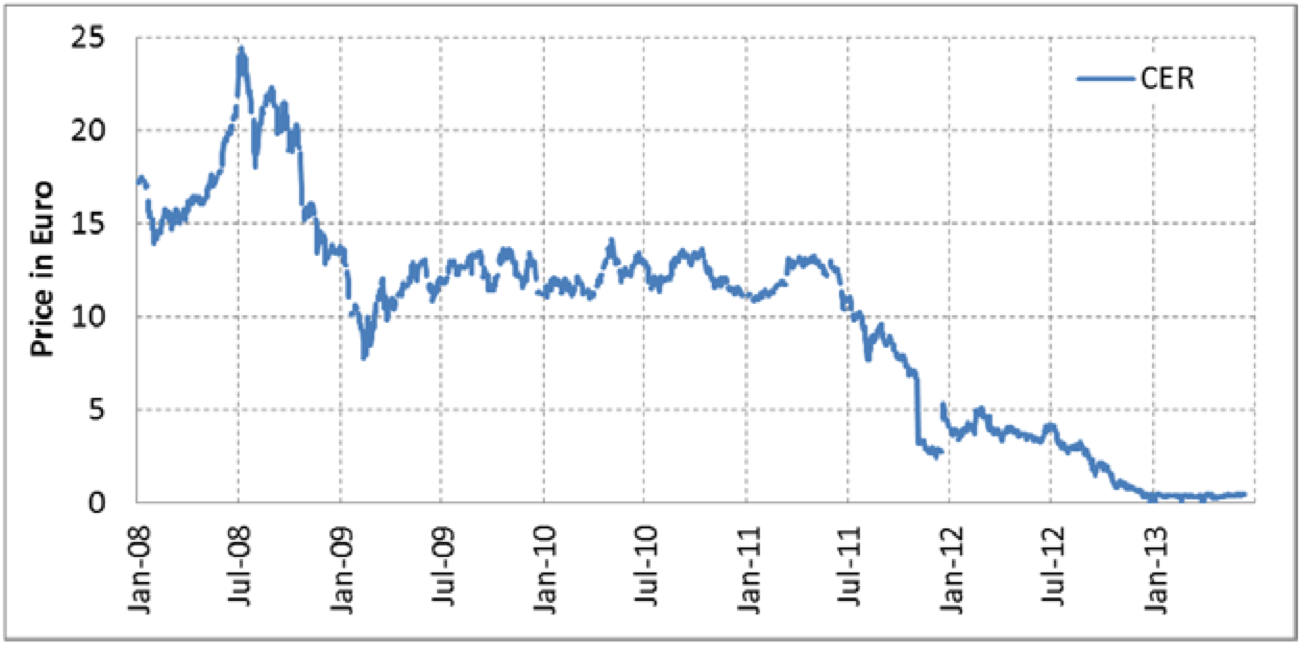


Note: The revenues are a func tion of the emissions (t CO_2 * price per ton), in the graph total emissions and cap/target line are expressed in value, too. For the illustrative example it was assumed that the carbon price will remain stable over the years. If the price fluctuates the revenues will fluctuate accordingly while, for example, the target line/cap remains unchanged. As those fluctuations are expected to be similar for both proposals; they are not assessed further here.

- GHG contribution:
  The price on shipping emissions set by the GHG contribution would be set in a way that revenues are generated to offset the emissions above the target line only (blue area in Figure 1). The revenues for a GHG fund will therefore be substantially lower than the overall amount spent on climate action in the case of the ETS. Also, if only the revenues generated for a climate fund (excluding other purposes) are compared, the revenues in the case of the GHG contribution are expected to be substantially lower than in the case of an ETS with full auctioning (unless the actual shipping emissions more than double the emissions defined by the target line/cap). In case the GHG fund aims to fund other purposes such as adaptation and technical cooperation on top of the offsets, the GHG contribution tariff would have to be set correspondingly at a higher level. But as the proposal of a GHG fund "is essentially focused on mitigation rather than raising a large amount of new revenue for a new climate fund" (Keen/Parry/Strand 2012); the GHG contribution per ton of CO_2 emitted will most likely still be lower than in the case of the ETS.

For both proposals the absolute amount of revenues can only be estimated when the instrument is introduced, as this depends largely on the prices for offsets and these interact, e.g. with the prices in the EU ETS, and are influenced by the demand by other players such as parties to the Kyoto Protocol purchasing offsets. In the past the prices, e.g. for CDM credits, have fluctuated substantially – from nearly 25 Euro in mid-2008 to below 1 Euro in 2013 (see Figure 2).

Figure 2 Prices for CDM credits on the secondary market



Source: Data by Point Carbon, compilation by Oeko-Institut

The difference in the price per ton of CO_2 and consequently per ton of bunker fuel will in turn influence the number of abatement measures that are economically viable in the shipping sector. The lower the price, the lower the number of technical and operational abatement measures that ship owners will implement. The overall emissions in the shipping sector are therefore envisaged to be higher in the case of implementing the GHG fund proposal.

3.3 Impact on developing countries/CBDR

Whereas the IMO adheres to the uniform treatment of all ships and flag states, the principle of "common but differentiated responsibilities" (CBDR) is at the core of the UNFCCC climate regime. In both proposals all ships regardless of whether they fly the flag of a developed or a developing country are envisaged to be treated in equal manner while the revenues generated should be used to compensate especially the least developed countries and small island developing states and thus ensure equity.

In the ETS proposal an option to exclude small island developing states is foreseen. Additionally, it is argued in MEPC 60/4/22 that participation is voluntary, but at the same time only parties to the instruments are eligible to receive financing from the fund. Also in the GHG fund proposal by Denmark only parties may benefit from the revenues gained.

Essentially, assessing whether the instrument is consistent with the CBDR principle depends on the use and the magnitude of the fund. In both proposals mitigation, adaptation and technical cooperation are the stated goals. The amount of revenues obtained will be significantly higher in the ETS case than for the GHG contribution if the tariff is determined to generate enough revenues for offsetting emissions above the target line only. In this case, there will be no funds left for other purposes or not all emissions above the target line can be offset.

In the case of the ETS there are two elements. Offsets will most likely be purchased by ship owners for compliance with their obligations under the ETS. Additionally, revenues are generated from auctioning or selling of allowances which can be used for mitigation, adaptation and technical cooperation.

Furthermore, it is argued that the introduction of a shipping ETS would benefit developing countries by enhanced emission cuts, as those countries are especially vulnerable to climate change (MEPC 60/4/22).

3.4 Administrative effort

The administrative effort involved in implementing any of the proposals will depend largely on the final design of the instruments. Whereas in the ETS proposal it is evident that the ship is the point of regulation, two options are presented in the GHG contribution proposal: either the bunker fuel deliverer or the ship. If the ships were chosen, the administrative burden is expected to be rather similar for both instruments, supposing they require ships to monitor and report emissions and/or fuel use (MEPC 63/5/9). In both proposals the option for a *de minimis* rule is envisaged which reduces the aggregate administrative burden by exempting very small entities. Compliance and enforcement could be controlled similar to the rules currently established in the IMO's MARPOL Convention Annex VI.

If it is decided that the GHG contribution is to be collected from the bunker fuel suppliers, the number of entities to be covered would be lower, while at the same time they have not been regulated by the IMO before. The control and - if necessary - sanctions would have to be carried out by the state in which they are based and for non-party states by a central institution (the GHG fund). Incorporating the collection of the GHG contribution to the tax authorities may reduce administrative efforts on the one hand but forwarding the revenues collected may require the consent of the institution with budget authority (national parliament) on the other hand.

The total administrative cost is deemed to constitute only a small part of the overall scheme (ZEW/Fraunhofer ISI 2011) and could be covered by the revenues generated. In the case of the GHG contribution this would have to be included in the calculation of the GHG contribution tariff to ensure that the remaining revenues are sufficient to purchase offsets for any shipping emissions above the target line.

4 Conclusions

The environmental effectiveness of the schemes proposed depends on the coverage in terms of shipping emissions and the stringency of the target. For both proposals the coverage of ships envisaged is similar but the target is not yet defined. Therefore, the stringency of the environmental target can only be assessed at a later stage. Growth in the shipping sector would still be possible since offsets can be used without limit. As offsets play an important role in both the ETS and the GHG contribution, exigent quality requirements for emission reductions achieved outside of the maritime scheme are key.

The generation of revenues is substantially higher in the ETS case. This is chiefly due to the fact that the GHG contribution tariff is set at a certain level to enable the offsetting of emissions above the target line only (instead of all emissions). As a consequence, the incentives to reduce emissions within the shipping sector are higher in the ETS so that the reduction within the sector is expected to be higher, too.

Ships from all countries are treated equally in the schemes proposed, as is customary in the IMO. The principle of equal treatment can be reconciled with the principle of "common but differentiated responsibility" of developing and developed countries customary in the UNFCCC by the guidelines on how the revenues can be used. If the use of the revenues is solely or chiefly dedicated to purchasing offsets (as in the GHG fund proposal), the criteria of CBDR cannot be met. Any uses of revenues above and beyond the purchase of offset credits would have to be reflected when setting the tariff for the GHG contribution. In the case of the ETS, the amount of revenues generated is substantially higher and the revenues are not required to offset a certain amount of emissions but can be spent according to priorities established for funding mechanisms under the UNFCCC and for purposes under the IMO (research & development). Additionally private parties (ship owners) are expected to purchase offsets units from other schemes in an order of magnitude similar to the purchases of the GHG fund proposed. The administrative efforts are expected to be similar for both schemes. If the point of regulation is the ship, a *de minimis* rule is advisable.

In summary it can be concluded that the two proposals are in many aspects similar, e.g. in coverage or administrative efforts. As the GHG contribution per ton of CO_2 is expected to be substantially lower than the price per ton of CO_2 resulting from an ETS, the incentives to reduce emissions in the shipping sector itself will be higher in the ETS case. While both proposals are based on the principle of equal treatment of ships, only the ETS proposal provides options to reflect the principle of "common but differentiated responsibilities" by dedicating a certain amount of revenues for climate mitigation and adaptation in developing countries unless the GHG fund proposal is revised.

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The GHG fund and the ETS: finding common ground

DISCUSSION PAPER

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This paper was written for the German Federal Environment Agency (UBA) as part of the project titled “Analysis and further development of climate protection measures of sea shipping taking into account current developments at European and international level” (FKZ 3711 45 104). This project is being carried out by Öko-Institut (coordination), CE Delft and Tim Bäuerle LL. M.

Summary

The shipping sector contributes with around 3.2 % to worldwide CO_2-emissions and its emissions are expected to grow in the future. Two market based mechanisms have been proposed by EU countries to address the climate impacts and reflect the principle of common but differentiated responsibilities: a GHG Fund and an Emissions Trading Scheme (ETS).

This paper concludes that the differences between the two are primarily due to differences in design, and not to differences in principle. Both systems can be designed to have similar costs to industry, including administrative costs, similar environmental effectiveness, and yield a similar amount of revenue for other purposes than offsetting shipping emissions. Differences remain in short term price volatility.

Based on either the ETS or the GHG Fund hybrid approaches can be designed. They would have in common that emissions above the target line are off-set and revenues raised that can be attributed to developing countries should – through the Green Climate Fund – be recycled back to them for mitigation and adaptation. Furthermore proceeds stemming from developed countries should be used to mitigation and adaptation projects in developing countries only and to enhance emission reductions in the sector itself by providing additional financial incentives e.g. investment subsidies for the deployment of green technologies in the shipping sector.

This way, the hybrid approaches would combine several advantages of the GHG fund and the ETS approach. They would both ensure that the reduction target of the shipping sector is exactly achieved and that the principle of CBDR can be reflected adequately. At the same time would also provide incentives to the shipping sector to spur investments in GHG efficient technologies and thus accelerate the take-up of such technologies while alleviating the cost of addressing the climate change in the shipping sector. The remaining differences in the volatility of prices can be reduced by establishing a clear price path in the GHG Fund and introducing price regulating elements such as a floor price and safety valve in the ETS.

Zusammenfassung

Der Schiffssektor trägt mit rund 3,2 % zu den weltweiten CO2-Emissionen bei, mit steigender Tendenz. Zwei marktbasierte Mechanismen zu Emissionsreduktion im Schiffssektor wurden von EU-Ländern vorgeschlagen, die dem Prinzip der gemeinsamen aber unterschiedlichen Verantwortung Rechnung tragen: ein Treibhausgasfond und ein Emissionshandelssystem (EHS).

Dieses Papier arbeitet heraus, dass die Unterschiede zwischen den beiden Ansätzen vor allem im Design und nicht in den Grundsätzen liegen. Beide Systeme können so ausgestaltet werden, dass sie ähnliche Kosten (inklusive Verwaltungskosten) für die Industrie verursachen, eine vergleichbare Umweltwirkung haben und eine ähnliche Menge an Einnahmen für Zwecke über die Kompensation von Schiffsemissionen hinaus generieren. Unterschiede bleiben jedoch in der kurzfristigen Preisvolatilität bestehen.

Sowohl auf der Basis des Emissionshandelssystem sowie des Treibhausgasfonds können Hybrid-Ansätze entwickelt werden. In beiden Fällen können Emissionen oberhalb der Ziellinie für Schiffsemissionen kompensiert werden. Einnahmen, die Entwicklungsländern zugeordnet werden können, sollen mittels des grünen Klimafonds zurück in Entwicklungsländer fließen, um dort THG Vermeidung und Anpassung an den Klimawandel zu finanzieren. Einnahmen, die aus Industrieländern stammen, sollen ebenfalls für Emissionsvermeidung und Anpassung nur in Entwicklungsländern verwendet werden sowie zusätzlich Emissionseinsparungen im Schiffssektor durch finanzielle Anreize unterstützen, beispielweise durch Investitionszuschüsse für Umwelttechnologien.

Auf diese Weise können die Hybrid-Ansätze Vorteile des Treibhausgasfonds mit dem Emissionshandel verbinden. Beide würden sicherstellen, dass das Emissionsreduktionsziel im Schiffssektor erreicht werden kann und das Prinzip der gemeinsamen aber unterschiedlichen Verantwortung gewahrt wird. Gleichzeitig werden Anreize gesetzt, in Umwelttechnologien im Schiffssektor zu investieren und damit die Verbreitung solcher Technologien zu beschleunigen und die Kosten für die Emissionseinsparungen im Sektor zu senken. Der weiterhin bestehende Unterschied, die Preisvolatilität, kann reduziert werden indem im Fall des Treibhausgasfonds ein klarer Preispfad definiert wird und im Emissionshandel preisregulierende Elemente eingeführt werden, wie beispielsweise ein Mindestpreis und ein Sicherheitsventil.

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1 Introduction

Sea transport contributes to global CO_2-emissions with approximately 3.2% (UNEP 2011) and is expected to grow further in the future. So far emissions from international shipping are not covered under the Kyoto protocol. In order to prevent dangerous climate change, the international community faces two challenges: How to economically reduce emissions in the shipping sector and how to scale up finance for climate action.

The International Maritime Organization (IMO) has therefore collected submissions on how a market based mechanism (MBM) in the shipping sector could be designed to addresses these challenges. Currently two different types are intensively discussed under the IMO: a Greenhouse Gas (GHG) Fund with contribution on bunker fuels and an emissions trading scheme (ETS). Both approaches are based on a non-preferential treatment of all ships, as is customary practice in the IMO. Differentiating between ships based on their flag would provide strong incentives to re-flag ships to non-covered countries and thus result both in only minor emission reductions and a significant distortion in international competition.

However, undifferentiated treatment of all ships conflicts with the principle of common but differentiated responsibilities (CBDR) of the United Nations Framework Convention on Climate Change (UNFCCC). To reconcile this conflict both approaches suggest reflecting CBDR by devoting a certain share of MBM revenues to developing countries.

Despite these communalities, both market-based approaches show a number of differences. In this paper we identify the most significant differences, in particular the certainty to achieve the reduction target, the volatility of the carbon price, the amount of revenues raised and the cost burden for the shipping sector and suggest a two options aiming at combining preferred elements of both approaches.

2 Comparing MBM approaches

2.1 GHG fund

The International Fund for GHG emissions from ships was proposed by Cyprus, Denmark, the Marshall Islands, Nigeria and the International Parcel Tankers Association (IPTA) (MEPC 60/4/8; MEPC 59/4/5). The fund is envisaged to be filled by a GHG contribution to be paid on every ton of bunker fuel purchased by all ships engaged in international trade. The GHG contribution would either be collected by the bunker fuel supplier or directly paid by the ship owner to the International GHG fund. If bunker fuel suppliers would be tasked to collect the GHG contribution, they would be required to register to be eligible to sell bunker fuels in compliance with the scheme. All ships flying the flag of a Party to the new convention and non-party ships entering Party ports must buy fuels at registered bunker fuel suppliers and keep the documentation on board of the ship as evidence. Whereas the choice of point of regulation (ships or bunker fuel suppliers) is important for the practical design of the MBM, it does not affect the environmental integrity as long as compliance can be ensured by the parties.

A global reduction target for International Shipping would be set either by UNFCCC or IMO. The purpose of the fund is to offset shipping emissions above (and only above) this target line, "A significant reduction of GHG emissions from international shipping in absolute terms is not foreseen" (MEPC 60/4/8). To this goal offset units are purchased from other sectors, e.g. from the Clean Development Mechanism (CDM) or from other mechanisms eligible under the new global climate regime.

The tariff of the GHG contribution needs to be high enough to allow purchasing enough units to offset shipping emissions above the target line. Regular adjustments are needed to ensure that an adequate amount of credits can be purchased. An interval for those updates should be set in the new IMO convention, the initial proposal (MEPC 59/4/5) suggest a time span of four years to provide predictability and certainty to the shipping industry on the one hand and reflect changes in emissions and market prices for credits on the other hand.

The proposal (MEPC 60/4/8) lists apart from mitigation of shipping emissions above the target line also other purposes for the allocation of revenues from the GHG fund. These include adaptation (especially in the most vulnerable developing countries); research and development (R&D); technical cooperation within the IMO framework and administrative costs of the Fund Administrator. These additional revenue uses and resulting financing needs are not included in the example calculation on the level of the GHG contribution (MEPC 60/4/8, p.10).[1] The receipt of revenues for mitigation and adaptation purposes would be limited to those countries which are Parties to the new convention in order to incentivise participation in the scheme.

2.2 Emissions trading system

A global Emissions Trading Scheme for International Shipping was brought forward by Norway, France, Germany and UK (MEPC 59/4/25, MEPC 59/4/26, MEPC 60/4/22, MEPC 60/4/26). The cap and trade scheme would cover emissions from all ships over a size yet to be defined engaged in international voyages. An emission limit, the cap, would be defined and emission rights (allowances) sold/auctioned. At the end of the compliance period every ship owner will have to report their emissions and surrender an amount of allowances equal to these.

It is foreseen that units from other compatible trading schemes and credits from project based approaches such as the Clean Development Mechanism (CDM) are eligible without quantitative limit. Ship owner can therefore acquire units from within the sector or buy them from other sectors. Therefore the cap will not be an absolute emission limit and not thus limit growth in the shipping sector.

Allocation free of charge would require data which is currently not available, give thus rise to substantial administrative efforts, and may in addition cause competitive distortions amongst sector participants. Therefore it is suggested that initially only a certain share of the monitored emissions needs to be covered while this share can gradually be stepped up to 100% (MEPC 59/4/25).

An exemption clause is foreseen which can be used to cater for voyages to and from small island developing States (SIDS) and least developed countries (LDCs). Exemptions would have to be approved by the IMO on the condition that they do not lead to carbon leakage.

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[1] It is assumed that the support of the Adaptation Fund will include but not be limited to the 2% share of proceeds of credits issued for CDM projects going to the Adaptation Fund.

2.3 Comparison

2.3.1 Certainty to achieve the reduction target

Provided that there are no issues of non-compliance an ETS always ensures that the agreed GHG reduction is achieved. From an environmental perspective it thus provides a high level of target certainty. Whether the target under the GHG fund is achieved or not depends on the ability to predict the price developments on the global carbon market. Since prices are volatile, over or underachieving the reduction target is therefore not unlikely. This may be addressed by retroactively reflecting the difference while determining the contribution tariff for the next period.

2.3.2 Volatility of the carbon price

Predicting offset prices will be a challenge. There have been substantial fluctuations in the market price for CDM-Credits (Certified Emission Reductions – CERs) over the past four years from nearly 25 Euro in mid-2008 to below 1 Euro in 2013(Point Carbon 2013).

Under the GHG fund approach policy makers would be confronted with this task while under an ETS shipping companies would have to estimate the prices. Although "wrong" expectations at the policy-makers level would have more serious impacts in terms of providing inadequate price signals, shipping companies generally prefer fixed tariffs over a volatile market price since it eliminates one commodity for which they would have to hedge their expectation. From the perspective of the covered entities the over a certain period fixed tariff is therefore considered as an advantage of the GHG fund.

2.3.3 Amount of revenues raised

The tariff of the GHG fund is determined in such a way that the revenues raised allow covering the expected cost for purchasing the offset units required to meet the shipping sector target. The amount of revenues would be roughly equivalent to the amount which would be raised under an ETS with free allocation of allowances, if only a share equivalent to the quantity of emissions above the shipping sector target would be auctioned or sold. This amount of revenues would only last to achieve the target. Reflecting CBDR through the distribution of revenues would not be possible following the tabled GHG fund proposal since the revenues would not suffice. If the revenues should be used to cover other purposes, the tariff would need to be increased accordingly. The amount of revenues raised in an ETS with full auctioning would be substantial higher and thus offer the opportunity to reflect CBDR in the spending of revenues.

2.3.4 Cost burden for the shipping sector

The amount of revenues raised obviously determines the cost burden for the shipping sector. The higher the amount of revenues, the higher the direct cost of the shipping sector. Compared to an ETS with full auctioning or selling of allowances, the GHG fund aiming at beating the shipping sector's target line would result in a lower cost burden for the shipping sector. This is seen as one of the most prominent advantages of the GHG fund approach supporters.

However, this approach would not allow reflecting CBDR through the use or more specifically through the differentiated redistribution of revenues since there would be no revenues left for this purpose. In addition, it could be put into question why under a global approach which would ensure no distortion of competition, the shipping sector should achieve such a preferential treatment, which usually is only granted under regional GHG regulations to alleviate distortions of international competition. If such distortion is avoided, the shipping sector should be faced with the full cost of internalizing the external cost of climate change, i.e. with the full cost of carbon units required to cover all its GHG emissions.

3 Options to reflect 'common but differentiated responsibilities' & use of revenues

3.1 Options to reflect common but differentiated responsibilities

At the core of the UNFCCC climate regime is the principle of common but differentiated responsibilities (CBDR). Several proposals have been brought forward how the principle of common but differentiated responsibilities could be met by an MBM in the shipping sector. They can be classified in two groups, either by exempting certain ships or routes so that only the shipping attributed to developed countries is regulated or by a differentiated distribution of revenues raised by an MBM covering all ships non-discriminatory (GHG-WG 3/3/3).

In order to only cover shipping attributed to developed countries shipping emissions could be differentiated e.g. depending on i) the flag state; ii) the country of genuine control of the ship, iii) the route of the ship or iv) the final destination of its' cargo. All these options have in common that the coverage of the scheme would be substantially lower than in a universally applied scheme. Additionally there is a danger of avoidance: flags and country of domicile of the shipowner ("country of genuine control") can be changed and routes adapted. Determining the final destination of cargo is expected to be complex, especially for container ships carrying cargo for destinations both in developed and developing countries, and the verification of the data would yield a high administrative burden. The environmental effectiveness of a scheme covering only a part of global shipping and with the risk of avoidance will be lower than in a scheme covering all ships. Furthermore this would not be in line with IMO approach of uniform treatment of all ships and flag States.

Another possibility is an un-discriminatory coverage of all ships and ensuring equity by spending the revenues in line with the CBDR principle. This option would enhance the environmental effectiveness, reduce substantially the risk of avoidance and be in line with the IMO approach. If meeting the CBDR principle depends on the use of revenues, the spending should be as carefully designed as the collection of the contribution when setting up the MBM. This option is further developed in the present discussion paper. [2]

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[2] In the case of emissions from international aviation a similar question is discussed in order to reflect "special circumstances and respective capabilities" (SCRC) when introducing market based instruments (Cames; forthcoming). They include two proposals on criteria to define which countries qualify for special treatment (by distinguishing different market blocks or how fast aviation markets are growing), these (or similar) definition could also be used in the shipping sector to distinguish more than just two groups (developed and developing countries) and would lead to a reduced coverage of the scheme – as argued for the case of distinguishing developing and developed countries. Also a phased implementation with certain countries being partially or fully exempted from parts of the obligation under the MBI for a certain period of time will have a similar implication, albeit to a lesser

3.2 Use of revenues

A MBM in the shipping sector will incentivise ship owners to reduce fuel consumption and thus emissions of their fleet by adding to the cost of fuels. If on top of this the revenues raised by the MBM are spent in a way to enable further emissions reductions both in the shipping sector and in other sectors, the MBM will multiply its impact. A MBM from the shipping sector should contribute to reach four goals:

- Reaching the emission target for the shipping sector by off-setting emissions above the target line,
- reflecting the principle of CBDR by recycling back proceeds stemming from developing countries to the group of all developing countries
- raising funds for mitigation and adaptation projects in developing countries by contributing to the Green Climate Fund and
- enhancing the development and deployment of green technologies in the shipping sector with the support of the Green Shipping Fund.

These elements are presented in more detail below. Furthermore the administrative costs of the fund itself are envisaged to be covered by the MBM itself and thus need to be covered by the proceeds raised. As they are expected to be minimal, they are not elaborated further in this paper.

3.2.1 Proceeds stemming from developing countries

As the MBM is envisaged to cover all ships, part of the proceeds will be stemming from developing countries. The share of proceeds stemming from the group of developing countries should be deducted first from the overall proceeds stemming from the MBM and be used to fund mitigation and adaptation project in the participating developing countries.

Instead of building up a Green Climate Fund financed by the shipping sector alone, the share of proceeds could be administered by the Green Climate Fund established by the UNFCCC parties in December 2011 at Durban, South Africa, and thus ensure a coordinated approach and avoid unnecessary administrative costs by doubling structures. The Green Climate Fund is currently building up its infrastructure (http://gcfund.net/home.htmlhttp://gcfund.net/home.html), the goal is to raise US$ 100 billion additional climate finance. Climate finance is provided by developed countries to *"promote the paradigm shift towards low-emission and climate-resilient development pathways by providing support to developing countries to limit or reduce their greenhouse gas emissions and to adapt to the impacts of climate change, taking into account the needs of those developing countries particularly vulnerable to the adverse effects of climate*

extent. Furthermore several proposals were tabled at the ICAO taking into account early action and exemption thresholds (e.g. de minimis). These are important consideration to ensure the acceptability and practicability of the scheme, but will not be able to address the CBDR concern alone, as both developed and developing countries may benefit and it is expected that not all developing countries will benefit. There are three proposals concerning SRCS which can be addressed by targeted spending of revenues: revenue channeling, technical assistance/cooperation and – especially in the case of a central off-set buyer – emission unit sourcing. These approaches are similar to the use of revenues for off-sets, Green Climate Fund and Green Shipping Fund elaborated in this paper.

change" (http://gcfund.net/about-the-fund/mandate-and-governance.html). Therefore the contribution from the shipping sector that stems from developing countries should not contribute to the goal of the fund to raise US$100 billion annually from 2020 but should be added on top of it. In order to incentivise ratification of the convention establishing a GHG fund, options to earmark the funding generated in the shipping sector to developing countries being parties to the new convention should be agreed with the Green Climate Fund.

Quantifying the contribution of developing countries based on the flag or country of residence of the ship owner would yield unrepresentative results. The quantification should rather be based on the incidence, asking "who really pays" for the costs induced by the MBM) of the contribution, a question that was also addressed by the Report by the High-level Advisory Group on Climate Change Financing (AGF 2010a, AGF 2010b). Shipping is the predominant and most economic mode of transport in international trade. Shipping companies will likely be able to pass on the price increase (AGF 2010b).Consumers in the importing country will have to bear the price increase, unless there is very strong competition from domestic producers or they will refrain from buying a certain good if it becomes more expensive. The price increase due to an increase in shipping costs will constitute only a small share of the final price of this good to the end-consumer, so that the reduction in demand is likely to be very small. In some cases exporters will not be able to pass through the full cost increase and will have to reduce other costs or accept a lower profit margin. In general it can be assumed that the share in global imports can be used as a rule of thumb on you pays for the cost of a MBM in international shipping. Based on this indicator, developing countries bear the cost for about one third of the GHG contribution collected (AGF 2010b).

3.2.2 Off-sets for emissions above the target line

A target line for GHG emissions from the shipping sector will be defined when establishing the MBM. The target should reflect the contribution of shipping to worldwide emissions and the emission reductions necessary to prevent dangerous climate change. If shipping emissions exceed the emission target in a given year, the MBM shall provide the resources to off-set shipping emissions above the GHG-target line. This is based on the principle that emissions in one sector can be compensated by emission reductions in other sectors. The use of units from other schemes as off-sets is an option to cater for the concerns of shipping industry that their growth might be hampered and offers the opportunity to tap low cost emission reductions in other sectors and thus act as a cost reducing mechanism.

The environmental integrity is not affected as long as emissions are effectively reduced in other sectors. High quality standards for eligible offsets are therefore essential. In the case of other schemes with an absolute limit on emissions (e.g. the EU ETS) emission reduction can be assumed safely to occur as long as the absolute limit (or cap) does not exceed "business as usual" (BAU) emissions. In the case of project based mechanisms (e.g. the CDM) no quantitative limit exists, the reduction is estimated by comparing the actual emissions of a single project with a baseline which is inevitable a hypothetical reference scenario. As those hypothetical savings can be recognized in the shipping sector, the question of whether the project would have been carried out also without the project based mechanism or not (additionality) is crucial to the integrity of the project-based credits generated and thus the environmental integrity of the market based instrument in the shipping sector. An option could be to only allow project types where there are no doubts on the environmental integrity. Depending on the international developments other mechanisms, such as national appropriate mitigation actions (NAMAs) which are currently being developed under the UNFCCC, should be eligible as long as the environmental integrity can be assured.

3.2.3 Green Climate Fund

After deducting the contribution of developing countries and the expenses for off-setting emissions above the target line, the remaining revenues could be spend in equal shares for mitigation and adaptation projects in developing countries and the support of emission reduction measures in the shipping sector itself.

Again it should be considered to use the existing infrastructure of the Green Climate Fund instead of building up a new fund to support mitigation and adaptation projects in developing countries. As opposed to the share that can be attributed to developing countries, this money stems from developed countries and can be considered as new and additional climate finance. Therefore it can contribute to reaching the $ 100 billion goal of the Green Climate Fund. Again options of earmarking for countries being parties to the convention could be discussed.

3.2.4 Green Shipping Fund

The Green Climate Fund aimed at mitigation and adaptation to climate change in general could be complemented by a more specific fund oriented towards the shipping sector itself. This would add to the push-factor of price increase of shipping fuels a strong pull factor for development and deployment of green technologies in the shipping sector. Estimates are that ship designs can be up to 50% more fuel efficient but due to non-market barriers this potential is not realised at the moment (Buhaug et al., 2009). The risk for investors would be minimized and thus trigger the deployment of technologies that might not be economically viable if only the fuel price increase by the GHG contribution were taken into account. Especially in the beginning of the scheme when experiences on the development of the level of the GHG contribution do not exist yet, a Green Shipping Fund may play an important role in reducing insecurities and thus trigger emission reductions from the very start. Emission reductions in the shipping sector will in contrast to off-sets have a dampening effect on the level of the GHG contribution as they reduce the difference between emissions and the target line. The amount of money involved in the fund would be limited, as expenditures on shipbuilding R&D in OECD countries amounted to USD 1.4 billion in 2008 (the lst year for which comprehensive data are available), and sudden increases could probably not be put to productive use (OECD ANBERD 2013).

There are many options to set-up a fund. One option is establishing an innovative technology deployment scheme, that could grant investment subsidies and/or preferential access to credits with attractive conditions. The amount available for subsidies or credits would be made available at regular intervals during the year, e.g. every three months and would be granted to those which offer the largest emission reduction per money spent. Ship owners would apply for those subsidies and credits and would be ranked according to the projected mitigation cost per t of CO_2 equivalent (CO_2e). The applicants with the lowest mitigation cost would be served up to the limit of the available budget. In order to avoid unrealistic applications that later cannot be realised e.g. due to over-optimistic assumptions in terms of economic feasibility as happened severe conventional fines should apply if subsidies are not obtained. An advantage of the approach is that it is technology neutral – new technologies can be included as soon as they are available without need to be specifically incorporated into the funding rules specifically – and establishes a basis for comparison amongst applications. And contrary to other funding schemes there is no risk of overshooting the budget. There might be other viable options to ensure the goal of the fund: adding a pull factor for green development in the shipping sector. A detailed description and assessment would deserve a paper of its own.

4 Incorporating elements of the ETS in the GHG Fund

This approach tries to combine the main advantages of both the GHG fund and the ETS. The hybrid approach "enhanced GHG Fund" is based on a fixed tariff for the contribution as under the GHG fund. However, the tariff should be based on a long term price path projection for internalizing the full external GHG costs of the shipping sector. This price path should be continuously increasing and should be reviewed after certain periods of time (i.e. 1, 3 or 5 years). However, to provide certainty to investments in efficiency improvements in the shipping sector, at the reviews the tariff path may only be increased but not alleviated. Alternatively the tariff could also be based on the weighted average carbon prices observed in previous year in one or several of exchanges where carbon units are traded. In this respect, the hybrid approach would be rather similar to the ETS. Whether the tariff would be due on fuels sold or consumed and whether it is payable by bunker fuel providers or the ships is an administrative detail which does not have to be decided in the first place.

This approach would combine several advantages of the GHG fund and the ETS:

- It would provide a clear long term incentive for internalizing external GHG costs of the shipping sector and avoid that shipping companies would have to deal with the volatility and hedging of carbon prices.
- In terms of environmental integrity, it would provide the same level of certainty that the shipping sector's target line is always achieved, since the revenues raised would always by higher than those required to beat the target line.
- It would treat the shipping sector in the same way as other sector without distortions in competition and thus avoid an unjustified preferential treatment to the shipping sector.
- It would allow raising sufficient revenues to cover the cost required to achieve the shipping sectors target line and would in addition provide sufficient revenues to reflect CBDR through the differentiated redistribution of revenues.

Particularly the last bullet is important to understand the merits of the hybrid approach. The next section therefor addresses the way for which purposes revenues should be used and how they should be allocated to the different purposes.

4.1 Setting the level of the GHG contribution and its distribution

The level of the GHG contribution should be defined in a way to incentivise emission reductions in the shipping sector. Giving emissions a price is key to incentivise running the existing fleet in the most emission effective way. Decisions whether to invest in emission saving technologies and in low emitting new ships will depend not only on the current price to emissions, but mainly on the expected price in future years. Planning security that also in coming years there will be a stable price to emissions is a pre-condition to trigger green investment decisions. Therefore the GHG contribution should be crafted in a way to generate enough revenues to fulfil the multiple functions of the fund and provide planning and investment security for a longer time horizon. This could be done by setting the contribution at a higher level than necessary to buy enough offsets (e.g. a certain percentage above that level or a certain fixed amount of money above that level). An option could be to define a GHG contribution pathway at the moment of introduction of the scheme securing the minimum level. A technical committee could be assigned to regularly check whether the amount of revenues raised is sufficient to fund the different goals of the fund (reflecting CBDR; off-set emissions above the target line; support adaptation and mitigation activities in developing countries; and promote low-carbon technologies in the shipping sector itself). If the revenues raised are not sufficient to meet the defined goals, the level of the GHG contribution per ton of fuel would be raised. As there is some flexibility in the distribution among the different uses, minor changes would not require changes but only major differences to the envisaged development.

There are three uses of the proceeds from the GHG fund: Off-setting emissions above the target line, fund mitigation and adaptation projects in developing countries and support emission reduction efforts in the shipping sector itself. And there are two groups of countries the revenues stem from: developing and developed countries. All ships would be covered by the scheme (and thus the un-discriminatory approach of the IMO is fulfilled). The spending of the revenues reflects the principle of common but differentiated responsibilities in two ways. First the proceeds stemming from developing countries are recycled back to the participating developing countries via the Green Climate Fund adding on top of the US$ 100 billion goal (see Figure 1). Second, the proceeds stemming from developed countries are used for three purposes: to off-set emissions above the emission target for the shipping sector, to provide new and additional climate finance and support emission reduction measures in the shipping sector itself. In this way the main share also of the proceeds stemming from developed countries are channelled to developing countries – the contribution to the Green Climate Fund will go entirely to developing countries and most off-sets are expected to be generated in developing countries, too. The Green Shipping Fund is addressed un-discriminatory to all ships, so part of it will benefit developing countries.

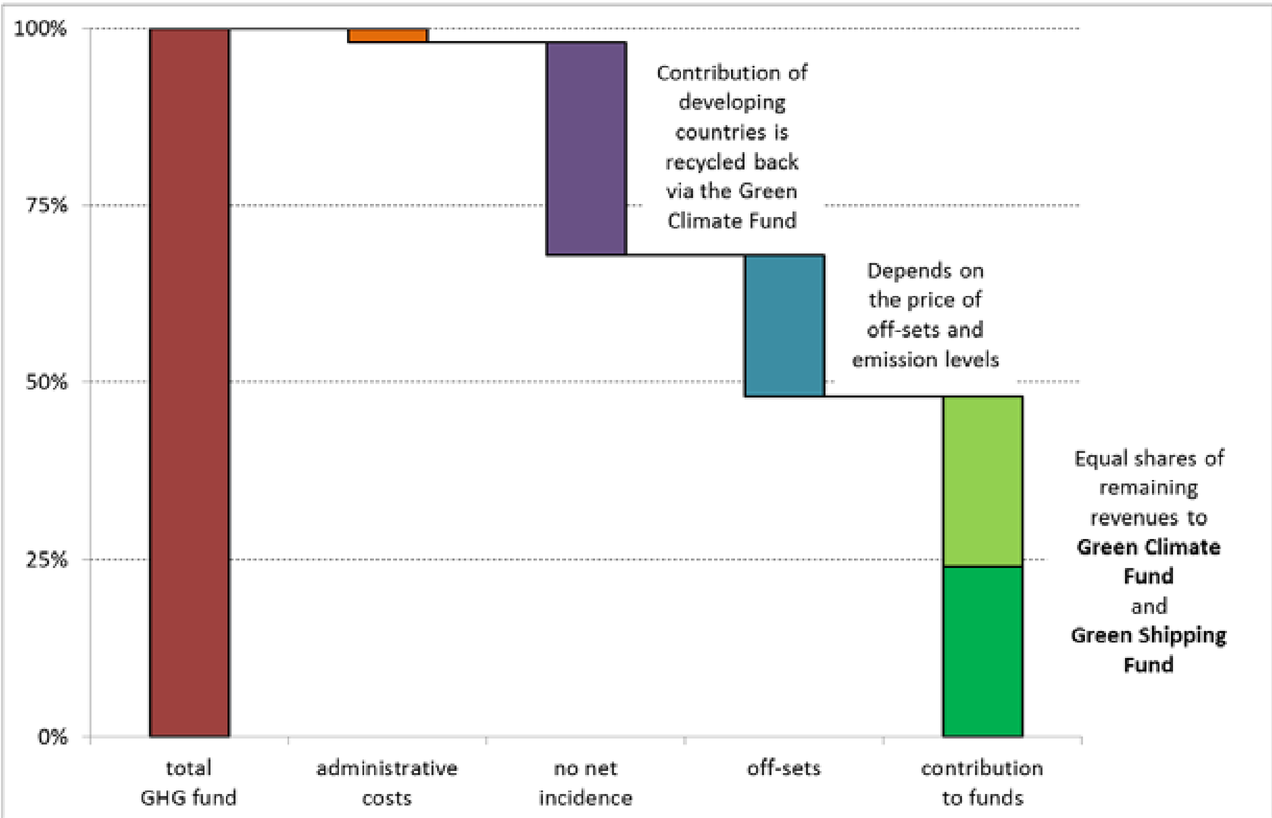

Figure 1 Elements of the proposed GHG fund

The three goals of off-setting emissions above the target line; funding mitigation and adaptation projects in developing countries; and incentivise emission reductions in the shipping sector are considered to be of equal importance. Therefore each of them should receive an equal share of revenues.

The GHG contribution per ton CO_2 could be calculated based on the revenues needed to purchase off-sets equivalent to one ton of CO_2 on every ton covered by the scheme. This would yield higher revenues than if only the estimated revenues needed to purchase off-sets above the target line are divided by the total amount of emissions covered by the scheme and thus ensure the capability to fulfil the other purposes as well. The moment the off-sets are purchased, prices might differ compared to the level expected when setting the level of the GHG contribution. If prices are lower/higher than expected the remaining revenues dedicated to the Green Climate Fund and the Green Shipping Fund will be adapted accordingly (increased in the case of low prices for off-sets and reduced in the case of high off-set prices). This flexibility ensures that – except in extreme cases – the necessary amount of offsets can always be purchased.

4.2 Environmental effectiveness

The GHG contribution will give emissions a price and thus incentivise and reward emission reductions. The push effect of increased costs is enhanced by adding a pull-factor: the Green Shipping Fund. The price per ton is defined in advance and gives the ship operators planning security. It is expected that the GHG contribution alone will not achieve that shipping emissions are reduced to the target line. The emissions goal can nevertheless be reached by using the revenues generated to purchase off-sets for emissions above the target line. The certainty to achieve the target is by this design enhanced compared to a conventional tax. If the GHG contribution per ton of CO_2 is comparable to the cost of one ton of CO_2 in linked markets the probability is very high that enough resources will be available to purchase off-sets with the proceeds stemming from industrialized countries. Changes in the price of off-sets compared to the moment the level of the GHG was set are absorbed by the adjusting the budget available for the Green Climate Fund and Green Shipping Fund. Extreme volatility of prices may pose a difficulty, though. Therefore at regular intervals a technical committee should assess whether the level of the GHG contribution is still adequate and raise it, if need be.

5 Incorporating elements of the GHG Fund in the ETS

In principle, the ETS and GHG Fund can be designed in such a way that they deliver the same emissions while generating the same revenues. The tariff in the GHG Fund would need to be raised beyond the level envisaged in the current proposal to offset emissions above the emission target, e.g. by adding an element to the tariff or applying a multiplier. The higher tariff would raise revenues for purposes other than purchasing offsets. The net cost to the industry of the ETS could be lowered by allocating a share of the allowances for free.

Regular revisions of the tariff and the use of a long term price path as an anchor in the hybrid approach to the GHG Fund should ensure that the emission target is met and that planning and investment uncertainty is reduced. Similar elements could be implemented in an ETS to ensure that the volatility in revenues and planning and investment uncertainty is reduced. The next section discusses alternative designs for an ETS that incorporate some of the elements of the GHG Fund.

5.1 Price volatility and investment certainty

Even though the ETS and the GHG fund can be designed to generate the same amount of revenues for offsetting and/or other purposes, and therefore the long term average value of the allowances will equal the long term average of the contribution, the value of the allowances will be more volatile in the short term than the contribution. Volatile allowance prices are not a problem per se for the shipping sector, which is well accustomed to dealing with volatile costs (fuel prices for example) and revenues (freight rates). However, volatility may have a negative impact on investments in energy efficiency, as benefits become less predictable.[3]

The ETS proposal allows ship-owners to purchase out-of-sector emission rights. The price of these emission rights, the carbon price, acts as a price ceiling on the price of allowances. Volatility in an ETS is due to day-to-day movements in the carbon price. Volatility is thus greater in an ETS than in the GHG Fund proposal, even when all allowances in the ETS are allocated for free i.e. when the price of allowances is initially set to zero. The day-to-day movements in the carbon price still define volatility in the ETS for offsets purchased, whereas the fluctuations in the price of offsets is dampened by the fixed contributions in the GHG fund which is only changed at regular intervals.

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[3] In reality, the impact of the volatility may be less significant as the main benefit of improving efficiency is reducing fuel costs, which are currently much higher than carbon prices.

Fluctuations in the price of allowances and/or carbon price causes volatility in revenues raised and the cost burden to ship-owners. To some extent, this may impede investments in fuel-saving technologies and in low emitting new ships. There are several ways to reduce price volatility. The design of the system can reduce volatility by introducing price floors and price caps of allowances. Moreover, actors can reduce the volatility they are exposed to by using financial tools.

A price floor could be set for allowances in the auction, provided that this floor is lower than the carbon price. The price floor would initially be implemented as a reserve price at the auction. If parties bid less than the reserve price, allowances are not auctioned. After the auction, a price floor can be implemented by a quantity measure: The auctioneer needs to temporarily set aside allowances if the price of allowances approaches the floor (Grubb, 2012). This hybrid approach to an ETS limits fluctuations in the price of allowances, but does not shield the sector from fluctuations in the carbon price.

A price ceiling on allowances in the ETS can be introduced as a ‘safety valve’: the system allows the regulator to sell an unlimited number of allowances at a previously agreed maximum price. Although a safety valve reduces the risk of high prices, it reduces the environmental effectiveness because selling these allowances increases the emissions cap.

By introducing a price floor and a safety valve, emission allowances will remain volatile, but prices will move between the price floor and the price cap. Hence, there is larger investment certainty.

In addition to these regulatory changes, ship-owners have several means at their disposal to minimize the risks of fluctuating prices of offsets and allowances. They can buy allowances or offsets when the carbon price is low and sell them at a later date if they have adequate funds of their own. Ship-owners can use a myriad of financial instruments if funds are insufficient: they can buy futures which allow them to obtain allowances in the future at current carbon prices, they can buy options which gives them the right to buy allowances at a predetermined price, they can use hedges to reduce the losses incurred when the price of allowances rises and so on.

The fact that an allowance is a tradable financial asset for the ship-owner is seen as an advantage of the ETS. However, the use of arbitrage is meant to bring the same stability to the price of allowances as the fixed tariff in the GHG Fund. As arbitrage brings with it additional trading risks, proposals have been made to limit the danger of speculation and over-allocation in the ETS. These proposals include more frequent auctions, a limited bid size and restricted participation for a number of recognized actors (MEPC 60/4/41).

5.2 Cost burden for the shipping sector

The direct cost of the ETS relates to the purchases of allowances below the cap, the costs of out-of-sector emission rights above the cap and the costs of investing in fuel efficiency. The carbon price or price of allowances (possibly reduce to zero when free allocation takes place) defines the share of direct cost attributable to the ETS auctioning mechanism. Ship-owners may reduce these direct costs through arbitrage. As allowances are sold for emissions below the cap, revenues should be larger in the ETS then in the original proposal for the GHG fund. However, this outcome is dependent upon the condition that the tariff in the GHG fund compensates for offsets only. A hybrid tariff that internalizes the external cost of emissions in the shipping sector could well lead to the same direct costs and revenues as the ETS.

The direct costs of the ETS approach correspond to those of the original proposal for the GHG Fund if all allowances are allocated for free. The basis for the free allocation of allowances could be historical emissions of ships based on actual fuel use, historical emissions based on average fuel use per ship type, or output-based measures such as kilotons of freight transported.

Free allocation, although less costly to the shipping sector than auctioning, has a number of disadvantages. It can lead to windfall profits which may be undesirable. It could increase the administrative burden if data need to be collected and verified for the free allocation. And it could create distortions in the shipping sector when for example allowances are allocated on the basis of output and some ship types have much higher emissions per unit of output than others, or when allowances are allocated on the basis of historical emissions and some ships have already reduced their emissions.

5.3 Administrative complexity and costs

Often it is assumed that the implementation of environmental taxes (or similar such as the system for Greenhouse Gas Contribution) is less complicated and entails fewer transaction and administrative costs than the implementation of systems of tradable rights. According to Crals and Vereeck (2005) this is a mistake, however, the result of policy-makers being more familiar with taxes than with tradable rights.

Although the literature on environmental economics has been discussing transaction and administrative costs of tradable permit systems (e.g. LECG, 2003; Jaraite et al., 2010; Heindl, 2012), hardly any *comparative* analysis of the costs incurred by environmental policy instruments has been performed (Krutilla, 1999; Crals and Vereeck, 2005). As far as such comparisons are made (see e.g. Crals and Vereeck, 2005; Keohane, 2009), the transaction and administrative costs of tradable permits and taxation seem similar, however, although dependent on design of the system.

According to Crals and Vereeck (2005) the set-up costs may be higher for tradable permit systems than for taxes. If the GHG contributions can be levied and collected by an established tax agency, set-up costs are negligible and sunk, while for a system for tradable rights new organisations have to be established. In the case of the maritime sector there is no established tax agency, however. This means that both types of systems face the same kind of set-up costs.

Monitoring, enforcement and compliance make up a substantial part in total administrative costs. According to Keohane (2009), emissions monitoring alone accounts for roughly two-thirds of administrative costs in the case of tradable permits. In principle, these costs are the same for both tradable permits and taxation. Regardless of whether emissions are taxed or capped, they must be measured.

However, dependent on the specific design of the instrument costs may differ. As Crals and Vereeck (2005) note: “Basically, there are two ways to monitor ...: upstream where producers are monitored, and downstream where policing is focused on the end-users. Significant differences between the two approaches exist with regard to the type and number of market players that need to be monitored. Whereas an upstream scheme has fewer and larger agents, downstream monitoring involves more players and thus higher costs. Yet, downstream monitoring may yield significant public awareness benefits."

The proposals for a METS assume ships or ship-owners as the trading entities, which implies downstream monitoring. The proposals for a GHG Fund mention two possibilities: GHG contributions paid by ships or ship-owners (downstream), or GHG contributions paid by bunker-fuel suppliers (upstream). In the latter case, the number of participants will be substantially lower than if ship-owners have to pay GHG contributions or have to trade permits. Therefore, it may be assumed that monitoring, enforcement and compliance costs will be lower in the case of GHG contributions paid by bunker-fuel suppliers than in the case of a METS where ships are the trading entities.

Trading costs include the costs of searching trading partners, negotiating the price and establishing contracts. At first sight, such costs may appear much higher in the case of tradable permits than in the case of taxation. However, a METS should not be seen as a system in which individual ship owners search other individual trading partners after which negotiations about the price starts. Any possible trading scheme for the maritime sector will be a large scale system based upon brokered markets (with intermediaries but with market players still holding the rights) or dealer markets (where intermediaries hold the rights). Financial institutions or insurance companies can reduce search costs by acting as brokers between buyers and sellers (Crals and Vereeck, 2005). In the case of broker markets, the sale of a permit is a spot transaction that does not entail any contracting costs. Furthermore, the METS as well as the GHG Contributions system is open to other trading schemes such as the European ETS and the Clean Development mechanism. This means that a broker market for CO_2 allowances already exists, which reduces the transaction costs. In practice, the negotiation, search and contract costs in the case of the METS will hardly be any higher than the administrative costs of paying taxes.

Experiences of the EU ETS may give some insight in the magnitude of trading costs, although it is difficult to distinguish between the costs of monitoring and reporting emissions, which would be required in both MBMs, and the costs of emissions trading itself. A survey of Irish businesses shows that it costs them a few cents per tonne of CO_2 to trade (Jaraite et al., 2010). In the EU, compliance costs of paying taxes are typically 2-4% of tax revenue (European Commission, 2004), so at a CDM price of € 15 also a few cents per tonne of CO_2.

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

Regardless of whether a contribution is levied on emissions or emissions are capped in an ETS, a major share of the administrative costs comprises of monitoring and reporting emissions. These costs are the same in the ETS and the GHG Fund in which the ships are liable for paying the contribution. If the fuel suppliers are liable for paying a contribution to the GHG Fund, or if they are the regulated entities in the ETS, the number of entities that have to monitor emissions (or rather, fuel sales) would be lower so the administrative costs could also be lower. Other cost items of these systems are the costs of paying the contribution or the costs of allowances trading. The empirical evidence suggests that these are roughly comparable at a few tenths of a percent of the value. The costs of the administration are also very similar. Hence, we conclude that there is no empirical evidence to suggest that the administrative and transaction costs of an ETS are higher than the costs of a GHG Fund in which the ship is liable.

5.4 Environmental effectiveness

The cap in the ETS would normally ensure that the emission target can always be reached. The marginal costs of shipping would also be higher than in the current proposal for the GHG Fund as the cost of allowances in the ETS (whether allocated for free or auctioned) apply to emissions below the cap as well. This would create an added incentive to minimize on fuel use in the short run (reduction in speeds, running at full loading capacity, scrapping of fuel-inefficient ships or routes) and in the long run (fuel-saving technologies and low emitting new ships).

However, this assumes that the tariff of the GHG Fund does not fully internalize the external cost of GHG emissions in shipping. The higher tariff in the hybrid approach could ensure that marginal costs are at a comparable level in the GHG Fund. Furthermore, the ability to purchase offsets and trade in out-of-sector emission rights allows the shipping sector to emit GHGs beyond the cap in the same way that the hybrid approach to the GHG Fund allows for the purchase of and trade in offsets below and above the cap. Both MBMs could therefore be equally effective in curbing emissions, provided that the direct costs of the allowances in the ETS are as high as the tariff in the GHG Fund.

One element of the MBMs designs warrants further attention. The offsetting of emission levels beyond the cap or target depends on revenues raised and the quality of offsets, as the proposals allow for the purchase of CDMs or some other approved carbon credit. These could include Voluntary Carbon Offsets, and carbon credits based on various standards such as Gold Standard, CCBA Credits, VER and so on. The quality of offsets is not just dependent on the type of carbon credit, but also on the quality of projects selected by the operational entity in the case of a single carbon credit. A poor choice of offset type and/or projects within a single type of offset could hamper the intended purpose of offsetting shipping emissions. Hence, it is important to set standards for the quality of the allowances in order to guarantee the environmental effectiveness of any system.

6 Conclusions

The shipping sector contributes with around 3.2 % to worldwide CO_2-emissions. With the introduction of a market based mechanism the shipping sector can do an important step to reduce emissions and contribute to the effort to combat climate change. The mechanism faces the challenge to reconcile two principles which at first glance are contradictory: the uniform treatment of all ships on the one hand and common but differentiated responsibility (CBDR) on the other hand. While a uniform GHG contribution/CO_2-price can cater for the former and reduce significantly the risk of avoidance; revenue spending is the key for the latter principle.

Two MBMs have been proposed by EU countries to address the climate impacts: a GHG Fund and an ETS. This paper concludes that the differences between the two are primarily due to differences in *design*, and not to differences in principle. Both systems can be designed to have similar costs to industry, including administrative costs, similar environmental effectiveness, and yield a similar amount of revenue for other purposes than offsetting shipping emissions. Differences remain in short term volatility and the possibility to pass through opportunity costs.

Hence a hybrid approach could be designed, starting either from the ETS or the GHG Fund. Under a hybrid approach, revenues raised that can be attributed to developing countries should – through the Green Climate Fund – be recycled back to them for mitigation and adaptation. The remaining proceeds should in the first place be used for offsetting shipping emissions above the target line through purchasing units from other sectors. Half of the finally remaining share of revenues can – in order to reflect CBDR – be devoted to mitigation and adaptation projects in developing countries only. The other half of the finally remaining revenues should be used to enhance emission reductions in the sector itself by providing additional financial incentives e.g. investment subsidies for the deployment of green technologies in the shipping sector.

This way, the hybrid approaches would combine several advantages of the GHG fund and the ETS approach. They would both ensure that the reduction target of the shipping sector is exactly achieved and that the principle of CBDR can be reflected adequately. At the same time would also provide incentives to the shipping sector to spur investments in GHG efficient technologies and thus accelerate the take-up of such technologies while alleviating the cost of addressing the climate change in the shipping sector. The remaining differences in the volatility of prices can be reduced by establishing a clear price path in the GHG Fund and introducing price regulating elements such as a floor price and safety valve in the ETS.

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EU policies to address maritime GHG emissions
Analysis of the impacts on GHG emissions

DISCUSSION PAPER

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ON BEHALF OF THE

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Summary

The EU Commission committed itself to include emissions from shipping into the existing EU reduction commitment if no international agreement was achieved on a global level. To this aim the EU Commission is currently considering different regional policy options in an impact assessment. In this paper the impact of these policy options on GHG emissions has been analysed.

We conclude that a carefully designed emissions trading scheme (ETS) is the best option from an environmental point of view, mainly because of an overall emission cap.

A target-based compensation fund, which also has an overall emission cap, could be as effective as an ETS. However, funds would be allowed to choose how they meet the target and would presumably have a certain degree of freedom on the use of offsets. This makes it difficult to assess the instrument and raises the risk of the funds not meeting the target. A thorough design, especially a clear allocation of responsibilities between funds and its members, is therefore crucial.

An emission tax has the advantages of a market based measure and will incentivise emission reductions. However, overall emissions are not capped.

A contribution-based compensation fund could have the same environmental effect as an emission tax. If parts of the emissions were exempted, the environmental effectiveness would of course be less than for an emission tax.

The two options of the mandatory emission reduction per ship have the disadvantage that overall emissions are not capped. Moreover, they can be evaded by ship operators easier than the measures above.

Due to the high risk of evasion, a bunker fuel tax, which is a very effective policy instrument in cutting GHG emissions if applied on a global scale, is not an effective instrument when applied on a regional scale.

For the instruments that allow for off-setting (other than ETS allowances) it is important to ensure the environmental integrity of the off-sets.

Zusammenfassung

Für den Fall, dass kein internationales Abkommen auf internationaler Ebene erzielt wird, hat sich die Europäische Kommission dazu verpflichtet, die Emissionen der Seeschifffahrt in ihr bestehendes Reduktionsziel aufzunehmen.

Zu diesem Zweck lässt die Europäische Kommission derzeit verschiedene regionale politische Instrumente auf ihre Auswirkungen hin untersuchen. Im vorliegenden Papier wird der Effekt dieser Instrumente auf die Treibhausgasemissionen untersucht.

Dabei kommen wir zu dem Ergebnis, dass in Bezug auf die Umweltauswirkungen ein sorgfältig entworfenes Handelssystem für Treibhausgasemissionsrechte die beste Option ist, dies hauptsächlich aufgrund dessen, dass eine Gesamtemissionsobergrenze gesetzt wird.

Target-based compensation funds, die sich auch durch eine Gesamtemissionsobergrenze auszeichnen, könnten genauso effektiv sein wie ein Handelssystem für Emissionsrechte. Die Fonds könnten jedoch selbst darüber entscheiden, wie sie ihr Emissionsziel erreichen. Dies macht eine Bewertung dieses Instrumentes schwierig und birgt das Risiko, dass die Fonds ihr gestecktes Ziel möglicherweise nicht erreichen. Eine sorgfältige Ausgestaltung des Instruments, insbesondere eine deutliche Zuordnung der Verantwortlichkeiten der Fonds und ihrer Mitglieder, ist hierbei essenziell.

Eine Emissionssteuer hat die Vorteile eines marktbasierten Instruments und gibt den Anreiz Emissionen zu reduzieren, eine Gesamtemissionsobergrenze wird jedoch nicht gesetzt.

Ein C*ontribution-based compensation fund* könnte den gleichen Umwelteffekt haben wie eine Emissionssteuer. Wäre ein Teil der Emissionen jedoch ausgenommen, so würde der Umwelteffekt natürlich weniger günstig ausfallen als bei einer Emissionssteuer.

Die zwei Varianten der *Mandatory emission reduction per ship* haben den Nachteil, dass keine Gesamtemissionsobergrenze gesetzt wird. Darüber hinaus können sie noch einfacher als die oben genannten Instrumente umgangen werden.

Eine Bunkeröl- / Kraftstoffsteuer, die bei einer globalen Implementierung ein effektives Instrument ist, ist wegen des hohen Risikos einer Umgehung, ein kein effektives Instrument, wenn sie auf regionaler Ebene implementiert wird.

Bieten die Instrumente die Möglichkeit des *Off-settings* (mittels anderer Rechte als Emissionshandelsrechte), ist es wichtig, die Umweltwirkung dieser *Off-sets* sicherzustellen.

Table of Contents

1 Introduction

The EU commission has committed itself to include emissions from shipping into the existing EU reduction commitment if no international agreement is achieved on IMO/UNFCCC level. The IMO has agreed to introduce a global energy efficiency standard for ships, the so called EEDI (Energy Efficiency Design Index). However, this efficiency standard is only compulsory for new ships and only incentivises technical measures. DNV (Det Norske Veritas) and LR (Lloyd´s Register) have estimated that emissions will continue to increase after the EEDI comes into force, albeit at a slower pace. While global market based measures are still under discussion, the EU Commission is investigating possible measures on EU level. In November 2011, in the third meeting of the Working Group 6 of the ECCP (European Climate Change Programme; Reducing greenhouse gas emissions from ships), the main policy options that the EU Commission considers for impact assessment have been presented. The impact assessment of these policy options is currently being carried out. In addition, from 19 January – 12 April, the EU Commission has held an internet consultation to receive input from stakeholders regarding the following four main policy options:

1. A compensation fund;
2. An emission trading system (ETS);
3. A tax on fuel or on emissions;
4. A mandatory emission reduction per ship.

In this paper the impacts of these policy options on GHG emissions are analysed.

Ideally, the emission reduction that can be achieved by the different policy options could be determined and the options compared on these grounds. However, due to the limited information on the policy options available from the internet consultation and due to a lack of detailed data on the fleet that would be affected by the policy options, it is not possible for the authors to quantify the environmental impact of the policy options.

Therefore an alternative approach has been chosen for the assessment of the policy options with respect to their environmental impact:

First we identify the factors that determine the impact of the policy options on GHG emissions in general, such as the geographic scope, the possibilities for evasion etc. Then we discuss the policy options considered by the EU Commission for impact assessment.

Prior to this analysis the policy options are exemplified briefly. Where possible, the rudimental description of the policy options in the internet consultation questionnaire is thereby complemented by a background document of the European Climate Change Programme (EU Commission, 2011a).

2 Policy options

2.1 Compensation fund

The first policy option proposed by the EU is a so called compensation fund. Two main approaches are thereby differentiated, the contribution-based approach and the target-based approach.

The common elements of the two approaches are as follows:

1. The geographical scope of the options is the same: the emissions of the ships on routes to and from the EU as well as on routes within the EU are covered.
2. Ships calling at an EU port have to be affiliated to a compensation fund; a penalty has to be paid otherwise.
3. The fund is not publicly administered.
4. Certain standards have to be fulfilled by a compensation fund to be recognized by the EU.
5. More than one compensation fund could be set up under both options.

The specific design elements of the two approaches are as follows:

1. Contribution-based approach:
    a. No emission reduction target is set ex-ante.
    b. A fee per ton CO_2 is levied by the compensation fund(s) from its members.
    c. Optional: the fee has to be paid not for all emissions but for a proportion of the emissions only.
    d. For a compensation fund to be recognized by the EU it has to levy the minimum CO_2 fee that is set by the EU.
    e. A mandatory contribution to international climate finance would be a criterion for approval of the fund(s) “in the event that revenues are needed for international climate finance”.
2. Target-based approach:
    a. An overall target based on historical transport performance or emissions is set.
    b. The emission target is divided between individual compensation funds according to the emissions of the ships they cover.
    c. How the emission target is met is completely up to the compensation fund(s).
    d. An additional contribution to international climate finance is mentioned as a design option.

2.2 An emissions trading system (ETS)

In the internet consultation the EU Commission describes the ETS system considered with: “the environmental outcome [of ETS] is guaranteed.” This means that the EU Commission considers a cap-and-trade and not a baseline-and-credit ETS[1]. An overall emission target would thus be set

[1] A baseline-and-credit scheme is characterized by a ship specific standard that is combined with a trade mechanism. Ships that perform better than the standard receive credits which have to be purchased by ships that do

under an ETS for maritime shipping. The cap would be determined on the basis of historical performance (EU Commission, 2011b).

The geographic scope of the intended emissions trading system would be the same as of the compensation fund: the emissions of the ships on routes to and from the EU as well as on routes within the EU are covered.

The other design elements of the ETS are not specified yet. The following design options are mentioned:

- The ETS for maritime shipping could be an independent system (a 'closed' ETS) or could be linked to the existing EU ETS (an 'open' ETS).
- Allowances could be allocated for free during a transitional period.
- There is a range of options for allocation (EU Commission, 2011b).
- There is a range of options for the use of the "allowance value", i.e. the revenue from auctioning of allowances (EU Commission, 2011b).

2.3 Tax

Two taxation schemes are considered by the EU Commission: a tax on bunker fuel and a tax on emissions.

2.3.1 Bunker fuel tax

The EU Commission considers a tax on bunker fuel for impact assessment. The tax rate would be based on the carbon content of the fuel. The tax would be levied on fuel sold in the EU. Fuel exported as cargo would be exempted. Like any national tax, Member States would receive the tax revenue.

2.3.2 Emissions tax

The geographical scope of the considered emissions tax would be the same as for the compensation fund and the emissions trading system: the emissions of the ships on routes to and from the EU as well as on routes within the EU are covered. For each ton of CO_2 emitted on these routes, a tax would have to be paid. According to EU Commission (2011a), "[r]evenues have to go to Member States."

2.4 Mandatory emission reduction per ship

Two options for a mandatory emission reduction per ship are given in the internet consultation document.

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not comply with the standard. Under a baseline-and-credit scheme, overall emissions are not controllable since sector growth is not restricted. In contrast, total emissions are capped under a cap-and-trade mechanism. The amount of tradable emission allowances issued in a year corresponds with this cap and each unit emitted has to be covered by an allowance.

2.4.1 Option 1 ("target related to historic baseline")

Option 1 sets an emission cap per ship. The mandatory emission reduction target would thereby be relative to the historic baseline emissions of the ship. The geographical scope of the instrument would be the emissions of the ships on routes to and from the EU as well as on routes within the EU.

2.4.2 Option 2 ("target related to an index")

The internet consultation questionnaire states about the second option that per ship a "mandatory emission reduction target can be set in comparison with an index, such as the EEDI…" Our understanding of this option is that an efficiency target for ships is set, but that the index has to be decided upon.

3 Factors determining environmental impact of policy options

The four policy options that the EU Commission considers for the maritime sector can have an impact on the GHG emissions of the maritime shipping sector itself (in-sector emissions) as well as on the GHG emissions outside the maritime shipping sector.

The factors that can have an impact on the in-sector and/or the outside emissions are as follows:

1. The **geographical scope** of the policy instrument determines the amount of emissions that fall under the instrument and thus the reduction potential and the emission target of the instrument.
2. **Cap**: The emission reduction depends on whether or not overall emissions are capped/an absolute emission target is set. When the overall emissions are not capped/no absolute emission target is set, growth of activities in the sector might lead to an increase in overall emissions.
3. The emission reduction depends on the **stringency** of the policy instrument, e.g. the level of cap/target.
4. The more possibilities a policy option leaves for **evasion**, the less its' environmental effectiveness.
5. **Incentives**: When an instrument rewards emission reduction beyond the emission target, overall GHG emission reduction may be higher.
6. If a policy instrument does not allow for offsetting (using ETS allowances and/or CDM/JI credits), then the CO_2 abatement options of the maritime shipping sector itself and their costs will, at least for market based measures, determine, next to the factors mentioned above, the in-sector emission reductions. If offsetting is (partially) allowed, then the share between in-sector emission reductions and emission reductions outside the sector will not only depend on the abatement options and abatement costs of the maritime shipping sector itself but also on the abatement options and costs in other sectors. If **offsetting is allowed** by **using** Certified Emission Reduction Credits (**CERs**) and Emission

Reduction Units (**ERUs**)[2], then the quality of these offset options will play a crucial role in the actual emission reduction achieved outside the sector.

7. Good **enforceability** of a policy instrument is a necessary condition for the environmental effectiveness of an environmental policy instrument.
8. The policy instruments could indirectly lead to an increase of the emissions outside the maritime shipping sector: A **modal shift effect** could be induced, shifting GHGs emissions to other transport modes rather than reducing overall GHG emissions.
9. Long run GHG reductions will depend on
   i. whether an instrument can be **expanded to a global level**,
   ii. the **flexibility** of a policy instrument to adjust its stringency if necessary,
   iii. the instrument's **incentive** for **technological improvements**,
   iv. the amount of **revenues** available for additional GHG reduction: when under a policy instrument revenues are generated these could, next to buying offsets, be used to additionally stimulate GHG reductions, e.g. by subsidizing the adoption of CO_2 abatement measures.

4 Evaluation

4.1 Geographical scope

- The proposed geographical scope for the compensation fund, the ETS and the emission tax is the same: the emissions of the ships on routes to and from the EU as well as on routes within the EU are covered.
- For a bunker fuel tax, the geographical scope is the EU. Whether more or less emissions would be covered under a bunker fuel tax is unclear: ships that are sailing on routes that fall in the geographical scope of the other policy instruments may sail on fuel that they have bunkered outside the EU and ships that are sailing on routes that lay outside the scope of the other policy instruments may sail on fuel that was bunkered in the EU.

4.2 Overall emission cap

- Under an ETS overall (and not ship specific) emissions would be capped. If a separate maritime ETS was established the in-sector emissions would thereby be capped. If shipping were

[2] The **Clean Development Mechanism (CDM)** allows a country with an emission-reduction or emission-limitation commitment under the Kyoto Protocol (Annex B Party) to implement an emission-reduction project in developing countries. Such projects can earn saleable **certified emission reduction credits (CER)**, each equivalent to one tonne of CO_2, which can be counted towards meeting Kyoto targets.

The **Joint Implementation mechanism (JI)** allows a country with an emission reduction or limitation commitment under the Kyoto Protocol (Annex B Party) to purchase **emission reduction units (ERUs)** from an emission-reduction or emission removal project in another Annex B Party, each equivalent to one tonne of CO_2, which can be counted towards meeting its Kyoto target.

to join the existing ETS as a new sector, one cap would hold for the industry, the power sector, aviation and the maritime sector.

- Under a target-based compensation fund overall emissions would be capped if the emission target was based on *historical emissions*.
- The EU Commission states that the target of the target-based compensation fund could also be set on the grounds of historical *transport performance*. It is not clear for us how a target would be specified under this option. We thus cannot rule out that under this option overall emissions are not capped.
- Under a contribution-based compensation fund, under a fuel or emission tax, and under a mandatory emission reduction overall emissions are not capped.

4.3 Stringency

The stringency of a policy instrument, like the tax rate or the emission cap, naturally plays a key role in the environmental effectiveness of an environmental policy instrument.

- For some policy instruments (e.g. ETS) baseline emissions may have to be determined in order to determine the stringency of the instrument (e.g. the ETS cap). The period for which the baseline emissions are determined is thereby crucial. If the baseline period is a "boom" period, the sector may not need to take any action at all to comply with the instrument.
- Note that if a separate, closed ETS system was introduced for the maritime shipping sector alone, there could be a tendency not to work with a stringent cap in fear of a relatively high allowance price. On the other hand, a loose cap would result in low allowance prices in a closed system. The sector would not be able to buy allowances from other sectors which may have cheaper abatement options.
- Note also with respect to the contribution-based compensation fund that the EU Commission gives the option that "the contribution may be required in respect of only a portion of the emissions only." The extent to which an exemption is granted is of course crucial for the environmental effectiveness of the instrument.

4.4 Evasion

- Under a compensation fund, an ETS, an emission tax, as well as a mandatory emission reduction per ship two evasion strategies are conceivable:
  1. An extra port call outside the EU or the shift from transhipment to ports outside the EU can reduce the emissions that are captured by a policy instrument.
  2. A redistribution of the geographical deployment of ships: ships that are relatively efficient could be deployed on routes that are covered by the instrument, whereas ships that are relatively inefficient are deployed on routes outside the geographical scope of the instrument.
- For ship-specific absolute emission targets (option 1 of mandatory emission reduction per ship) a strategy could be to use the ships on routes covered by the instrument until the target is reached and switch subsequently to routes not covered by the instrument.
- None of these evasion strategies are relevant under a bunker fuel tax, but as the EU Commission puts itself in the questionnaire for the internet consultation: "... applying a tax

purely on bunker fuel sold in the EU could lead to a significant risk of evasion and, may, as a result, undermine the environmental effectiveness ... of the fuel tax."

Ships that fully or partly operate on non-intra EU routes can be expected to evade an EU bunker fuel tax by bunkering outside the EU. This is, at least in the long run, likely to be the case since the ships that operate on these routes generally have a high cruising radius. A drop in bunker fuel sales in the ports of California after the exemption of bunker fuel from the sales and use tax had temporally been abolished in the early 90s shows that this fear is not unfounded (OECD, 1997).

For ships that normally sail on intra-EU routes only, the risk for evasion by bunkering outside the EU will naturally be lower. Depending on the net bunker fuel price and the level of the tax rate, some ships may have an incentive to make a detour for bunkering outside the EU. However, clearing formalities regarding the ships' freight will be an obstacle for this kind of evasion.

4.5 Incentive to reduce emissions beyond target

Most instruments result in an incentive to reduce carbon, regardless of the level of emissions. In contrast, a mandatory emissions reduction per ship results in an incentive to reduce emissions up to the point where the mandatory level has been achieved. There is no incentive to reduce emissions beyond that level. When an instrument rewards the emission reduction beyond a ship-specific emission target, overall GHG emission reduction may be higher.

Hence, on the basis of this analysis the following instruments result in higher emissions reductions:

- A contribution-based compensation fund;
- An ETS system;
- A bunker fuel tax;
- An emission tax.

4.6 Quality of offsets

Under some of the considered policy options the use of offsets (other than ETS allowances) may be allowed/be mandatory:

- Under an ETS offsets may be allowed (e.g. if the ETS for the shipping sector would be integrated in the existing EU ETS)
- Under the considered target-based compensation fund, the funds are free in the way that they meet the target. Whether the target is an in-sector target or whether the target can also be met by the use of offsets is not clear from EU Commission (2011a).

Assumedly, these offsets will be CER Credits and/or ERUs (see footnote 2). The quality of the CER Credits and the ERUs will then play a crucial role in the actual emission reduction that is achieved outside the sector. Doubts have been raised as to the quality of the offsets (see e.g. Sepibus, 2009) The EU Commission states itself that "the European Union is calling for its [CDM] reform to improve its environmental integrity, effectiveness, efficiency and governance." (EU Commission, 2011b).

4.7 Enforceability

Good enforceability of a policy instrument is a necessary condition for the environmental effectiveness of an environmental policy instrument.

- Comparing the considered policy options, enforcement of a bunker fuel tax is clearly the easiest.
- The geographic scope of most of the instruments considered, not only comprises the emissions on routes to the EU and on intra-EU routes but also on routes from the EU. Enforcement could turn out difficult for the routes from the EU, especially for ships that only occasionally sail to EU ports.
- Under a compensation fund assignment of responsibilities has to be clearly defined. Does the responsibility lie with the fund or its members? This will especially be crucial for the target-based compensation fund under which the funds themselves can decide on how they meet the target.

4.8 Modal shift

In CE Delft et al. (2009) the impact of climate policy for shipping on modal shift is analysed. The findings are as follows:

- Modal shift is confined to transport routes where alternatives via other modes exist. If at all, it will most likely occur in unitised short sea shipping, including Roll-on/roll-off and Lift-on/Lift-off. For intercontinental shipping other modes of transport hardly exist and elasticity estimates of short sea bulk transport suggest that these are not very price sensitive.
- Modal shift may result in higher CO_2-emissions as well as in lower emissions. Small vessels (up to approximately 1,800 DWT) have emissions that are comparable to road transport and higher than emissions of rail transport. So modal shift only results in higher emissions on routes where relatively large ships compete with road transport.
- On routes where unitised cargo is transported and relatively large vessels compete with road transport, modal shift may occur if road and rail transport are not subjected to cost increasing climate policies or if the cost increase per unit of transport is lower than in maritime transport. If the cost increase in road and rail transport is higher than in maritime transport, modal shift may occur in a way that increases the share of maritime transport.

The cost increases arising from a policy instrument have an impact on the probability of modal shift: the larger the increase, the higher the probability of a modal shift. Cost increases will differ between the instruments. A ranking of the instruments with respect to their cost increases is however not possible at this stage, since the design of the options is not specific enough yet.

4.9 Long term GHG reductions

The long run GHG reductions will depend on

1. whether and how easily the policy instrument is expandable to other regions,
2. the flexibility of a policy instrument to adjust its stringency if necessary,
3. the instrument's incentive for technological improvements in the sector, and
4. the amount of revenues available for additional GHG reduction.

4.9.1 Possibility of implementation on a global level

Most of the options are theoretically also implementable on a global level. Only option 2 ("target related to an index") of the mandatory emission reduction per ship might, depending on its design, not be implementable on IMO level. MEPC has decided that the EEDI cannot be the basis for a mandatory policy instrument. The challenge would then be, not to work with the EEDI but to find another commonly agreed ship efficiency index.

4.9.2 Flexibility in stringency

The possibility to adjust the stringency seems to be comparably for all the policy options, except for the contribution-based compensation fund. To be recognized as a compensation fund, a fund has to levy the minimum CO_2 fee. Raising this minimum fee at a later stage could thus pose a problem.

4.9.3 Incentive for technological improvements in the sector

The long-run GHG reductions will depend on, among other things, the incentive that the instruments give for the adoption of abatement technologies and therefore also for the development of new technologies. All instruments incentivise the adoption of technological abatement technologies, market based mechanisms (MBM) however provide a higher incentive than non-MBM.

4.9.4 Revenue for additional GHG reduction

If revenue is generated by a policy instrument, this revenue may be used for financing additional GHG emission reductions (other than offsets), e.g. by subsidizing the adoption of in-sector CO_2 abatement measures.

- Under a contribution-based compensation fund, revenues are generated. Funds could be obliged to use (parts of) this revenue for additional GHG reductions.
- Under a target-based compensation fund, funds are free to choose their compliance strategy. Even if the funds would be obliged to use offsets and thus would have to generate some revenue it is not realistic to assume that more than the revenue needed to buy offsets would be raised.
- When allowances are auctioned under an ETS, revenues would be generated. To oblige Member States to use these revenues for financing additional GHG emission reductions is politically probably not feasible. Some Member States however may decide to spend (some of) the revenue to finance additional GHG emission reductions.
- Revenues of a bunker fuel tax and an emission tax has to go to the Member States (EU Commission, 2011a). Not only the implementation of the taxes but also hypothecation of their revenues requires unanimity amongst Member States (CE Delft, 2009). Hypothecation

of the revenues to finance additional GHG reductions may therefore be difficult to implement.

4.9.5 Use of revenues

Some policy options raise revenues. These could in principle be used to promote improvements in fuel efficiency. The feasibility depends on who collects the revenues, as it could require hypothecation of fiscal revenues, which some countries oppose. A use of revenues in the sector could increase the acceptance of a policy instrument.

4.10 Overview

In the following table an overview is given on the policy options and the main factors that determine the environmental impact of the instruments.

	ETS	Compensation fund		Bunker fuel tax	Emission tax	Mandatory reduction target per ship	
		Contribution-based	Target-based			Option 1: target related to historic emissions	Option 2: target related to an index
Geographical scope	Emissions of the ships on routes to and from the EU as well as on routes within the EU are covered.	Same as ETS.	Same as ETS.	EU; unclear whether more or less emissions are covered compared to other instruments.	Same as ETS.	Same as ETS.	Same as ETS.
Overall emission cap	Yes.	No.	Historic emissions baseline: Yes. Transport performance baseline: this policy option is unclear to us.	No.	No.	No.	No.
Stringency	If free allocation: baseline emissions to be determined carefully. Separate, closed system: risk of too lax cap.		Baseline emissions to be determined carefully.			Baseline emissions to be determined carefully. Ship-specific baseline difficult to determine.	
Risk of evasion	Yes.	Yes.	Yes.	Yes; very high.	Yes.	Yes; easy.	Yes; easy.

	ETS	Compensation fund		Bunker fuel tax	Emission tax	Mandatory reduction target per ship	
		Contribution-based	Target-based			Option 1: target related to historic emissions	Option 2: target related to an index
Incentive to go beyond target	Yes.	Yes.	Unclear.	Yes.	Yes.	No.	No.
Offsetting (other than ETS allowances) is allowed	Maybe.	May be mandatory.	Unclear.	No.	No.	No.	No.
Enforceability	Enforcement of routes from EU difficult	Enforcement of routes from EU difficult Not clear: Fund or member of fund responsible?	Enforcement of routes from EU difficult Not clear: Fund or member of fund responsible?	Easiest.	Enforcement of routes from EU difficult	Enforcement of routes from EU difficult	Enforcement of routes from EU difficult
Risk of modal shift	Yes.	Yes; expectedly less than for MBM if there are emissions exempted.	Yes; depends on instrument choice of fund.	Yes.	Yes.	Yes; expectedly less than for MBM.	Yes; expectedly less than for MBM.
Implementable on global level?	Yes.	Yes.	Yes.	Yes.	Yes.	Yes.	Not if EEDI is used.
Flexibility in stringency	Average.	Could be more problematic.	Average.	Average.	Average.	Average.	Average.

	ETS	Compensation fund		Bunker fuel tax	Emission tax	Mandatory reduction target per ship	
		Contribution-based	Target-based			Option 1: target related to historic emissions	Option 2: target related to an index
Incentive for technological improvement	Yes.	Yes; maybe lowered by emission exemption.	Yes.	Yes.	Yes.	Yes; lower than for MBM.	Yes; lower than for MBM.
Revenue available for additional GHG reduction	Yes, but earmarking politically probably not feasible.	Maybe.	Unlikely.	Yes, but earmarking politically probably not feasible.	Yes, but earmarking politically probably not feasible.	No.	No.

5 Conclusions

The EU commission has committed itself to include emissions from shipping into the existing EU reduction commitment if no international agreement is achieved on IMO/UNFCCC level. The IMO has agreed to introduce a global energy efficiency standard for ships, the so called EEDI (Energy Efficiency Design Index). However, this efficiency standard is only compulsory for new ships and only incentivises technical measures. DNV and LR have estimated that emissions will continue to increase after the EEDI comes into force, albeit at a slower pace. While global market based measures are still under discussion, the EU Commission is investigating possible measures on EU level. In November 2011, in the third meeting of the Working Group 6 of the European Climate Change Programme (Reducing greenhouse gas emissions from ships), the main policy options that the EU Commission considers for an impact assessment have been presented. The impact assessment of these policy options is currently being carried out. In addition, from 19 January – 12 April, the EU Commission has held an internet consultation to receive input from stakeholders regarding the following four main policy options:

1. A compensation fund;
2. An emission trading system (ETS);
3. A tax on fuel or on emissions;
4. A mandatory emission reduction per ship.

In this paper the impact of these policy options on GHG emissions has been compared by looking at the different factors that determine the impact of the policy options on GHG emissions. From this analysis we conclude the following:

A carefully designed **Emission Trading System (ETS)** seems to be the best instrument from an environmental point of view. Under an ETS, and this is the main advantage, overall emissions are capped. The emissions baseline/cap has thereby to be chosen carefully. If a closed ETS for the shipping sector was introduced, the emission cap should not be chosen too lax in fear of high allowance prices. Just as the other MBMs, ETS gives an incentive to reduce emissions beyond the target. If CER/ERU offsets are included in the measure, their environmental integrity has to be ensured. The use of CER/ERU offsets could be limited. Disadvantages of an ETS are that the hypothecation of revenues from auctioning is restricted and thus also their use for additional GHG emissions and that the modal shift effect is probably higher than for non-MBMs.

A **target-based compensation fund** could be set up comparable to an ETS and could thus induce a similar impact on reduction of GHG emissions. However, funds are free to choose how they meet the target which makes it difficult to assess this instrument. What can be assessed is that the instrument has the advantage of an overall emission cap if the target is set on the basis of historical emissions. Disadvantages are that it cannot be expected that there are revenues which can be used for additional GHG emission reduction. But more important is that the funds have a high responsibility in choosing their own instruments. This raises the risk that the funds may not meet their target: approaches that ex ante seem plausible could turn out to be ineffective; conflicts between members of a fund could arise etc. This makes a clear allocation of the responsibility between fund and members very important.

An **emission tax** has the advantages of a MBM, however has no overall emission cap. An advantage compared to ETS is that no CER/ERU offsets are used of which the environmental integrity has to be ensured. Revenues could be used for additional GHG reduction; implementation of hypothecation may however be difficult.

A **contribution-based compensation fund** could induce the same environmental effect as an emission tax. An advantage compared to the emission tax is that the revenues could be used easier to finance additional GHG reduction. The disadvantage compared to emission tax is that the adjustment of the stringency could be a problem. If mandatory offsets are used, then the environmental integrity has to be guaranteed. If parts of the emissions were exempted, the environmental effectiveness would of course be less than of an emission tax.

The two options of the **mandatory emission reduction per ship** have the disadvantage that no overall emission cap is set, that evasion is easier under a ship-specific regulation and, on top, that the options have the disadvantages of non-MBMs that no incentive is given to reduce emissions beyond the target and that a lower incentive for technological innovation is given. The modal shift effect however is probably lower than under MBMs.

With regards to option 2 ("target related to an index") of the mandatory emission reduction, it has to be pointed out that if the measure was based on the EEDI, it would not be implementable on a global level, since MEPC has decided not to use the EEDI for a mandatory instrument.

The least effective policy instrument in terms of the environmental effect is probably the **bunker fuel tax**. A bunker fuel tax, which is a very effective policy instrument in cutting GHG emissions if applied on a global scale, is not an effective instrument for cutting GHG emissions when applied on a regional scale due to the high risk of evasion.

Note finally, that for all the instruments except fuel tax it holds that enforcement with respect to emissions on the routes from EU may be problematic.

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