Quantifying CO_2 emission avoidance potential and benefits of early action

[SD1: Supporting Document #1 for discussion of MEPC 56/4/9]

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SUMMARY

Executive Summary: This document introduces a validated forecast of international maritime CO_2 emissions and quantifies the impact of balancing short- and long-term policies to achieve significant emission reductions. Total emissions can be halved and improvements paid for from the savings generated, providing global action is taken. Acting 3 years earlier avoids emission of 0.6 $GtCO_2$ by 2050 (equivalent to 1 year of emissions)[2].

Related documents: Resolution A.963(23), MEPC 55/4/5, MEPC 45/8

Introduction

1 In the resolution A.963(23), the Assembly urged MEPC to undertake further work to identify and develop the necessary mechanisms needed to achieve limitation or reduction of greenhouse gas (GHG) emissions from ships. Validated emission data together with a cost and benefit analysis could contribute to discussions and agreements on viable solutions.

2 Building on rigorous scientific emission forecasts, this document quantifies the benefits of combining short and long-term policies to tackle the stock and emissions of GHG gases in the atmosphere, and of taking swift action by the maritime sector.

A credible emission model for 2005-2050

3 A credible but easy to understand emission model for international maritime transport is used[3]. The generated emission trends follow very closely the results from comprehensive models with normalized **results within 3% range**.

4 The model uses the following net emission growth factors: 2%, 2.4% and 1.7% for 2005-2020, 2021-2036 and 2036-2050, respectively (details in Annex)[4].

5 The year 2005 is selected as a baseline, with emission estimated at 477 $MtCO_2$ (details in Annex).

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[1] IMERS – International Maritime Emission Reduction Scheme
[2] $1GtCO_2$ – one Giga-tonne of CO_2 equals one billion tonnes of CO_2 (metric tonnes).
[3] International means, as per IPCC: departing in one country and arriving in another.
[4] The factors reflect the difference between the seaborne trade trends and future maritime improvements.

Note: To align with the 2008 IMO's emission estimates mulitply the results by 2 (1GtCO2 in 2005).

A plausible model for 2050-2100

6 The long lifetime of ships and their engines require scenarios well beyond 2050 to quantify benefits of longer-term policies. No relevant shipping emission forecasts were found and simple extrapolations are inappropriate. An indicative scenario was created by defining plausible net emission growth factors and rules to model three technological step changes (details in Annex).

Emission cap and forecast

7 In all climate mitigation scenarios global CO_2 emissions will grow before they decline. A maritime emission cap that is constant till 2050 and declines afterwards could be an acceptable option (justified in Annex, shown in Fig. A1). Cap decline ratios were selected to follow the trend of a scenario to stabilize concentration of greenhouse gases at 550 ppm[5].

8 Figure 1 shows the calculated forecast of maritime emissions and the sample emission cap. The total CO_2 emissions above the cap are 15 $GtCO_2$ for 2010-2050, and 31 $GtCO_2$ for 2051-2100[6].

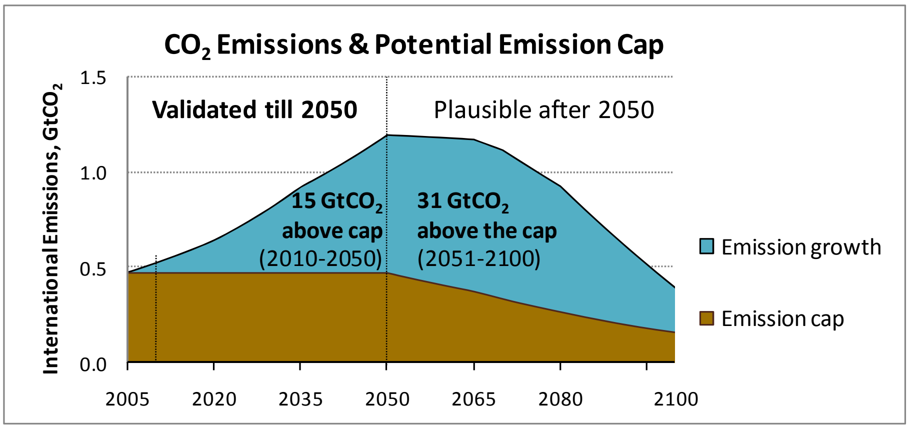

Fig. 1 – Forecast for maritime CO_2 emissions and emission cap used.

9 Results presented can be easily used for a different starting level, for instance when only a portion of maritime fleet is considered or if the actually measured baseline proves to be different. To obtain the adjusted results only a multiplication by the relative ratio is needed.

Improvement factors

10 <u>Short-term factor</u>. There is a significant potential for additional operational and technology driven improvements in the maritime transport industry. Assuming that appropriate funding is available, short-term improvements should lead to reducing the emission growth by around 0.7% - 1% annually for the next few decades[7].

11 <u>Longer-term factor.</u> A harmonized approach to maritime emissions will stimulate long-term investments. It should result in bringing forward the technological step changes and their wide adoption by about 10 years, on average as some changes are 50-70 years away.

[5] ppm (parts per million) is the ratio of the number of greenhouse gas molecules to the total number of molecules of dry air. Many commentators argue that 550ppm is already a very dangerous territory for climate change.
[6] The estimate beyond 2050 depends on the technological breakthroughs taking place and affecting relevant fleet, but is independent from what they are.
[7] Equivalent to 1/3 – 1/2 of the emission growth (derived from the IMO GHG Study 2000, MEPC 45/8).

Note: To align with the 2008 IMO's emission estimates mulitply the results by 2 (1GtCO2 in 2005).

Reducing impact and paying for improvements

12 Reducing the annual emission growth by 1% and bringing forward step changes by 10 years would more than halve the CO_2 emission growth impact. Out of the 28 $GtCO_2$ total reductions, 7 $GtCO_2$ would be avoided by 2050, and 21 $GtCO_2$ after 2050 (as detailed in Fig. 2).

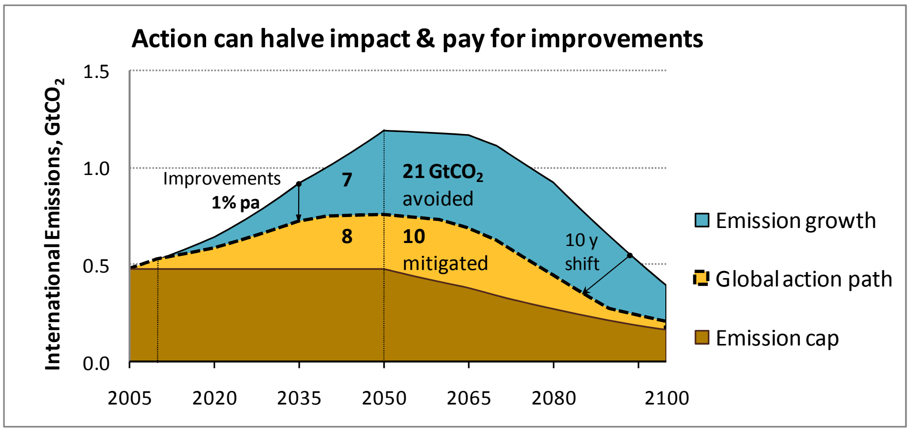

Fig. 2 – Significant benefits of combining short-term (1% pa) and long-term (10 y shift) goals.

13 Reducing the impact by more than 50% also means that a much lower amount of CO_2 over the cap needs to be mitigated outside the maritime sector (8 $GtCO_2$ rather than 15 by 2050, and 10 $GtCO_2$ rather than 31 after 2050).

14 However, these savings cannot be realized for free as investments are needed to achieve the improvements in the first place. In a market-based approach, the collected monies should cover both the cost of the emission offset and a contribution to the sector improvements.

15 A charging formula for the 50% reduction is simple: double the charge based on the lower emission trajectory followed[8].

Benefits of swift action

16 The benefits of swift action could be measured in monetary terms or in millions of tons of avoidable CO_2 emissions. To asses the benefits, the cost of inaction was calculated. It was assumed that a global approach could be achieved but would be delayed by 3 years due to protracted discussions and negotiations[9].

17 The calculated delay costs are equivalent to emission of additional 0.6 GtCO2 by 2050, and 1.2 GtCO2 after 2050 (in total 1.8 GtCO2). The cost of 3 years delay in monetary terms is \$15bn and \$45bn, by 2050 and by 2100, respectively (for \$25/tCO_2)[10].

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[8] Performance mechanisms including benefits tracking should be in place to achieve required reductions.

[9] The delays lead to the short-term improvement starting 3 years later while the step change forward shift is reduced by 1 year to 9 years, due to lost time. The conservative improvements of 0.7% pa were assumed. If improvements of 1% are achievable then the delay costs are greater and reach 0.8 $GtCO_2$ by 2050 alone (equivalent to \$20bn).

[10] Alternatively, bringing a global approach 3 years earlier is equivalent to avoiding 1 year of entire maritime emissions by 2050 only. In annual terms, 1 year is equivalent to avoiding emission of 200 MtCO2 by 2050, approximately \$5bn in offset costs by 2050 (for \$25/tCO2).

Note: To align with the 2008 IMO's emission estimates mulitply the results by 2 (1GtCO2 in 2005).

ANNEX

Emission model details

1 Existing emission forecasts can cover different ship categories; they often use dissimilar assumptions such as different emission factors and estimates for baselines. The absolute emissions therefore vary significantly (nearly by a factor of 2, for some models). However, the relative trends are strikingly similar for the more elaborate forecasts, as shown in Table A1 for the relative emission growth multiples (calculated versus a base year of 2005).

Table A1 – Model validation: CO_2 Emission multiple within 3% of known forecasts.

Source for mutliple	2005	2020	2035	2050
IMO, 2000	1	1.36	-	-
Eyring, 2005	1	1.35	1.88	2.42
den Elzen, 2006	1	1.32	1.97	2.58
Eyring, 2007	1	1.39	1.92	-
This Model (ERS)	**1**	**1.35**	**1.93**	**2.50**

2 Four emission forecasts were used to validate this ERS model:

.1 IMO, 2000 – Two fuel consumption growth scenarios were provided till 2020, based on 1.5% and 3% annual fleet growth, respectively. To derive the emission multiple for 2020/2005 the average fuel values were used for 2020 and 2005.

.2 Eyring, 2005 – Before calculating the relative multiples a minor source adjustment was needed. The emissions from military vessels were deducted (36MtCO_2; constant after 2020). The combination of a business-as-usual technology scenario with the A1 SRES growth forecast was selected, the closest to A1B scenario used in this document. The emission reduction factor of 0.95 for 2050 was ignored. No deductions were made for the fishing and tug vessels, that the Eyring's model includes (without them the multiples could be slightly higher).

.3 Den Elzen, 2006 – Direct calculations were used, without any adjustments.

.4 Eyring, 2007 – An average emission growth of 2.2% per annum was provided from 2000 to 2030. Emission multiples were calculated for 2020 and 2035 from the 2.2% growth.

3 In paragraph 4, global net growth factors were given. In fact, the model is slightly more complex as it defines emission growth factors for two regions: countries of Annex 1 to the Kyoto Protocol, and non-Annex 1 countries (mostly developing countries). The faster growth of developing countries is reflected in their emission factor that is 0.4% greater that of Annex 1 countries (shown in Table A2). The world net growth is a weighted average between growth factors for these two set of countries. Emission data, based on maritime bunker fuels, are only available for Annex 1 countries and are reported to UNFCCC.

Table A2 – Regional emission growth factors used and derived global values.

Annual Emission Growth International Maritime Transport	2005 – 2020	2012 – 2035	2036 – 2050	2051 – 2065	2066 – 2080	2081 – 2100
Annex 1 countries	1.8%	2.2%	1.5%	0.5%	-0.3%	-0.5%
Non Annex 1	2.2%	2.6%	1.9%	0.5%	-0.3%	-0.5%
Implied global values:						
Average emission growth (global)	2.0%	2.4%	1.7%	0.5%	-0.3%	-0.5%
Emission multiple: end year/2005	1.3	1.9	2.5	Depends on step changes		

Note: To align with the 2008 IMO's emission estimates mulitply the results by 2 (1GtCO2 in 2005).

4 In paragraph 5, a value of 477 $MtCO_2$ was selected as a baseline for 2005. This note details how it was obtained. The estimates for total CO_2 maritime emissions vary widely, with the models based on activity data of vessels producing significantly greater values than top down estimates based on sale of fuel (partially due to inclusion of greater range of vessels). The global maritime transport emission is estimated as 468 $MtCO_2$ for 2004. It is based on scaling up the most recent data from European Union by a factor of 100/32 (EU data is for maritime bunker fuels as reported to the UNFCCC). The factor was derived by reviewing relevant proportions from several other estimates (including estimates from the International Energy Agency, IEA).

5 The emission estimate for 2005 is increased by 2% from the value for 2004. It is greater by a credible 14% from the mean reported for 1994-1997 (419 $MtCO_2$; MEPC 55/4/5).

Model for 2050-2100

6 Net emission growth factors are equal to: 0.5%, -0.3% and -0.5% for 2051-2065, 2066-2080 and 2081-2100, respectively (applied before the step change corrections).

7 Three technological step changes from 2050 onwards assume combination of alternative fuels and new ships reducing the emissions dramatically. Reductions cover the entire fuel cycle, including its production[11]. The assumptions for emission reduction, portion of existing fleet affected and time it takes for each transition to be fully deployed are shown in Table A3

Table A3 – Step change assumptions.

Step change	Emission reduction	Fleet affected	Switch-over period
1	40%	30%	2050 – 2070
2	95%	40%	2070 – 2100
3	97%	30%	2080 – 2120

8 Without being specific about the technological breakthroughs, the above assumptions allow to quantify the impact of short- and long-term emission policies. Plausible adjustments to the step change parameters have an insignificant impact on the justification to balance both policies.

Emission cap details

9 To define a global cap for maritime emissions, a balance is required between the mitigation calls from developed countries and the growth needs of developing economies. A constant emission cap till 2050 is introduced as a potential option by noticing that global fossil emissions is expected to come down to the current level around then (as per number of estimates such as the IEA 2050 Outlook bottom-up analysis). The cap level is assumed to be equal to the emission at 2005 (as shown in Annex Fig. A1).

10 The shape of the emission cap for the post 2050 was obtained by adjusting the cap decline shape to roughly follow the global GHG emission reductions. The global emission path was selected to reflect the 550 ppm GHG stabilization scenario using a Contract & Converge calculation (augmented further by including emissions from international maritime transport and

[11] It is important to review the impact over the entire supply chain. This is to avoid crediting emission reductions in shipping while creating increase in upstream production for instance. The emission reductions in the model have been adapted from work on alternative fuels.

Note: To align with the 2008 IMO's emission estimates mulitply the results by 2 (1GtCO2 in 2005).

aviation). The cap declines annually after 2050 by: 1.5%, 2.2% and 2.5% for 2051-2065, 2066-2080 and 2081-2100, respectively.

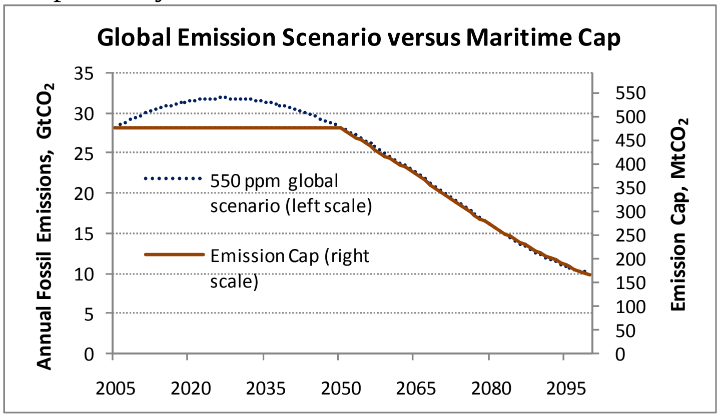

Fig. A1 – Maritime CO_2 emission cap function created.

11 In 2100 the cap reaches 34% of the initial level. Selecting a more stringent stabilization path would necessitate a greater decline of the cap.

12 In reality, any cap would be subject to modification by IMO/UNFCCC as information becomes available and to ensure that maritime transport contributes a fair share to the effort to tackle climate change without paying disproportional costs.

Benefits of swift action

13 The calculated delay costs (benefits of swift action) are shown in Fig. A2:

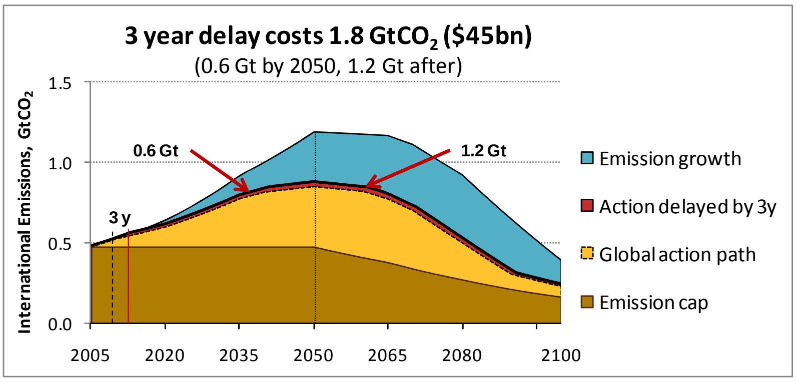

Fig. A2 – Total benefits of acting now are measured in $GtCO_2$ or \$bn.

14 Main forecast references:

.1 den Elzen M.G.J., J.G.J. Olivier, M.M. Berk: An analysis of options for including international aviation and marine emissions in a post-2012 climate mitigation regime, Netherlands Environmental Assessment Agency (MNP), MNP Report 500114/2007

.2 Eyring, V., H. W. Köhler, A. Lauer, and B. Lemper (2005), Emissions from international shipping: 2. Impact of future technologies on scenarios until 2050, J. Geophys. Res., 110, D17306, doi:10.1029/2004JD005620.

.3 Eyring V., D. S. Stevenson, A. Lauer, F. J. Dentener, T. Butler, W. J. Collins, K. Ellingsen, M. Gauss, D. A. Hauglustaine, I. S. A. Isaksen, M. G. Lawrence, A. Richter, J. M. Rodriguez, M. Sanderson, S. E. Strahan, K. Sudo, S. Szopa, T. P. C. van Noije1, and O. Wild: Multi-model simulations of the impact of international shipping on Atmospheric Chemistry and Climate in 2000 and 2030, Atmos. Chem. Phys., 7, 757–780, 2007

.4 IMO, Study on Greenhouse Gas Emission from Ships, 2000, MEPC 45/8

Note: To align with the 2008 IMO's emission estimates mulitply the results by 2 (1GtCO2 in 2005).