Environmental Research

of the Federal Ministry for the Environment,

Nature Conservation, Building and Nuclear Safety

Project No. (3711 45 104)

Greenhouse gas emission reduction targets for international shipping

DISCUSSION PAPER

by

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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.

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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.

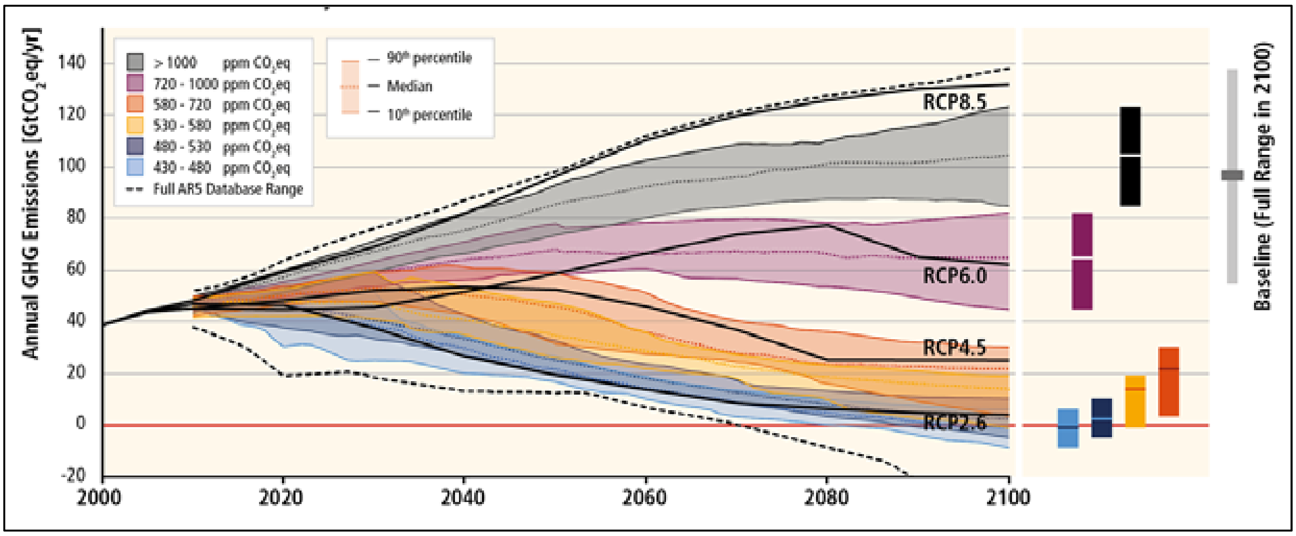
Taking into account that reducing emissions globally is more cost-effective when all sectors contribute and that shipping has significant technical and operational potential to reduce emissions, we analyze the possibility of setting GHG mitigation targets for the shipping sector. The paper starts with 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.							

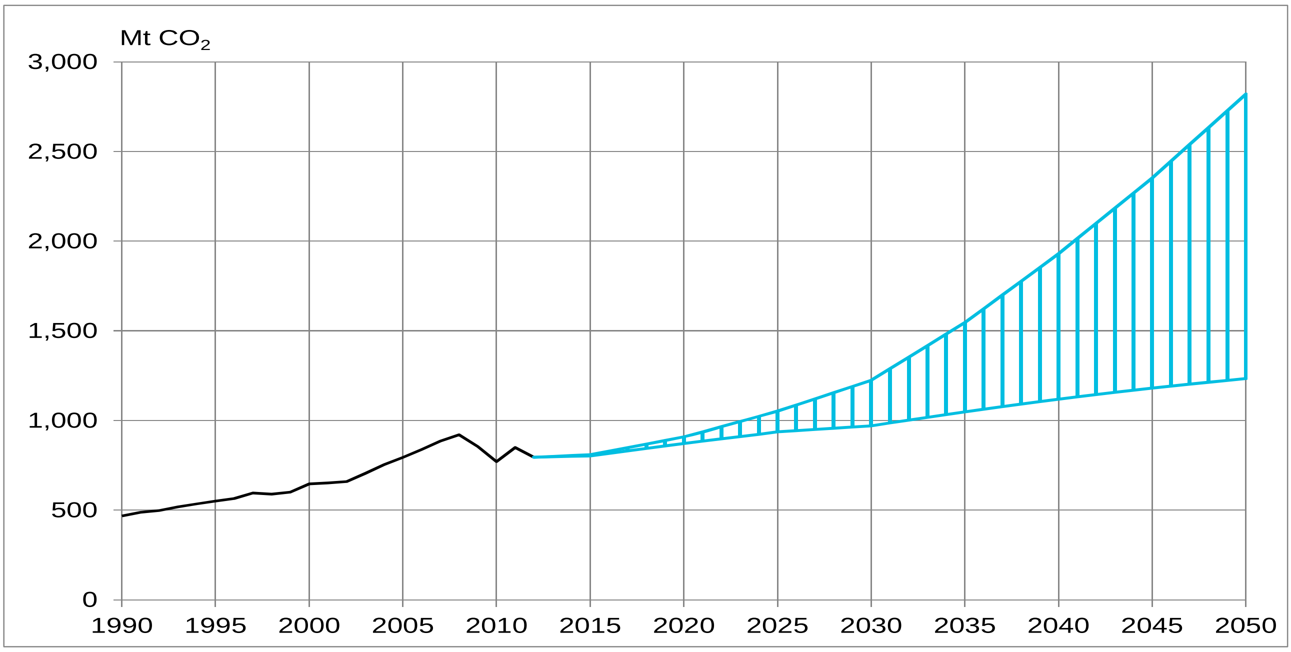
Sources: IPCC 2014

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.

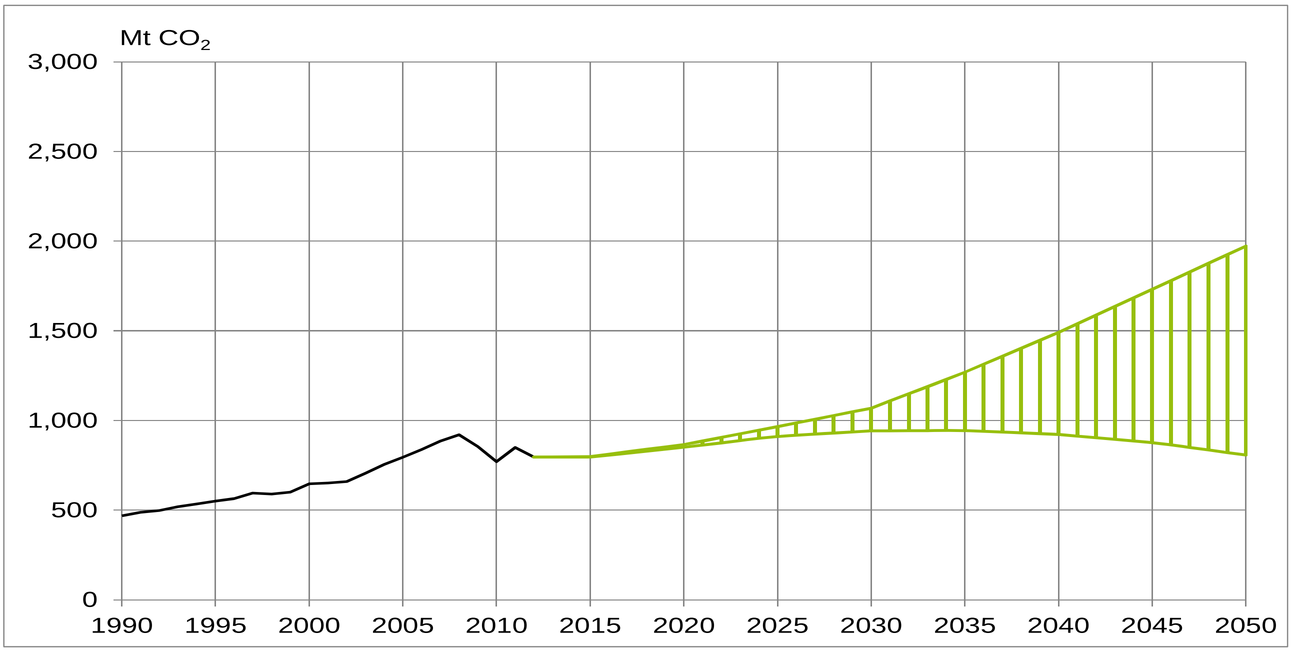
Figure 2 Range of CO_2 emissions in the business-as-usual scenarios



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.

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.

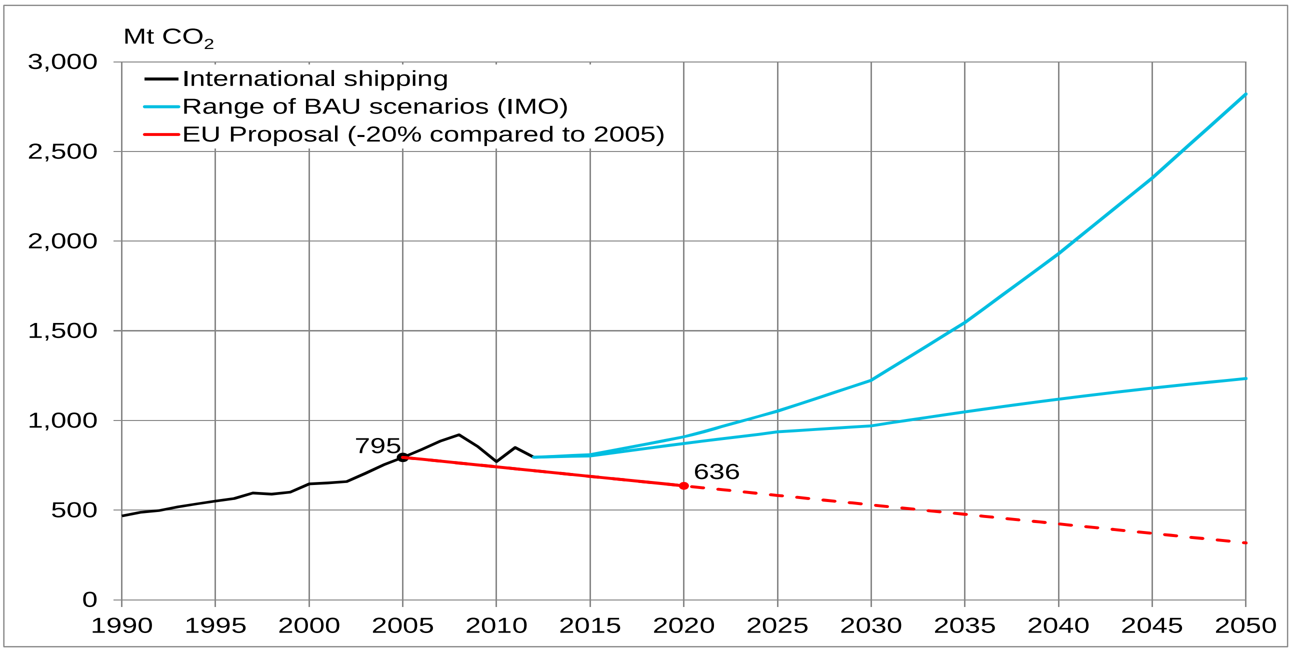
3.1 Targets suggested for international shipping and in similar contexts

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.

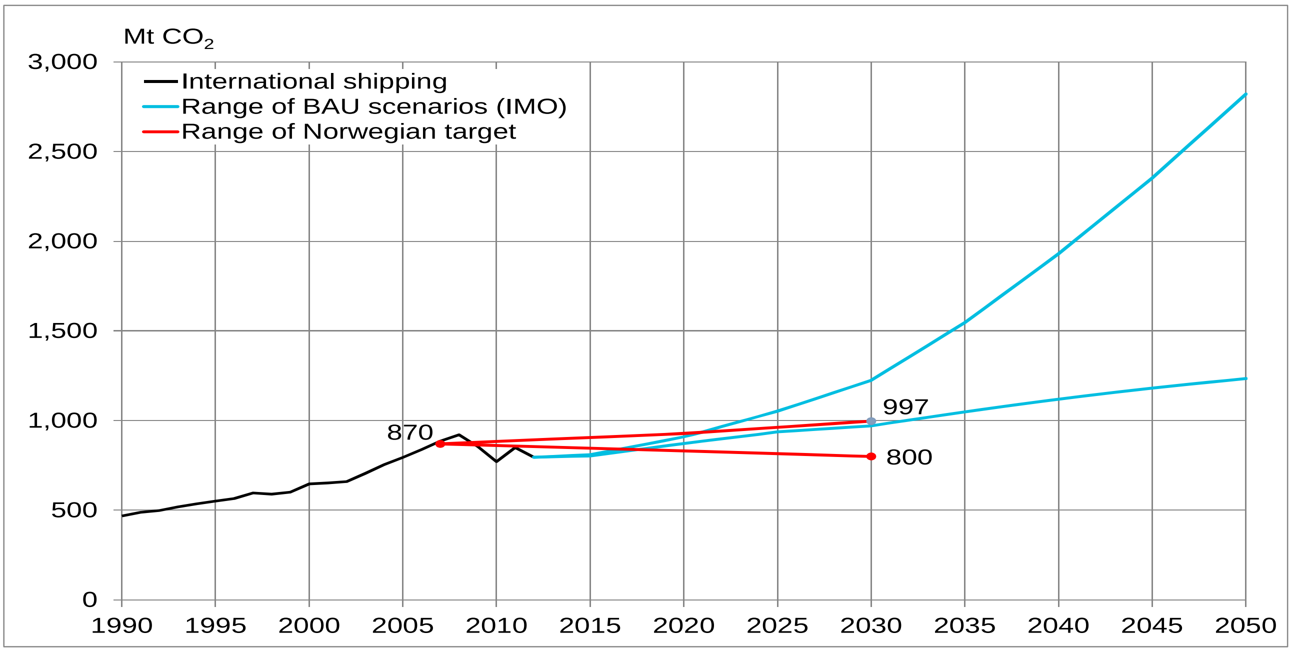
3.1.2 Norwegian target proposal for international shipping

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

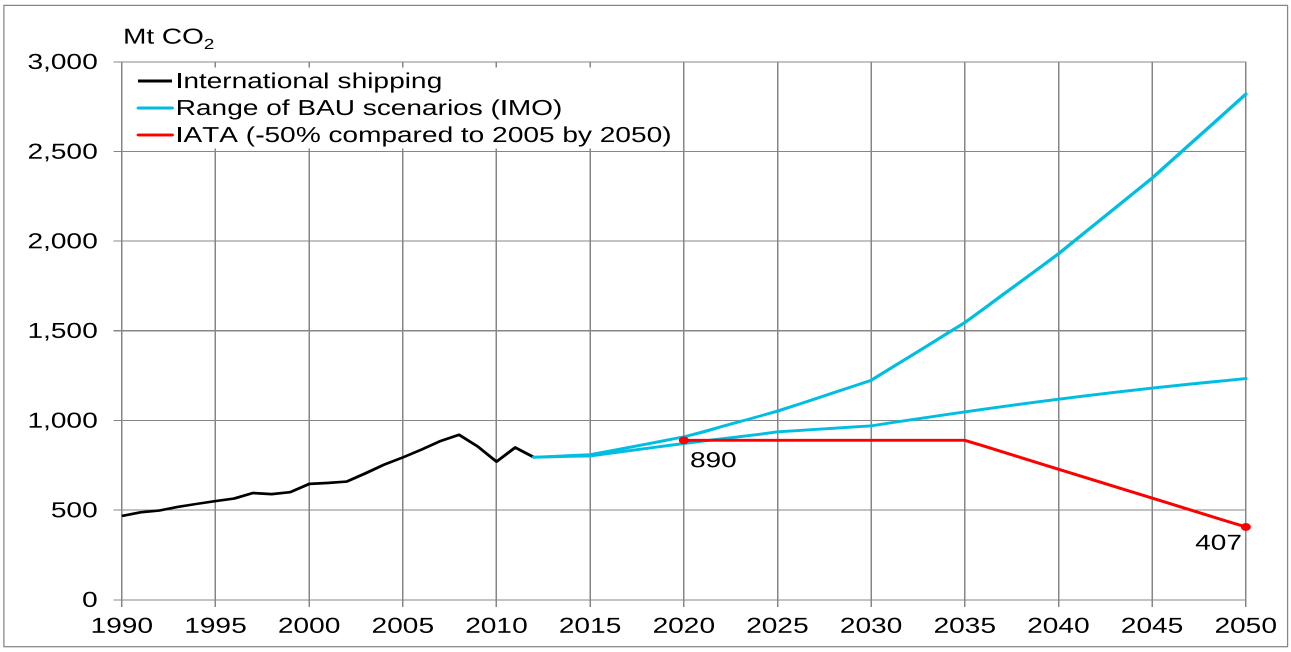
Similar to the IMO's BAU projection, the range of Norwegian targets (red lines) reflects the different assumptions in terms of future economic development (Figure 5). Currently, actual emissions are below the target range. This is because in 2010 it was not yet possible to take into account in the BAU 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

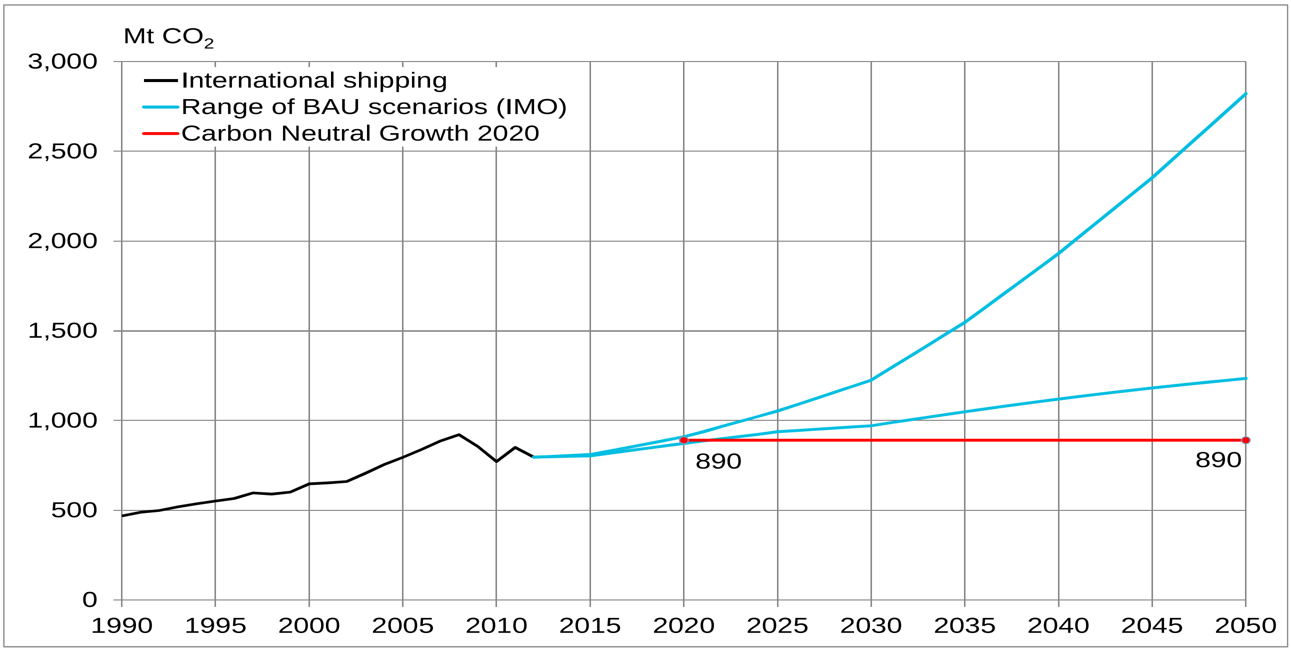


Sources: IATA 2013, IMO 2014, authors' own calculations

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



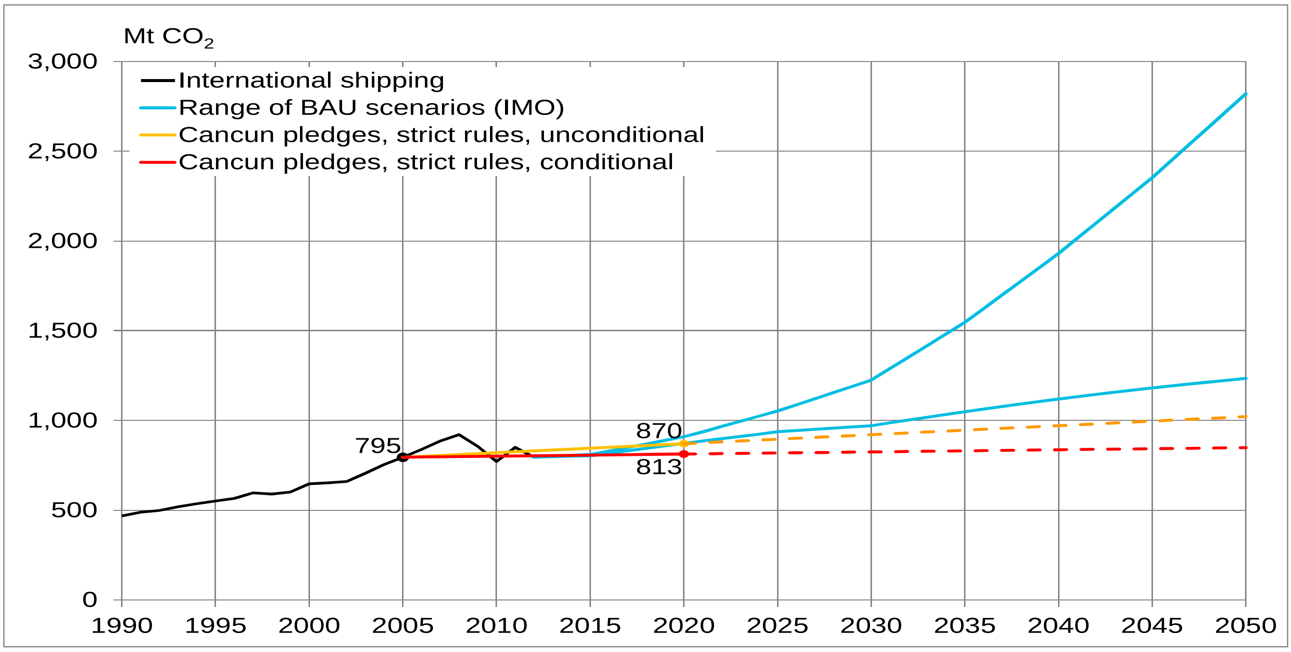
Sources: ICAO 2010, IMO 2014, authors' own calculations

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

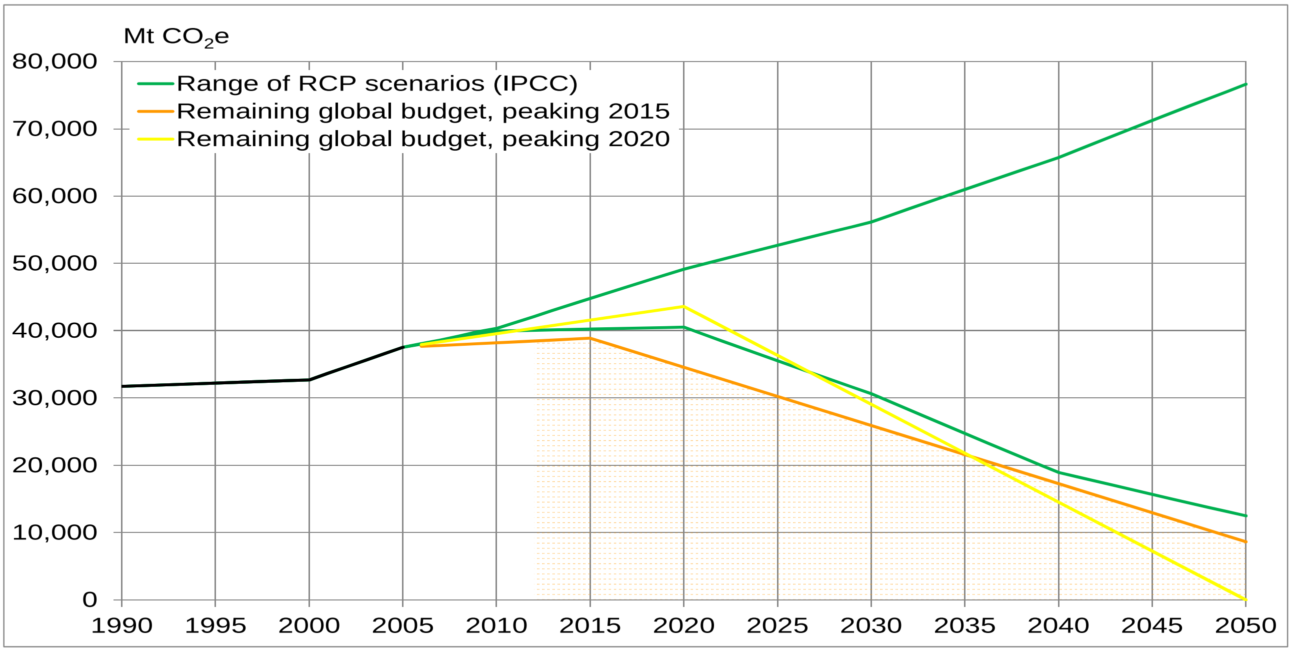
In total, the Cancun pledges roughly result in a stabilization of emissions at 2005 levels (including conditional pledges) or a slight increase of emissions (unconditional pledges only).[4] For the shipping industry this would mean that up to 2020 projected emissions are in a similar range than the target 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.

[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.

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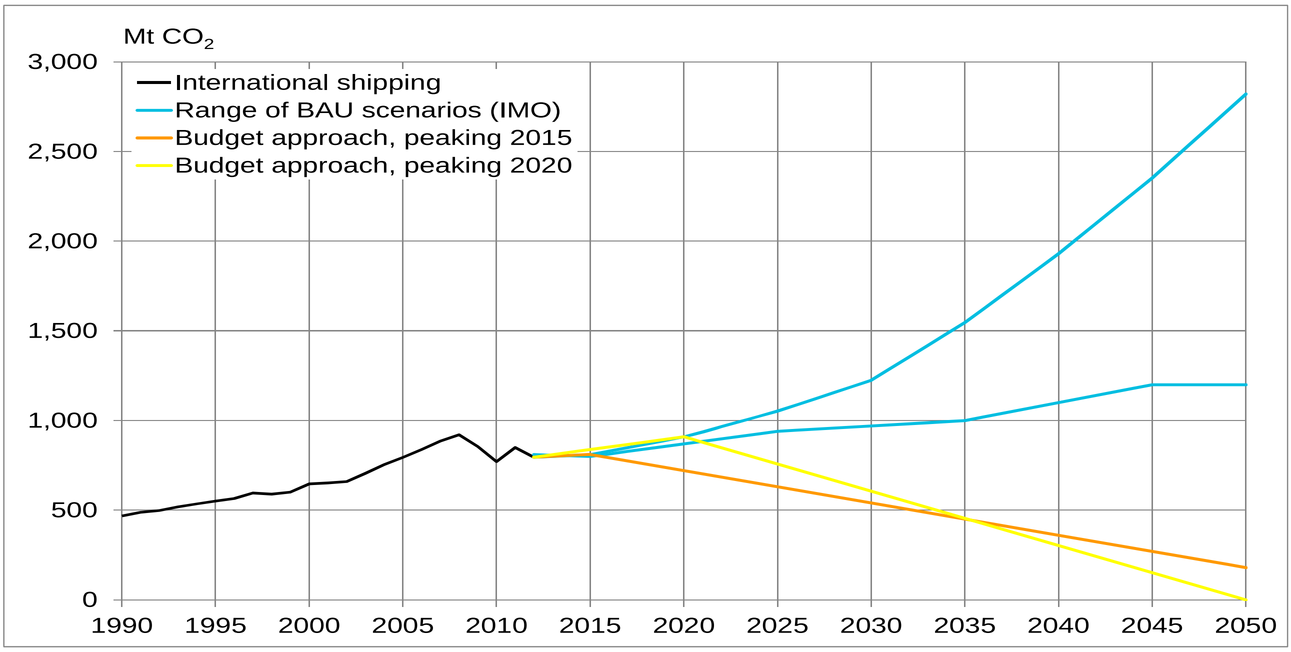
5 To stay below an increase of 2°C, the all-time aggregated GHG emissions should not exceed 2,900 Gt CO_2e (Tyndall Centre 2014). To date, some 1,800 Gt CO_2e have already been emitted, with the result that a budget of some 1,000 Gt CO_2e can still be emitted before the 2°C threshold will be exceeded.

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.

6 References

CEU (Council of the European Union) 2009: EU position for the Copenhagen Climate Conference. Brussels, http://register.consilium.europa.eu/pdf/en/09/st14/st14790.en09.pdf

EC (European Commission) 2011: White Paper – Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system. COM(2011) 144 final, Brussels, http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52011DC0144&from=EN

Eide, M., Chryssiakis, C., Endresen, Ø. 2013: CO_2 abatement potential towards 2050 for shipping, including, alternative fuels. Carbon Management 4(3), 275–289

IATA (International Air Transport Association) 2013: Historic Agreement on Carbon-Neutral Growth. http://www.iata.org/pressroom/pr/Pages/2013-06-03-05.aspx

ICAO (International Civil Aviation Organization) 2010: Resolutions Adopted by the Assembly 37th Session - A37-19 Consolidated statement of continuing ICAO policies and practices related to environmental protection – Climate change. Montreal, http://www.icao.int/Meetings/AMC/Assembly37/Documents/ProvisionalEdition/a37_res_prov_en.pdf

IIASA (International Institute for Applied Systems Analysis) 2009: RCP Database. http://www.iiasa.ac.at/web-apps/tnt/RcpDb

IMO (International Maritime Organization) 2009: Prevention of air pollution from ships - Second IMO GHG Study 2009. London, http://www.imo.org/OurWork/Environment/PollutionPrevention/AirPollution/Documents/GHGStudyFINAL.pdf

IMO (International Maritime Organization) 2014: Reduction of GHG Emissions from Ships - Third IMO GHG Study 2014. London, http://www.iadc.org/wp-content/uploads/2014/02/MEPC-67-6-INF3-2014-Final-Report-complete.pdf

IPCC (Intergovernmental Panel on Climate Change) 2014: Summary for Policymakers, In: Climate Change 2014, Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlomer, C. von Stechow, T. Zwickel and J.C. Minx (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, http://www.ipcc.ch/pdf/assessment-report/ar5/syr/SYR_AR5_SPMcorr2.pdf

MEPC (Marine Environment Protection Committee) 2009: Detailed information on the prospect of energy efficiency improvement of new ships, Submitted by Japan. London, MEPC 59/INF.27, http://legacy.sname.org/committees/tech_ops/O44/imo/mepc/59-inf-27.pdf

MEPC (Marine Environment Protection Committee) 2010: Alternative emission caps for shipping in 2020 and 2030, Submitted by Norway. London, MEPC 60/4/23

MEPC (Marine Environment Protection Committee) 2011: Marginal Abatement Costs and Cost Effectiveness of Energy-Efficiency Measures, Submitted by the Institute of Marine Engineering, Science and Technology (IMarEST). London, MEPC 62/INF.7, http://www.imo.org/OurWork/Environment/PollutionPrevention/AirPollution/Documents/Technical%20and%20Operational%20Measures/Marginal%20abatement%20cost.pdf

PBL (Netherlands Environmental Assessment Agency) et al. 2012: Analysing the emission gap between pledged emission reductions under the Cancún Agreements and the 2°C climate target. Bilthoven,http://www.pbl.nl/sites/default/files/cms/publicaties/pbl-2012-analysing-the-emission-gap-between-pledged-emission-reductions-500114021.pdf

Sims, R. et al. 2014: Chapter 8 – Transport. In: Climate Change 2014, Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlomer, C. von Stechow, T. Zwickel and J.C. Minx (eds.)]. Cambridge University

Tyndall Centre (for Climate Change Research) 2014: High Seas, High Stakes. Manchester, http://www.globalmaritimehub.com/custom/domain_2/extra_files/attach_358.pdf

UNFCCC (United Nation Framework Convention on Climate Change) 2009: Copenhagen Accord. Bonn, Decision, 2/CP.15, http://unfccc.int/resource/docs/2009/cop15/eng/11a01.pdf

UNFCCC (United Nation Framework Convention on Climate Change) 2010: The Cancun Agreements – Outcome of the work of the Ad Hoc Working Group on Long-term Cooperative Action under the Convention. Bonn, Decision, 1/CP.16, http://unfccc.int/resource/docs/2010/cop16/eng/07a01.pdf