Annex VIII. - Impact on the shipping sector

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VIII.1 Introduction

Market based measures have several impacts on the shipping sector:

- By increasing the cost of fuel consumption, they incentivise measures aimed at improving the fuel-efficiency of ships;
- By increasing the costs of fuel consumption, they increase the cost of shipping;
- By increasing the cost of shipping, they reduce demand.

This annex analyses these impacts.

1.1 Fuel price projections

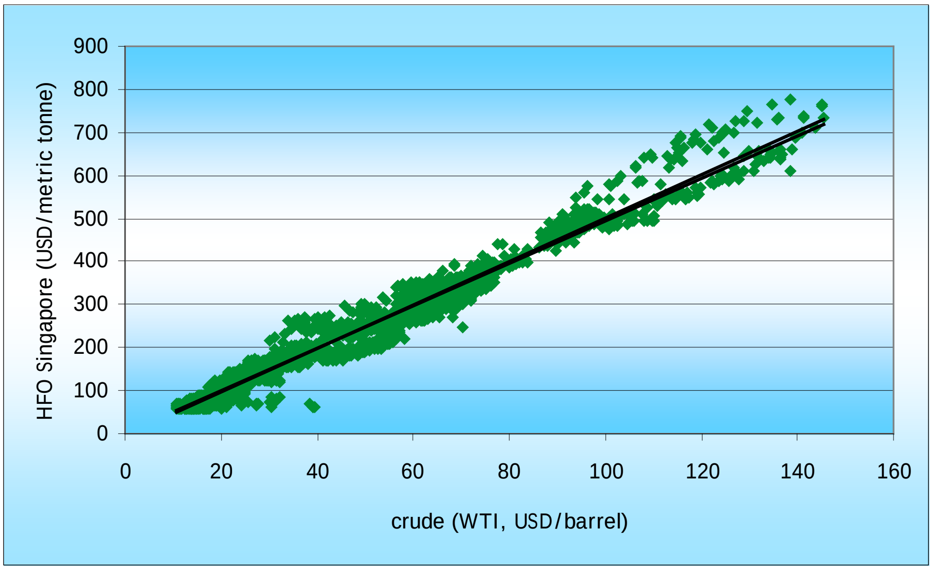
The costs of fuel consumption result from fuel price and market based measures. The fuel price is built up from a market driven crude oil price and a regulatory driven cost increase due to sulphur regulations. This section discusses the projected fuel price developments first and the impact of MBMs second.

1.1.1 Fuel price developments

Ocean going ships may use a variety of fuels, but the most important is heavy fuel oil (HFO), a refining residue (Buhaug et al., 2009). This study assumes that all fuel used is HFO.

When looking at historical prices for HFO and crude oil, a well-defined relationship can be established. Using EIA data on prices of HFO in Singapore and West Texas Intermediate (WTI) crude oil prices, we found that the price of HFO in USD per metric tonne is on average five times the price of WTI in USD per barrel (4.95 with $R^2 = 0.97$). The figure below shows the correlation of both prices in the period 1986-2009. An analysis of the prices for different time periods, for example using Brent instead of WTI as the benchmark for the crude oil price; or using Rotterdam LSO instead of Singapore HFO, did not significantly alter this result.

Figure VIII.1 **Historic relationship between crude oil price (USD/barrel) and HFO 180 spot price (Singapore, USD/tonne), 1986-2009**



Source: EIA.

The crude oil price projections used in this report have been taken from the 2011 World Energy Outlook (WEO) from the International Energy Agency (IEA) assuming an increase (in real terms) of the crude oil price from 78.1 US$ in 2010 to 113.6 US$ in 2025.

Future requirements on the sulphur content of maritime fuels are likely to affect prices. The sulphur content is regulated by Annex VI of the MARPOL convention. In October 2008, the IMO’s Marine Environmental Protection Committee (MEPC) adopted a revision of this Annex which, among other things, sets stricter standards for the sulphur content of maritime fuels. The maximum sulphur content limit will decrease from 4.5% m/m today to 3.5% m/m in 2012 and on to 0.5% m/m in 2020 or 2025 (depending on the availability of low sulphur fuels as determined in 2018) and to 0.1% m/m in emission control areas (ECAs) (see Table VIII.1).[1]

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[1] Note that the regulation allows ships to meet the criteria by removing sulphur dioxide from the exhaust gas, using a so-called scrubber. While this appears to be a cost-effective option in many cases, our model has not taken this option into account. If ships would use scrubbers instead of low sulphur fuels, their fuel costs would not increase to the same extent. This would result in smaller fuel-efficiency gains and lower increases in shipping costs. As less of the efficiency gains would result from the sulphur regulation, more relatively cheap options would still be available. Thus, MBMs would have a relatively larger impact on fuel efficiency and hence on shipping emissions.

Table VIII.1 MARPOL Annex VI Fuel Sulfur Limits

Year	Sulphur limit in fuel (% m/m)	
	ECA	Global
2000	1.5%	4.5%
2010	1.0%	
2012		3.5%
2015	0.1%	
2020*		0.5%
* - alternative date is 2025, to be decided by a review in 2018		

Source: MARPOL Annex VI.

Recently, a number of studies on the costs of low sulphur fuels have been published. An IMO expert group estimated in 2007 that low sulphur fuels have a historical price premium of 50 to 72% (BLG 12/6/1). For 2020, the expert group suggested a price increase of 25%. Since then, additional studies have been published. In the Purvin et al. (2009) study, it is estimated that bunker fuel with 0.5% maximum sulphur content will cost $ 120 to $ 170 more per tonne than the current high sulphur quality, leading to an increase of the costs of bunker fuel in the range of 30-50%, depending on the process option. In a study for the Ministry of Transport and Communications Finland (2009), it is estimated that HFO with a maximum sulphur content of 0.5% will be about 13-29% more expensive than the HFO with a maximum sulphur content of 1.5%. Based on these findings, we assumed a cost increase of 30%.

Hence, the price of HFO before 2020 is given by:

$$pHFO = 5 * pCrude$$

Where:
pHFO: the price of a tonne of HFO in USD
pCrude: the price of a barrel of oil in USD

From 2020, the price of fuel is given by:

$$pHFO = 1.3 * 5 * pCrude$$

This means that there is often a jump in fuel prices between 2015 and 2020.

1.1.2 Impact of MBMs on fuel costs

MBMs have an additional impact on fuel consumption costs. For each tonne of HFO consumed, 3.1 tonne of CO_2 is emitted (Buhaug et al., 2009). Hence, at a price of USD 30 per tonne of CO_2, an MBM would add USD 93 to the price of a tonne of fuel.

While calculation of the fuel price impact of emissions trading schemes with full auctioning is rather straightforward, the impact of the GHG Fund requires additional calculations in order to establish the level of the contribution.

We have calculated the level of the contribution by setting the CO_2 target at 20% below 2005 global emission levels, i.e. at 764 Mt CO_2. The emissions projections were taken from Buhaug et al. (2009), using the so-called A1B scenario with base assumptions on demand, speed and efficiency. BAU emissions are 1156 Mt CO_2 in 2015 and 1485 Mt CO_2 in 2025. Assuming a 10%

surcharge on the contribution to allow for mitigation of undesired impacts, the contribution is calculated to have the level shown in Table VIII. 2.

Table VIII. 2 Level of the contribution in the GHG fund (USD per tonne of fuel, constant 2010 price level)

credit price per tonne of CO2 (USD2010)	2015	2020	2025
10	12	14	17
30	35	42	50
50	58	69	83

Table VIII. 3 summarises the resulting fuel costs of the different MBMs.

Table VIII. 3 Resulting fuel costs of the different MBMs (USD$_{2010}$)

		2010	2015	2020	2025
BAU					
Fuel price		391	510	706	738
ETS					
USD 30	carbon	0	93	93	93
	fuel	391	603	799	832
USD 10	carbon	0	31	31	31
	fuel	391	541	737	770
USD 50	carbon	0	156	156	156
	fuel	391	666	861	894
GHG Fund					
USD 30	carbon	0	35	42	50
	fuel	391	545	748	788
USD 10	carbon	0	12	14	17
	fuel	391	522	720	755
USD 50	carbon	0	58	69	83
	fuel	391	568	775	822

1.2 Impact on fuel efficiency of ships

An increase in fuel prices has the effect that efficiency improving measures become more cost-effective. In addition, ships built from 2013 onwards have to comply with the Energy Efficiency design index (EEDI). We have calculated the impact on the efficiency of the world using the Ship Emission Projection and Freight Cost Model (CE Delft et al., 2011). The following assumptions have been used:

- All ships entering the fleet from 2013 onwards comply with the EEDI as set in MARPOL Annex VI. In order to comply, they use technical measures, regardless of their cost-effectiveness;
- 90% of the measures that can be implemented at a net benefit, are implemented;
- The discount rate for calculating cost-effectiveness is 9%.

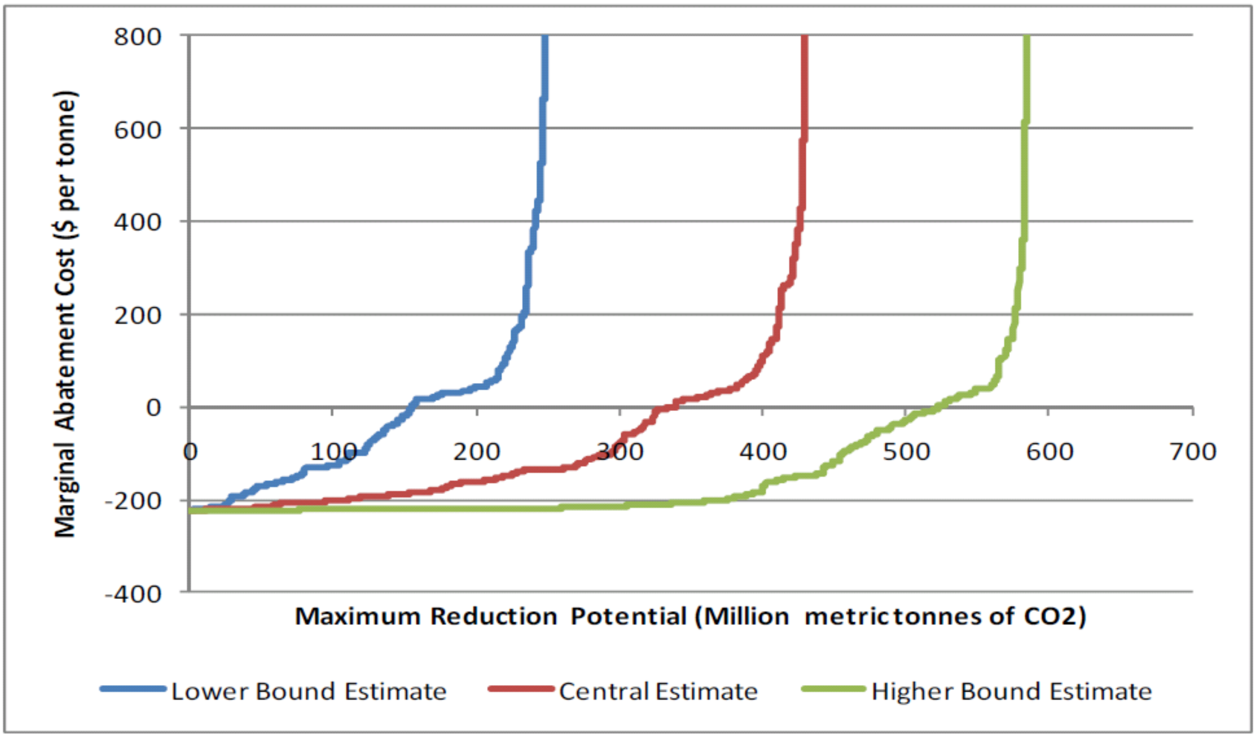
Table VIII. 4 shows that while the fuel efficiency improvements of ships relative to 2007 levels are large, the *additional* impacts of MBMs is limited. In other words, most of the improvements in efficiency are due to the fuel price increases and EEDI requirements for new ships.

Table VIII. 4 Fuel efficiency improvements of ships in 2025 relative to 2007

		bulk carrier	tanker	unitized cargo ship	passenger ship	average improvement
BAU (EEDI and fuel price)		47%	34%	35%	15%	34%
ETS						
USD 30	additional	0.04%	0.08%	0.11%	0.72%	0.16%
	total	47%	34%	35%	16%	34%
USD 10	additional	0.04%	0.08%	0.09%	0.70%	0.15%
	total	47%	34%	35%	16%	34%
USD 50	additional	0.13%	0.08%	1.10%	0.72%	0.66%
	total	47%	34%	36%	16%	35%
GHG Fund						
USD 30	additional	0.04%	0.08%	0.11%	0.70%	0.16%
	total	47%	34%	35%	16%	34%
USD 10	additional	0.00%	-0.01%	0.00%	0.70%	0.08%
	total	47%	34%	35%	16%	34%
USD 50	additional	0.04%	0.08%	0.11%	0.72%	0.16%
	total	47%	34%	35%	16%	34%

The reason that the additional fuel efficiency improvements are small is that the marginal abatement cost curve for ships is almost vertical when it crosses the x-axis (see Figure VIII. 2 for an example). In other words, a slight increase in fuel prices results in a minor increase in abatement. This would be different if the costs of expensive technologies are reduced or new technologies are developed.

Figure VIII. 2 Aggregated Marginal Abatement Cost Curve for shipping (2030, fuel price USD 900)



Bron: Wang et al. (2009), MEPC 62/INF.7

1.3 Impact on shipping costs

Shipping costs, in our Ship Emission Projection and Freight Cost Model (CE Delft et al., 2011), comprise of capital costs, non-fuel operational costs, and fuel costs. The first two are assumed to be constant in real terms. The values depend on the type and size of ship and are based on CE Delft et al. (2010).

The impacts of the MBMs on shipping costs comprise of the carbon costs times the amount of carbon emitted. Table VIII.5 shows that the cost increases are larger for ETS than for the GHG Fund because the contribution is lower than the carbon price. Another difference is that the ETS impact decreases over time because carbon prices are assumed to be constant while fuel prices increase. The decrease is small, too small to be noticeable in a two-digit representation. In contrast, the impact of the GHG fund increases over time, because the increase in the amount of carbon that needs to be offset is larger than the relative decrease of carbon costs.

Table VIII.5 Cost increases from MBMs

	2015	2025
ETS		
USD 30	2.1%	2.1%
USD 10	0.7%	0.7%
USD 50	3.4%	3.4%
GHG Fund		
USD 30	0.8%	1.1%
USD 10	0.3%	0.4%
USD 50	1.3%	1.9%

1.4 Impact on demand

There are few estimates of the price elasticity of demand for maritime transport (PBL and CE Delft, 2010). Most studies use estimates from Oum et al. (1990) which is an overview of a few studies from the 1970s and 1980s. PBL and CE Delft (2010) find that the price elasticity of demand depends on the length of the route (short haul routes tend to have higher price elasticities, presumably because of the availability of other modes of transport) and on the type of cargo (bulk cargoes tend to have lower price elasticities). We have used a price elasticity of demand of 0.25.

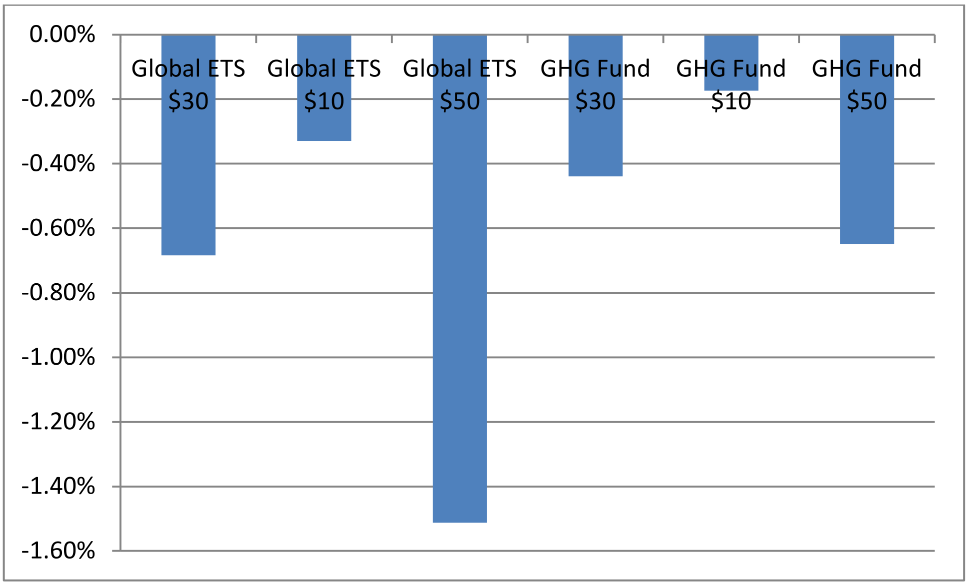
Table VIII.6 Demand reductions resulting from MBMs

	2025
ETS	
USD 30	0.52%
USD 10	0.18%
USD 50	0.85%
GHG Fund	
USD 30	0.28%
USD 10	0.09%
USD 50	0.48%

1.5 Conclusion

Ship emissions are projected to double or triple in the period up to 2050. Our analysis assumes they will increase by over 50% in 2025 relative to 2005 levels. In order to meet a target of 20% *below* 2005 levels, market based measures are needed. The main impact of the MBMs is to offset emissions increases in the shipping sector with emission reductions in other sectors. This is true for both an emissions trading scheme, in which private actors make the offsets, and a GHG fund, in which a central organisation makes the offsets. The reduction of in sector emissions is small, as shown in Figure VIII. 3.

Figure VIII. 3 **Impact of MBMs on in-sector emissions**



In addition to offsetting emissions, MBMs incentivise the development of new technology to improve the fuel efficiency of ships and reduce shipping emissions. As a result, one may expect the in-sector emission reductions to increase over time as new technology becomes available.

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