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The price of sulphur reductions in the Baltic Sea and North Sea shipping

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The requirements set for SOx Emission Control Areas in the MARPOL Annex VI of the International Maritime Organization will increase the cost of maritime transport. How much and who will be hit depends on many factors, such as fuel consumption, feasibility of scrubber retrofitting and the adoption of alternative fuels.

In an attempt to decrease the harmful effects of sulphur emissions, sulphur limits for maritime fuels were agreed on the 58th meeting of the Marine Environment Protection Committee of the IMO in October 2008. The largest benefit from the sulphur reduction in the Baltic Sea area comes from the decrease of detrimental human health effects. Elevated atmospheric concentrations of particulate matter (PM) contribute e.g. to cardiopulmonary and lung cancers and may lead to premature death. According the an AEA study[1], each disease case and death carries a very high price tag for Europe outweighing the increased cost of the low sulphur fuel by a factor of 3.6-11 on a European level, depending on the geographical area applied and the chosen method of sulphur reduction. Generally, the high cost scenario involves switching the whole fleet to low sulphur fuel and the low cost scenario(s) involves the installation of emission abatement techniques. In case of sulphur reduction sulphur scrubbers seem the most viable option.

The emissions from shipping inside the European SECAs (Baltic Sea and the North Sea including the English Channel) in 2009 are illustrated in Table 1.These emissions were obtained from real vessel movements reported by the Automatic Identification System (AIS) and using the Ship Traffic Emission Assessment Model[2, 3] (STEAM) of Jalkanen et al.

Table 1. Emissions of Baltic Sea and North Sea shipping in 2009, estimated with the STEAM model based on AIS observations.

[1] Cost Benefit Analysis to Support the Impact Assessment accompanying the revision of Directive 1999/32/EC on the Sulphur Content of certain Liquid Fuels, AEA, 2009

[2] J.-P. Jalkanen, A. Brink, J. Kalli, H. Pettersson, J. Kukkonen and T. Stipa, A modelling system for the exhaust emissions of marine traffic and its application in the Baltic Sea area, *Atmos. Chem. Phys.*, 9 (2009) 9209-9223.

[3] J.-P. Jalkanen, L. Johansson, J. Kukkonen, A. Brink, J. Kalli and T. Stipa, Extension of an assessment model of ship traffic exhaust emissions for particulate matter and carbon monoxide, *Atmos. Chem. Phys.*, 12 (2012) 2641-2659.

Component	Baltic Sea, kilotons	North Sea/English Channel, kilotons	European SECA, kilotons
SO_x	100	194	294
NO_x	382	652	1 034
CO_2	19 500	29 700	49 200
CO	64	87	151
PM	28	52	80
Fuel consumption	5 734	9 693	15 427

In July 2010, maximum allowable sulphur content in marine fuels was reduced from 1.5% to 1.0% (w/w) in SECA countries that have ratified the revised IMO Annex VI. Further, from Jan 1st 2010 requirement for the use of 0.1%S fuel in SECA port areas became effective. Together these actions decreased SOx and PM emissions by 20% and 9% in the Baltic Sea area, respectively. Removing all sulphur from marine fuels will not eradicate PM emissions completely, because there exist components of PM which are not linked to fuel sulphur content. The overall trend of sulphur emissions from shipping is gradually decreasing and sulphur emissions have been practically eliminated from all other modes of transport (Directive 2009/30/EC). Stringent limits for marine fuel sulphur content (0.1% S, w/w) will be introduced in the SECA areas as of Jan 1st 2015. SECA areas are currently the Baltic Sea, North Sea/English Channel, North America (enforceable from August 2012) and US Caribbean Sea. Mediterranean Sea will not be included, but passenger vessels in all EU waters are already now required to use 1.5%S fuel outside port areas. It is expected that this limit will be decreased further to maintain consistency with the MARPOL Annex VI limits by revising the EU sulphur directive accordingly.

Mitigating the costs of SECA

The increase of fuel costs will have the largest impact on vessels with high fuel consumption. These include RoRo, RoPax and container carriers, which together consume almost half of the fuel used by the Baltic Sea and the North Sea shipping. The role of these vessels becomes even more distinctive if the total fuel consumption is divided by the number of ships in each ship class. For RoRo/RoPax vessels the additional costs of the low sulphur fuels per vessel will be the highest. In the North Sea SECA majority of the SECA cost will fall on container vessels, though the cost per vessel will still be the highest among RoPaxes. Equipping these vessels with sulphur scrubbers, if technically feasible, will be the most cost effective way of minimizing the cost of the sulphur reductions. The cheapest and the quickest way to reduce fuel consumption is to travel at lower speed, which several ship owners have already done during

the recession. In the Baltic Sea there exist less than 400 RoRo/RoPax vessels and about 350 container vessels. In the North Sea corresponding numbers are 900 and 1400, respectively.
The use of high sulphur heavy fuel oil (HFO, up to 3.5% sulphur by mass) in vessels which use sulphur abatement technique to meet the SECA requirements should be allowed in the revised sulphur directive.

Economic impact of fuel switching in 2015

According to our results, fuel consumption of all shipping in the European SECA is about 15.4 million tons (table 1). Ships are generally using heavy fuel oil (HFO). However, due to 0.1%S limit in ship fuels at berth in EU ports, has increased the usage of middle distillate oils (mainly marine gas oil <0.1%S, MGO) in auxiliary engines. There are no detailed statistics what the share of distillates could be but we estimate it as 10 - 20% (based on personal communication with Niklas Hagström, Teboil and Varpu Markkanen, Neste Oil) from the total fuel consumption. On the basis of this in the beginning of 2015 the demand for MGO will increase more than 13 million tons (which represents close to 7% of EU gas oil demand in 2008, Eurostat) if sulphur scrubbers are not used.

Additional costs will arise when ships have to change from the HFO to MGO in 2015. MGO is considerably more expensive and practically the only conventional marine fuel which fulfills the stringent criteria. Note that the application of the 2020 global limit of 0.5%S instead of the 0.1%S requirement on SECAs is not going to be a viable solution, either.There is some heavy fuel oil available with sulphur content less than 0.5% but not nearly enough to operate the whole European SECA fleet (personal communication with Niklas Hagström, Teboil). Thus, the 0.5%S limit in the SECA would have led to the similar additional costs that we are facing now with the 0.1%S limit.

The additional costs of fuel switch can be estimated by multiplying the current HFO consumption with the price difference of HFO and MGO. The price difference was about $300 (USD) per ton in January 2012. Thus the additional costs of new regulations are near to 3.3 billion dollars in 2015 in the Northern SECA, if the traffic and fuel price difference remain constant. Fuel price projections described later show a price difference of 417 dollars in 2015. This price development would lead to additional cost of 4.6 billion dollars in 2015 in the area.

Ship fuel prices in the future

Forecasting of ship fuel prices is challenging but it is estimated that the price difference between HFO and MGO will increase in the future. This is mainly due to assumptions that the crude oil price will continue to increase, and the demand of middle distillates will be growing mainly due to shipping. It can also be assumed that refinery industry is not likely to invest on production of middle distillates in Europe in the near future even if the demand is growing (Avis and Birch

(2009)[4]). At the same time the demand of HFO will decrease, hindering its relative price increase in comparison to middle distillates. One of the biggest open questions is the market penetration of the exhaust gas scrubbing that would continue the demand of high sulphur HFO and would diminish the investment need of refineries.

These assumptions lead to forecasts where the price difference between marine fuels generally used today and the middle distillates used after 1.1.2015 will grow. Avis and Birch (2009) estimated that the MGO under 0.1%S will cost 250$ - 300$ more than HFO under 1.5%S in 2015. We have created price projections (figure 1) for ship fuels to estimate the additional costs of fuel switch and potential of scrubbers to decrease the additional costs. According to the scenario, the price difference between the MGO and HFO1.5 would be 450 USD/tn in 2020.

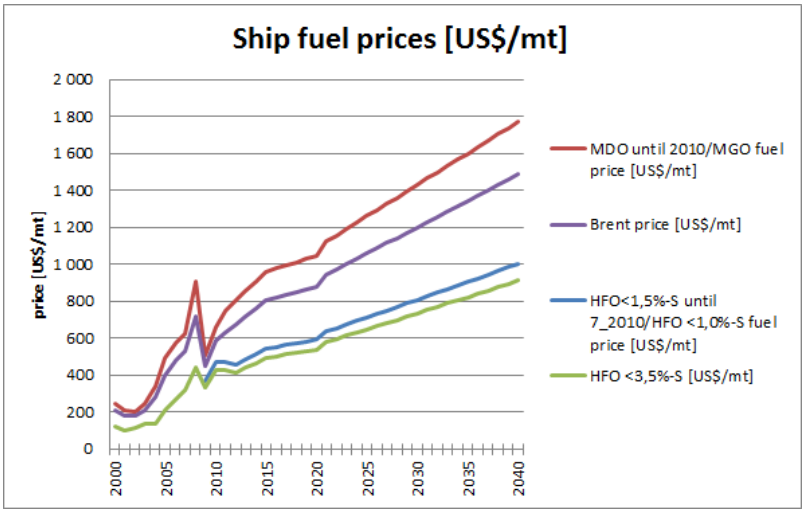

Figure 1. Price scenarios of marine fuels. All values in USD per metric tons.

Exhaust gas scrubbing

There are several different types of sulphur scrubbers designed for maritime use today. Scrubbers would allow the ship to use high sulphur heavy fuel oil to comply the regulation inside the SECA areas. Ships that have large fuel consumption inside the SECA could gain remarkable economic advantages for operating a scrubber.

Due to low salinity of the Baltic Sea, seawater scrubbers might face technical problems when used in the area. A closed loop scrubber is not dependent on the sulphur absorbing

[4] Avis M.J., Birch C.H. (2009), Impacts on the EU refining industry & markets of IMO specification changes & other measures to reduce the sulphur content of certain fuels. Purvin&Gertz Inc. Prepared for: Directorate General Environment

characteristics of seawater and is thus suitable for use in the Baltic Sea area. However, it is slightly more expensive than a seawater scrubber. Furthermore, many shipowners would prefer to leave the scrubber sludge at port, and therefore require port reception facilities for the scrubber sludge.

We have estimated the potential of the closed loop scrubbers to decrease the additional costs of fuel switch after 1.1.2015. The equipment cost of the scrubber is estimated based on the installed engine power of a ship (figure 2.). However, the total investment costs are higher due to installing costs which are assumed to be 50% of the equipment costs. There are also other capital and operation costs which are taken into account similarly as in Reynolds (2011)[5]. Capital costs are assumed to be 5%.

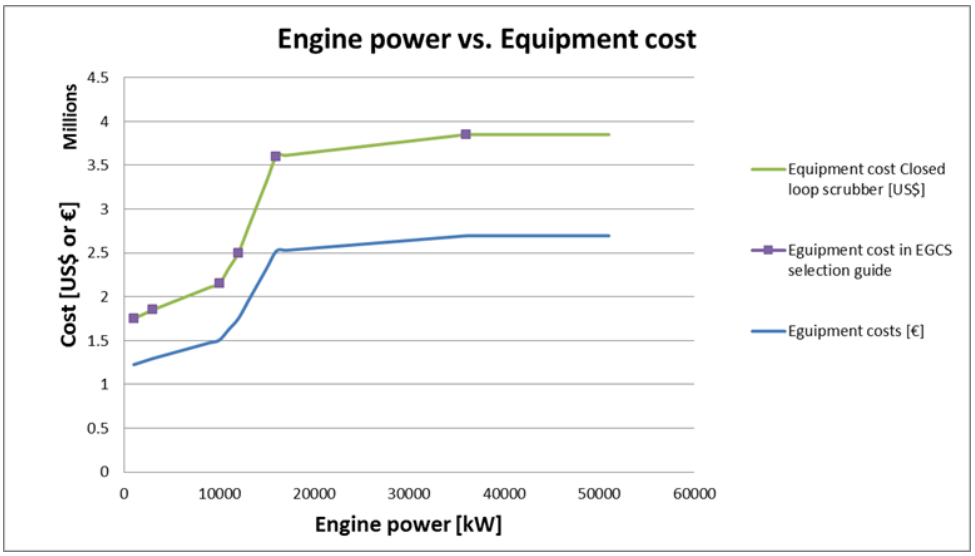

Figure 2. Engine power vs. equipment cost

Two calculations are presented, both based on the fuel consumption of individual ships in the European SECA areas from the 2009 results of the STEAM model. First, the maximum additional costs are calculated assuming that the MARPOL Annex VI compliance is achieved by fuel switch only. Second, the potential of scrubbers to decrease the additional costs is estimated (Figure 3). In the second case it has been assumed that a scrubber is installed if a ship has a fuel consumption more than 2 300 tons per year (an iterated value representing the minimum consumption after which the additional costs turn to increase again) inside the SECA area.

[5] Reynolds, K.J. (2011). Exhaust gas cleaning systems selection guide. Ship operations cooperative program. The Glosten Associates. Feb. 2011. USA.

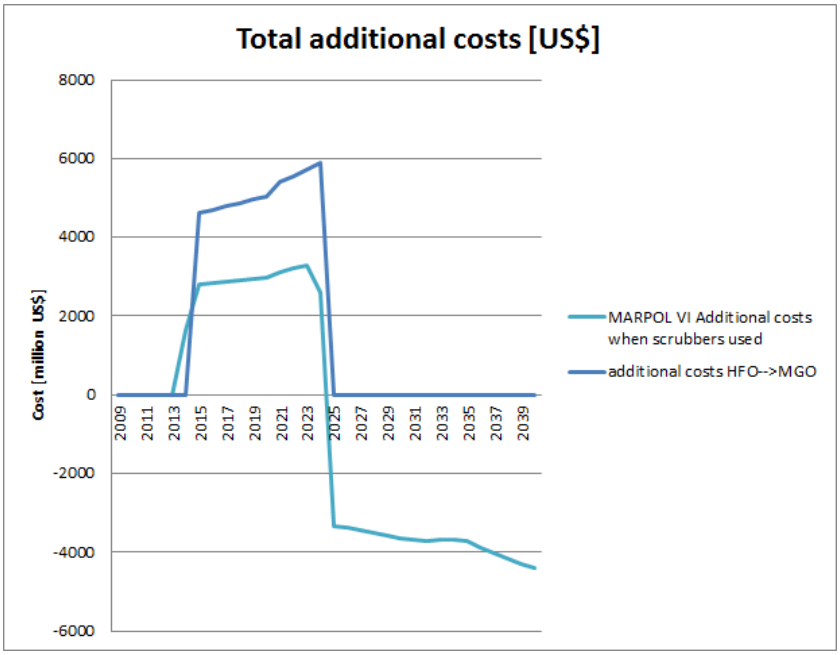

Figure 3. Predicted annual additional costs of the SECA fleet (Baltic Sea + North Sea) due to MARPOL Annex VI sulphur reduction requirements.

Results show that 1 162 ships pass the criteria of 2 300 tons consumption limit in SECA traffic on which the scrubbers are assumed to be installed. Additional costs in 2015 would be 2.8 billion USD. The decrease of additional costs is about 40% (which represents the maximum potential of scrubbers) compared to fuel switch scenario (4.6 billion US dollars). It can also be seen that additional costs become negative after 2025 (assumption of global limit to drop to 0.5%S leading worldwide use of middle distillates). Reynolds (2011) recommends that ships having more than 4 000 tons consumption inside SECA areas per year should consider scrubber installation. With this assumption there are 517 ships passing the criteria still decreasing the additional costs by 35% compared to fuel switch. These calculations do not take the possible traffic growth or efficiency increase into account.

Discussion and conclusions

MARPOL Annex VI regulations on sulphur in ship fuels will cause remarkable additional costs for the sea transport. These costs can be estimated to be about 4.6 billion US dollars annually for the commercial shipping in the European SECA (Baltic Sea, North Sea and English channel) from 2015 onwards, with projected fuel price difference. Costs would be mainly borne by ships with large annual fuel consumption inside the SECA. These ships are mainly RoRo/RoPax and container carriers in typical North European ship traffic.

Exhaust gas cleaning with scrubbers can be a cost efficient solution for hundreds of ships in SECA traffic to decrease the operation costs. Installing scrubbers to 500 ships with the largest fuel consumption in the area can decrease the overall additional costs by about 35%. However, this solution can aid only the industries which are mainly using the same ships for their import

and export actions. Fuel switch is more economical solution for ships that rarely visit the SECA area. Installing the scrubber to these vessels will become more attractive when we are closer to the global limit of 0.5%S which is planned to realize in 2020 or 2025.

The internalization of scrubbers will affect the fuel price in the future. Refinery industry needs a consumer for the high sulphur heavy fuel oil and so far it has been found from the marine sector. Changing procedures in the refinery sector to lower the amount of produced HFO and to produce new marine fuels will require heavy investments. Thus, the marine fuel prices are very difficult to forecast. Both marine sector and refinery sector are monitoring each others developments in order to evaluate the need of investments to prosper in the changing operational environment.

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