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Scrubber: A potentially overestimated compliance method for the Emission Control Areas

The importance of involving a ship's sailing pattern in the evaluation

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ABSTRACT

Different methods for sulphur emission reductions, available to satisfy the latest Emission Control Areas (ECA) regulations, may lead to different sailing patterns (route and speed choices of a vessel) and thus have significant impact on a shipping company's operating costs. However, the current literature does not include sailing pattern optimization caused by ECA, and its corresponding cost effects, in the evaluation and selection process for sulphur abatement technology. This leads to an inaccurate estimation of the value of certain technologies and hence an incorrect investment decision. In this paper, we integrate the optimization of a ship's sailing pattern into the lifespan cost assessment of the emission control technology, so that such expensive and irreversible decisions can be made more accurately. The results shows that a considerable overestimation of the value of scrubbers, and thus a substantial loss, can occur if the sailing pattern of a ship is not considered in the decision-making process. Furthermore, we also illustrate that it is more important to involve a ship's sailing pattern when the port call density inside ECA is low.

1. Introduction

Almost 90% of the world's trade is carried by sea. Therefore, the shipping industry plays a critical part in the global economy (ICS, 2015). However, since marine bunkers normally has a very high sulphur content, shipping activities actually emit more sulphur related exhausts per tonne-mile of cargo than other modes of transport (Wang and Corbett, 2007). Therefore, the International Maritime Organization (IMO) introduced the Emission Control Areas (ECA) regulation which is designated under MARPOL Annex VI on 19 May 2005 (IMO, 2016). The latest ECA regulation came into force in January 2015, see Fig. 1. It requires that the vessels operating inside the regulated regions use fuel oil with a sulphur content of no more than 0.1%. In the meantime, the limit for sulphur content of fuel oil burnt outside ECA is 3.5%. However, this cap will decrease to 0.5% after 2020.

Three alternatives that can be used to comply with the ECA regulation are currently available on the market. The first approach is fuel-switching, which allows a ship to change between heavy fuel oil (HFO) and marine gasoline oil (MGO). The HFO is the traditional fuel, with high sulphur content, and can only be used outside ECA. Note that after 2020 the HFO will be replaced by another ultra low sulphur fuel oil (ULSFO), which contains 0.5% sulphur, when the ship sails outside ECA. The MGO is the cleaner fuel, with less than 0.1% sulphur, and can be used inside ECA. The fuel-switching approach

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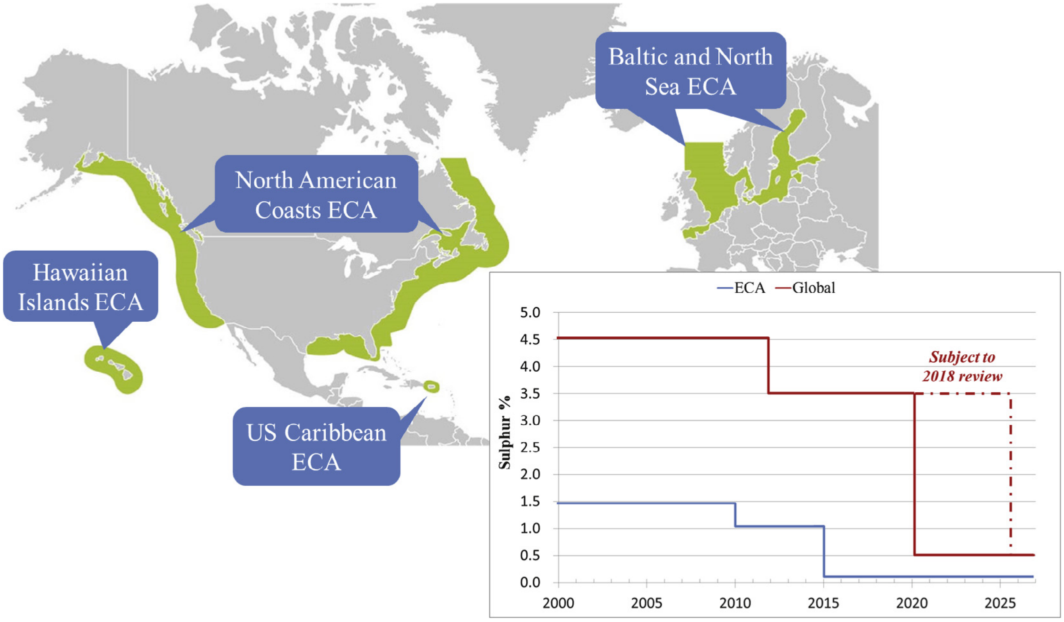

Fig. 1. Map and requirements of the Emission Control Areas.

requires only slight modifications on the ship, and thus very limited initial investments. But the price of MGO is much higher than that of HFO, and its future replacement ULSFO, which means the operational costs of a vessel can increase dramatically if the fuel-switching approach is applied. On the other hand, the shipowner may also choose to install a scrubber system which absorbs the majority of the sulphur content in the exhaust, and therefore enables the ship to keep using cheap HFO in- and outside ECA. However, the capital costs of the scrubber installation is considerable. The last option is to use liquefied natural gas (LNG) as fuel for the ship's propulsion system. Similar to the scrubber approach, the LNG option can effectively avoid the consumption of expensive MGO in exchange for a substantial initial capital investment. Furthermore, the LNG approach also suffers from other problems, such as large space requirements and supply limitations at ports.

Since the three alternatives have different pros and cons, and the investments in certain technologies are irreversible, the choice of sulphur emission control method for a shipping company becomes critical and complex. The selection among the three abatement technologies mainly depends on the trade-off between their fix costs (e.g., capital costs and maintenance costs) and variable costs (fuel costs). The former is relatively clear, while the latter is uncertain. The fuel cost of a vessel is affected by its ***sailing pattern***, including route and speed decisions. Such patterns may change after choosing a certain emission control method. The major motivation for this paper is to study the impact of a ship's sailing pattern on the selection of ECA compliance method as this is a costly, irreversible decision.

There is a solid body of literature on the selection of sulphur emission reduction technology. Ren and Lützen (2015) propose a multi-criteria approach to assist the decision-makers in a shipping company to choose the most sustainable emission reduction technology for all existing environmental regulations. Balland et al. (2013) develop a two-stage stochastic programming model to decide the selection of emission abatement technologies for a certain time period so that the vessel can comply with the air emission regulations in the most cost-efficient way. The model involves the consideration of the interaction between different abatement technologies and the pollution reduction uncertainties of different existing air emission controls. Patricksson et al. (2015) extend the maritime fleet renewal problem and include the ECA as a key factor in the decision-making process. A stochastic programming model is built to facilitate the selection between fuel-switching and scrubber system for the shipping company by minimizing the expected total costs including the initial capital cost and the expected operational cost in the future. Jiang et al. (2014) examine the costs and benefits of different sulphur reduction measures from a comprehensive viewpoint by integrating the private cost of the shipowners and the social benefits from emission reduction. Schinas and Stefanakos (2012) also use stochastic linear programming to minimize the total costs of a ship operator who has business in the ECA. The model determines the fleet-mix and the capacity under budgetary and fleet attribute constraints, while taking demand and growth patterns into account. The uncertainty in this research refers to the probability of the vessels sailing in ECA. Furthermore, Lindstad et al. (2015) evaluate costs as a function of emission abatement alternatives used in the ECA. Their study shows that there is no absolute answer to what is the best choice for emission reduction. The optimal option depends on several factors including engine size, annual fuel consumption in the ECA and future fuel prices. Lindstad and Eskeland (2016) claim that the scrubbing and tuning solution will become the dominant response after the global sulphur cap being implemented in 2020. However, such end-of-pipe solutions reduce energy efficiency and may deflect attention from developing cleaner fuels and improving energy efficiency. Hence, instead of extending