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The evaluation of investments efficiency of SO_x scrubber installation

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ABSTRACT

The article analyses the investments efficiency of sulphur oxide (SO_x) scrubber installation to comply with the requirements of MARPOL 73/78 Annex VI, which sets 0.1% SO_x limits in 2015 in Emission Control Area (ECA) and 0.5% in 2020 globally. There are two most realistic technologies to reduce SO_x emission suitable for existing fleet: low sulphur fuel; scrubber. Mentioned technologies are compared and economic issues of each are analyzed in the article. The comparison of the technologies shows that no matter which technology will be selected each will require the additional costs: capital and operating costs, loss of profits due to the reduce of cargo capacity. That is why the technology introduction will be considered as investments in the article. Each of mentioned technology has certain specific of the investments. Therefore, the evaluation of the investments efficiency should be carried out by comparing the different technologies (in our case scrubber and low sulphur fuel) that meet the requirements of MARPOL 73/78. Investments efficiency in technology will be evaluated by cash flow modeling during the billing period covering the time interval from the technology introduction to the completion of use. The concept of cash flow allows forming a systematic view of funding and determining the dynamics of the financial effects at the each stage of technology introduction. In turn, a comparative analysis of technologies will identify the best option of investment applying to a particular ship.

Introduction

Annex VI of MARPOL 73/78 which will entered into force in a short time sets limits on sulphur oxides (SO_x) from ship exhausts: to 0.1% by 2015 in ECA and globally to 0.5% by 2020. Annex VI contains provisions allowing for special SO_x ECA to be established with more stringent controls on sulphur emissions. The existing ECA include the Baltic Sea, the North Sea, the North American, including most of US and Canadian coast and the US Caribbean, including Puerto Rico and the US Virgin Islands (IMO, 2008). ECA regulations are now enforced across many countries and there are further designated zones under discussion. In the medium and long term it can be expected that most of global trading centers will be pass through ECA (Asariotis and Benamara, 2012). Therefore, an increasing number of scientists are exploring mentioned issues in their researches. Most attention is paid to assessments of abatement technologies and alternatives for complying with MARPOL 73/78 Annex VI regulations. Several researchers emphasize and illustrate the great environmental improvement potential of the different technologies and alternative fuels. Several authors also highlight the complicated issue of selecting

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optimal measures to comply with new requirements (Cullinane and Bergqvist, 2015). Most of researches contain analysis of environmental impact of ship exhaust and ways to reduce harmful emission (Caiazzo et al., 2012; Fridell et al., 2008; Kennan, 2014; Lack et al., 2012). According to Annex VI of Marpol 73/78 the regulations will be applicable not only to new building but also to existing ships. According to most researchers (Brynolf et al., 2014; Fridell et al., 2008; Kjølholt et al., 2012; Kruse, 2012; Schinas and Stefanokos, 2014; Tai and Dung-Ying Lin, 2013) SO_x restrictions will bring considerable financial and technological challenges especially for modernization of existing ships. That is why there is a need to analyze SO_x emission reduction technology installation economic and technological impact on existing fleet.

Some aspects of problematic of technology installation are analyzed in articles. However the method of the evaluation of investments efficiency described insufficient.

To ensure compliance with mentioned requirements shipowners may choose one of the most appropriate technologies: fit an exhaust gas cleaning system or use any other technological method to reduce SO_x emissions (IMO, 2008). Presently, the most realistic technology to reduce SO_x of ship exhausts is:

- Low sulphur fuel: according to marine fuel standards (ISO 8217) intermediate fuel oil IFO contains <3.5% SO_x; marine diesel oil MDO <1.0% SO_x; low sulphur marine gas oil LSMGO <0.1%. In our case, the restriction in ECA is equal 0.1%. Thus, only LSMGO will be analyzed in the article (ISO 8217: 2012).
- Liquefied natural gas (LNG).
- Scrubber.

Each of mentioned technology has advantages and disadvantages which are listed in Table 1 (Kjølholt et al., 2012; Kruse, 2012; McGill et al., 2013; Germanisher Lloyd, 2013; Brynolf et al., 2014):

SO_x reduction technologies are a common and proven technology on land. That is why the cost of SO_x reduction at sea generally being lower because the easiest and least expensive measures have already been taken on land in most EU countries (Kageson, 1999). On the average the costs of typical measures of ships SO_x emission reduction is from 0.52 to 4.52 $/kg (Wang and Corbett, 2007). Speaking about capital costs of scrubber installation for the particular ship, the costs of technology introduction is from 1 to 5 million $. It is noteworthy that the costs of each technology can vary greatly depending on the specific of ship operating (being in ECA, amount of fuel consumption). Despite the fact that mentioned technologies are well known, there is not enough practical knowledge of its economic efficiency. The cost-effectiveness of different technologies (LNG, LSMGO, scrubbers) was studied by many scientists and equipment manufacturers (Schinas and Stefanokos, 2014; Tai and Dung-Ying Lin, 2013; Walter and Wagner, 2012; Wang and Corbett, 2007; Wärtsilä, 2010, 2013; Yang et al., 2012). There are several ways to achieve the compliance with SO_x requirements and many articles contain a comparison of advantages and disadvantages of technologies of SO_x reduction (Brynolf et al., 2014; Glosten, 2011; Kruse, 2012). Mainly, the offered cost-benefit analysis of SO_x reduction technologies is based on some key assumptions, related to ship and route characteristics (Cullinane and Bergqvist, 2015) Also, others authors investigate economic issues SO_x scrubber installation but there are still not enough recommendations of assessment of technology installation efficiency (SOCP, 2011; Yang et al., 2012). However, there is still a lack of information about the investments aspects of life cycle of technology introduction (cost elements, specific of return of investments, billing period and etc.). Issues of technology efficiency are investigated only by calculating payback period without specifying the method of calculation. For this reason, the article analyzes the method of assessment of scrubber installation efficiency in comparison with using of LSMGO (see Table 2).

According to Table 1, no matter which technology will be selected by the shipowner the additional expenses (capital and operating costs, loss of profits due to the reduce of cargo capacity) cannot be excluded. However, it should be noted that each of mentioned technology has certain specific of the investments. Thus, in accordance with the data presented in Table 1, the use of LSMGO requires comparatively low capital costs. However, the operating costs are considerably higher because of

Table 1
The comparison of SO_x reduction technologies.

Criteria	LSMGO	LNG	Scrubber
Advantages	• Simple to use (if modification is not required) • Less engine maintenance • Suitable for new building and retrofit	• Reduce 90–100% SO_x, 60% NO_x, 70% PM and 25% CO_2 • No additional abatement measures are needed	• Reduce 90–99% SO_x and 60–85% PM • Allows using IFO • Comparatively quick payback • Suitable for new building and retrofit
Disadvantages	• Availability is already limited • More expensive than IFO • Reduce engine life if conversion is not performed • Changeover time can add several hours to the trip • Higher fuel consumption rate	• Requires a modification of ship (engines replacing, specially designed systems, larger fuel tanks, gas sensors and etc.) • Retrofit is difficult and expensive • Lack of infrastructure and LNG is currently limited	• Not a really proven and well used technology yet • Significant investment cost • Additional energy during operation, discharge of water and etc. • Reduced income due to less cargo capacity • Insignificant reduction of NO_x