A Review of Future Energy Efficiency Measures and CO2 Emission Reduction in Maritime Supply Chain

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INTRODUCTION

As the world's largest industry, the maritime supply chain sector is a significant contributor to global CO2 emissions. Based on the recent report (see Figure 1) by the International Maritime Organization (IMO), the maritime supply chain sector currently accounts for approximately 3% of global CO2 emissions, projected to double or triple by 2050 (Buhaug et al., 2009). Conversely, it is also projected that 25-70 per cent of CO_2 emission can also be lessened with appropriate strategies through better energy efficiency practice, adoption green technologies and improved logistics system (Johnson & Styhre, 2015). However, the implementation of all current cost-efficient technologies aiming at reducing fuel consumption and curbing emissions have proved to be inadequate to counteract the effects of rapid growth of maritime supply chain sector (Eide, Longva, Hoffmann, Endresen, & Dalsøren, 2011).

Due to this concern, numerous studies have been taken in the field of substitute power sources and energy-saving measures for shipping operation to reduce CO_2 emission. Nevertheless, the gaps remain between existing knowledge and the execution of energy efficiency measures by maritime supply chain organizations (Styhre & Winnes, 2013). As in other numerous sectors, several measures that would improve fuel efficiency and CO_2 emission in the maritime supply chain have yet to be implemented despite their known cost efficiency. This situation is known as energy efficiency gap in the literature. This situation is generally occurred due to lack of understanding/awareness, low capital, weak policies and slow technology adoption. While Sorell, Mally, Schleich and Scott (2004) underpin this problem through recognition of organizational barriers such as organizational risk, asymmetrical of information, hidden costs, higher capital, split incentives and bounded rationality.

From the legislator viewpoint, these problems call for proactive policy intervention in this sector. IMO as a sole global legislator has been implementing a few chapters in its MARPOL Annex VI in achieving a comprehensive goal to reduce GHG emission in shipping operation (Kader, 2013). Current IMO declarations such as Energy Efficiency Design Index (EEDI), Ship Energy Efficient Management Plan (SEEMP) and Energy Efficiency Operational Indicator (EEOI) are to collect data on energy consumption and emission so that reliable measures can be implemented. IMO also is in the ongoing discussion on the possible implementation of sector-specific market-based measures (MBM) to further curb specific CO2 reduction within this sector (Hannes Johnson & Andersson, 2016). This annex will

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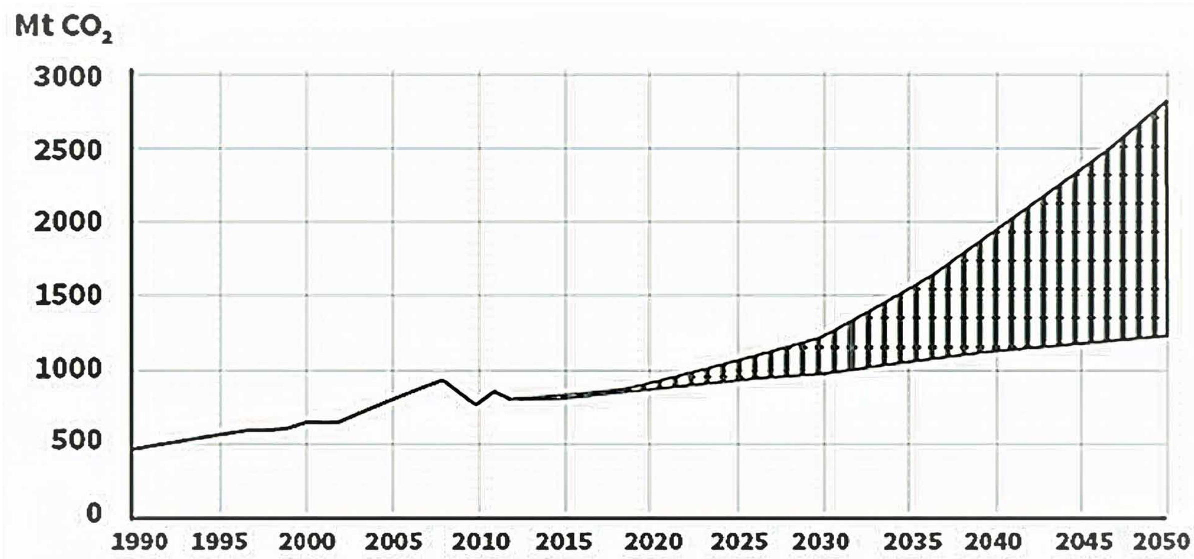
Figure 1. CO_2 emission projection for maritime transportations
Source: International Maritime Organization (IMO)



eventually become a blueprint for many maritime organizations to abide as it is obligatory to follow suit these regulations in order to fulfil the global requirement for trade in the future. However, as the volume of trade is predicted to rise over the year, total reductions in fuel consumption and CO2 emissions from the sector are not expected to lower despite these new regulations (Anderson & Bows, 2012).

Currently, it is more important to focus on what prevents energy efficiency and emission improvements within the maritime organization and what can be done to overcome the current barriers. Overcoming energy efficiency gaps should be a priority since direct fuel costs are expected to rise in the future. The role of energy efficiency should be considered as a critical success factor for any maritime organization to be profitable and to achieve long-term sustainability. Thus addressing this need, this paper provides an overview of measures that can be considered for future energy efficiency and emission reduction in the maritime supply chain. In addition, the current stage of adoption, barriers, overcoming the barriers and potential research direction is discussed through the remaining of the paper.

BACKGROUND

The Future Potential of Energy Efficiency Measure and CO_2 Emission Reduction

The energy in maritime supply chain can be defined as a source of power necessary to carry out logistics and transportation activities. While maritime transport can be powered by various sources of energy (e.g. fossil fuels, biofuels, nuclear electricity, or alternative energy), fossil fuels are still the most common form of energy source used in this sector (M. F. A. Jasmi & Fernando, 2018). However, as the scarcity of fossil fuels and concern on climate change increased, there is an urgent need for proper technical and managerial measures within maritime supply chain sector. Additionally, as maritime supply chain is an energy-intensive sector, energy costs contribute a large share of total operating costs. This is a substantial

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