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Decarbonizing the international shipping industry: Solutions and policy recommendations

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A R T I C L E I N F O

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A B S T R A C T

Ship-source greenhouse gas (GHG) emissions could increase by up to 250% by 2050 from their 2012 levels, owing to increasing global freight volumes. Binding international legal agreements to regulate GHGs, however, are lacking as technical solutions remain expensive, and crucial industrial support is absent. In 2003, the International Maritime Organization adopted Resolution A.963 (23) to regulate shipping CO_2 emissions via technical, operational, and market-based routes. However, progress has been slow and uncertain; there is no concrete emission reduction target or definitive action plan. Yet, a full-fledged roadmap may not even emerge until 2023. In this policy analysis, we revisit the progress of technical, operational, and market-based routes and the associated controversies. We argue that 1) a performance-based index, though good-intentioned, has loopholes affecting meaningful CO_2 emission reductions driven by technical advancements; 2) using slow steaming to cut energy consumption stands out among all operational solutions thanks to its immediate and obvious results, but with the already slow speed in practice, this single source has limited emission reduction potential; 3) without a technology-savvy shipping industry, a market-based approach is essentially needed to address the environmental impact. To give shipping a 50:50 chance for contributing fairly and proportionately to keep global warming below 2 °C, deep emission reductions should occur soon.

1. Introduction

Ocean shipping, the most energy-efficient form of freight transport, is the backbone of global trade, but this sector heavily depends on fossil fuel. The lengthy debate on whether ship-source greenhouse gas (GHG) emissions are classified as marine pollution has delayed the international regulation and subsequent implementation to limit the carbon emissions from the shipping sector (Shi, 2016a).

Ship-source GHG emissions could increase by up to 250% by 2050 from 2012 levels, owing to increasing global freight volumes (Fig. 1). Unchecked, such emission levels are projected to constitute 17% of the global CO_2 emissions by 2050 from the current figure of approximately 2% (Cames et al., 2015). Yet, at the Paris Climate Agreement of 2015, the shipping industry was neither included in the global emissions reduction targets nor mentioned in the agreement (United Nations Framework Convention on Climate Change, 2015). Discussions regarding shipping emissions were simply left, like in the Kyoto agreement, to the International Maritime Organization (IMO), who is expected to develop regulations, set emission reduction targets, and determine measures to facilitate their practical implementation.

To satisfy the lofty goal of the Paris Agreement to limit global warming below 1.5 °C–2 °C, all sectors may be ultimately required to produce zero emissions or develop tools to remove GHGs from the atmosphere (Williamson, 2016). Regarding shipping emissions, large shipping nations and the shipping industry are slow and sometimes reluctant to introduce appropriate measures aimed at reducing emissions and improve global rules for the industry (Upton, 2016).

The IMO placed the climate impact of shipping in the agenda in 2003. On December 5 of the same year, the IMO adopted Resolution A.963 (23) requiring the Marine Environment Protection Committee (MPEC) to regulate shipping CO_2 emissions through technical, operational, and market-based routes (IMO, 2004). However, stakeholder values are diverse, leading to slow negotiations and no concrete emission reduction pathways or definitive action plan. A full-fledged roadmap may not even emerge until 2023 (Green4sea, 2016). Many widely discussed market tools, such as the cap and trade approach, implemented in other sectors are unlikely to be implemented in the shipping business soon because they are linked to a fuel data collection

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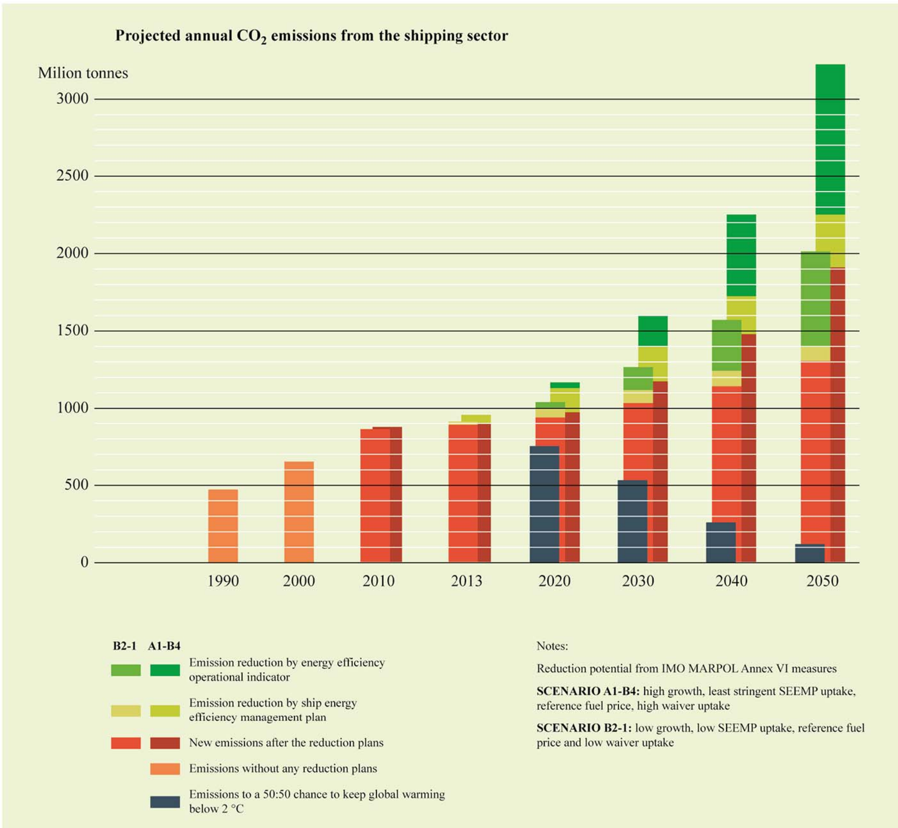

Fig. 1. CO_2 emissions in the shipping sector
Illustration based on Buhaug et al. (2009), Smith et al. (2014), Anderson and Bows (2012), Lloyd's list of intelligence data, and OECD analysis. If shipping aims at delivering its fair and proportionate contribution at 50:50 chance to keep global warming well below 2 °C, a deep emission reduction up to 85% by 2050 compared with the 2010 baseline is needed. Existing technology and operational solutions are not enough.

system that will start only in 2019 (Dufour, 2016).

In this policy analysis, we revisit the progress of technical, operational, and market-based instruments and their associated controversies. Based on existing evidence, we argue the following.

1) Many technical solutions remain too expensive, and crucial industrial support is absent. A performance-based index, though good-intentioned, has loopholes leading to concerns on the meaningful effect on CO_2 emission reductions.
2) Using slow steaming to cut energy consumption is apparent among other operational solutions due to its immediate and obvious results, but with the already slow speed in practice, further emission reduction potential from this single source may be limited. On the other hand, ships could still adopt faster speed when the market and economic circumstances improve. A potential impact will be exerted on fuel use and associated emissions correspondingly. Other types of operational solutions must be incorporated into shipping companies' energy management strategies for extra reduction potential.
3) Without a technology-savvy shipping industry, a market-based approach is essentially needed to address the environmental impact. The core of the maritime emissions trading system (ETS) system lies in the "carbon emissions ceiling" and "trading process." However, the method of using benchmarking plus grandfathering rights adopted by the European Union (EU) aviation industry cannot simply be applied to the more complex international shipping industry.
4) If shipping has a 50% probability of delivering its fair and proportionate contribution to keep global warming well below 2 °C, a deep emission reduction should take place soon. Constructive regional actions must be recognized as they can be both responsive and cost effective.

2. Technical and operational solutions

2.1. Technical solutions

Technical solutions aim at using technical means to improve a ship's energy efficiency, thereby reducing the CO_2 impact per capacity mile (expressed in ton-mile) (IMO, 2012). The IMO has introduced the mandatory Energy Efficiency Design Index (EEDI) for newly built ships with the hope that such a measure will stimulate a series of technology and engineering innovations ranging from optimized hulls and propellers and improved engine performance to better waste heat recovery systems (MEPC, 2011). Most newly built ships only need to become 0%–10% (the actual number depends on the vessel type and size) more energy efficient between 2015 and 2020, but the index will be tightened incrementally every five years.

A performance-based index, though good-intentioned, has loopholes that led to concerns on the meaningful effect on the CO_2 emission reductions driven by technical advancing. In theory, the use of derated engines with less power can yield significant EEDI reductions at the expense of speed without extra technology improvements (Psaraftis and Kontovas, 2013). An empirical study found that regulations on EEDI would even result in slight increases in CO_2 emissions in large crude carriers because by limiting the installed power on board, vessels would be induced to operate on higher revolutions-per-minute engines that consume more fuel though the EEDI limit is met (Devanney, 2011). In practice, EEDI only reflects the efficiency of ship design but totally neglects the operational variations that determine the real energy efficiency (Cichowicz et al., 2015).

Moreover, increasing competition has led to ever increasingly larger ships with better fuel economy, which translates into a smaller EEDI (Ozaki et al., 2010), but uncertain demand could complicate the real performance—ships could consume more energy per goods transported if half loaded than fully loaded (Wan et al., 2016a). Increasingly larger ships can yield other unexpected side impacts from concentrated