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Opinion

Developing a Fuel Efficiency Index for Small Sized Marine Vessels

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Abstract

International Maritime Organization (IMO) has adopted the energy efficiency design index (EEDI) regulation to limit greenhouse gases (GHG) emissions from medium and large ships. However, small ships, boats and leisure watercrafts with load line length below 24m or deadweight tonnage (DWT) below 2000 DWT are not bound by the EEDI regulation. These small vessels exist in large numbers and there is a great scope to reduce GHG emissions from these watercrafts. This short opinion paper proposes an approach to evaluate the GHG emissions performance of small watercrafts that fall outside IMO regulation. To this end, a novel index termed small watercraft index is proposed by adapting the existing EEDI for different categories of small watercrafts. The approach proposed here helps standardise the evaluation of small watercrafts and may provide policy inputs for sub-IMO crafts. Furthermore, the proposed approach aids performance comparison of different small watercrafts.

Keywords: energy efficiency design index, small watercraft index, GHG emissions, marine transportation

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1 INTRODUCTION

New fuel-efficient ships are urgently needed to reduce maritime greenhouse gases (GHG) emissions and meet International Maritime Organization's (IMO) 2050 targets[1]. Although the IMO has Energy Efficiency Design Index (EEDI) regulation to limit GHG emissions from medium and large ships[2], small vessels with load line length below 24m and below 2000 deadweight tonnage (DWT) are not bound by the EEDI regulation. Existing research focus on large container ships[3] since they are considered to be the main source of GHG emissions from shipping sector. However, detailed GHG emissions data are not available for small watercrafts since they are not regulated. Nonetheless, it is noteworthy that small watercrafts exist in large numbers. For instance, in the UK alone, there are over a million leisure watercraft of various forms[4] and around 12,000 fishing vessels[5]. Given the high volume of small vessels, there is a great scope to reduce GHG emissions from these vessels by applying a standard similar to EEDI that is suited for small vessels.

Although European Union[6] and UK[7] have standards and regulations for small watercrafts and associated engine emissions, they do not exclusively evaluate GHG emissions performance of small crafts. Therefore, an approach solely focused on evaluation of GHG emissions from small watercrafts is needed. The main aim of this short opinion paper is hence to develop a framework that can enable the evaluation of GHG emissions performance of small watercrafts. Another objective is to draw the attention of the research community towards emissions evaluation of small watercrafts as there is a dearth of literature on this topic.

The working hypothesis of this paper is that the GHG emissions from small watercrafts contribute to reasonably significant proportion of GHG emissions from maritime sector and it is therefore necessary to systematically evaluate the performance of these crafts. To this end, we propose a novel energy efficiency index termed as small watercraft index (SWI) to evaluate the GHG emissions performance of small watercrafts that do not fall under the IMO regulation by adapting the EEDI. SWI helps systematise and standardise the evaluation of sub-IMO crafts and allow direct comparisons of different types of small crafts. It may also support policy instruments intended to limit GHG emissions from marine sector.

2 CLASSIFICATION FOR PERFORMANCE EVALUATION

IMO has set EEDI reduction rates for medium and large ships. For instance, reduction rate for containerships of and above 200,000 DWT is set at 50% of the 2008 level[8]. Likewise, reduction rate for containerships of and above 15,000 DWT is set at 30% of the 2008 level[8]. However, EEDI is not a suitable parameter to evaluate GHG performance of small watercrafts as discussed below. Based on the classification of small watercrafts, a more suitable parameter termed SWI is proposed.

2.1 Limitation of EEDI

EEDI utilises 'transportation work' as one of the parameters in its calculation[9] which is a mathematical function dependant on DWT. This may not be applicable for small crafts such as leisure boats and fishing vessels that are not primarily used for haulage. Therefore, a new measure of efficiency is needed for small watercrafts that are not bound by IMO regulation and where EEDI is not very suitable. A new index termed as SWI is proposed here for such small watercrafts. The SWI can be utilised to evaluate the performance of small watercrafts or for GHG emissions comparisons.

2.2 Application Based Classification

Small watercrafts are used for various purposes and their GHG emissions performances need to take their applications into account for standardized evaluation and comparisons. Therefore, small watercrafts are classified into four different categories based on their applications here for SWI estimation. These categories are cargo carrying vessel, leisure vessel, passenger vessel and fishing vessel.

3 SWI

Broadly, SWI is a metric that measures the performance of small watercrafts that fall outside the IMO regulation in terms of GHG emissions. This section provides an approach to calculate SWI for different small watercrafts listed above.

3.1 Cargo Carrying Vessel

A cargo carrying vessel could be any small watercraft below the IMO regulation that transports only cargoes and not passengers. SWI for cargo carrying vessel is defined as the ratio of GHG emission per unit ton of cargo by the watercraft to the GHG emission per unit ton for same distance by train. It may be mathematically expressed as:

$$\mathrm{SWI} = \frac{\text{GHG emission per unit distance per ton of cargo by the watercraft}}{\text{GHG emission per unit distance per ton of cargo by train}} \quad (1)$$

The standard emission from freight train is suggested as 27.5g CO_2e per ton per km[10]. Thus, the allows standardisation of evaluation of efficiency of small cargo vessels below the IMO regulation. It may be noted here that lower value of indicates higher efficiency in terms of GHG emissions.

3.2 Leisure Vessel

The need to reduce GHG emissions from tour boats and leisure watercrafts has been stressed[11] and a consensus based benchmark is needed to compare emissions performance of different leisure vessels. In the case of sailboats being used for recreational activities, fuel consumptions of diesel and petrol based marine generators per hour of recreational activity may be used as a proxy for GHG emissions performance. Although sailboats primarily rely on wind energy for propulsion, it is important to quantify the fossil fuel consumption for hotel electric power such as lighting, air conditioning, refrigeration et cetera. In general, equivalent CO_2 emissions per hour of leisure activity per person could be a suitable metric to compare GHG emissions performance of leisure vessels. Another option could be to compare inland waterway or marine transportation based leisure activities with land transportation based leisure activities. For example, if a benchmark GHG emission of a standardised road trip is established, it can be used to compare with watercraft based leisure activities.

3.3 Passenger Vessel

There are different types of small passenger vessels such as catamarans, channel and car ferries, roll-on/roll-off ferries, and double-ended ferries[12]. These vessels could either transport only passengers or transport passengers as well as cargos. Vessels carrying up to 12 passengers may be categorised as small passenger vessel. Crew Transfer Vessels are also included in this category. For vessels that only transports passengers, SWI is defined as the ratio of GHG emission of a passenger traveling by the watercraft to the GHG emissions of the passenger traveling the same distance by train. It may be mathematically expressed as:

$$\mathrm{SWI} = \frac{\text{GHG emission per unit distance per passenger by the watercraft}}{\text{GHG emission per unit distance per passenger by train}} \quad (2)$$

The standard emission from passenger train is suggested as 35.1g CO_2e per passenger per km[10]. Thus, allows standardisation of evaluation of efficiency of small passenger vessels outside the IMO regulation and also enables direct efficiency comparisons of different watercrafts.

For vessels that transport both cargo and passenger, the expression for is slightly modified as below:

$$\mathrm{SWI} = \frac{\text{GHG emission per unit distance per passenger per ton cargo by the watercraft}}{\text{GHG emission per unit distance per passenger per ton cargo by train}} \quad (3)$$

It may be noted here that standard emissions for cargo and passenger by trains are suggested to be 27.5g and 35.1g as previously stated.

3.4 Fishing Vessel

Evaluation of GHG emission performance of fishing vessel needs to take fuel consumption as well as energy consumption due to refrigeration requirements into account. SWI may be quantified as GHG emission per energy consumption per kg of fish. The energy consumption here is total energy content of the fuel including energy consumed for fish refrigeration. The SWI needs to be made non-dimensional by normalizing it with suitable reference value for standardization and comparison purposes.

4 CONCLUSION

A novel approach to estimate the GHG emissions performance of small watercrafts that are not under IMO regulation is presented in this short opinion paper by adapting the EEDI. The fuel efficiency in terms of GHG emissions is measured by using a new index termed here as SWI by classifying small watercrafts into four categories, namely, cargo carrying vessel, leisure vessel, passenger vessel and fishing vessel. The SWI enables emissions comparisons of different types of small watercrafts and may provide policy support to reduce GHG emissions from shipping sector.

Although the current research focus primarily on GHG emissions of medium and large ships, there is a necessity to critically investigate emissions of small watercrafts. There is also a need to gather sufficient empirical GHG emissions data on small watercrafts that do not fall under IMO regulations. Benchmarking of GHG emissions for different categories of small watercrafts is possible after the collection of sufficient empirical data and utilisation of SWI metric proposed here. This short opinion paper is thus intended to stimulate research on small watercrafts so that GHG emissions of these crafts can be systematically studied and eventually reduced.

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Conflicts of Interest

The author declared no conflict of interest.

Author Contribution

Pyakurel P primarily contributed towards writing the paper and supported conceptualization of the paper. Ridley J primarily contributed towards conceptualization of the paper and supported the paper writing.

Abbreviation List

DWT, Deadweight tonnage
EEDI, Energy efficiency design index
GHG, Greenhouse gases
IMO, International maritime organization
SWI, Small watercraft index

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