

Monitoring, Reporting, and Verification of CO₂ Emissions in Shipping



Key Characteristics

Database

- Provided by leading Danish shipowners/operators
- The fleet contains more than **1,500 ships** divided into four categories
- More than **35,000 legs** concluded in 2018 by the entire fleet

GHG emissions regulation policies

- The EU Monitoring, Reporting, and Verification Regulation 2015/757
- The Data Collection System of IMO's Resolution MEPC.278(70)

Indicators for monitoring efficiency

- Energy Efficiency Operational Indicator (EEOI)
- Individual Ship Performance Indicator (ISPI)
- Energy Efficiency per Service Hour (EESH)
- Annual Efficiency Ratio (AER)

Mandatory in the EU MRV Regulation

Used by the IMO DCS scheme

Dry bulk carriers in the data sample by category

Category	Number of ships
Handysize	204
Handymax	476
Panamax	365
Capesize	6

Motivation & Objectives

- Aims to support the policy debate on greening international shipping
- Analyses of available data on fuel consumption and CO₂ emissions of ships to:
 - **assess the effectiveness of the proposed performance indicators** in serving the corresponding policy objectives. EU approach targets the lack of market information on ship efficiency, while at the global level, the IMO follows an approach based on data collection and analysis
 - **compare the merits and pitfalls of the approaches that the EU and IMO use** in enhancing the sustainability of the shipping industry

Methodology

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graph TD; A[Literature review] --> C[Choice of indicators]; B[Data collection] --> C; C --> D[Data analysis]; C --> E[Assessment/Regression]; D --> F[Discussion/Conclusion]; E --> F;
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Results

Figure 1. The EEOI, AER, EESH, and ISPI of the dry bulk fleet by size.

What stands out from Figure 12 is the decreasing function of the EEOI and AER with respect to DWT. This trend is due to the economies of scale characterising larger ships, which, when compared to smaller ships, exhibit an increase in fuel consumption that is lower than the corresponding increase in cargo carrying capacity. However, since the AER ignores the capacity utilization of the ship, it produces a significantly underestimated figure of energy efficiency.

The EESH and the ISPI indicators disregard both the cargo and capacity of the ship. The regression curves exhibit an upward moving trend due to the fact that, ceteris paribus, larger ships emit more than the smaller ones per hour or per mile sailed.

Figure 1. The effect of draft and weather condition on the EEOI on the DryBulk 4.

A case study of a single ship was conducted and the corresponding EEOI values per voyage are shown in Figure 2 plotted against speed. Moreover, Figure 2 also presents a set of EEOI-speed curves reflecting combinations of the ship's loading condition, the sea state, and the wind direction.

Under ballasted conditions, the EEOI cannot be defined (infinite value) and the feasible EEOI set of Figure 2 is the entire space above the lowest curve (laden/calm seas/tailwind).

Therefore, given that the average speed is not known, the only information that an average EEOI value can convey is that of the dotted line in Figure 2.

Some questions then remain:

- Can the dotted line say anything about the energy efficiency of this ship, when the minimum requirement for this is the entire laden/calm seas/tailwind curve?
- How good of an approximation of this curve is the dotted line?
- How rational is the decision of chartering a ship based on a dotted line a little lower than that of Figure 19?

Figure 3. The geographical coverage effect on the EEOI of the sample fleet.

The graph shows significant differences that question the accuracy of the reported MRV data. More specifically, the EEOI values at EU level are much lower than those of the same ships when all voyages performed within the year are included in the calculation irrespective of geographical coverage (regression curve in green).

A probable explanation relates to the load factor of the respective voyages. As Europe is a major consumer of bulk commodities, the ships of this type tend to exhibit better capacity utilization around this part of the world.

This is confirmed by the descriptive statistics, where the average cargo carried in EU territory is significantly higher than the average figure outside the EU, when considering only ships that serve both regions.

As such, the geographical restriction of the EU MRV Regulation introduces an exogenous bias on the reported energy efficiency indicators that further weakens their utility when it comes to providing accurate information to the market players.

Research Outlook

The **EEOI would be suitable** for monitoring the efficiency of individual ships if **properly normalised** to nullify the influences of speed, load and possible weather conditions. In addition, the metric for the calculation of the transport work should be the one that best fits and suits each ship segment. The limited geographic coverage of the EU MRV creates a bias in the data, as **EEOI values at EU level are considerably lower than those of the same ships at global level**.

Moving into phase three of the DCS, it will be necessary for the IMO to develop an indicator or a set of indicators that address the aforementioned issues. Only after developing an accurate energy efficiency measure can procedures and policies be developed in order to achieve meaningful reduction in shipping emissions.

