

- A voluntary monitoring tool to monitor CO₂ emissions and ship's operational performance efficiency
- To provide users on how to establish a mechanism to reduce emissions from ships during operations
- An efficiency indicator for all ships (new and existing) obtained from fuel consumption, voyage (miles) and cargo data (tonnes)
- No baseline and no compliance required yet
- A Representative value for the energy efficiency of the ship's operation over a consistent period
- The EEOI is similar to the EEDI in that it is a calculation that presents the ratio of carbon emissions emitted over the useful work done (capacity transported).
- The units are presented in grams of CO₂ per capacity-mile. However, this time the equation is influenced by operational variables rather than design features of the ship.
- Due to the great diversity in ship design, operational patterns, cargo contracts, changing sailing environments (weather conditions), as well as possible changes in the type of trade, the EEOI varies greatly between ships, and even for the same ships.
- To use the rolling average a suitable time period needs to be selected for evaluation; e.g. one year (closest to the end of a voyage), number of voyages, etc.

The basic expression for the EEOI formula for a voyage is given as:

$$EEOI = \frac{\sum_j FC_j \cdot C_{Fj}}{m_{cargo} \cdot D}$$

$$\therefore EEOI = \frac{Fuel\ Type \times C_F}{Cargo\ Mass \times Distance}$$

- j is the types of fuel consumed
- i is the voyage number
- FC_{ij} is the mass of consumed fuel j at voyage i
- C_{Fj} is the fuel mass to CO₂ mass conversion factor for fuel j
- m_{cargo} is the cargo carried in tones or work done in tones or gross tones

- D_i is the distance measure in nautical miles for the cargo carried or work done

Parameters

- Real Fuel Consumption
- Distance Sailed
- Cargo Mass carried or Work Done
- Types of Voyage Operations
- Measured and calculated on daily basis

Type of Fuel	Reference	Carbon Content(by mass)	$C_F \left(\frac{t_{CO_2}}{t_{Fuel}} \right)$
Diesel/Gas Oil	ISO 8217 Grades DMX through DMC	0.875	3.206000
Light Fuel Oil (LFO)	ISO 8217 Grades RMA through RMD	0.86	3.151040
Heavy Fuel Oil (HFO)	ISO 8217 Grades RME through RMK	0.85	3.114400
Liquefied Petroleum Gas	Propane	0.819	3.000000
	Butane	0.827	3.0.0000
Liquefied Natural Gas		0.75	2.750000

Establishing an EEOI

- Define the period for which EEOI is calculated
- Define data sources for data collection
- Collect data
- Convert data to the appropriate format
- Calculate EEOI

Analysis on EEOI values

High EEOI values

- High HFO consumption and the low transport work: low energy efficiency in return trip
- LNG cargo during return trip has been very much unloaded in the delivery trip.

Low EEOI values

- High LNG consumption, Low HFO consumption in deliver trip
- High transport work, Cleaner fuel consumed
- High speed travelled by the vessel results in high duty load
- High demand of fuel and thus high emissions

Method of Calculations for EEOI

1. *Transport Work = Mass of cargo carried x Distance Sailed*

= *tonnes x Nautical miles*

= *t.Nm*

2. CO_2 emitted by HFO = Mass of HFO consumed x Conversion Factor

= Mass of HFO x 3.1144

= tonnes

CO_2 emitted by MDO = Mass of HFO consumed x Conversion Factor

= Mass of MDO x 3.206

= tonnes

CO_2 emitted by LNG = Mass of LNG consumed x Conversion Factor

= Mass of LNG x 2.75

= tonnes

$$3. \quad EEOI = \frac{\text{Total CO}_2 \text{ emitted}}{\text{Transport Work}}$$

$$= \frac{\text{CO}_2 \text{ emitted by HFO} + \text{CO}_2 \text{ emitted by LNG} + \text{CO}_2 \text{ emitted by MDO}}{\text{Mass of cargo carried} \times \text{Distance Sailed}}$$

$$\therefore EEOI = \frac{\text{tonnes.CO}_2}{\text{tonnes.Nautical Miles}}$$

$$\text{Average } EEOI = \frac{\sum_i \sum_j (FC_{ij} \times C_{Fj})}{\sum_i (m_{\text{cargo},i} \times D_i)}$$

i is the voyage number

The calculate the EEOI the following steps must be followed:

- Define the time period for the rolling average calculation
- Define the data sources for data collection (e.g. bridge and engine log books, bunker delivery note)
- Collect data
- Convert the data to the required format
- Calculate the EEOI