EEDI

MAN Energy Solutions
Future in the making

Energy Efficiency Design Index

Future in the making

We are seeing unprecedented climate change threaten our vital, yet fragile ecosystems. The knock-on effects of rising temperatures caused by greenhouse gas emissions such as carbon dioxide (CO_2) could have disastrous effects on global agriculture and trade. That's why it has never been more important to limit the cause and effects for future generations.

Shipping makes a difference

Maritime transport will continue to expand with increasing globalization, and although shipping is already considered to be the most efficient form of bulk transportation, the industry has recognized that more can be done. Optimized engines and improved designs lay the foundations for positive change. Working with key stakeholders, the International Maritime Organization (IMO) has outlined new standards for greater efficiency throughout all stages of a ship's lifecycle. One such measure, the Energy Efficiency Design Index (EEDI), is a perfect example of this ambitious goal.

It pays to get on board

With the international shipping industry so committed to ensuring positive change, it will be crucial for individual ship owners and operators to move with the tide. Market-based measures such as levies or emissions trading are foreseeable in the future, and this will only create further incentives to invest in efficient ships. Though final decisions have not yet been made in this respect, the IMO is certainly considering the possibility. So now is the time to act.

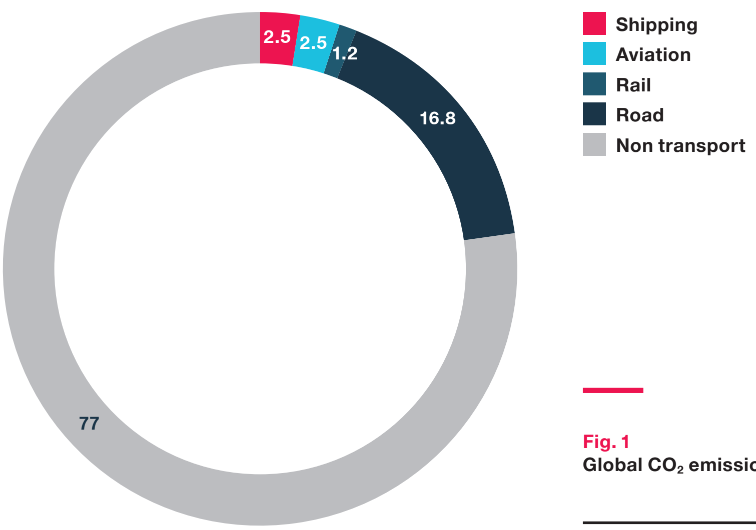


Fig. 1
Global CO_2 emissions in %

IMO regulations

What is the Energy Efficiency Design Index?

The EEDI is used to calculate a vessel's energy efficiency. This is based on a complex formula, taking the ship's emissions, capacity, and speed into account. The lower a ship's EEDI, the more energy-efficient it is and the lower its negative impact on the environment. IMO regulations stipulate that ships must meet a minimum energy efficiency requirement, so their EEDI must not exceed a given threshold.

No EEDI for:

- Gas turbine
- Diesel-electric drive*
- Offshore

* Except for cruise passenger ships and LNG carriers

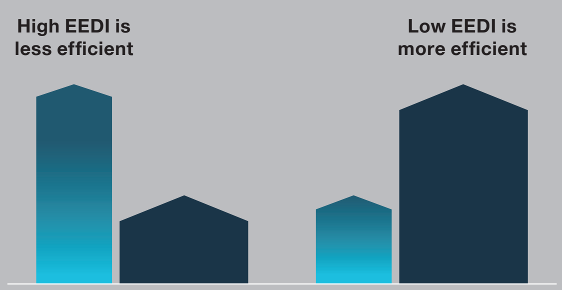
Targeted requirements

At present, the EEDI only applies to the worst offenders when it comes to maritime pollution. In other words, the vessels responsible for the most emissions. Ships commissioned after January 1, 2013 and weighing 400 GT or more have to meet the requirements. Older vessels are only affected by the EEDI standards if they have undergone a major retrofit in recent years.

That said, ship owners and operators would be wise to consider that EEDI requirements will gradually be tightened: ships built in 2015, 2020 and 2022 – 2025 will have to meet even higher standards.

Extension of regulated ship types

Although there were a lot of exemptions in the beginning, the number of ship types to which the EEDI does apply is steadily increasing. According to the latest updates, RoRo, RoPax, cruise ships with diesel-electric propulsion and LNG carriers with diesel-mechanic or diesel-electric propulsion have to meet the limits of the required EEDI. However, based on the results observed in the first phase of the initiative, the IMO intends to expand the EEDI to include additional types of ships in the future. Here too, it will be invaluable for ship operators to keep abreast of the changes.



$$\text{EEDI} = \frac{CO_2\ \text{Emissions}}{\text{Benefit Cargo}} = \frac{\sum P \times Cf \times SFC}{\text{Capacity} \times \text{Speed}}$$

EEDI
Efficiency

Fig. 2
High and low EEDI

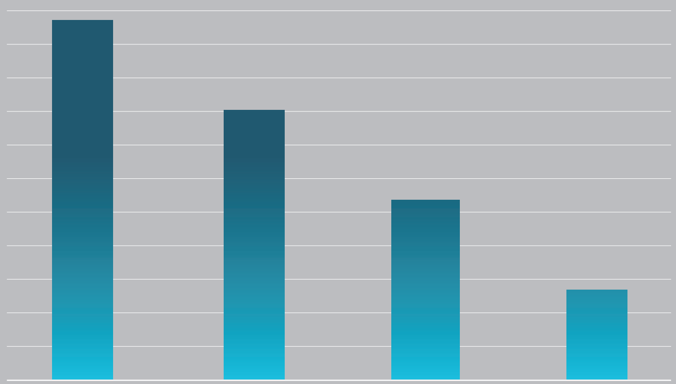


Fig. 3
New ships over 400 GT (keel-laying after July 2013)

EEDI
EEDI is valid for ships over 400 GT

EEDI spells efficiency

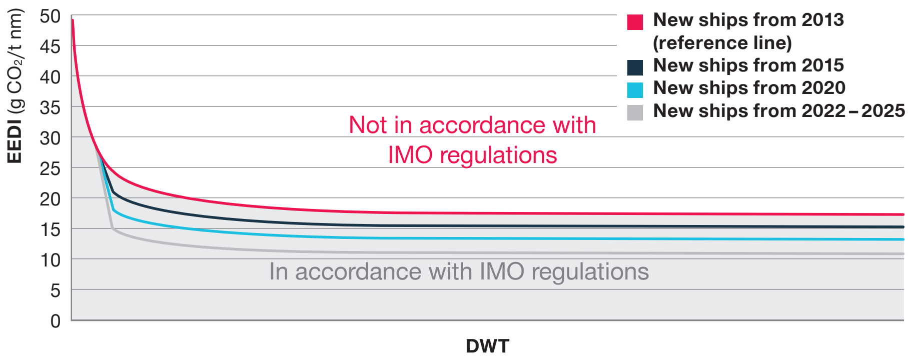


Fig. 4
Required EEDI

Required EEDI

The required EEDI is the limit for the attained EEDI of a ship and depends on its type and size. Starting with a reference line value in 2013, the limit will be reduced successively in three stages from 2022 to 2025. The reference line for the required EEDI is a function of the EEDI for vessels built after the year 2000.

Relevant energy consumption

The EEDI assesses the energy consumption of a vessel under normal seafaring conditions, taking into account the energy required for propulsion and the hotel load for the crew. Energy consumed to maintain the cargo and for maneuvering or ballasting is not considered.

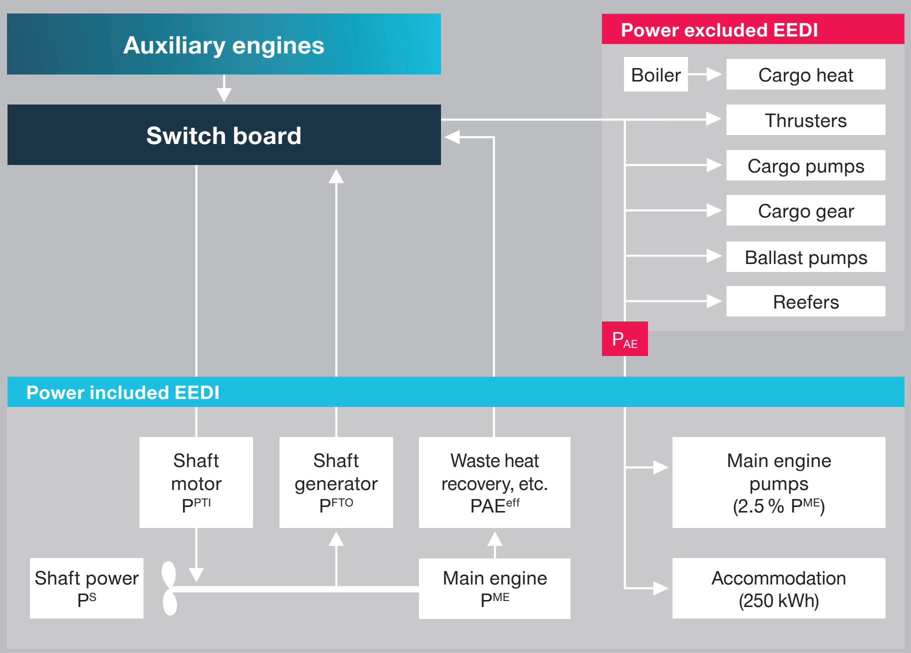
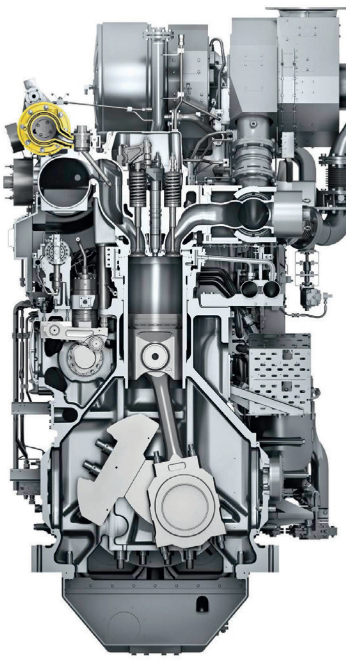


Fig. 5
Flow of energy considered by EEDI

Meeting the EEDI requirements

Optimized engines, components, and engine systems



Only ships fitted with state-of-the-art technology will stand a chance of complying with the EEDI. This is where MAN Energy Solutions steps in as a competent industry partner. Our comprehensive range of solutions – including engines, turbochargers and propellers – reflects the high standards that have made us a market leader across the seven seas.

Fig. 6
Due to reduced carbon factors, the use of LNG by the new MAN 35 /44DF results in approx. 14 % lower EEDI

Banking on efficiency

Burning liquefied natural gas (LNG) produces less CO_2 than other conventional sources, making it a powerful alternative for achieving a significantly reduced EEDI. MAN Energy Solutions has recently introduced a range of extremely efficient and versatile dual fuel engines, suitable for almost any type of shipping. With these engine models, ship owners benefit from attractive gas prices and full fuel flexibility.

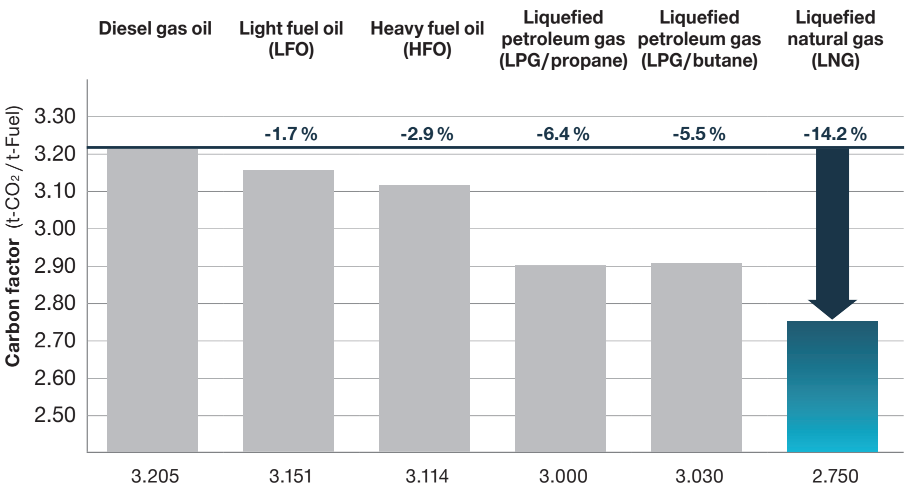


Fig. 7
Carbon factors (CF)

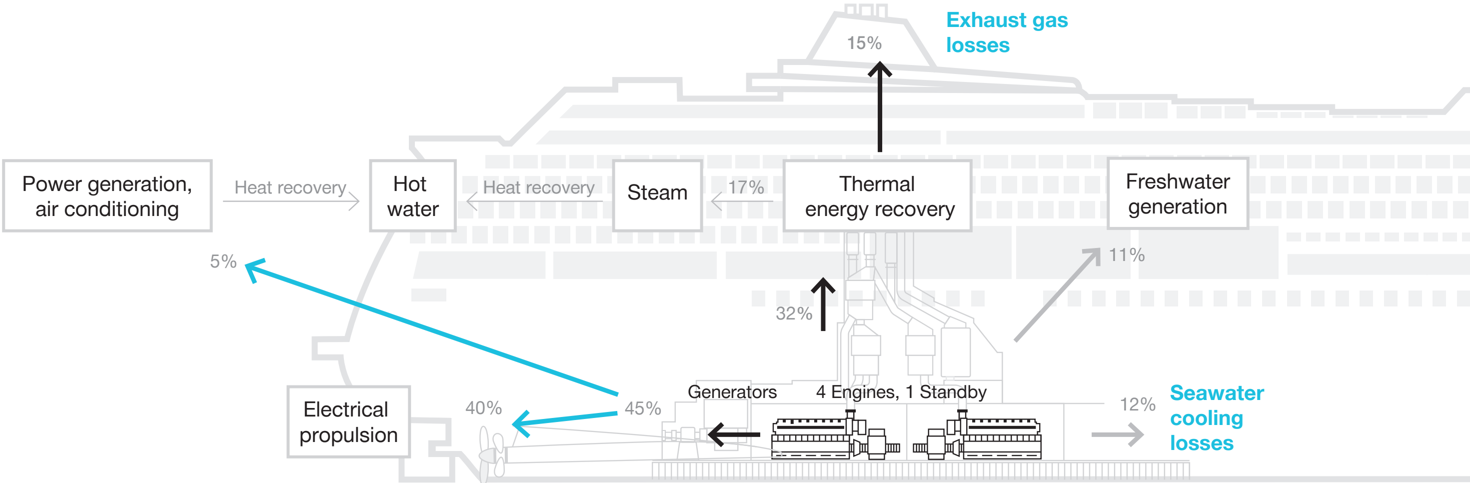


Fig. 8
Typical energy / heat balance of a cruise ship

Less input for greater output

Truly efficient engines have the capacity to derive more power from less fuel. At MAN Energy Solutions, we have channeled our expertise into adhering to a simple maxim: less is more. That's why we let nothing go to waste, not even the excess heat produced by the combustion process. With our engine systems, this heat is recovered, providing up to ten percent more power. It can easily be used to run a steam turbine or generator, or can flow into heating for accommodation and cargo.

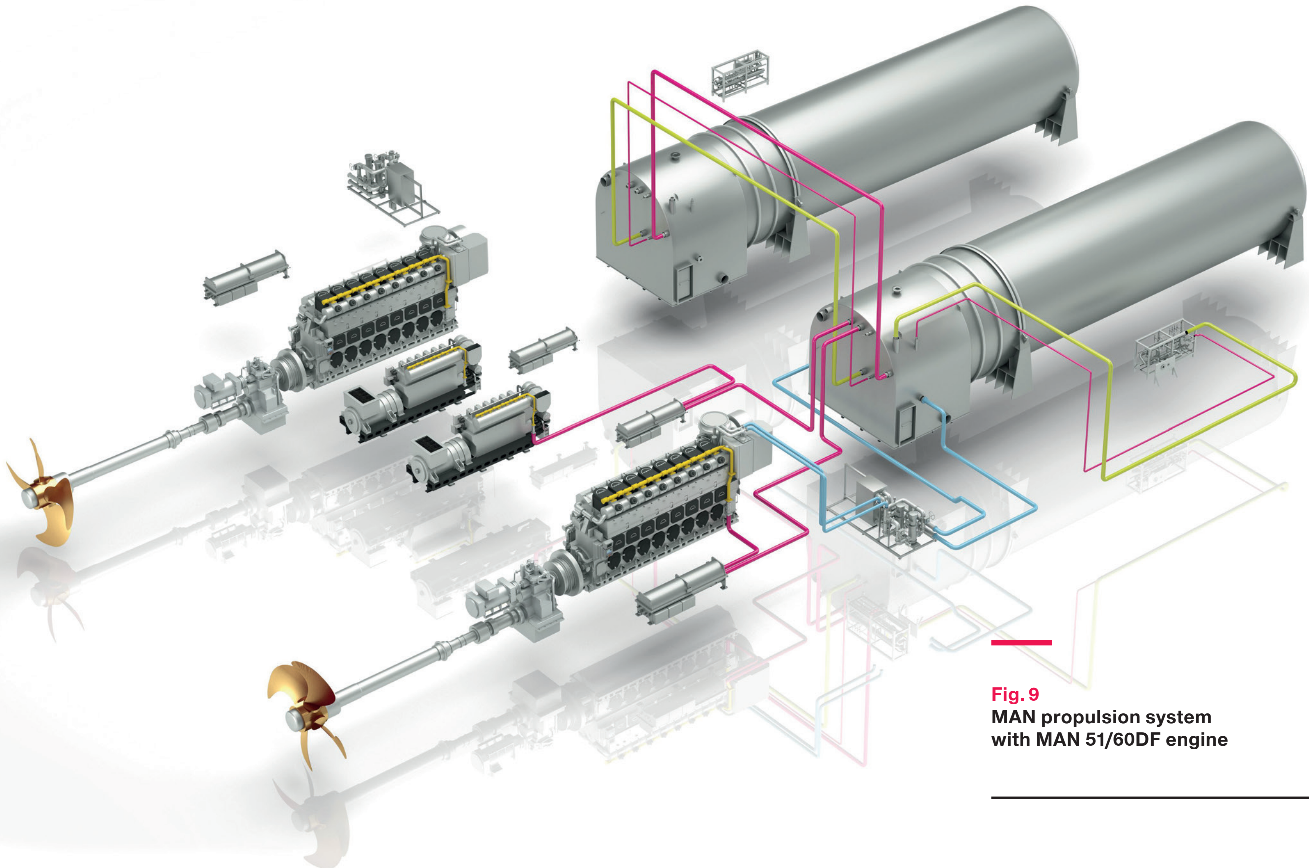


Fig. 9
MAN propulsion system with MAN 51/60DF engine

MAN Energy Solutions masters a vast number of disciplines in relation to the optimization of aft ship parameters and special installation requirements. The perfected layout and hydrodynamic propeller integration are always ship- and hull-optimized.

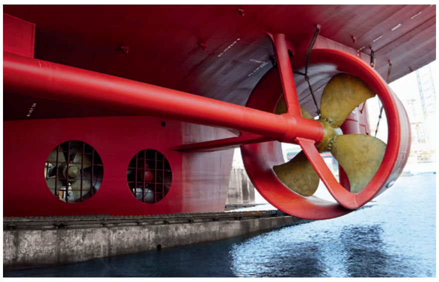
Efficiency-improving devices

MAN Alpha EcoBulbs

Efficiency improvements of up to 6 % (proven in model tests).

Customized Kappel propeller designs

Kappel propellers improve propulsion efficiency by up to 6 % while reducing power consumption, emissions and noise. This enable vessels to reduce EEDI/EEOI values and achieve higher ‘energy classes’. Kappel propellers are suitable for newbuilds and retrofits.



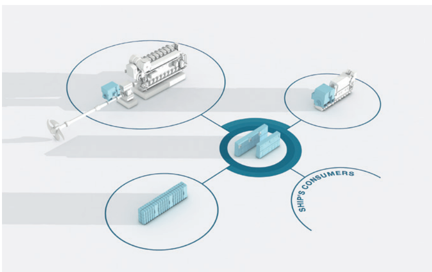
Alpha High Thrust (AHT) nozzles

AHT nozzles optimize the propeller thrust and pulling performance of heavy duty vessels. The individually customized designs increase bollard pull and limit free-sailing resistance.

Efficiency-improving technologies

EcoOptimizer for CCP systems

The EcoOptimizer combines the Alphatronic 3000 propulsion control system with individual main engine SFOC maps and MAN Alpha Controllable Pitch Propellers to enable fuel savings of up to 6 %.



MAN HyProp ECO and MAN HyProp Battery

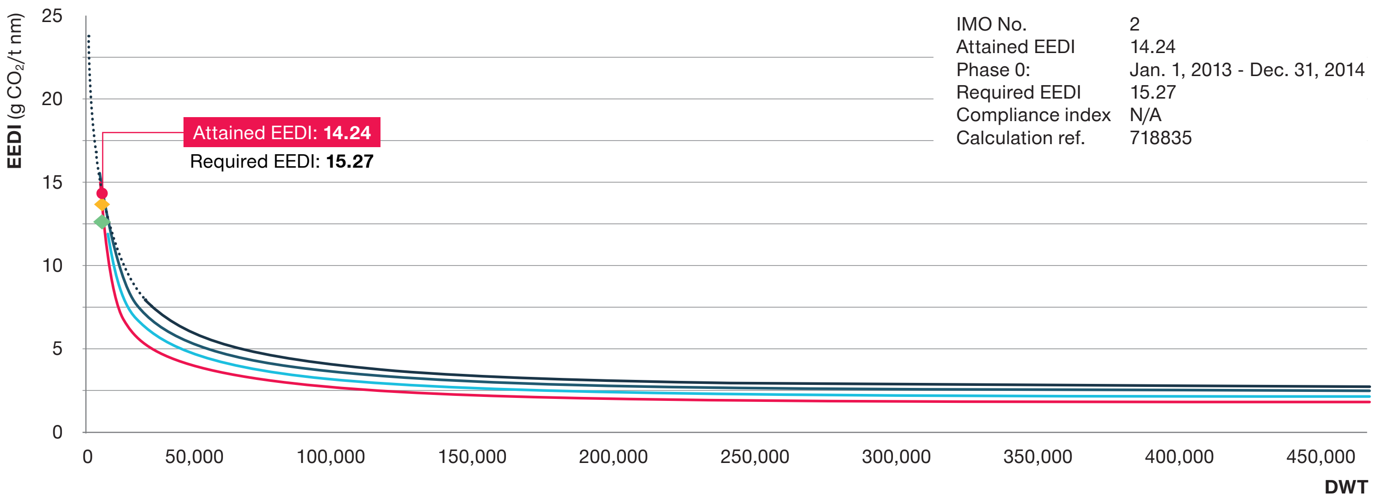
MAN HyProp ECO is a flexible hybrid propulsion system for controlling the power delivered by or to the shaft machine in the most efficient way. It overcomes the constraint on constant speed propulsion machinery by utilizing variable speed drive (VSD) technology at the shaft generator/motor. MAN HyProp ECO can reduce fuel oil consumption by 10 – 15 %.

Efficiency in action

Attained versus required EEDI

Requirement tanker (2008)

- **DWT design draft**
  7,900 t
- **Main engine**
  3,360 kW (MAN 6L32/44CR)
- **Auxiliary engine**
  1 x 1,290 kW (MAN 6L21/31)
- **Generator efficiency**
  93 %
- **Speed**
  13.3 knots
- **Fuels**
  Diesel/gas oil, ISO 8217, DMC – DMX



- New ships from 1/1/2013
- New ships from 1/1/2015
- New ships from 1/1/2020
- New ships from 1/1/2025
- Reference line

Sensitivity

- **Attained EEDI: 14.24**
- **Attained EEDI: 13.84**
  (with engine MAN 9L27/38; 3,060 kW and 185 g/kWh SFC*)
- **Attained EEDI: 12.64**
  (using MAN 6L35/44DF)

* 85 % MCR

Fig. 10
Requirement tanker

Assumptions and considerations:

All variations are only achieved by changing the main engine characteristics.

EEDI – an overview

Formula and definitions

Main engine emissions | Auxiliary engine emissions | Shaft generator / motor emissions | Efficiency technologies

$$\frac{\left(\prod_{j=1}^{M} f_j\right)\left(\sum_{i=1}^{nME} P_{ME(i)} \cdot SFC_{ME(i)} \cdot C_{FME(i)}\right) + \left(P_{AE} \cdot C_{FAE} \cdot SFC_{AE}{}^{*}\right) + \left(\left(\prod_{j=1}^{M} f_j \cdot \sum_{i=1}^{nPTI} P_{PTI(i)} - \sum_{i=1}^{neff} f_{eff(i)} \cdot P_{AEff(i)}\right) C_{FAE} \cdot SFC_{AE}\right) - \left(\sum_{i=1}^{neff} f_{eff(i)} \cdot P_{eff(i)} \cdot C_{FME} \cdot SFC_{ME}\right)}{f_i \cdot f_c \cdot f_l \cdot \text{Capacity} \cdot V_{ref} \cdot f_w}$$

Transport work

Engine power (P)

Individual engine power depending on application (e.g. P_{ME} = 75 % maximum continuous rating for diesel-mechanic propulsion)

- $P_{eff(i)}$ Main engine power reduction due to individual technologies for mechanical energy efficiency
- $P_{AEff(i)}$ Auxiliary engine power reduction due to individual technologies for electrical energy efficiency
- $P_{PTI(i)}$ 75 % of rated power consumption of shaft motor
- P_{AE} Combined installed power of auxiliary engines
- $P_{ME(i)}$ Individual power of main engines

CO_2 emissions (C)

CO_2 emission factor based on type of fuel used by given engine

- C_{FME} Main engine composite fuel factor
- C_{FAE} Auxiliary engine fuel factor
- $C_{FME(i)}$ Main engine individual fuel factors

Ship design parameters

- V_{ref} Ship speed at reference conditions (see P^{ME} defintion, etc.)
- *Capacity* Deadweight tonnage (DWT) rating for bulk ships and tankers; a percentage of DWT for container ships; DWT indicates how much can be loaded onto a ship; gross tonnage for passenger ships (cruise)

Specific fuel consumption (SFC)

Fuel use per unit of engine power

- SFC_{ME} Main engine (composite)
- SFC_{AE} Auxiliary engine
- $SFC_{AE}{}^{*}$ Auxiliary engine (adjusted for shaft generators)
- $SFC_{ME(i)}$ Main engine (individual)

Correction and adjustment factors (F)

Non-dimensional factors that were added to the EEDI equation to account for specific existing or anticipated conditions that would otherwise skew the ratings of individual ships

- $f_{eff(i)}$ Availability factor of individual energy efficiency technologies (=1.0 if readily available)
- f_j Correction factor for ship-specific design elements, e.g. ice-classed ships which require extra weight for thicker hulls
- f_w Coefficient indicating the decrease in ship speed due to weather and environmental conditions
- f_i Capacity adjustment factor for any technical/regulatory limitation on capacity (=1.0 if none)
- f_c Cubic capacity correction factor (for chemical tankers, LNG carriers and RoPax)
- f_l Correction factor to compensate deadweight losses through cargo-related equipment like cranes, RoRo ramps, etc.

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