Module 2:
Ship Energy Efficiency Regulations and Related Guidelines

IMO Train the Trainer Course
Energy Efficient Ship Operation

Name of the Presenter
Affiliation of the presenter, City, Country

Venue, City, Country
Day xx to Day yy, Month, Year
Content

- IMO regulatory framework for ship energy efficiency.
- Chapter 4 of MARPOL Annex VI regulations
- Guidelines for calculation of Attained EEDI
- Guidelines for verification of Attained EEDI
- Guidelines for development of SEEMP
- Guidelines for calculation of EEOI
IMO energy efficiency regulatory activities

IMO Energy Efficiency Regulatory Developments

Resolution 8 “CO2 emissions From ships”
Resolution A.963 (23) “IMO policies and practices related to reduction of GHG emissions from ships”

- MEPC 40 (Sep 1997)
- MEPC 53 (Dec 2003)
- MEPC 57 (Jun 2005)
- MEPC 58 (Mar 2008)
- MEPC 59 (June 2008)
- MEPC 60 (Feb 2009)
- MEPC 61 (Jul 2009)
- MEPC 62 (Jun 2010)
- MEPC 63 (July 2011)
- MEPC 64 (Feb 2012)
- MEPC 65 (Oct 2012)
- MEPC 66 (May 2013)
- MEPC 67 (Mar 2014)
- MEPC 68 (Oct 2014)

- Resolution MEPC 203(62) Marpol VI Amendments
- Resolution MEPC 251(66) Marpol VI Amendments
- Resolution MEPC 212(63) EEDI Calculation
- Resolution MEPC 213(63) SEEMP
- Resolution MEPC 214(63) EEDI Verification
- Resolution MEPC 245(66): EEDI Calculation Guidelines
- Resolution MEPC 231(65) Reference Lines
- Resolution MEPC 232(65) Minimum power
- Resolution MEPC 233(65) Reference lines for cruisships
- MEPC.1/Circ.815 Innovative EE Technologies
- MEPC.1/Circ.816 Consolidated on EEDI verification
- Debate on Data collection
- 3rd GHG Study 2014
IMO framework for GHG emissions control from ships

- EEDI and SEEMP: Mandatory from 2013
- EEOI: Voluntary
- Data collection: Under discussion
- MBMs: Discussion currently suspended
EEDI, EEOI and SEEMP links

Source: IMO presentation on Technical measures
EEDI, EEOI and SEEMP processes
PART 1 – MARPOL Annex VI Regulations on Energy Efficiency for Ships

- Amendments to existing Annex VI regulations
- Chapter 4 regulation
Amendments to Existing Annex VI Regulations
Res.MEPC.203(62) vs Res.MEPC.176(58)

- Regs with RED has changed as a result of Chapter 4

<table>
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<th>Resolutions MEPC.203(62) &amp; MEPC251 (66), …..</th>
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<td>Reg. 11 Detection of Violations and Enforcements</td>
</tr>
</tbody>
</table>
"New ship" means a ship:

1. for which the building contract is placed on or after 1 January 2013; or

2. in the absence of a building contract, the keel of which is laid or which is at a similar stage of construction on or after 1 July 2013; or

3. the delivery of which is on or after 1 July 2015.

In the UI (Unified Interpretation), MEPC.1/Circ.795.rev2, the above is further clarified for other phases of EEDI implementation.
"Major Conversion" means in relation to chapter 4 a conversion of a ship:

- which substantially alters the dimensions, carrying capacity or engine power of the ship; or
- which changes the type of the ship; or
- the intent of which in the opinion of the Administration is substantially to prolong the life of the ship; or
- which otherwise so alters the ship that, if it were a new ship, it would become subject to relevant provisions …Convention not applicable to it as an existing ship; or
- which substantially alters the energy efficiency of the ship and includes any modifications that could cause the ship to exceed the applicable Required EEDI as set out in Regulation 21.

In the UI (Unified Interpretation), MEPC.1/Circ.795.rev2, the term “major conversion” is further clarified.
Ship types definitions (part of Regulation 2)

For Chapter 4, **ship types** are defined under these Regulations:

- **2.25** Bulk carrier
- **2.26** Gas carrier (none LNG carriers)
- **2.27** Tanker
- **2.28** Container ship
- **2.29** General cargo ship
- **2.30** Refrigerated cargo ship
- **2.31** Combination carrier
- **2.32** Passenger ship
- **2.33** Ro-Ro cargo ships (vehicle carrier)
- **2.34** Ro-Ro cargo ships
- **2.35** Ro-Ro Passenger ship
- **2.38** LNG carrier
- **2.39** Cruise passenger ships

A number of other clarifications are made under Regulations 2 (ice breaking cargo ship, conventional and non-conventional propulsions ..)
Surveys and certification (Reg. 5.4)

- Ships of chapter 4 shall also be subject to the surveys as below:
  - An initial survey before a new ship is put in service …
  - A general or partial survey, after a major conversion of a ship … to ensure that the attained EEDI is recalculated as necessary……
  - For major conversions regarded as a newly constructed ship, the Administration shall decide the necessity of an initial survey …
  - For existing ships, the verification of having a SEEMP on board … shall take place at the first intermediate or renewal survey whichever is the first, on or after 1 January 2013."

- Survey and verification for EEDI shall be according to IMO’s “EEDI survey and verification Guidelines”.
An IEE Certificate … issued to any ship of 400 gross tonnage and above before that ship **may engage in voyages to ports or offshore terminals under the jurisdiction of other Parties**.

The certificate shall be issued or endorsed either by the Administration or any organization duly authorized by it.
No IAPP (International Air Pollution Prevention) Certificate or IEE Certificate shall be issued to a ship which is entitled to fly the flag of a State which is not a Party (Reg. 7).

The IEE Certificate shall be drawn up in a form corresponding to the model given in appendix VIII to this Annex (Reg. 8).
The IEEC shall be valid throughout the life of the ship subject to the provisions of paragraph 11 below.

11 An IEEC issued under this Annex shall cease to be valid in any of the following cases:

- If the ship is withdrawn from service or
- If a new certificate is issued following major conversion of the ship; or
- Upon transfer of the ship to the flag of another State ….
Port State Control on operational requirements (Reg. 10)

In relation to chapter 4, any Port State inspection shall be limited to verifying, when appropriate, that there is a valid IEEC on board, in accordance with article 5 of the Convention.

Article 5 - Certificates and special rules on inspection of ships

1. Subject to …. a certificate issued under the authority of a Party to the Convention … shall be accepted by the other Parties …

2. …. Any such inspection shall be limited to verifying that there is on board a valid certificate, unless there are clear grounds for believing that …

3. ……..

4. With respect to the ship of non-Parties to the Convention, Parties shall apply the requirements of the present Convention as may be necessary to ensure that no more favourable treatment is given to such ships.
New Chapter 4 of MARPOL Annex VI Regulations
<table>
<thead>
<tr>
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</thead>
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<tr>
<td>Reg. 12 Ozone Depleting Substances</td>
<td>Reg. 12 Ozone Depleting Substances</td>
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<tr>
<td>Reg. 13 Nitrogen Oxides(NOx)</td>
<td>Reg. 13 Nitrogen Oxides(NOx)</td>
</tr>
<tr>
<td>Reg. 14 Sulphur Oxides(SOx) and Particular Matter</td>
<td>Reg. 14 Sulphur Oxides(SOx) and Particular Matter</td>
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<td>Reg. 15 Volatile Organic Compounds (VOCs)</td>
<td>Reg. 15 Volatile Organic Compounds(VOCs)</td>
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<td>Reg. 16 Shipboard Incineration</td>
<td>Reg. 16 Shipboard Incineration</td>
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<td>Reg. 17 Reception Facilities</td>
<td>Reg. 17 Reception Facilities</td>
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<td>Reg. 18 Fuel Oil Availability and Quality</td>
<td>Reg. 18 Fuel Oil Availability and Quality</td>
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<tr>
<td>Appendix I ~VI</td>
<td>Appendix I ~VI</td>
</tr>
</tbody>
</table>

Res.MEPC.203(62) vs Res.MEPC.176(58)
Regulation 19 - Application
Regulation 19 - Applications

- This chapter shall apply to all ships of **400 gross tonnage** and above.

- The provisions of this chapter **shall not apply** to:
  - Ships solely engaged in **voyages within waters** of Flag State.
  - However, each Party should ensure …that such ships are constructed and act in a manner consistent with chapter 4, so far as is reasonable and practicable.

- Regulations 20 and 21 shall not apply to ships which have **non-conventional propulsion**, except cruise passenger ships and LNG carriers having conventional or non-conventional propulsion, delivered on or after 1 September 2019.
Regulation 19 – Application (Waiver)

- ……. the Administration may waive the requirement for a ship … from complying with regulation 20 and regulation 21.

- The provision of the above shall not apply to ships with:
  - Contract date 1 January 2017.
  - Keel laying 1 July 2017
  - Delivery date of 1 July 2019.

- The above implies that waiver is only for 4 years.

- The Administration of a Party … which allows application of waiver … to a ship …. shall communicate this to the Organization for circulation to the Parties ……….
Regulation 20 – Attained EEDI
Regulation 20 – Attained EEDI

- The attained EEDI shall be calculated for:
  - each new ship;
  - each new ship which has undergone a major conversion; and
  - each new or existing ship which has undergone so extensive major conversion, that is regarded by the Administration as a newly constructed ship.

- The above are applicable to ships defined in Regulations 2.25 to 2.35, 2.38 and 2.39.

- The attained EEDI shall be specific to each ship .......... and be accompanied by the EEDI Technical File ....

- The attained EEDI shall be calculated taking into account guidelines developed by the Organization (Resolution MEPC.245(66))

- The attained EEDI shall be verified either by the Administration or by any organization duly authorized by it.
Regulation 21 – Required EEDI
Regulation 21.1 – Required EEDI

1 For each:
   - new ship;
   - new ship which has undergone a major conversion; and
   - each new or existing ship which has undergone so extensive major conversion, that is regarded by the Administration as a newly constructed ship

For ships defined in Regulation 2.25 to 2.31, 2.33 to 2.35 and 2.39:
   - Attained EEDI ≤ Required EEDI ; and
   - Required EEDI = (1-\(X/100\)) \times \text{reference line value}

Where
   - \(X\) is the reduction factor
   - Reference line value is estimated from EEDI Reference line.
# Regulation 21 – Required EEDI details
## Cut-off levels, phases and reduction rates

<table>
<thead>
<tr>
<th>Ship Type</th>
<th>Size</th>
<th>Phase 0 1 Jan 2013 – 31 Dec 2014</th>
<th>Phase 1 1 Jan 2015 – 31 Dec 2019</th>
<th>Phase 2 1 Jan 2020 – 31 Dec 2024</th>
<th>Phase 3 1 Jan 2025 and onwards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulk carrier</td>
<td>20,000 DWT and above</td>
<td>0</td>
<td>10</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>10,000 – 20,000 DWT</td>
<td>n/a</td>
<td>0-10*</td>
<td>0-20*</td>
<td>0-30*</td>
</tr>
<tr>
<td>Gas carrier</td>
<td>10,000 DWT and above</td>
<td>0</td>
<td>10</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>2,000 – 10,000 DWT</td>
<td>n/a</td>
<td>0-10*</td>
<td>0-20*</td>
<td>0-30*</td>
</tr>
<tr>
<td>Tanker</td>
<td>20,000 DWT and above</td>
<td>0</td>
<td>10</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>4,000 – 20,000 DWT</td>
<td>n/a</td>
<td>0-10*</td>
<td>0-20*</td>
<td>0-30*</td>
</tr>
<tr>
<td>Container ship</td>
<td>15,000 DWT and above</td>
<td>0</td>
<td>10</td>
<td>15</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>10,000 – 15,000 DWT</td>
<td>n/a</td>
<td>0-10*</td>
<td>0-20*</td>
<td>0-30*</td>
</tr>
<tr>
<td>General Cargo ships</td>
<td>15,000 DWT and above</td>
<td>0</td>
<td>10</td>
<td>15</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>3,000 – 15,000 DWT</td>
<td>n/a</td>
<td>0-10*</td>
<td>0-15*</td>
<td>0-30*</td>
</tr>
<tr>
<td>Refrigerated cargo carrier</td>
<td>5,000 DWT and above</td>
<td>0</td>
<td>10</td>
<td>15</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>3,000 – 5,000 DWT</td>
<td>n/a</td>
<td>0-10*</td>
<td>0-15*</td>
<td>0-30*</td>
</tr>
<tr>
<td>Combination carrier</td>
<td>20,000 DWT and above</td>
<td>0</td>
<td>10</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>4,000 – 20,000 DWT</td>
<td>n/a</td>
<td>0-10*</td>
<td>0-20*</td>
<td>0-30*</td>
</tr>
<tr>
<td>LNG carrier***</td>
<td>10,000 DWT and above</td>
<td>n/a</td>
<td>10**</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>Ro-ro cargo ship (vehicle carrier)***</td>
<td>10,000 DWT and above</td>
<td>n/a</td>
<td>5**</td>
<td>15</td>
<td>30</td>
</tr>
<tr>
<td>Ro-ro cargo ship***</td>
<td>2,000 DWT and above</td>
<td>n/a</td>
<td>5**</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>1,000 – 2,000 DWT</td>
<td>n/a</td>
<td>0-5*,**</td>
<td>0-20*</td>
<td>0-30*</td>
</tr>
<tr>
<td>Ro-ro passenger ship***</td>
<td>1000 DWT and above</td>
<td>n/a</td>
<td>5**</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>250 – 1,000 DWT</td>
<td>n/a</td>
<td>0-5*,**</td>
<td>0-20*</td>
<td>0-30*</td>
</tr>
<tr>
<td>Cruise passenger ship*** having non-conventional propulsion</td>
<td>85,000 GT and above</td>
<td>n/a</td>
<td>5**</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>25,000 – 85,000 GT</td>
<td>n/a</td>
<td>0-5*,**</td>
<td>0-20*</td>
<td>0-30*</td>
</tr>
</tbody>
</table>
Reference lines

- Reference lines are ship specific.
- Dependent on ship type and size.
- Calculated ship data from HIS Fairplay database:

\[
\text{Estimated Index Value} = \frac{190 \cdot \sum P_{\text{EID}} + 215 \cdot P_{\text{AE}}}{\text{Capacity} \cdot V_{Nf}^{i4}}
\]

For details of how reference lines are developed, see **Resolution MEPC.231(65): 2013 Guidelines for calculation of reference lines**……
### Regulation 21.3 – Reference line

Reference line = \( a^*b^{-c} \)

<table>
<thead>
<tr>
<th>Ship type defined in regulation 2</th>
<th>a</th>
<th>b</th>
<th>c</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.25 Bulk carrier</td>
<td>961.79</td>
<td>DWT of the ship</td>
<td>0.477</td>
</tr>
<tr>
<td>2.26 Gas carrier</td>
<td>1120.00</td>
<td>DWT of the ship</td>
<td>0.456</td>
</tr>
<tr>
<td>2.27 Tanker</td>
<td>1218.80</td>
<td>DWT of the ship</td>
<td>0.488</td>
</tr>
<tr>
<td>2.28 Container ship</td>
<td>174.22</td>
<td>DWT of the ship</td>
<td>0.201</td>
</tr>
<tr>
<td>2.29 General cargo ship</td>
<td>107.48</td>
<td>DWT of the ship</td>
<td>0.216</td>
</tr>
<tr>
<td>2.30 Refrigerated cargo carrier</td>
<td>227.01</td>
<td>DWT of the ship</td>
<td>0.244</td>
</tr>
<tr>
<td>2.31 Combination carrier</td>
<td>1219.00</td>
<td>DWT of the ship</td>
<td>0.488</td>
</tr>
<tr>
<td>2.33 Ro-ro cargo ship (vehicle carrier)</td>
<td>((\text{DWT/GT})^{0.7} \cdot 780.36)</td>
<td>DWT of the ship</td>
<td>0.471</td>
</tr>
<tr>
<td></td>
<td>1812.63</td>
<td>where (\text{DWT/GT} \leq 0.3)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>where (\text{DWT/GT} \geq 0.3)</td>
<td></td>
</tr>
<tr>
<td>2.34 Ro-ro cargo ship</td>
<td>1405.15</td>
<td>DWT of the ship</td>
<td>0.498</td>
</tr>
<tr>
<td>2.35 Ro-ro passenger ship</td>
<td>752.16</td>
<td>DWT of the ship</td>
<td>0.381</td>
</tr>
<tr>
<td>2.38 LNG carrier</td>
<td>2253.7</td>
<td>DWT of the ship</td>
<td>0.474</td>
</tr>
<tr>
<td>2.39 Cruise passenger ship</td>
<td>170.84</td>
<td>GT of the ship</td>
<td>0.214</td>
</tr>
<tr>
<td>having non-conventional propulsion</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Reg. 21 - Reduction factor and cut-off limits

• Reduction factor is the % reduction in Required EEDI relative to Reference Line.

• Cut off levels:
  • Bulk Carriers: 10,000 DWT
  • Gas carriers: 2,000 DWT
  • Tankers: 4,000 DWT
  • Container ship: 10,000 DWT
  • Gen./ref. Cargo: 3,000 DWT
At the **beginning of Phase 1** and **at the midpoint of Phase 2**, the Organization shall review the status of technological developments and, if proven necessary, amend the time periods, the EEDI reference line parameters for relevant ship types and reduction rates set out in this regulation.

<table>
<thead>
<tr>
<th>Ship Type</th>
<th>Size</th>
<th>Phase 0 1 Jan 2013 - 31 DEC 2014</th>
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<th>Phase 2 1 Jan 2020 - 31 DEC 2024</th>
<th>Phase 3 1 Jan 2025 onwards</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bulk Carrier</strong></td>
<td>20,000 DWT and above</td>
<td>0</td>
<td>10</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>10,000 ~ 20,000 DWT</td>
<td>n/a</td>
<td>0 ~ 10*</td>
<td>0 ~ 20*</td>
<td>0 ~ 30*</td>
</tr>
<tr>
<td><strong>Gas Tanker</strong></td>
<td>10,000 DWT and above</td>
<td>0</td>
<td>10</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>2,000 ~ 10,000 DWT</td>
<td>n/a</td>
<td>0 ~ 10*</td>
<td>0 ~ 20*</td>
<td>0 ~ 30*</td>
</tr>
<tr>
<td><strong>Tanker</strong></td>
<td>20,000 DWT and above</td>
<td>0</td>
<td>10</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>4,000 ~ 20,000 DWT</td>
<td>n/a</td>
<td>0 ~ 10*</td>
<td>0 ~ 20*</td>
<td>0 ~ 30*</td>
</tr>
<tr>
<td><strong>Container Ship</strong></td>
<td>15,000 DWT and above</td>
<td>0</td>
<td>10</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>10,000 ~ 15,000 DWT</td>
<td>n/a</td>
<td>0 ~ 10*</td>
<td>0 ~ 20*</td>
<td>0 ~ 30*</td>
</tr>
<tr>
<td><strong>General Cargo Ship</strong></td>
<td>15,000 DWT and above</td>
<td>0</td>
<td>10</td>
<td>15</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>3,000 ~ 15,000 DWT</td>
<td>n/a</td>
<td>0 ~ 10*</td>
<td>0 ~ 15*</td>
<td>0 ~ 30*</td>
</tr>
<tr>
<td><strong>Refrigerated Cargo Ship</strong></td>
<td>5,000 DWT and above</td>
<td>0</td>
<td>10</td>
<td>15</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>3,000 ~ 5,000 DWT</td>
<td>n/a</td>
<td>0 ~ 10*</td>
<td>0 ~ 15*</td>
<td>0 ~ 30*</td>
</tr>
<tr>
<td><strong>Combination Carrier</strong></td>
<td>20,000 DWT and above</td>
<td>0</td>
<td>10</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>4,000 ~ 20,000 DWT</td>
<td>n/a</td>
<td>0 ~ 10*</td>
<td>0 ~ 20*</td>
<td>0 ~ 30*</td>
</tr>
</tbody>
</table>
Technology review for EEDI Phase 2

- Corresponding Group was established at MEPC 67.

- Purpose: To review the status of technological developments relevant to implementing Phase 2 of EEDI regulation via:
  - Data collection and analysis
  - Use of information in IMO EEDI database (established at MEPC 66)
  - Publicly available and verifiable information from all stakeholders.

- Report on the following:
  - The range of technologies that may be used to comply with the EEDI Phase 2.
  - The current use of these technologies and the progress needed for EEDI Phase 2.

- Progress report to MEPC 68, interim report to MEPC 69.
Regulation 22 - SEEMP
Regulation 22

*Ship Energy Efficiency Management Plan (SEEMP)*

1. Each ship shall keep on board a ship specific Ship Energy Efficiency Management Plan (SEEMP). This may form part of the ship's Safety Management System (SMS).

2. The SEEMP shall be developed taking into account guidelines adopted by the Organization.
SEEMP and IEE Certificate

For existing ships, a Record of Construction needs to be filled and an IEE Certificate issued when the existence of SEEMP on-board is verified.

Supplement to the International Energy Efficiency Certificate (IEE Certificate)

RECORD OF CONSTRUCTION RELATING TO ENERGY EFFICIENCY

Notes:

1. This Record shall be permanently attached to the IEE Certificate. The IEE Certificate shall be available on board the ship at all times.

5. Ship Energy Efficiency Management Plan

5.1 The ship is provided with a Ship Energy Efficiency Management Plan (SEEMP) in compliance with regulation 22
Verification that a SEEMP is on-board

- The verification will be done as part of first intermediate or renewal survey, whichever is the first, after 1 January 2013.

.4 For existing ships, the verification of the requirement to have a SEEMP on board according to regulation 22 shall take place at the first intermediate or renewal survey identified in paragraph 1 of this regulation, whichever is the first, on or after 1 January 2013.
Regulation 23 - Promotion of technical cooperation and technology transfer
Regulation 23 - Promotion of technical co-operation and transfer of technology

- Administrations shall, in co-operation with the Organization and other international bodies, promote and provide, as appropriate, support directly or through the Organization to States, especially developing States, that request technical assistance.

- The Administration of a Party shall co-operate actively with other Parties, …, to promote the development and transfer of technology and exchange of information to States which request technical assistance, particularly developing States, for implementation of … the requirements of chapter 4 of this annex, in particular regulations 19.4 to 19.6.
The records of construction contains the following information:

- Particular of ship
- Propulsion system
- Attained EEDI
- Required EEDI
- SEEMP
- EEDI Technical File
- Endorsement that provided data are correct.
PART 2 – Guidelines on EEDI Calculation and Verification

• Guidelines for Attained EEDI calculation
• Guidelines for Attained EEDI verification
Guidelines on the Calculation of the Attained EEDI

Attained EEDI: Formula

- EEDI (gCO2/tonne.mile) =

\[
\prod_{j=1}^{n} f_j \left( \sum_{i=1}^{n_{ME}} P_{ME(i)} \cdot C_{FME(i)} \cdot SFC_{ME(i)} \right) + \left( \prod_{j=1}^{n} f_j \cdot \sum_{i=1}^{n_{PTI}} P_{PTI(i)} - \sum_{i=1}^{n_{eff}} f_{eff(i)} \cdot P_{AEeff(i)} \right) C_{FAE} \cdot SFC_{AE} - \sum_{i=1}^{n_{eff}} f_{eff(i)} \cdot P_{eff(i)} \cdot C_{FME} \cdot SFC_{ME} **
\]

- Not applicable to a ship having diesel-electric propulsion, turbine propulsion and hybrid propulsion except for:
  - Cruise passenger ships and
  - LNG carriers
Attained EEDI: Calculation formula

\[
EEDI = \left( \prod_{j=1}^{M} f_j \left( \sum_{i=1}^{nME} \frac{P_{ME(i)} \cdot C_{ME(i)} \cdot SFC_{ME(i)}}{M} \right) + \left( \prod_{j=1}^{M} f_j \left( \sum_{i=1}^{nPTT} P_{PTT(i)} - \sum_{i=1}^{nPTT} f_{eff(i)} \cdot P_{AE(i)} \right) C_{FAE} \cdot SFC_{AE} \right) - \left( \sum_{i=1}^{nPTT} f_{eff(i)} \cdot P_{eff(i)} \cdot C_{ME} \cdot SFC_{ME} \right) \right) \cdot f_c \cdot f_i \cdot \text{Capacity} \cdot V_{ref} \cdot f_w
\]

[\text{gCO2/(tonne.nm)}]

Boilers are excluded from EEDI
APPENDIX 1

A GENERIC AND SIMPLIFIED MARINE POWER PLANT

Note 1: Mechanical recovered waste energy directly coupled to shafts need not be measured, since the effect of the technology is directly reflected in the $V_{ref}$.  

Note 2: In case of combined PTI/PTO, the normal operational mode at sea will determine which of these to be used in the calculation.
Attained EEDI: Parameters

\[ \text{EEDI} = \left( \prod_{i=1}^{M} \sum_{j=1}^{n_{ME}} P_{ME(i)} C_{FME(i)} \cdot SFC_{ME(i)} \right) + \left( P_{AE} \cdot C_{FAE} \cdot SFC_{AE} * \right) + \left( \prod_{j=1}^{M} \sum_{i=1}^{n_{PT}} P_{PT(i)} - \sum_{i=1}^{neff} P_{AE\text{eff}(i)} \right) C_{FAE} \cdot SFC_{AE} - \left( \sum_{i=1}^{neff} P_{AE\text{eff}(i)} \cdot C_{FME} \cdot SFC_{ME} \right) \]

**Ship specific design factor**

**Shaft Motor**

**Waste Heat**

**Energy Saving**

**Main power:**
\[ P_{ME} = 0.75 \text{MCR} \]

**Capacity factor**

**Wave factor**

**Carbon factor**

**Auxiliary power:**
\[ P_{ME} \geq 10000\text{KW} : \]
\[ P_{AE} = 0.025Me + 250 \]
\[ P_{ME} < 10000\text{KW} : \]
\[ P_{AE} = 0.05Me \]

**Reference Speed**

**Capacity:**
- **DWT:** Bulk carriers, Containers, Tankers, Gas carriers, cargo ships, etc.
- **GTR:** Passenger Ship
EEDI condition

- EEDI is calculated for a single operating condition of the ship. This will be referred to as **EEDI Condition**.

- The EEDI Condition is as follows:
  - **Draft**: Summer load line draft.
  - **Capacity**: Deadweight (or gross tonnage for passenger ships) for the above draft (container ship will be 70% value).
  - **Weather condition**: Calm with no wind and no waves.
  - **Propulsion shaft power**: 75% of main engine MCR (conventional ships) with some amendments for shaft motor or shaft generator or shaft-limited power cases.
  - **Reference speed (Vref)**: is the ship speed under the above conditions.
Main Parameters
Capacity

- Deadweight for cargo ships:
  - 70% of deadweight for Containerships.

- Gross tonnage for passenger ships
Main (engine) power – $P_{ME}$ (options)

- Power for propulsion
  - $(P_{ME})$ main engine
    - $P_{ME} = 0.75 \times MCR_{ME}$
  - $(P_{PTO})$ Shaft generator
    - $P_{PTO}(\text{small})$
    - $P_{ME} = 0.75 \times (MCR_{ME} - P_{PTO})$
  - Main engine (big)
    - $P_{PTO}(\text{big})$
    - $P_{ME} = 0.75 \times MCR_{\text{Limited}}$
Main engine power (options)

- Power for propulsion – Electric ship type
  - \( P_{PTI} \) shaft motor
    \[
    \sum P_{PTI(i),shaft} = \sum (P_{PTI(i)} \cdot \eta_{PTI(i)}) \cdot \eta_{Gen}
    \]
    \( P_{PTI} = 0.75 \times P_{PTI} \)

- Measurement of \( V_{ref} \) (main engine + shaft motor)

\[
\sum P_{PTI(i),shaft} = \sum (P_{PTI(i)} \cdot \eta_{PTI(i)}) \cdot \eta_{Gen}
\]

\( P_{PTI} = 0.75 \times P_{PTI} \)

- Measurement of \( V_{ref} \) (main engine + shaft motor)

\[
\sum P_{PTI(i),shaft} = \sum (P_{PTI(i)} \cdot \eta_{PTI(i)}) \cdot \eta_{Gen}
\]

\( P_{PTI} = 0.75 \times P_{PTI} \)

\[
\sum P_{PTI(i),shaft} = \sum (P_{PTI(i)} \cdot \eta_{PTI(i)}) \cdot \eta_{Gen}
\]

\( P_{PTI} = 0.75 \times P_{PTI} \)

\[
\sum P_{PTI(i),shaft} = \sum (P_{PTI(i)} \cdot \eta_{PTI(i)}) \cdot \eta_{Gen}
\]

\( P_{PTI} = 0.75 \times P_{PTI} \)

\[
\sum P_{PTI(i),shaft} = \sum (P_{PTI(i)} \cdot \eta_{PTI(i)}) \cdot \eta_{Gen}
\]

\( P_{PTI} = 0.75 \times P_{PTI} \)

\[
\sum P_{PTI(i),shaft} = \sum (P_{PTI(i)} \cdot \eta_{PTI(i)}) \cdot \eta_{Gen}
\]

\( P_{PTI} = 0.75 \times P_{PTI} \)
Reference speed - $V_{\text{ref}}$

- Measured under **EEDI Condition** using the $P_{\text{ME}}$ as propulsion shaft power.
**Auxiliary (engine) power - $P_{AE}$**

- $P_{AE}$ is the required auxiliary engine power to supply normal maximum sea load ship’s (excluding cargo) requirements.

- $P_{AE}$ is calculated as follows:

  \[ P_{AE(MCR\geq10000kW)} = 0.025 \times \left( \sum_{i=1}^{n_{ME}} MCR_{MEi} + \frac{\sum P_{PTI(i)}}{0.75} \right) + 250 \]

  \[ P_{AE(MCR\lt10000kW)} = 0.05 \times \left( \sum_{i=1}^{n_{ME}} MCR_{MEi} + \frac{\sum P_{PTI(i)}}{0.75} \right) \]

- $P_{AE}$ calculations has specific rules for LNG carriers where re-liquefaction plant involved.

- For cases where calculated $P_{AE}$ is significantly different from actual $P_{AE}$, the ship Electric Power Tables should be used to estimate $P_{AE}$. 
For engines certified to the E2 or E3 test cycles of the NOx Technical Code 2008, the engine $SFC_{ME(i)}$ is … at 75 per cent of MCR power.

For engines certified to the D2 or C1 test cycles of the NOx Technical Code 2008, the engine $SFC_{AE(i)}$ is … at 50 per cent of MCR power.

There are more details on SFC for cases:

- When there is no certified value (manufacturer value …)
- For pure gas or dual fuel engines (conversion to standard 48000 MJ/kg base).
- For LNG ships with steam turbines
- $C_F$ and SFC shall be compatible
Factors and Correction Factors
Factors in EEDI formula

- $C_F$ is the carbon factor to take into account the type of fuel
- $f_w$: Weather factor indicating the decrease of speed due to representative sea conditions of wave height, wave frequency and wind speed (e.g., Beaufort Scale 6).
- $f_{\text{eff}(i)}$ is the availability factor of each innovative energy efficiency technology.
- **Correction factors**: There are a number of correction factors including $f_i$, $f_i$, $f_c$, etc.
**C_F (carbon factor) [Clause2.1]**

- **C_F**: Conversion factor between fuel consumption and CO2 emission.
- **C_F** corresponds to the fuel used when determining **SFC** listed in the NOx Technical File (part of EIAPP certificate).

<table>
<thead>
<tr>
<th>Type of fuel</th>
<th>Reference</th>
<th>Carbon content</th>
<th>C_F (t-CO2/t-Fuel)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Diesel/Gas Oil</td>
<td>ISO 8217 Grades DMX through DMB</td>
<td>0.8744</td>
<td>3.206</td>
</tr>
<tr>
<td>2 Light Fuel Oil (LFO)</td>
<td>ISO 8217 Grades RMA through RMD</td>
<td>0.8594</td>
<td>3.151</td>
</tr>
<tr>
<td>3 Heavy Fuel Oil (HFO)</td>
<td>ISO 8217 Grades RME through RMK</td>
<td>0.8493</td>
<td>3.114</td>
</tr>
<tr>
<td>4 Liquefied Petroleum Gas (LPG)</td>
<td>Propane</td>
<td>0.8182</td>
<td>3.000</td>
</tr>
<tr>
<td></td>
<td>Butane</td>
<td>0.8264</td>
<td>3.030</td>
</tr>
<tr>
<td>5 Liquefied Natural Gas (LNG)</td>
<td></td>
<td>0.7500</td>
<td>2.750</td>
</tr>
<tr>
<td>6 Methanol</td>
<td></td>
<td>0.3750</td>
<td>1.375</td>
</tr>
<tr>
<td>7 Ethanol</td>
<td></td>
<td>0.5217</td>
<td>1.913</td>
</tr>
</tbody>
</table>
Availability factor $f_{eff(i)}$ 

- $f_{eff(i)}$ is the availability factor of each innovative energy efficiency technology.
- Guidelines for estimation of availability factor for wind power, solar power, etc. has been developed in the relevant Guidelines.
- Currently availability factor of 1.0 is used for waste heat recovery.
Correction factors

- **Power correction factor** ($f_j$)
  - Ice-classed ships ($f_j$)
  - Shuttle tankers with propulsion redundancy (80,000~160,000 DWT) ($f_j$)
  - Ro-Ro ships, all types ($f_{jRoRo}$)
  - General cargo ships

- **Capacity factor** ($f_i$)
  - Ice-classed ships ($f_i$)
  - Ship specific voluntary structural enhancement ($f_{iVSE}$)
  - Bulk carriers and oil tankers, built in accordance with Common Structural Rules ($f_{iCSR}$)

- **Cubic capacity correction factor** ($f_c$)
  - Chemical tanker’s ($f_c$)
  - Gas carriers having direct diesel driven propulsion system ($f_{cLNG}$)
**f_j design correction factor for propulsion power**

- **f_j for ice-class ships**: the greater value of \( f_{j0} \) and \( f_{j,min} \):

  \[
  f_{j} = \begin{cases} 
  0.77 & \text{for shuttle tankers of with propulsion redundancy between 80,000 and 160,000 deadweight.} \\
  f_{jRoRO} & \text{and } f_j \text{ for general cargo ship according to specific formulas} \\
  F_j = 1.0 & \text{for all other ships.}
  \end{cases}
  \]

<table>
<thead>
<tr>
<th>Ship type</th>
<th>( f_{j0} )</th>
<th>( f_{j,min} ) depending on the ice class</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>IA Super</td>
</tr>
</tbody>
</table>
| **Tanker**               | \[
  \frac{0.308L_{pp}^{1.920}}{\sum_{i=1}^{nME}P_{ME(i)}}
  \]                                      | 0.15\(L_{pp}^{0.30}\) | 0.27\(L_{pp}^{0.21}\) | 0.45\(L_{pp}^{0.13}\) | 0.70\(L_{pp}^{0.06}\) |
| **Bulk carrier**         | \[
  \frac{0.639L_{pp}^{1.754}}{\sum_{i=1}^{nME}P_{ME(i)}}
  \]                                      | 0.47\(L_{pp}^{0.09}\) | 0.58\(L_{pp}^{0.07}\) | 0.73\(L_{pp}^{0.04}\) | 0.87\(L_{pp}^{0.02}\) |
| **General cargo ship**   | \[
  \frac{0.0227 \cdot L_{pp}^{2.483}}{\sum_{i=1}^{nME}P_{ME(i)}}
  \]                                      | 0.31\(L_{pp}^{0.16}\) | 0.43\(L_{pp}^{0.12}\) | 0.56\(L_{pp}^{0.09}\) | 0.67\(L_{pp}^{0.07}\) |
**fi correction factor for ship capacity for technical/regulatory limitations (1)**

- **fi for ice-class ships:** the greater value of \( fi_0 \) and \( fi_{\text{max}} \):

- **\( fi_{\text{VSE}} \) for ship specific Voluntary Structural Enhancement:**

<table>
<thead>
<tr>
<th>Ship type</th>
<th>( fi_0 )</th>
<th>( f_{i,\text{max}} ) depending on the ice class</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>IA Super</td>
</tr>
<tr>
<td>Tanker</td>
<td>( \frac{0.00138 \cdot L_{pp}^{3.351}}{\text{capacity}} )</td>
<td>2.10( L_{pp}^{-0.11} )</td>
</tr>
<tr>
<td>Bulk carrier</td>
<td>( \frac{0.00403 \cdot L_{pp}^{3.123}}{\text{capacity}} )</td>
<td>2.10( L_{pp}^{-0.11} )</td>
</tr>
<tr>
<td>General cargo ship</td>
<td>( \frac{0.0377 \cdot L_{pp}^{2.625}}{\text{capacity}} )</td>
<td>2.18( L_{pp}^{-0.11} )</td>
</tr>
<tr>
<td>Container ship</td>
<td>( \frac{0.1033 \cdot L_{pp}^{2.329}}{\text{capacity}} )</td>
<td>2.10( L_{pp}^{-0.11} )</td>
</tr>
<tr>
<td>Gas carrier</td>
<td>( \frac{0.0474 \cdot L_{pp}^{2.590}}{\text{capacity}} )</td>
<td>1.25</td>
</tr>
</tbody>
</table>

\[
fi_{\text{VSE}} = \frac{DWT_{\text{reference design}}}{DWT_{\text{enhanced design}}}
\]

Where:

\[
DWT_{\text{reference design}} = \Delta_{\text{ship}} - \text{lightweight}_{\text{reference design}}
\]

\[
DWT_{\text{enhanced design}} = \Delta_{\text{ship}} - \text{lightweight}_{\text{enhanced design}}
\]
fi correction factor for ship capacity for technical/regulatory limitations (2)

- for bulk carriers and oil tankers, built in accordance with Common Structural Rules (CSR)

\[ f_{CSR} = 1 + (0.08 \cdot \frac{LWT_{CSR}}{DWT_{CSR}}) \]

Where, \( DWT_{CSR} \) is the deadweight determined by paragraph 2.4 and \( LWT_{CSR} \) is the light weight of the ship.

- \( fi = 1.0 \) for all other ships.
fc : Cubic Capacity correction factor

- For chemical tankers:
  
  \[ f_c = R^{-0.7} - 0.014, \text{ where } R \text{ is less than } 0.98 \]
  
  or
  
  \[ f_c = 1.000, \text{ where } R \text{ is } 0.98 \text{ and above}; \]

  where: \( R \) is the capacity ratio of the deadweight of the ship (tonnes) as determined by paragraph 2.4 divided by the total cubic capacity of the cargo tanks of the ship (m³).

- For RoRo Passenger ship:

  \[ f_{c_{RoPax}} = \left( \frac{DWT}{GT} \right)^{-0.8} \left( \frac{0.25}{0.25} \right) \]

- For diesel electric LNG ship:

  \[ f_{c_{LNG}} = R^{-0.56} \]

  where: \( R \) is the capacity ratio of the deadweight of the ship (tonnes) as determined by paragraph 2.4 divided by the total cubic capacity of the cargo tanks of the ship (m³).
Summary on Attained EEDI calculations

- Attained EEDI is calculated for “EEDI Condition” that represents:
  - Capacity at summer load line draft
  - Ship speed at 75% of main shaft power MCR and the above capacity.
- Required engine data are derived from engine NOx Technical File.
- A large number of “correction factors” are included in the formula.
- Method of calculation of correction factors are defined within the Guidelines.
Guidelines on Survey and Verification of EEDI

- 2014 Guidelines on survey and certification of the energy efficiency design index (EEDI), Resolution MEPC.254(67), as amended by Resolution MEPC.261(68)
Content

- Introduction
- Verification process
- Preliminary verification
- Final verification
- Verification of major conversions
- Summary
Verification stages

- Survey and certification of the EEDI should be conducted on two stages:
  - **Preliminary verification** at the design stage, and
  - **Final verification** at the sea trial.
Verification process (Clause 4.1)

Submitter

Basic Design
Tank Test*, EEDI Calculation

Development of EEDI Technical File

Submission of additional information

Verifier

Witness Model
Tank Test

Verification:
- EEDI Technical File
- Additional information

Issuance of Report of pre-verification

Pre-verification

Start of ship construction

Sea Trial

Modification and Resubmission of EEDI Technical File

Final verification

Delivery of ship

- To be conducted by a test organization or a submitter itself.
Preliminary Verification
Preliminary verification

For the preliminary verification at the design stage, the following should be submitted to the verifier:

- An application for an initial survey
- An EEDI Technical File containing the necessary information
- Other relevant background documents
Tank test aspects

- The power curves used for the preliminary verification should be based on results of tank test.

- A tank test for an individual ship may be omitted based on technical justifications such as availability of the results of tank tests for ships of the same type.

- In addition, omission of tank tests is acceptable for a ship for which sea trials will be carried under the EEDI Condition ....

- Model tank test should be witnessed by the verifier.
Additional information

- The verifier may request the submitter for additional information such as:
  - Descriptions of a tank test facility.
  - Lines of the model and the actual ship for the verification of the similarity of model and actual ship.
  - Lightweight of the ship and displacement table for the verification of the deadweight;
  - Detailed report … the tank test; this should include at least the tank test results at sea trial condition and under the EEDI Condition.
  - Detailed calculation process of the ship speed ….
  - Reasons for exempting a tank test, if applicable; … plus relevant information ….
Final Verification
Sea trials

- Sea trial conditions should be set as EEDI Conditions, if possible.

- Prior to the sea trial, the following should be submitted to the verifier:
  - Test procedure to be used for the speed trial,
  - Final displacement table and the measured lightweight, or a copy of the survey report of deadweight,
  - NOx Technical File as necessary.

- The test procedure should include, as a minimum, descriptions of all necessary items to be measured, measurement methods....
Sea trials

- The verifier should attend the sea trial and confirm:
  - Propulsion and power supply system,
  - Particulars of the engines, and other relevant items described in the EEDI Technical File;
  - Draught and trim;
  - Sea conditions;
  - Ship speed; and
  - Shaft power and RPM of the main engine.
Parameters to be checked

- **Draught and trim**: should be confirmed by the draught measurements taken prior to the sea trial.

- **Sea conditions**: Sea conditions should be measured in accordance with ITTC Recommended Procedure 7.5-04-01-01.1 Speed and Power Trials Part 1; 2014 or ISO 15016:2015.

- **Ship speed**: Should be measured in accordance with ITTC Recommended Procedure 7.5-04-01-01.1 Speed and Power Trials Part 1; 2014 or ISO 15016:2015, and at more than two points of engine power ……

- **The main engine output**: Should be measured by shaft power meter or a method which the engine manufacturer recommends and the verifier approves.
The submitter should develop power curves … from results of sea trial.

The effect of wind, current, waves, shallow water, displacement, water temperature and water density in accordance with ITTC Recommended Procedure 7.5-04-01-01.2 Speed and Power Trials Part 2; 2014 or ISO 15016:2015.

The submitter should compare the power curves obtained as a result of the sea trial and the estimated power curves at the design stage.

In case differences, the attained EEDI should be recalculated.
Verification of the attained EEDI for major conversions

- In case of a major conversion, the ship-owner should submit to a verifier an application for an Additional Survey with the revised EEDI Technical File and relevant background documents.

- The background documents should include at least but are not limited to:
  - Documents explaining details of the conversion;
  - EEDI parameters changed after the conversion …;
  - Reasons for other changes made in the EEDI Technical File.
  - Calculated value of the attained EEDI, with the calculation summary for each value of the calculation parameters and the calculation process …
Other EEDI Relevant Guidelines
Guidelines on Ship Minimum Power

- **Resolution MEPC.232(65) as amended by 225(67) and 262(68):** the 2013 Interim Guidelines for determining minimum propulsion power to maintain the manoeuvrability of ships in adverse conditions.

- **Purpose:** To assist Administrations and ROs in verifying that ships, complying with EEDI, have sufficient installed propulsion power to maintain the manoeuvrability in adverse conditions, as specified in Regulation 21.5.

- **Adverse conditions**

<table>
<thead>
<tr>
<th>Significant wave height $h_s$, m</th>
<th>Peak wave period $T_p$, s</th>
<th>Mean wind speed $V_w$, m/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.5</td>
<td>7.0 to 15.0</td>
<td>19.0</td>
</tr>
</tbody>
</table>

- **Currently applicable to:**
  - Tankers
  - Bulk carriers
  - Combination carriers
Minimum power: Assessment method

- **Assessment Level 1 – Minimum power lines assessment**
  - Check if the ship has an installed power not less than the minimum power defined by line below:

  \[
  \text{Minimum Power Line Value [MCR, kW]} = a \times (DWT) + b
  \]
  
  - a and b are constants and varies with ship type.

- **Assessment Level 2 – Simplified assessment**

The assessment procedure consists of two steps:

1. Definition of the required advance speed in head wind and waves, ensuring course-keeping in all wave and wind directions.

2. Assessment whether the installed power is sufficient to achieve the above required advance speed.

**Further details on Assessment Level 2 are given in the Guidelines**
Guidelines on Innovative EE Technologies

- **MEPC.1/Circ.815**: 2013 Guidance on treatment of innovative energy efficiency technologies for calculation and verification of the attained EEDI for ships in adverse conditions.

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1. **GENERAL**
2. **DEFINITIONS**
3. **CATEGORIZING OF INNOVATIVE ENERGY EFFICIENCY TECHNOLOGIES**
4. **CALCULATION AND VERIFICATION OF EFFECTS OF INNOVATIVE ENERGY EFFICIENCY TECHNOLOGIES**

**ANNEX 1**
Guidance on calculation and verification of effects of Category (B) innovative technologies

- Appendix 1 Air lubrication system (Category (B-1))
- Appendix 2 Wind propulsion system (Category (B-2))

**ANNEX 2**
Guidance on calculation and verification of effects of Category (C) innovative technologies

- Appendix 1 Waste heat recovery system for generation of electricity (Category (C-1))
- Appendix 2 Photovoltaic power generation system (Category (C-2))
The technologies covered so far

- Wind Power
- Hull Air Lubrication
- Waste Heat Recovery
- Solar Electricity
### Categories of Innovative EE Technologies

<table>
<thead>
<tr>
<th>Innovative Energy Efficiency Technologies</th>
<th>Reduction of Main Engine Power</th>
<th>Reduction of Auxiliary Power</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Category A</strong></td>
<td><strong>Category B-1</strong></td>
<td><strong>Category B-2</strong></td>
</tr>
<tr>
<td>Cannot be separated from overall performance of the vessel</td>
<td>Can be treated separately from the overall performance of the vessel</td>
<td>Effective at all time</td>
</tr>
<tr>
<td></td>
<td>$f_{\text{eff}} = 1$</td>
<td>$f_{\text{eff}} &lt; 1$</td>
</tr>
<tr>
<td>- low friction coating</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- bare optimization</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- rudder resistance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- propeller design</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- hull air lubrication system (air cavity via air injection to reduce ship resistance) (can be switched off)</td>
<td>- wind assistance (sails, Flettner-Rotors, kites)</td>
</tr>
<tr>
<td></td>
<td>- waste heat recovery system (exhaust gas heat recovery and conversion to electric power)</td>
<td>- photovoltaic cells</td>
</tr>
</tbody>
</table>

Details on how to deal with the above technologies for EEDI calculations are given in the Guidelines.
Summary on EEDI verification

- EEDI verification will be performed in two stages:
  - Preliminary verification at design stage
  - Final verification at commissioning sea trials.

- Pre-verification is based on model tank test results.

- Final verification is based on actual speed trial results.

- Verifier is required to witness both tank test and sea trials.

- Development of speed power curve for EEDI Condition will involve use of tank test data, speed trial data, + use of ISO standard for data correction.

- EEDI Technical File should be developed as part of the process.
PART 3 – Guidelines on SEEMP and EEOI
Content

- SEEMP Guidelines
- SEEMP main features
- Implementation aspects
- EEOI Guidelines
- EEOI calculation process
- Discussion
Guidelines for Development of SEEMP

Introduction

- The SEEMP Guidelines have been developed to assist with the preparation of the SEEMP that is required by Regulation 22 of MARPOL Annex VI.

- A SEEMP provides:
  - A possible approach for improving ship and fleet efficiency performance over time; and
  - Some options to be considered for optimizing the performance of the ship.

- SEEMP purpose
  - The purpose of a SEEMP is to establish a mechanism for a company and/or a ship to improve the energy efficiency of a ship's operation.
SEEMP for ship OR company?

- The SEEMP should be developed as a ship-specific plan by the company.

- … SEEMP should be adjusted to the characteristics and needs of individual companies and ships.

- … it is recommended that a company also establishing an “energy management plan” to improve fleet energy performance and stakeholders’ coordination.
SEEMP Framework and Main Elements
The SEEMP works through four steps:
- Planning,
- Implementation
- Monitoring, and
- Self-evaluation

These components play a critical role in the continuous cycle to improve ship energy management.
Planning
Planning - Importance

- Planning is the most crucial stage of the SEEMP.
- It primarily determines both the current status of ship energy usage and the expected improvements.
- Therefore, it is encouraged to devote sufficient time to planning.
Planning – Identification of ship-specific “energy efficiency measures”

- Recognizing that:
  - There are a variety of options to improve efficiency.
  - That the best measures differs to a great extent for ship type, cargoes, routes and other factors,
  - The specific measures for the ship to improve energy efficiency should be identified in the first place.

- After identification of the EEMs (Energy Efficiency Measures), they should be listed as a package for implementation.
The improvement of energy efficiency of a ship does not necessarily depend on ship management only. A number of stakeholders are involved.

More coordination between stakeholders is more rewarding …

Company should do the coordination rather than the ship.

… a “company energy management plan” is recommended to manage the fleet and make stakeholders’ coordination.
Human resources development

- Raising awareness and providing necessary training for personnel both on-shore and on-board are an important element.

- Such human resource development is encouraged and should be considered as an important component of planning as well as a critical element of implementation.
Planning - Goal setting

- Goal setting is part of planning.

- Goal settings are voluntary and there is no need for announcement to public nor are they subject to external inspection.

- Purpose of goal setting is to increase commitment to improving energy efficiency.

- The goal can take any form:
  - Annual fuel consumption
  - EEOI targets

- The goal should be measurable and easy to understand.
Implementation
Implementation – Establishment of implementation system

- A system for implementation of the selected measures by developing the procedures, tasks and responsibilities ...

- The SEEMP should describe how each measure should be implemented and who the responsible person(s) is.

- The implementation period (start and end dates) of each selected measure should be indicated.

- The development of such a system can be considered as a part of planning, and therefore may be completed at the planning stage.
The planned measures should be implemented in accordance with the predetermined implementation system.

Record-keeping for the implementation of each measure is beneficial for self-evaluation and should be encouraged.

If any identified measure cannot be implemented for any reason(s), the reason(s) should be recorded for internal use.
Monitoring and Evaluation

Continual Improvement

Plan

Implementation

Do

Check

Monitoring

Evaluation and Improvement

Act
Monitoring tools

- Consistent data collection is the foundation of monitoring.

- The monitoring system, including the procedures for collecting data and the assignment of responsible personnel, should be developed.

- The development of such a system can be considered as a part of planning, and therefore should be completed at the planning stage.

- … to avoid … burdens on ships' staff, monitoring should be carried out as far as possible by shore staff, ……..
Self-evaluation and improvements

- Self-evaluation and improvement is the final phase of the management cycle.

- This phase should produce meaningful feedback for the next improvement cycle.

- The purpose of self-evaluation is to evaluate the effectiveness of the planned and implemented measures.

- For this process, procedures for self-evaluation of ship energy management should be developed.

- Furthermore, self-evaluation should be implemented periodically by using data collected through monitoring.
A proposed format is included in the Guideline.

A SAMPLE FORM OF A SHIP EFFICIENCY ENERGY MANAGEMENT PLAN

Name of Vessel: 
GT: 
Vessel Type: Capacity: 

Date of Development: Developed by:
Implementation Period: From: Implemented by: 
Until: 
Planned Date of Next Evaluation: 

1 MEASURES

<table>
<thead>
<tr>
<th>Energy Efficiency Measures</th>
<th>Implementation (including the starting date)</th>
<th>Responsible Personnel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weather Routeing</td>
<td>&lt;Example&gt; Contracted with [Service providers] to use their weather routeing system and start using on-trial basis as of 1 July 2012.</td>
<td>&lt;Example&gt; The master is responsible for selecting the optimum route based on the information provided by [Service providers].</td>
</tr>
<tr>
<td>Speed Optimization</td>
<td>While the design speed (85% MCR) is 19.0 kt, the maximum speed is set at 17.0 kt as of 1 July 2012.</td>
<td>The master is responsible for keeping the ship’s speed. The log-book entry should be checked every day.</td>
</tr>
</tbody>
</table>

2 MONITORING
Description of monitoring tools

3 GOAL
Measurable goals

4 EVALUATION
Procedures of evaluation
Summary on SEEMP Guidelines

- SEEMP framework is based on Plan-Do-Check-Act continuous improvement cycle.

- When developing SEEMP, all the above elements needs to be defined at the planning phase.

- At its core, SEEMP has a number of EEMs together with their:
  - Implementation methods
  - Monitoring and checking
  - Self assessment
  - Roles and responsibility
  - Processes and procedures.
Guidelines for Calculation of the EEOI

MEPC.1/Circ.684 Guidelines for Voluntary use of the Ship Energy Efficiency Indicator (EEOI), 17 August 2009
Content on EEOI

- EEOI Guidelines purposes
- EEOI formula and data requirements
- Calculation aspects
- Typical calculations
GUIDELINES FOR VOLUNTARY USE OF THE SHIP ENERGY EFFICIENCY OPERATIONAL INDICATOR (EEOI)

1 The Marine Environment Protection Committee, at its fifty-ninth session (13 to 17 July 2009), agreed to circulate the Guidelines for voluntary use of the Ship Energy Efficiency Operational Indicator (EEOI) as set out in the annex.

2 Member Governments are invited to bring the Guidelines to the attention of all parties concerned and recommend them to use the Guidelines on a voluntary basis.

3 Member Governments and observer organizations are also invited to provide information on the outcome and experiences in applying the Guidelines to future sessions of the Committee.
EEOI Guidelines: Some extracts from Circ.684

- These Guidelines present the concept of **an indicator for the energy efficiency of a ship**, ........

- These Guidelines **can be used** to establish a **consistent approach** for **voluntary** use of an EEOI.

- It will assist ship-owners/operators ...... in the **evaluation of the performance of their fleet** with regard to CO2 emissions.

- These Guidelines are **recommendatory in nature** and present a possible use of an operational indicator.

- Ship-owners .... **are invited to implement either these Guidelines or an equivalent method** in their environmental management systems.
EEOI Formula

- **j** is the fuel type
- **i** is the voyage number;
- **$FC_j$** 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 cargo mass (tonnes) or work done (number of TEU, passengers, etc.) depending on ship type.
- **$D$** is the distance in nautical miles corresponding to the cargo carried or work done

$$\text{EEOI} = \frac{\sum_j FC_j \times C_{Fj}}{m_{cargo} \times D}$$
Definitions (1)

- **Fuel consumption (FC)**
  - *Fuel consumption, FC*, is defined as all fuel consumed at sea and in port or for a voyage or period in question, by main and auxiliary engines including boilers and incinerators

- **Distance sailed (D)**
  - *Distance sailed* means the actual distance sailed in nautical miles

- **Voyage**
  - *Voyage* generally means the period between a departure from a port to the departure from the next port. **Alternative definitions of a voyage could also be acceptable**
Definitions (2)

Cargo mass carried \( (m_{\text{cargo}}) \)

- For cargo ships (dry, wet, etc.):
  - **Metric tonnes (t)** of the cargo carried.

- For containerships (carrying solely containers):
  - **Number of containers (TEU)** or **metric tons (t)** of the total mass of cargo and containers.

- Ships carrying a combination of containers and other cargoes
  - A TEU mass of 10 t could be applied for loaded TEUs and 2 t for empty TEUs.

- Passenger ships, including Ro-Ro passenger ships
  - **Number of passengers** or **gross tonnes** of the ship.

- Etc.
Establishing the EEOI

- Main steps for establishing an EEOI are:
  1. Define the period for which EEOI is calculated (or the voyage)
  2. Define data sources for data collection
  3. Collect data
  4. Calculate EEOI

- Port operation and ballast voyages, as well as voyages which are not used for transport of cargo, such as voyage for docking service, should also be included.

- Voyages for the purpose of securing the safety of a ship or saving life at sea should be excluded.
EEOI Calculation
Basic expression of the EEOI

Average EEOI (rolling average)

- \( j \) is the fuel type
- \( i \) 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 cargo carried (tonnes) or work done (number of TEU or passengers) or gross tonnes for passenger ships
- \( D \) is the distance in nautical miles corresponding to the cargo carried or work done.

\[
EEOI = \frac{\sum_j FC_j \times C_{Fj}}{m_{cargo} \times D}
\]

\[
\text{Average EEOI} = \frac{\sum_i \sum_j (FC_{ij} \times C_{Fj})}{\sum_i (m_{cargo,i} \times D_i)}
\]
Calculation of the EEOI – Rolling average

- EEOI is normally calculated for one voyage.
- Average EEOI for a number of voyages can be carried out.
- Rolling average, when used, can be calculated in a suitable time period, for example:
  - One year or
  - Number of voyages, for example six or ten voyages.
- For calculation of rolling average for three voyages, the average for the following voyages need to be calculated:
  - Average of voyages 1, 2 and 3 will give the 1st rolling average
  - Average of voyages 2, 3 and 4 will give the 2nd rolling average
  - Average of voyages 3, 4 and 5 will give the 3rd rolling average
  - And so on.
Calculation of the EEOI – Data sources

- Data sources
  - Bridge log-book
  - Engine log-book
  - Deck log-book
  - Other official records

- Fuel mass to CO₂ mass conversion factors ($C_F$)

<table>
<thead>
<tr>
<th>Type of fuel</th>
<th>Reference</th>
<th>Carbon content</th>
<th>$C_F$ (t-CO₂/t-Fuel)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Diesel/Gas Oil</td>
<td>ISO 8217 Grades DMX through DMC</td>
<td>0.875</td>
<td>3.206000</td>
</tr>
<tr>
<td>2. Light Fuel Oil (LFO)</td>
<td>ISO 8217 Grades RMA through RMD</td>
<td>0.86</td>
<td>3.151040</td>
</tr>
<tr>
<td>3. Heavy Fuel Oil (HFO)</td>
<td>ISO 8217 Grades RME through RMK</td>
<td>0.85</td>
<td>3.114400</td>
</tr>
<tr>
<td>4. Liquified Petroleum Gas (LPG)</td>
<td>Propane</td>
<td>0.819</td>
<td>3.000000</td>
</tr>
<tr>
<td></td>
<td>Butane</td>
<td>0.827</td>
<td>3.030000</td>
</tr>
<tr>
<td>5. Liquified Natural Gas (LNG)</td>
<td></td>
<td>0.75</td>
<td>2.750000</td>
</tr>
</tbody>
</table>
Calculation of the EEOI – Data sheet template

CO₂ Indicator reporting sheet

<table>
<thead>
<tr>
<th>NAME AND TYPE OF SHIP</th>
<th>Voyage or day (i)</th>
<th>Fuel consumption (FC) at sea and in port in tonnes</th>
<th>Voyage or time period data</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Fuel type ( )</td>
<td>Cargo (m) (tonnes or units)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fuel type ( )</td>
<td>Distance (D) (NM)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fuel type ( )</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NOTE: For voyages with $m_{\text{cargo}} = 0$, it is still necessary to include the fuel used during this voyage in the summation above the line.
Calculation of the EEOI (example)

Example (includes a single ballast voyage)

<table>
<thead>
<tr>
<th>NAME AND TYPE OF SHIP</th>
<th>Fuel consumption (FC) at sea and in port in tonnes</th>
<th>Voyage or time period data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voyage or day (i)</td>
<td>Fuel type (HFO)</td>
<td>Fuel type (LFO)</td>
</tr>
<tr>
<td>1</td>
<td>20</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>20</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td>50</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>

\[
EEOI = \frac{100 \times 3.114 + 23 \times 3.151}{25,000 \times 300 + 0 \times 300 + 25,000 \times 750 + (15,000 \times 150)} = 13.47 \times 10^{-6}
\]

unit: tonnes CO2/(tons x nautical miles)
EEOI calculations and variability

- Calculations over two years for a container ship
- Significant variability (voyage to voyage)
- Reasons for changes could include:
  - Ship size/type
  - Cargo level (load)
  - Ship speed
  - Length of ballast voyages
  - Idle and waiting times
  - Weather and current
  - Measurement errors
Thank you for your attention

For more information please see: www.imo.org