Goal-based efficiency improvement measure for existing ships (EEXI)

Maritime Bureau
Ministry of Land, Infrastructure, Transport and Tourism
Japan
The EEXI proposal

- ISWG-GHG 7/2/6: Draft amendments to MARPOL VI
  (Greece, Japan, Norway, Panama, United Arab Emirates, ICS, BIMCO and INTERTANKO)

- ISWG-GHG 7/2/7: Draft guidelines to implement EEXI
  (Greece, Japan, Norway, Panama, United Arab Emirates, ICS, BIMCO, INTERTANKO and RINA)

- ISWG-GHG 7/2/8: Additional impact assessment of EEXI
  (Greece, Japan, Norway and ICS)

- ISWG-GHG 7/2/15: Addressing concerns on EEXI
  (Greece, Japan and Norway)
Decided to initiate two workstreams in parallel

1. Technical approach

- Coordinated by Japan
- Pre-certification of energy efficiency of ships, based on EEXI (proposed by Japan and Norway)

2. Operational approach

- Coordinated by Denmark, France and China
- Post-operational control based on:
  1. Mandatory AER/EEOI limit (proposed by Denmark et al and France); or
  2. Mandatory CII rating mechanism (proposed by China)
Informal group on technical approach

Group members

- **Coordinator:** Japan
- **Member State:** Australia, Canada, Finland, Germany, Greece, Japan, Norway, Singapore, United Arab Emirates, United Kingdom, United States
- **NGOs:** BIMCO, EUROMOT, IACS, ICS, INTERTANKO, RINA, WSC

Working arrangement

Three rounds of discussions and review of draft submissions

- Dec 13-27  First round
- Jan 8-20    Second round
- Jan 23-31  Third round and confirmation of draft submissions

Incorporated **all comments and concerns without compromising the EEXI framework and target**
Informal group on technical approach

Working items and outcomes

1. Draft amendments to MARPOL Annex VI to incorporate EEXI
   Reduction rates / implementation date / review clause

2. Draft EEXI Calculation Guidelines
   EEXI formula / calculation method / correction factors

3. Draft EEXI Survey and Certification Guidelines
   Verification procedures / EEXI technical file

4. Draft SHaPoLi / EPL Guidelines for the EEXI
   Technical requirements / power reserve / Management Plan

Prepared for approval at MEPC 75
Overview of the EEXI
The proposed EEXI measure

- **New ships**
  - Mandatory EEDI under MARPOL VI

- **Existing ships**
  - Currently no requirement

- **Proposed EEXI under MARPOL VI**
Improving operational efficiency

EEXI changes operation in a controllable way

Design factors
- Hull design
- Equipment
- Engine
- Fuel etc

Navigation factors
- Planning (route, schedule, etc)
- Interlinked
- Engine load

External factors
- Wave, wind
- Sea current
- Economic change etc

Current regulation
Mandatory EEDI
For new ships only

Mandatory EEXI
Scope of AER, EEOI, etc
(to be addressed by SEEMP, rating, MBM etc)
Fair treatment for all ships

Attained EEDI/EEXI should be taken into account

Baseline of efficiency
(EEDI reference line)

Target efficiency*
*20-50% based on ship type and size

Same target for all ships in each category

Superior efficiency

Attained EEDI/EEXI

Additional measure needed

Ship A

Ship B

Ship C
Goal-based approach

Allowing **multiple options** for design improvement

- **Existing low-efficient ship**
  - Shaft/Engine power limit (with safety reserve)
  - Fuel change and/or Energy saving devices
  - Replacement with new ships

- **Existing high-efficient ship**
  - (with limited power)
  - Speed optimization from technical approach

- **Existing high-efficient ship**
  - (with higher performance)

- **New high-efficient ship**
  - (with higher performance)
Proposed EEXI framework

Attained EEDI/EEXI

Existing ship

Calculate energy efficiency performance

Meet

Required EEXI

Not meet

Shaft/Engine power limit (power optimization)

Fuel change and/or Energy saving devices

Replacement with new ships

Other verifiable options

Survey & Certificate

Efficient operation

IEE Certificate

Efficiency improvement required
Equivalent to *2022 EEDI (Phase 2-3) level*

Existing ships shall meet the EEDI reduction rate as of the date of EIF (assumed to be before 2023) of EEXI.
Recent updates
(incorporated in submissions to ISWG-GHG 7)
Addressing uncertainties towards 2030

- Growth in global shipping demand
- Changes in fleet composition
- Increase in average ship size
- Uptake of new technologies / alternative fuels
- Potential impacts on global trade

Influence fleet-average carbon intensity in 2030

**Regulation 21A. 3**

*By the end of [2026][2027], the Organization shall review the status of implementation and effect of this regulation and, if proven necessary, amend the relevant regulations as appropriate.*
**EEXI formula**

Based on EEDI formula

EEXI  = CO₂ emissions per DWT-miles

= Fuel conversion factor × fuel consumption per hour / DWT-speed

\[
EEXI = \text{Fuel conversion factor} \times \text{fuel consumption per hour} / \text{DWT-speed}
\]

\[
EEXI = \left( \prod_{j=1}^{M} f_i \right) \left( \sum_{i=1}^{n_{ME}} P_{ME(1)} \cdot C_{P_{ME(1)}} \cdot SFC_{ME(1)} \right) + \left( P_{AE} \cdot C_{P_{AE}} \cdot SFC_{AE} \right) + \left( \prod_{j=1}^{M} f_i \cdot \sum_{i=1}^{n_{PTI}} P_{PTI(1)} - \sum_{i=1}^{n_{PTI}} f_{eff(i)} \cdot P_{AE(i)} \right) \cdot C_{P_{AE}} \cdot SFC_{AE} - \left( \sum_{i=1}^{n_{PTI}} f_{eff(i)} \cdot P_{AE(i)} \cdot C_{P_{AE}} \cdot SFC_{AE} \right)
\]

\[
f \cdot f_i \cdot \text{Capacity} \cdot V_{ref} \cdot f_v
\]

- Documented in the EEXI Technical File
- Pre-certified by the International Energy Efficiency Certificate
- Utilizes the same factors and coefficients as those of EEDI
- Introduces the concept of shaft / engine power limitation
# Sample format of EEXI Technical File

## 1 Data

### 1.1 General information

<table>
<thead>
<tr>
<th>Shipowner</th>
<th>XXX Shipping Line</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shipbuilder</td>
<td>XXX Shipbuilding Company</td>
</tr>
<tr>
<td>Hull no.</td>
<td>12345</td>
</tr>
<tr>
<td>IMO no.</td>
<td>94112XX</td>
</tr>
<tr>
<td>Ship type</td>
<td>Bulk carrier</td>
</tr>
</tbody>
</table>

### 1.2 Principal particulars

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Length overall</td>
<td>250.0 m</td>
</tr>
<tr>
<td>Length between perpendiculars</td>
<td>240.0 m</td>
</tr>
<tr>
<td>Breadth, moulded</td>
<td>40.0 m</td>
</tr>
<tr>
<td>Depth, moulded</td>
<td>20.0 m</td>
</tr>
<tr>
<td>Summer load line draught, moulded</td>
<td>14.0 m</td>
</tr>
<tr>
<td>Deadweight at summer load line draught</td>
<td>150,000 tons</td>
</tr>
</tbody>
</table>

### 1.3 Main engine

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturer</td>
<td>XXX Industries</td>
</tr>
<tr>
<td>Type</td>
<td>6J70A</td>
</tr>
<tr>
<td>Maximum continuous rating (MCR&lt;sub&gt;ME&lt;/sub&gt;)</td>
<td>15,000 kW x 80 rpm</td>
</tr>
<tr>
<td>Limited maximum continuous rating with the Engine Power Limitation installed (MCR&lt;sub&gt;ME,lim&lt;/sub&gt;)</td>
<td>11,000 kW x 72 rpm</td>
</tr>
<tr>
<td>SFC at 75% of P&lt;sub&gt;ME&lt;/sub&gt;</td>
<td>166.5 g/kWh</td>
</tr>
<tr>
<td>Number of sets</td>
<td>1</td>
</tr>
<tr>
<td>Fuel type</td>
<td>Diesel Oil</td>
</tr>
</tbody>
</table>

### 1.4 Auxiliary engine

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturer</td>
<td>XXX Industries</td>
</tr>
<tr>
<td>Type</td>
<td>5J-200</td>
</tr>
<tr>
<td>Maximum continuous rating (MCR&lt;sub&gt;AE&lt;/sub&gt;)</td>
<td>600 kW x 900 rpm</td>
</tr>
<tr>
<td>SFC at 50% MCR&lt;sub&gt;AE&lt;/sub&gt;</td>
<td>220.0 g/kWh</td>
</tr>
<tr>
<td>Number of sets</td>
<td>3</td>
</tr>
<tr>
<td>Fuel type</td>
<td>Diesel Oil</td>
</tr>
</tbody>
</table>

### 1.5 Ship speed

| Ship speed (V<sub>sw</sub>) (with the Engine Power Limitation installed) | 13.20 knots |

---

\[
EEXI = \frac{\left(\prod_{i=1}^{M} f_i\right)\left(\sum_{i=1}^{n_{ME}} P_{ME(i)} \cdot C_{FME(i)} \cdot SFC_{ME(i)}\right) + \left(P_{AE} \cdot C_{FAE} \cdot SFC_{AE}\right)}{f_i \cdot f_c \cdot f_l \cdot \text{Capacity} \cdot f_w \cdot V_{ref} \cdot f_m} \\
+ \left(\prod_{i=1}^{M} f_i \cdot \sum_{i=1}^{n_{PTI}} P_{PTI(i)} - \sum_{i=1}^{n_{eff}} f_{eff(i)} \cdot P_{AEeff(i)}\right) \cdot C_{FAE} \cdot SFC_{AE} \\
\left(\sum_{i=1}^{n_{eff}} f_{eff(i)} \cdot P_{eff(i)} \cdot C_{FME \cdot SFC_{ME}}\right) \\
\frac{1 \times (8250 \times 3.206 \times 166.5) + (625 \times 3.206 \times 220.0) + 0 - 0}{1 \times 1 \times 1 \times 150000 \times 1 \times 13.20 \times 1} \\
= 2.41 (g - CO_{2}/\text{ton \cdot mile})
\]

attained EEXI: 2.41 g-CO<sub>2</sub>/ton mile
- Ships can choose the most **cost-effective** measure.
- Voyage cost will be reduced.
- **Overall transport cost can be reduced**, if appropriate level of the required EEXI is set.
Way forward
Possible collaboration with operational approach

**Ex-ante**

- Technical approach
- Robust EEXI
  - Eliminates non-compliant ships in advance
  - Ensures minimum standards for entire fleet in a robust way
  - Eliminates influence of uncontrollable factors

**Ex-post**

- Operational approach
- Flexible CII auditing/rating
  - Monitors and checks the ship’s actual operation
  - Differentiates and encourages the **top-runners**
  - Provides database for the real-world emissions

---

**At least Δ40%**
(estimated Δ49% under the proposed EEXI)
Thank you.
FAQ
Q. Study shows EEXI contributes to only 1-7% reduction!

A. NO, the study is…

- NOT on EEXI, but on fixed-rate EPL (non-goal-based).
- NOT on effectiveness from the agreed baseline under the Strategy, but from the manipulated baseline.
EEXI mandates CO₂/ton-mile, not engine power

Case of 8,000 TEU (80,000 DWT) containerships

Ship A
(10% worse than baseline)

Δ65% by EPL

Ship B
(10% better than baseline)

Δ46% by EPL

Ship C
(40% better than baseline)

No need of EPL

Baseline
(EEDI reference line)

Target EEXI = 40% CO₂/ton-mile
(for 80,000–120,000 DWT containership)
Baseline aligned with the Strategy = 2008

Source: “Limiting engine power to reduce CO₂ emissions from existing ships” (ICCT, 2020)
* Notes added by MLIT, Japan (highlighted in green)

Figure 1. CO₂ intensity of international shipping, 2008 to 2030. Note. Derived from Smith et al. (2015), Olmer, Comer, Roy, Mao, and Rutherford (2017), and UNCTAD (2019). Solid bars indicate historical values, while hatched bars indicate projections.
● EEXI can improve fleet average carbon intensity (in AER) in **2030 by 49%** (compared with 2008).

● EEXI can be **complemented** with other operational measures (auditing/rating etc).

● Fleet average carbon intensity can be **further improved** by **combination** of EEXI and other operational measures, such as strengthened SEEMP and rating mechanism.
Q. Is a power limit ineffective as opposed to a speed limit?

A. No, speed and power are closely related.
- The impact on emissions of a speed or power limitation depends on the stringency of the requirement and effectiveness of enforcement.
- The EEXI and a power limit is easier to enforce than a speed limit.

Advantage of EPL
- Can be pre-certified
- Can be logged and controlled
- Directly related to emissions
- No effect by uncontrollable external factors
Which one is likely to control the operation?

Operational speed limit

Annual average efficiency limit

Engine power technical limit

Report

The last year’s energy efficiency was

XX.X gCO2/ton-mile

Ship name: ABC
How Engine Power Limit works

Before (2008)
More GHG, Higher speed

After
Less GHG, Lower speed

Maximum power
Sea margin

Power limit

Operation range

Safety Power Reserve

Ship A (more efficient)

Ship B (less efficient)

Engine load

20%
40%
60%
80%
100%
How Engine Power Limit works

Inefficient operation (more fuel consumption)

- More fluctuation
- Higher max. power/speed
- Same avg. power/speed

EPL

Efficient operation (less fuel consumption)

- Less fluctuation
- Lower max. power/speed
- Same avg. power/speed

Same transport time
Q. Isn’t EPL overridden?

A. Only in case of extreme emergency, subject to reporting, recording and re-limiting.

![Graph showing engine speed (rpm) vs. engine power (kW) with shaded areas indicating engine load at high-speed operation and adverse weather conditions.](image)
Q. Does EEXI bring “rebound effect”?

A. NO, ships cannot boost beyond the certified power.
CO₂ / transport work (EEDI, EEXI, CII)

Ship speed

Inefficient ship
Efficient ship

Efficient operation

Req. EEXI
Why not directly limit operational efficiency?

We can design dice, but can’t control their number

= Designed to be 3.5 in average

\[ E[X] = 3.50 \]

Analogy:
EEDI or EEXI on each ship

A single die

\[ E[X] = 3.50 \]
\[ V[X] = 2.92 \]

Uncontrollable random number

Analogy:
A single ship’s operational efficiency

Average of \( N \) dice

\[ E[\bar{X}] = 3.50 \]
\[ V[\bar{X}] = \frac{2.92}{N} \]

Converges to 3.5

Analogy:
Entire fleet’s carbon intensity (e.g. AER \( \Delta 40\% \) by 2030)
Relevant information
### Case study (1): Bulk carriers

<table>
<thead>
<tr>
<th></th>
<th>2008 base level</th>
<th>EPL (with safety reserve)</th>
<th>Energy saving device* with EPL</th>
<th>Retrofit or replacement with new ship</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Handy</strong> (33,000 DWT)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$P_{ME}$</td>
<td>5,067 kW</td>
<td>3,626 kW</td>
<td>3,822 kW</td>
<td>4,410 kW</td>
</tr>
<tr>
<td>$V_{REF}$</td>
<td>14.2 knot</td>
<td>12.7 knot</td>
<td>13.4 knot</td>
<td>14.2 knot</td>
</tr>
<tr>
<td>EEXI</td>
<td>6.73</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Handymax</strong> (60,000 DWT)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$P_{ME}$</td>
<td>7,222 kW</td>
<td>5,168 kW</td>
<td>5,448 kW</td>
<td>6,467 kW</td>
</tr>
<tr>
<td>$V_{REF}$</td>
<td>14.6 knot</td>
<td>13.1 knot</td>
<td>13.8 knot</td>
<td>14.6 knot</td>
</tr>
<tr>
<td>EEXI</td>
<td>5.06</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Panamax</strong> (81,000 DWT)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$P_{ME}$</td>
<td>8,228 kW</td>
<td>5,860 kW</td>
<td>6,177 kW</td>
<td>7,343 kW</td>
</tr>
<tr>
<td>$V_{REF}$</td>
<td>14.2 knot</td>
<td>12.7 knot</td>
<td>13.4 knot</td>
<td>14.2 knot</td>
</tr>
<tr>
<td>EEXI</td>
<td>4.38</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Capesize</strong> (200,000 DWT)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$P_{ME}$</td>
<td>13,837 kW</td>
<td>9,780 kW</td>
<td>10,333 kW</td>
<td>12,372 kW</td>
</tr>
<tr>
<td>$V_{REF}$</td>
<td>14.7 knot</td>
<td>13.1 knot</td>
<td>13.8 knot</td>
<td>14.7 knot</td>
</tr>
<tr>
<td>EEXI</td>
<td>2.85</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Energy saving device: 10% improvement (e.g. by waste heat recovery system) is assumed. EPL is installed to further improve efficiency and to avoid rebound effect of using redundant engine power.
## Case study (2): Tankers

<table>
<thead>
<tr>
<th></th>
<th>2008 base level</th>
<th>EPL (with safety reserve)</th>
<th>Energy saving device with EPL</th>
<th>Retrofit or replacement with new ship</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Small Chemical (20,000 DWT)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$P_{ME}$</td>
<td>4,588 kW</td>
<td>3,283 kW</td>
<td>3,461 kW</td>
<td>4,206 kW</td>
</tr>
<tr>
<td>$V_{REF}$</td>
<td>14.5 knot</td>
<td>13.0 knot</td>
<td>13.7 knot</td>
<td>14.5 knot</td>
</tr>
<tr>
<td>EEXI</td>
<td>9.71</td>
<td>7.76 (Δ20%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Product (50,000 DWT)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$P_{ME}$</td>
<td>7,702 kW</td>
<td>5,504 kW</td>
<td>5,801 kW</td>
<td>7,257 kW</td>
</tr>
<tr>
<td>$V_{REF}$</td>
<td>15.0 knot</td>
<td>13.4 knot</td>
<td>14.1 knot</td>
<td>15.0 knot</td>
</tr>
<tr>
<td>EEXI</td>
<td>6.21</td>
<td>4.97 (Δ20%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Aframax (105,000 DWT)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$P_{ME}$</td>
<td>10,291 kW</td>
<td>7,259 kW</td>
<td>7,660 kW</td>
<td>9,697 kW</td>
</tr>
<tr>
<td>$V_{REF}$</td>
<td>14.5 knot</td>
<td>12.9 knot</td>
<td>13.6 knot</td>
<td>14.5 knot</td>
</tr>
<tr>
<td>EEXI</td>
<td>4.32</td>
<td>3.46 (Δ20%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>VLCC (300,000 DWT)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$P_{ME}$</td>
<td>19,372 kW</td>
<td>13,745 kW</td>
<td>14,511 kW</td>
<td>18,291 kW</td>
</tr>
<tr>
<td>$V_{REF}$</td>
<td>15.8 knot</td>
<td>14.1 knot</td>
<td>14.9 knot</td>
<td>15.8 knot</td>
</tr>
<tr>
<td>EEXI</td>
<td>2.59</td>
<td>2.07 (Δ20%)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Energy saving device: 10% improvement (e.g. by waste heat recovery system) is assumed. EPL is installed to further improve efficiency and to avoid rebound effect of using redundant engine power.*
### Case study (3): Containerships

<table>
<thead>
<tr>
<th></th>
<th>2008 base level</th>
<th>EPL (with safety reserve)</th>
<th>Energy saving device with EPL</th>
<th>Retrofit or replacement with new ship</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>3,000 TEU (37,000 DWT)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$P_{ME}$</td>
<td>18,686 kW</td>
<td>10,773 kW</td>
<td>11,379 kW</td>
<td>14,556 kW</td>
</tr>
<tr>
<td>$V_{REF}$</td>
<td>22.0 knot</td>
<td>18.3 knot</td>
<td>19.3 knot</td>
<td>20.8 knot</td>
</tr>
<tr>
<td>EEXI</td>
<td>21.0</td>
<td></td>
<td></td>
<td>14.7 ($\Delta$30%)</td>
</tr>
<tr>
<td><strong>8,000 TEU (90,000 DWT)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$P_{ME}$</td>
<td>45,311 kW</td>
<td>20,840 kW</td>
<td>21,989 kW</td>
<td>29,601 kW</td>
</tr>
<tr>
<td>$V_{REF}$</td>
<td>26.0 knot</td>
<td>20.1 knot</td>
<td>21.2 knot</td>
<td>24.0 knot</td>
</tr>
<tr>
<td>EEXI</td>
<td>17.6</td>
<td></td>
<td></td>
<td>10.6 ($\Delta$40%)</td>
</tr>
<tr>
<td><strong>14,000 TEU (140,000 DWT)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$P_{ME}$</td>
<td>67,105 kW</td>
<td>27,131 kW</td>
<td>28,621 kW</td>
<td>38,495 kW</td>
</tr>
<tr>
<td>$V_{REF}$</td>
<td>27.0 knot</td>
<td>20.0 knot</td>
<td>21.1 knot</td>
<td>23.9 knot</td>
</tr>
<tr>
<td>EEXI</td>
<td>16.1</td>
<td></td>
<td></td>
<td>8.85 ($\Delta$45%)</td>
</tr>
<tr>
<td><strong>20,000 TEU (200,000 DWT)</strong> <em>Phase 1 ship</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$P_{ME}$</td>
<td>87,888 kW</td>
<td>36,211 kW</td>
<td>37,101 kW</td>
<td>45,147 kW</td>
</tr>
<tr>
<td>$V_{REF}$</td>
<td>28.0 knot</td>
<td>20.8 knot</td>
<td>21.4 knot</td>
<td>23.2 knot</td>
</tr>
<tr>
<td>EEXI</td>
<td>13.50 ($\Delta$10%)</td>
<td></td>
<td></td>
<td>7.49 ($\Delta$50%)</td>
</tr>
</tbody>
</table>

*Energy saving device: 10% improvement (e.g. by waste heat recovery system) is assumed. EPL is installed to further improve efficiency and to avoid rebound effect of using redundant engine power.*
# Level of required EEXI

Equivalent to **2022 EEDI (Phase 2-3) level**

<table>
<thead>
<tr>
<th>Ship type</th>
<th>Required EEXI (Δ% from EEDI ref. line)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulk carrier</td>
<td>Δ20% (= EEDI phase 2)</td>
</tr>
<tr>
<td>Tanker</td>
<td>Δ20% (= EEDI phase 2)</td>
</tr>
<tr>
<td>Containership</td>
<td>Δ30-50% by size (= EEDI phase 3)</td>
</tr>
<tr>
<td>General cargo</td>
<td>Δ30% (= EEDI phase 3)</td>
</tr>
</tbody>
</table>
| Gas carrier                   | Below 14,999 DWT: Δ20% (= EEDI phase 2)  
                                  Above 15,000 DWT: Δ30% (= EEDI phase 3) |
| LNG carrier                   | Δ30% (= EEDI phase 3)                                  |
| Refrigerated cargo carrier    | Δ15% (= EEDI phase 2)                                  |
| Combination carrier           | Δ20% (= EEDI phase 2)                                  |
| Ro-ro vehicle/cargo/passenger| Δ20% (= EEDI phase 2)                                  |
| Cruise passenger ship         | Δ30% (= EEDI phase 3)                                  |
### Efficiency improvement

**Δ43% technical efficiency (EIV) by 2030**

<table>
<thead>
<tr>
<th>Ship type</th>
<th>2008 average</th>
<th>EEXI reduction rate</th>
<th>2030 average</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EIV</td>
<td>Δ%</td>
<td>EIV</td>
</tr>
<tr>
<td>Bulk carrier</td>
<td>4.24</td>
<td>Δ20%</td>
<td>3.29</td>
</tr>
<tr>
<td>Tanker</td>
<td>4.63</td>
<td>Δ20%</td>
<td>3.39</td>
</tr>
<tr>
<td>Containership</td>
<td>19.53</td>
<td>Δ30-50%</td>
<td>10.01</td>
</tr>
<tr>
<td>General cargo</td>
<td>15.66</td>
<td>Δ30%</td>
<td>10.11</td>
</tr>
<tr>
<td>Gas/LNG carrier</td>
<td>9.92</td>
<td>Δ20-30%</td>
<td>6.52</td>
</tr>
<tr>
<td>Refrigerated cargo carrier</td>
<td>23.02</td>
<td>Δ15%</td>
<td>17.43</td>
</tr>
<tr>
<td>Ro-ro vehicle</td>
<td>19.47</td>
<td>Δ15%</td>
<td>14.97</td>
</tr>
<tr>
<td>Ro-ro cargo</td>
<td>15.13</td>
<td>Δ20%</td>
<td>10.34</td>
</tr>
<tr>
<td>Ro-ro passenger</td>
<td>30.60</td>
<td>Δ20%</td>
<td>28.12</td>
</tr>
<tr>
<td>Cruise ships</td>
<td>NA</td>
<td>Δ30%</td>
<td>NA</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td>8.05</td>
<td></td>
<td>4.59</td>
</tr>
</tbody>
</table>

- Cruise ships are excluded from EEXI/AER calculation due to lack of data.
- 2030 fleet capacity is estimated from Scenario 16 (BAU) of the Third IMO GHG Study.
- 2030 fleet composition (ratio of each type and size) is fixed to average of 2011-2018. (Further ship size increase is not assumed.)
### Efficiency improvement

#### △49% operational efficiency (AER) by 2030

<table>
<thead>
<tr>
<th>Ship type</th>
<th>2008 average</th>
<th>EEXI reduction rate</th>
<th>2030 average</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AER</td>
<td>Δ%</td>
<td>AER</td>
</tr>
<tr>
<td>Bulk carrier</td>
<td>5.56</td>
<td>Δ20%</td>
<td>3.29</td>
</tr>
<tr>
<td>Tanker and combination carrier</td>
<td>5.04</td>
<td>Δ20%</td>
<td>4.04</td>
</tr>
<tr>
<td>Containership</td>
<td>18.5</td>
<td>Δ30-50%</td>
<td>10.9</td>
</tr>
<tr>
<td>General cargo</td>
<td>17.8</td>
<td>Δ30%</td>
<td>9.27</td>
</tr>
<tr>
<td>Gas/LNG carrier</td>
<td>10.8</td>
<td>Δ30%</td>
<td>9.27</td>
</tr>
<tr>
<td>Refrigerated cargo carrier</td>
<td>58.1</td>
<td>Δ15%</td>
<td>24.6</td>
</tr>
<tr>
<td>Ro-ro vehicle</td>
<td>20.4</td>
<td>Δ15%</td>
<td>14.7</td>
</tr>
<tr>
<td>Ro-ro cargo</td>
<td>NA</td>
<td>Δ20%</td>
<td>NA</td>
</tr>
<tr>
<td>Ro-ro passenger</td>
<td>NA</td>
<td>Δ20%</td>
<td>NA</td>
</tr>
<tr>
<td>Cruise ships</td>
<td>NA</td>
<td>Δ30%</td>
<td>NA</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td>9.93</td>
<td></td>
<td>5.03</td>
</tr>
</tbody>
</table>

- Ro-ro cargo, ro-ro passenger and cruise ships are excluded due to lack of data.
- Extracted from ISWG-GHG 7/2/15