An application of GHG emission reduction technologies in the future

- The concept of GHG technologies road map -

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Slide from Mr. Christian Breinholt

IMO action on GHG emissions from ships

- Nine fundamental principles
- Technical measures
- Operational measures
- Market-based measures
- A work plan on market-based instruments

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EEDI,EEOI

EEDI (Energy Efficiency Design Index)
EEOI (Energy Efficiency Operational Indicator)

\[
\text{EEDI} = \frac{\text{CO}_2 \text{Emission (CO}_2\text{ton)}}{\text{Volume of Transportation (ton} \times \text{mile)}}
\]

\[
\begin{align*}
\text{EEDI} &= \left( \frac{1}{f_w} \right) \left( \sum_j \left( \sum_i \left( \frac{C_i}{\text{SFC}_{\text{ref}} R_{\text{f,aux}}} \right) + P_{\text{r,aux},\text{ref}} \text{SFC}_{\text{ref}} \right) \right) + \left( \frac{1}{f_{\text{Vref}}} \right) \sum_i \left( \frac{P_{\text{r,aux},\text{ref}} \text{SFC}_{\text{ref}}}{ \text{Vref} \text{SFC}_{\text{ref}}} \right) \times \left( \frac{\text{Vref}}{\text{Vref}} \right) \times \left( \frac{1}{\text{f}_{\text{Vref}}} \right)
\end{align*}
\]

- Capabilities:
  - For cargo carriers, tankers, gas tankers, container ships, ro-ro cargo and passenger ships and general cargo ships,
  - For passenger ships,
  - For Gross Tonnage

f_{\text{Vref}} \text{ is a non-dimensional coefficient indicating the decrease of speed in representative sea conditions of wave height, wave frequency and wind speed (e.g., Beaufort Scale 6).}
Concept is simple, but decision is complex

Increase Efficiency

Increase Capacity

Increase speed

Three Principal Technologies
To obtain better EEDI

1. Pure Technical Countermeasure
2. Slow Steaming
3. Increase Capacity (phase 1)

<Phase 1: Under the same ship length and draft
Phase 2: Increase all ship dimensions>

Delivered Power

By 2030

Tanker: (1)80%×(2)70%×(3)80% = 45%
Container: (1)85%×(2)75%×(3)85% = 55%

What is the best solution?

1. Pure Technical
2. Slow Steaming
3. Increase Capacity

Key words: Cost Effective
Facts, Cost, Cooking

Three Energy Losses of Ship
at Navigation

Propulsion(Loss) ↔ Resistance(Loss)

Interaction(Loss & Gain)
What is Fact?

- Saving cannot exceed Loss
- Interaction among Savings is important

**Required Energy**

<table>
<thead>
<tr>
<th>Ideal</th>
<th>Loss</th>
<th>Gain</th>
</tr>
</thead>
</table>

**Counter measure A**

**Counter measure B**

**Interaction**

**Resistance**

<table>
<thead>
<tr>
<th></th>
<th>Calm Sea</th>
<th>Actual Sea (BF6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wave</td>
<td>5-30%</td>
<td>10-50%</td>
</tr>
<tr>
<td>Wind</td>
<td>1-5%</td>
<td>10-40%</td>
</tr>
<tr>
<td>Viscous (friction)</td>
<td>60-80%</td>
<td>&lt;5%</td>
</tr>
<tr>
<td>Viscous (pressure)</td>
<td>10-30%</td>
<td>&lt;5%</td>
</tr>
</tbody>
</table>

*Strongly depends on ship type and ship size*

*Priority of Technology is different*

**Resistance Components of Container Ship (22.5kts) and VLCC (15kts) at BF6**

- GHG emission reduction strategy for Container
- GHG emission reduction strategy for Tanker

**Effect of Ship size on Resistance Components**

**Resistance Components (Container)**

*Wave resistance is more important for smaller vessels*
### Energy Saving Strategy in case of Container Ship

<table>
<thead>
<tr>
<th>Hull Resistance</th>
<th>Hull Efficiency</th>
<th>Propeller Efficiency</th>
</tr>
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<tbody>
<tr>
<td>wave</td>
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<td>viscous(P)</td>
</tr>
<tr>
<td>Wind</td>
<td>Wake gain</td>
<td>Thrust deduction</td>
</tr>
<tr>
<td>Momentum loss</td>
<td>Rotation loss</td>
<td>Viscous loss</td>
</tr>
</tbody>
</table>

- Optimum stem in waves: 20% +
- Super structure: 20% +
- Boundary Layer CTL: 10% +
- Duct stern: -3% 10% -15% 50%
- Pre-swirl system: -3% 3% -- 50%
- CRP: -10% 80% 10%
- Post swirl system: 5% 10% -- 50%

PCT corresponds to reduction ratio for each component.

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### Energy Saving Strategy in case of Tanker

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</table>

- Optimum stem in waves: 30% +
- Super structure: 30% +
- Boundary Layer CTL: 15% -5% -10%
- Duct stern system: 10% 5% 10% --
- Pre-swirl system: 5% 5% -- 50%
- Duct stern: -3% + -5% 50%
- CRP: -5% 80% 10%
- Post swirl system: 5% 10% -- 50%

PCT corresponds to reduction ratio for each component.

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### Energy Saving Scenario by Hull Form and Energy Saving Devices for Propulser (keeping the size and speed)

- Container Ship: 25%
- Tanker:

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### Effect of Slow Steaming on Fuel Consumption/mile (ton/mile)

- Engine Output incl. sea margin
- Engine Output without sea margin

- 70%Vs
- 90%Vs
- 75%Power
- 50%Power

- Ship Speed (kts)

- Container Ship
**Slow Steaming of Dry Cargo (Panamax BC case)**

- Design Speed: 15kts
- NAVIGATION SPEED AT BF7: 11.2kts
- Limit of ship speed for safety navigation: 10.0kts

**Zeus Phase 1; Hydro-Aero Dynamics**

- Stream Lined Fore Bridge
- Side Wind Protector
- Ultra Wide Twin Skeg Hull
- Step Belt

**Energy Saving Combined Scenario**

- EEDI: 50%
- Energy Saving Technologies
- Slow Steaming
- Increase Capacity(Phase1)
- Hybrid Engine
- Electric Propulsion

**Increase Capacity (phase1)**

- NMRI ZEUS Project
- Hydro-Aero Technologies
- Zero Emission Ship

**CO₂ 65%**
**Conclusion**

- Energy saving strategy strongly depends on ship type and ship type
- More than two countermeasures will be required to obtain the target values
- The best solution can be obtained by taking mutual interaction into account
- It is very important to find cost effective counter measures which have a high potential for large energy saving capability above 10%

*Thank you for your attention*

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