CO2-index: matching the dredging industry’s needs with IMO legislation

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2 approaches to reduce CO$_2$ emissions

Market based

- Kyoto – Bali – Copenhagen
- Reduction ref. 1990:
  - 2020: -20%
  - 2050: -50%
- Effective increase fuel costs
  - 2009: 50 €/ton
  - 2020: 220 €/ton [Société Générale]
- Price increases if measures fail
- Common but differentiated principle: *will China pay less??*
Legislation based

- IMO: Energy Efficiency Design Index (EEDI)
  - often called: CO₂ index
  1. Take a formula
  2. Calculate EEDI
  3. Trendline: EEDI vs Deadweight
EEDI – IMO Approach

• Risks
  • What happens with ‘BAD’ ships?

• Objections
  • A formula does not cover the complex reality of many ship types, including all dredgers
  • IMO formula aims at reduction of installed power instead of reduction energy consumption
  • IMO formula is not correct!
IMO formula not correct?

\[
\left( \prod_{j=1}^{M} \left( \sum_{i=1}^{n_{ME}} SFC_{MEi} P_{MEi} C_{FMEi} \right) + P_{AE} C_{FAE} SFC_{AE} \right)
\]

\[
P_{AE(MCR_{ME}>10000kW)} = \left( 0.025 \cdot \sum_{i=1}^{n_{ME}} MCR_{MEi} \right) + 250
\]

\[
P_{AE(MCR_{ME}<10000kW)} = \left( 0.05 \cdot \sum_{i=1}^{n_{ME}} MCR_{MEi} \right)
\]

\[C \approx 3.1\]

\[SFC \approx 185 \text{ g / kWh (main engines)}\]

\[SFC \approx 220 \text{ g / kWh (small engines)}\]
So what does the formula say?

\[ 609.56 \times \text{[installed main engine power]} \]
\[ \text{EEDI} \approx \frac{\text{Deadweight} \times \text{speed}}{\text{[g / ton mile]}} \]

- **Numerator**
  - \( \text{CO}_2 \) – emissions: function of installed main power
- **Denominator:** **Benefit to Society**
  - Product of Deadweight & Speed
\[
EEDI = \left( \sum_{i=1}^{nME} C_{FMI} SFC_{MI} P_{MI} \right) + P_{AE} C_{FAE} SFC_{AE} \\
\text{Deadweight} \cdot V_{\text{ref}}
\]

- **Numerator**
  - \(\text{CO}_2\) – emissions
  - All main engines
    - Power
    - ‘A’ specific fuel consumption
    - Ratio \(\text{CO}_2\) emission to fuel consumption \((\approx 3.11)\)
  - Auxiliary engines
    - Power = 2.5 % ÷ 5 % of main engine power
    - ‘A’ specific fuel consumption
    - Ratio \(\text{CO}_2\) emission to fuel consumption \((\approx 3.11)\)
- **Denominator:** **Benefit to Society**
  - Product of Deadweight & Speed
Objections

• Formula focuses on reduction installed power
• Actual fuel consumption is not calculated
• Deadweight not an issue for cutter dredgers
• Speed not an issue for cutter dredgers
• Impact dredging cycle / conditions not taken into account
• Optimized / electrical design aggrieved with respect to diesel-direct design
Example:

Reference speed 12.8 knots
Deadweight 7500 tons
SFOC = 190 g / kWh (220 for aux engines)
Specific CO2 emissions 3.1 g / g Fuel

EEDI = 18.4 g CO2 / ton mile
Example: better

Reference speed 12.8 knots
Deadweight 7600 tons
SFOC = 190 g / kWh (220 for aux engines)
Specific CO2 emissions 3.1 g / g Fuel

EEDI = 19.8 g CO2 / ton mile
Example: all electric

Reference speed 12.8 knots
Deadweight 7500 tons
SFOC = 190 g / kWh (220 for aux engines)
Specific CO2 emissions 3.1 g / g Fuel

EEDI = 27.6 g CO2 / ton mile
Result: large scatter

\[ y = 221.09x^{0.2349} \]

\[ R^2 = 0.3011 \]
Dredgers were not the only ones...

Figure 11

Number of vessels: 43
Type: offshore supply + anchor handling

Picture obtained from D. Anink, CMTI
Conclusions IMO

- Large auxiliary consumers specifically mentioned
- Only 7 ship types included
- Only vessels > 15000 TDW included
- Possibility for industry to come up with own calculation methods
Main Question

Does the dredging industry want

‘an index’

or

‘a calculation method’?
Our Question

*How does such a* 

*calculation method / index*

*look?*
Statement

An EEDI for the dredging industry should be a practical performance indicator that rewards energetic efficient dredging.
TSHD

Dredging cycle, main parts:

1. Sailing empty to the winning location
2. Dredging
3. Sailing fully laden to the discharge location
4. Discharging

EEDI should incorporate energy consumption in all 4 phases
### CO2 emission during dredging

<table>
<thead>
<tr>
<th></th>
<th>( P_{\text{dredging}} )</th>
<th>( \text{kW} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average power consumption</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Specific CO2 emission</td>
<td>( f_{\text{dredging}} )</td>
<td>( \text{g} / \text{kWh} )</td>
</tr>
<tr>
<td>Dredging time</td>
<td>( t_{\text{dredging}} )</td>
<td>( \text{hours} )</td>
</tr>
<tr>
<td>CO2 emission dredging</td>
<td>( P_{\text{dredging}} \times f_{\text{dredging}} \times t_{\text{dredging}} )</td>
<td>( \text{g} )</td>
</tr>
</tbody>
</table>
## Total dredging cycle

<table>
<thead>
<tr>
<th>CO2 emission</th>
<th>Formula</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>sailing empty</td>
<td>$P_{\text{empty}} \times f_{\text{empty}} \times t_{\text{empty}}$</td>
<td>g</td>
</tr>
<tr>
<td>dredging</td>
<td>$P_{\text{dredenna}} \times f_{\text{dredenna}} \times t_{\text{dredenna}}$</td>
<td>g</td>
</tr>
<tr>
<td>sailing loaded</td>
<td>$P_{\text{loaded}} \times f_{\text{loaded}} \times t_{\text{loaded}}$</td>
<td>g</td>
</tr>
<tr>
<td>discharging</td>
<td>$P_{\text{discharging}} \times f_{\text{discharging}} \times t_{\text{discharging}}$</td>
<td>g</td>
</tr>
</tbody>
</table>
Mission of a Trailing Suction Hopper Dredger

Transport a mass of sand
over a certain distance
in a certain amount of time

Deadweight is reasonable

Distance? Sailing Distance

Time? Cycle Time

Reference Speed? Sailing Distance

Cycle Time
Definitions required

- What speed?  – sailing distance / cycle time
- Soil type  – ‘medium fine sand’
- Dredging depth  – 25 m
- Breakdown discharge
  - Dumping  - 50 %  - 50 %
  - Rainbowing  - 30 %  or  - 50 %
  - Shore pumping  - 20%  - 0%
- Sailing distance?  – one hour sailing
Conclusions

Market based approach likely will influence dredging business

EEDI:

Pro’s

• Correctly reflects ‘average’ energy consumption => CO2 emissions

Contra’s

• Very complex
• ‘A standard dredging cycle’ never occurs
Thank you