“Sustainable freight transport in support of the 2030 Agenda for Sustainable Development”

Potential GHG Reduction Pathways for International Shipping

by

Tristan Smith
Reader, UCL Energy Institute
Director, UMAS

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Potential GHG Reduction Pathways for International Shipping

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Reader, UCL Energy Institute
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Contents

• Possible scenarios for CO2, trade and fuels
• Estimates of CO2 abatement costs
• Drivers of CO2 abatement costs
Whilst supporting growth in trade

= high rates of carbon intensity reduction

Fuel Mix – possible scenarios for 1.5 and 2 degrees

Image Source: Shipping In Changing Climates
Hydrogen

Image source: bairdmaritime.com

Biofuels

Image source: Boskalis and GoodFuels
Wingsail technology (bound4blue) - built in Peru

Image source: bound4blue

China launches world’s first all-electric cargo ship

Image source: Chinanews.com
High renewable fuel price - $60/MWh

Low renewable fuel price - $30/MWh

ISWG 3-3
Renewable electricity at $30/MWh?

Auction prices $/MWh

2016:
UAE - 24
Morocco - 30
Chile - 29
Peru - 37
Mexico - 32

2017:
Saudi Arabia - 18
Mexico - 18
Chile - 21

Many countries have the potential for renewable fuel provision

Shipping – 20-40EJ/yr

IEA Renewable Fuels
How might this relate to historic costs/prices?

Effective fuel price is lower because of efficiency increases

Concluding remarks - technology

- For almost any rate of decarbonisation, zero emission fuels for ships will need to be entering the market in 10-15 year's time
- Batteries look challenging for deep sea applications
- But several liquid renewable fuels (bio, hydrogen, ammonia) have potential
- The cost of decarbonisation is closely linked to the cost of zero emission fuels and renewable electricity prices
- Any increase in energy efficiency reduces the impact on transport cost of fuel/energy cost
- A lot of work is already underway in shipping, and can also be leveraged from the wider economy's decarbonisation efforts
Questions?

Thank you for your attention

Backup material…
What are the capital cost implications?

![Graph showing percentage of capital cost newbuild vs. cost implications for different vehicles.]

Lloyd's Register and UMAS Electric H2+FC Hybrid H2+ICE NH3+F ICE NH3+C

What are the options?

<table>
<thead>
<tr>
<th>Operative speed</th>
<th>2008 spec</th>
<th>Max spec (no wind)</th>
<th>Max spec wind</th>
<th>Max spec wind + 50% fuel carbon factor reduction</th>
<th>Max spec wind + 75% fuel carbon factor reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Panamax bulk carrier</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>4.5</td>
<td>25%</td>
<td>29%</td>
<td>19%</td>
<td>10%</td>
<td>5%</td>
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<tr>
<td>6.0</td>
<td>31%</td>
<td>32%</td>
<td>21%</td>
<td>10%</td>
<td>5%</td>
</tr>
<tr>
<td>8.9</td>
<td>52%</td>
<td>49%</td>
<td>33%</td>
<td>16%</td>
<td>8%</td>
</tr>
<tr>
<td>9.7</td>
<td>60%</td>
<td>55%</td>
<td>38%</td>
<td>19%</td>
<td>9%</td>
</tr>
<tr>
<td>11.3</td>
<td>77%</td>
<td>69%</td>
<td>49%</td>
<td>24%</td>
<td>12%</td>
</tr>
<tr>
<td>11.7</td>
<td>83%</td>
<td>74%</td>
<td>52%</td>
<td>26%</td>
<td>13%</td>
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<tr>
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<td>86%</td>
<td>76%</td>
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<tr>
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<tr>
<td>15.0</td>
<td>158%</td>
<td>127%</td>
<td>88%</td>
<td>44%</td>
<td>22%</td>
</tr>
</tbody>
</table>

Yellow = 30-70% of 2008 baseline EEOI
Green < 30% of 2008 baseline EEOI
$fuel/tnm is lower, because of increased energy efficiency
### 7 Zero-emission technologies & 5 Ships

<table>
<thead>
<tr>
<th>Electric</th>
<th>Hybrid hydrogen</th>
<th>Hydrogen fuel cell</th>
<th>Hydrogen + HFO</th>
<th>Ammonia fuel cell</th>
<th>Ammonia + HFO</th>
<th>Biofuel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity</td>
<td>Hydrogen storage</td>
<td>Hydrogen storage</td>
<td>Hydrogen storage</td>
<td>Ammonia storage</td>
<td>Ammonia storage</td>
<td>Biofuel tank</td>
</tr>
<tr>
<td>Batteries</td>
<td>Batteries</td>
<td>Fuel cell</td>
<td>‘Emergency’ HFO tank</td>
<td>Reformer</td>
<td>‘Emergency’ HFO tank</td>
<td>Internal combustion engine</td>
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<tr>
<td>Electric motor</td>
<td>Electric motor</td>
<td>Electric motor</td>
<td>Dual fuel internal combustion engine</td>
<td>Electric motor</td>
<td>Dual fuel internal combustion engine</td>
<td></td>
</tr>
</tbody>
</table>

### How do costs change relative to a conventional ship (9000TEU container)?

<table>
<thead>
<tr>
<th>Technology</th>
<th>Extra Capital main machinery</th>
<th>Extra Capital storage</th>
<th>Extra Voyage Cost</th>
<th>Revenue lost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrogen Fuel Cells</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>H2 + HFO ICE</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ammonia Fuel Cells</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Ammonia + HFO ICE</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Biofuel</td>
<td></td>
<td></td>
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