Electrofuels for maritime transportation

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Shipping, the ‘greenest’ mode of transport?

Source: MEPC 68 Inf. 24
Shipping could reach 10-15% of the total CO$_2$ emissions in 2050

IMO signs intent to reduce emissions to at least 50% of 2008 levels by 2050
The initial IMO GHG strategy

.1 carbon intensity of the ship to decline through implementation of further phases of the energy efficiency design index (EEDI) for new ships
to review with the aim to strengthen the energy efficiency design requirements for ships with the percentage improvement for each phase to be determined for each ship type, as appropriate;

.2 carbon intensity of international shipping to decline
to reduce CO₂ emissions per transport work, as an average across international shipping, by at least 40% by 2030, pursuing efforts towards 70% by 2050, compared to 2008; and

.3 GHG emissions from international shipping to peak and decline
to peak GHG emissions from international shipping as soon as possible and to reduce the total annual GHG emissions by at least 50% by 2050 compared to 2008 whilst pursuing efforts towards phasing them out as called for in the Vision as a point on a pathway of CO₂ emissions reduction consistent with the Paris Agreement temperature goals.

Source: IMO MEPC 72
A range of potential operational and technical interventions

**Operational**
- Speed – “slow steaming”
- Rudder Bulb
- Preswirl Stator Duct
- Trim and Draught Optimisation
- Vane Wheels
- Contra-rotating Propeller
- Tip Loaded Propeller
- Stern Flaps
- Biocide Hull Coating
- Foul Release Hull Coating
- Steam WHR
- Organic Rankine Cycle WHR
- Engine Tuning
- Engine Derating
- Common Rail
- Autopilot Upgrade
- Air lubrication
- Wind assistance

**Technical**
- Energy efficiency technologies
- Engines and fuels
- 2 /4 strokes
- LNG/BioLNG
- Fuel cells
- Biofuels/ Bio-methanol
- Electric motor
- Hydrogen
- Gas turbine
- Ammonia
- Batteries/Electricity
Estimated CO$_2$ intensity pathways

Historic trend (estimated from UNCTAD and IMO data)

- **BAU**
- CO$_2$ max 2008
- CO$_2$ zero in 2075, start 2023
- CO$_2$ zero in 2050, start reducing 2025
- CO$_2$ 50% reduction in 2060, start reducing 2020
- CO$_2$ 70% reduction in 2050, start reducing 2025
- CO$_2$ 50% reduction in 2060, start reducing 2050

- Average economic lifespan of ships today
- 75-100% decrease in fleet average carbon intensity
- Very low / zero CO$_2$ fuels
- Slow steaming, increase ship size, increased attention to efficiency in design & operation
- IMO signs intent to reduce emissions to at least 50% of 2008 levels by 2050

In 2030 Zero Emissions Vessels will need to enter in the fleet
Fuel mix for a 2 degree compatible pathway

-The fuel mix progresses beyond FO/MDO with a gradual increase of biofuel used in blends.

-LNG is taking up and then progressively, a quantity of Hydrogen.

-Hydrogen is used as a proxy for renewable fuels generally (so this could include renewable methanol and ammonia).
Shell and ITM 10MW Electrolyser - online from 2020

“The Rhineland 10 MW system will be the largest PEM electrolyser in the world. It represents the maturing of PEM technology for large scale, industrial applications.”

Graham Cooley CEO ITM
Hydroville
The price of renewable electricity drives the price of renewable marine fuel

<table>
<thead>
<tr>
<th>Electricity price ($/MWh)</th>
<th>Hyrdogen price ($/t)</th>
<th>Energy equivalent HFO/MDO price ($/t)</th>
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<tbody>
<tr>
<td>$60/MWh</td>
<td>$3000/t</td>
<td>$945/t</td>
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<tr>
<td>$30/MWh</td>
<td>$1700/t</td>
<td>$540/t</td>
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Low renewable fuel price

Penetration of zero emission fuel

Cost of carbon per ton of CO₂ controlled

Abatement capacity relative to 2008 CO₂ emissions

$100/t

ISWG 3-3
An economic evaluation of Zero Emissions Vessels

- Profitability
  - Revenue \( vc \)
  - Voyage Cost
    - Sfc, FC
    - Dwt loss
    - Fuel storage volumetric energy density
    - Efficiency
  - CAPEX, OPEX\( t \)
    - Unit cost main engine
    - Unit cost storage system
    - Energy stored on board MWh (range)

- Biofuel
- Ammonia + HFO
- Ammonia fuel cell
- Hydrogen + HFO
- Hydrogen fuel cell
- Hybrid hydrogen
- Electric
Cost changes

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

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<tr>
<th>Fuel Type</th>
<th>-1.2</th>
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<th>-0.6</th>
<th>-0.4</th>
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<td>Hybrid (H2+Batt.)</td>
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- Extra Capital main machinery
- Extra Capital storage
- Extra Voyage Cost
- Revenue lost
Green Ammonia would be competitive vs. biofuels if electricity is below 0.05 USD/kwh

Zoom on bulk carriers cost – sensitivity on electricity cost

**Voyage cost – 2030**
Million USD

**Total cost – 2030**
Million USD

Hydrogen and ammonia emit less than HFO if the carbon intensity of electricity is below 200 gCO2/kwh

Conclusions and further research

• Narrow down the options with the associated pathways for implementation and adoption
• Understanding of how the shipping industry could cooperate with the energy sector, trying to find overlaps with other sectors needs of storage and demand management requirements.
• How the development of the candidate future marines fuels infrastructure would need to be coordinated with the growth and development of a compatible fleet.
• Newbuilds only, or newbuilds and retrofits? One winner for all ship types?
• Role of existing, interim and transition technologies
Thank you

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