Ammonia & maritime decarbonization

Dr. Tue Johannessen
Head of Maritime Application and Viability
Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping

Founded in 2020 with initial base funding of DKK 400mn (approx. US$ 64 mn) by A.P. Møller Foundation

Located in Copenhagen: a central team with a global outreach

Registered as a not-for-profit commercial foundation with a charitable purpose. Self owned entity.

Neutral and open platform for collaboration across the value chain, with an anticipated growing partnership base

Established by seven founding partners from across the ship-powering supply chain, with commitment to contribute resources

Our Guiding Principles

• We are independent and neutral, aiming for objectivity through transparency, facts and scientific methods
• We are open-minded to and unbiased about new ideas
• We enable and inspire leadership for the industry
• We believe in partnering and collaboration
• We are tenacious due to our sense of urgency
• We build confidence and trust
• We show the world it is possible – and how
Many industry projections – clarity of transformation path(s) needed

**DNV GL Energy Transition Outlook**
- 60% Low carbon fuels
- 30% LNG / 10% Fuel Oil

**ABS sustainability Outlook**
- 40% Fuel Oil / 10% LNG / 35% Ammonia + H2 /
- 7% Biofuels / 7% Methanol

**IEA**
- 50% Fuel Oil / 25% Ammonia + H2 / 20% Biofuels
(Total consumption 210 MTOE)
The scope of the challenge of maritime decarbonization

**Complexity**
- A global industry
- Approx. 70,000 vessels
- Long lifetime of assets
- Hard-to-abate sector

**Scale**
- Replace +250 million ton HFO/year
- Massive scale-up of renewable power and green fuel production
- Growth of infrastructure; bunkering

**Technical feasibility: P2X2P**
- Maturation and implementation of new end-to-end systems
- On-shore: From feedstock to “X”
- Vessels: Energy conversion, efficiency and emissions.
- Safety & regulation

### Graph
- Annual consumption in maritime sector
- Current global production
- Methanol needed for 100% maritime
- NH₃ needed for 100% maritime

### Table

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<thead>
<tr>
<th>Fuel</th>
<th>Current global production</th>
<th>Methanol production</th>
<th>NH₃ needed for 100% maritime</th>
<th>HFO MT/year</th>
<th>Annual consumption in maritime sector</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methanol</td>
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**Methanol production MT/year**

**Ammonia production MT/year**

**HFO MT/year**

**NH₃ needed for 100% maritime**

**Methanol production MT/year**

**NH₃ needed for 100% maritime**
Net-zero pathways & the role of the new center

End-to-end efficiency is key
- Indirect electrification
- Impact of the choice of “X”
- Reduces losses in the chain
- Reduce CAPEX in all process steps

The role of the new center...
- Structured R&D: Clarity & overview
- Comparison of possible future solutions using consistent frameworks, data and methods,

... to accelerate a transition
- Commercial viability vs. status quo
- Create level playing field
- Regulatory framework and financial instruments

H₂? NH₃? CH₃OH?
We apply a structured approach to technical- and commercial feasibility assessments.

The Center will create overviews and be involved in a portfolio of R&D- and demonstration projects to de-risk pathways with development needs for each vessel segment.
Estimation from Ricardo: eFuels for shipping by 2050

- Cost of CO₂ (= energy for capture) is critical for the methanol pathway
- Co-location of H₂ and biogenic CO₂?
- Long-distance transport of ‘hydrogen energy’ is more feasible as ammonia∗

* Assuming growth at the average of the rates forecast in the Third IMO GHG Study

Viewed at a global scale, the land area required is not excessive – especially because solar plants will be distributed around the world


Normalized renewable energy requirement (Ricardo)
Top-down overview to facilitate R&D focus
Cost, losses, decarbonization potential, life-cycle-analysis, safety, TRL

Efficiency and cost of renewable electricity for eFuels is closely linked to vessel OPEX

End-to-end efficiency and LCA to be developed for all pathways → Impact on where to put industry development effort
For same Power-to-X-to-Power path:
Example of individual links in the chain contributing with significant end-to-end impact.

Low-temperature electrolysis and ICE

Example: High-temperature electrolysis and SOFC
With future technology “bricks”, we could approach 45% RTE
Thank you for your attention

A 10% improvement in “wind-to-wake” efficiency can reduce by ~20,000 the number of 10 MW off-shore wind turbines required for maritime P2X

Contact:
e: tue.johannessen@zerocarbonshipping.com
m: +45 22 54 62 42
w: zerocarbonshipping.com