Ammonia

Could it replace HFO/LSFO?

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What will be discussed?

- **Classification society overview of the adoption pathways of new maritime fuel**
  - Overview: Alterations
  - Overview: Zero-carbon fuels

- **Ammonia as a fuel**
  - Fuel characteristics
  - Safety and Risks
  - Hurdles & Actions to be taken
  - Decarbonization

- **Conclusion**
  - Lloyd’s Register & Sustainability
Overview

To achieve an absolute reduction in GHG of at least 50% by 2050

- This equates to around 85% reduction in carbon intensity
- Efficiency and renewables are not enough to reach the goal
- Zero-emission vessels need to be entering the fleet from 2030
- This will not happen without policy intervention and a fundamental change to the incentives scheme

Source:
Nick Ash - Ricardo Energy & Environment
Tim Scarbrough - Ricardo Energy & Environment
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Overview: Alterations

**Up to 2030s**

2020 – 2030 is the most significant decade stressing the urgency for early action.

- A significant change in the energy supply market
- Full-scale prototypes and pilots now
- Easy to store zero-carbon fuels may be more attractive now
- Batteries play an important role
- Development of policy, standards and rules
- First adopters driven by consumer pressure

**The 2030s**

Scaling up of zero-carbon fuels.

- A clear signal on the evolution of the energy system
- Availability of cheap renewable electricity
- Consolidation of dominant technologies onboard
- Price, machinery costs and revenue loss will be better understood
- Fundamental change to ship’s operating profile
- LNG assets will need to find a way to remain competitive

**Up to 2050s**

May experience more than one dramatic fuel switch.

- The likelihood is very difficult to assess
- A growing share of biofuels in the 2030s
- A major shift to electro-fuels in the 2030s & 2040s
- Consolidation of the market with an end fuel mix dominated by one family of fuels
## Overview: Zero Carbon Fuels

To achieve an absolute reduction in GHG of at least 50% by 2050

<table>
<thead>
<tr>
<th>Energy source</th>
<th>Methanol</th>
<th>Gas oil</th>
<th>Hydrogen</th>
<th>Ammonia</th>
<th>Electricity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural gas with CCS</td>
<td></td>
<td></td>
<td>NG-H₂</td>
<td>NG-NH₃</td>
<td></td>
</tr>
<tr>
<td>Biomass</td>
<td>bio-methanol</td>
<td>bio-gas oil</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Renewable electricity</td>
<td>e-methanol</td>
<td>e-gas oil</td>
<td>e-H₂</td>
<td>e-NH₃</td>
<td>batteries</td>
</tr>
</tbody>
</table>
Ammonia (NH₃): Fuel Characteristics

- Ammonia is a colorless, flammable, highly toxic and corrosive gas
- Flame speed is low (0.07 m/s)
- Formation of NOx during consumption
- Highly soluble in water
- Ammonia has low flammability (15-28%)
- Latent heat of evaporation is high, meaning no reliquification would be required
- Liquification at -34°C
Ammonia (NH₃): Safety & Risks

1. Non-highly flammable
   - HAZARD PICTOGRAM REQUIRED: No

2. Toxic when inhaled
   - HAZARD PICTOGRAM REQUIRED: Yes

3. Corrosive when handled
   - HAZARD PICTOGRAM REQUIRED: Yes

4. Gas explosive (when stored in confined spaces)
   - HAZARD PICTOGRAM REQUIRED: Yes

5. High mortality rate when spilt in water or released in air
   - HAZARD PICTOGRAM REQUIRED: Yes
Hurdles

- **Regulatory – IMO**
  Toxic cargoes not permitted to be used as fuel

- **Bunkering**
  Has not been bunkered before

- **Consumers**
  Machinery makers have not reached the stage of complying with ammonia as a fuel

Actions to be taken

- Amendments to the IGC code following support from administrations

- Bunkering procedures and fuel quality standards to be adopted

- Makers need to adopt (re-design) their equipment to accommodate ammonia as a fuel
Ammonia (NH₃): Decarbonization

Bunkering
- No conversion

Vessel Storage
- Storage as a refrigerated liquid

Processing
- Gasification and ammonia reformation

Propulsion
- Hydrogen polymer electrolyte membrane fuel cell and electric motor
- Dual fuel internal combustion engine
- Direct ammonia solid oxide fuel cell and electric motor
Conclusion

- Are there risks?
- Are they manageable?
- Do we have the regulatory framework as well as the technology to achieve the required results?

Is it worth it?
Conclusion: Lloyd’s Register and Sustainability

- Aim to help our clients meet their own sustainability challenges
- Demonstrate our own commitment to working towards a cleaner, safer and more sustainable world.
- Stakeholders are investing and innovating for a sustainable future
- No single government, nor any one sector, can make the changes alone
- Long-term operations

What we do today will have an impact tomorrow.

We should all work together towards it!
Thank you

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