Ammonia as Marine Fuel
NH3 Fuel Conference
Niels de Vries - 31st Oct 2018
C-Job Naval Architects

• Largest independent ship design & engineering company in the Netherlands
• A passion for everything that floats
• 4 offices: Hoofddorp, Heervenveen, Rotterdam and Nikolayev
• >140 in-house engineers employed

• Activities
  • Naval Architecture
  • Mechanical Engineering
  • Structural Engineering
  • Interior Engineering
  • Building Supervision
Emissions Maritime Industry

- International shipping responsible for +/- 90% of the world trade
- Shipping and aviation not included in Paris agreement
Regulations

- SOx: Sulphur cap
  - 0.5% Global 2020
  - 0.1% ECA
- NOx: IMO Tier III (Global pending)
  - Tier II Global
  - Tier III ECA
- CO2: Energy Efficiency Design Index

ECA: Environmental Control Area
Natural Gas & Exhaust Gas Treatment Movement
IMO Goals

• IMO: reducing overall carbon intensity of the cargo transported per kilometer by at least:
  • 40% by 2030
  • 70% by 2050
  (compared to 2008)

• IMO: reduce total annual GHG emissions by at least 50% by 2050 (compared to 2008)
  • Pursuing efforts towards phasing them out entirely
Renewable Fuel Momentum

- Exhaust gas treatment and application of natural gas insufficient to meet IMO goals
- Upcoming momentum for renewable fuels
- Challenges
  - Capacity renewable energy production
  - Economic viability
    - Ship & Cargo owner
    - Emission taxation
# Renewable Fuel Options

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<td>Marine Gas Oil (reference)</td>
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<td>36.6</td>
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<td>Liquid Methane</td>
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<td>Ethanol</td>
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<td>21.1</td>
<td>3.6</td>
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<td>Methanol</td>
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<tr>
<td>Liquid Ammonia</td>
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<td>12.7</td>
<td>1.8</td>
<td>1 or 10</td>
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- Ammonia balanced solution
  - Volumetric energy density
  - Renewable synthetic production cost
Marine Power Generation

- Large scale
- Marine environment
- Dynamic behaviour/Load response
  - Experience natural gas
- Part load conditions
- Fuel direct & Fuel electric configurations
- Size, Mass, Efficiency and Emissions
Ammonia Power Generation

- **Steam Turbine**
  - Ammonia
  - Ammonia dual-fuel

- **Gas Turbine**
  - Ammonia
  - Ammonia dual-fuel

- **Internal Combustion Engine**
  - Compression ignition
  - Spark ignition
  - Proton Exchange Membrane
  - Hydrogen (Cracking & Purification)

- **Fuel Cell**
  - Alkaline
  - Solid Oxide
  - Hydrogen (Cracking)

- **Proton Exchange Membrane**
  - Ammonia

- **Hydrogen (Cracking & Purification)**
  - Ammonia dual-fuel

- **Alkaline**
  - Ammonia dual-fuel

- **Solid Oxide**
  - Ammonia