Distribution of Ammonia as an Energy Carrier

Engineering, procurement, consulting and construction company
100-year legacy of sustainably solving global infrastructure challenges
History of successful projects
Committed to sustainability

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Existing Ammonia Infrastructure

- Annual ammonia production over 180 million tons
- Global maritime trade of 18 million ton/yr
- Over 120 ports
- 170 ships
- Significant pipelines in USA, Russia, and Ukraine
Ammonia Infrastructure (transportation, storage, export)

- Ammonia Plant (2600 MTPD)
- Storage Tank: 2x60,000 Tonne (2 x 90,000 m³)
- Ammonia Pump
- BOG System
- Ammonia heater
- PUMP STATION
- Pipeline: 400#, 100 km, 12"
  Operating Pressure: 900 psig
- Ammonia Carrier (80,000 m³) (Once Per Week)

- 1200 kW
- 7,800 Tonne/Day
## Infrastructure Basics for “Hypothetical” Infrastructure

<table>
<thead>
<tr>
<th>Item</th>
<th>Specification</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shipment Capacity</td>
<td>50,000 Tonne (80,000 m$^3$)</td>
<td>Once per week</td>
</tr>
<tr>
<td>Export facility</td>
<td>2 x 60,000 Tonne (Ammonia Storage Tank)</td>
<td></td>
</tr>
<tr>
<td>Pipeline</td>
<td>12”, 5LX, Gr X46, 400# Underground</td>
<td>Construction cost depends on the pipeline profile, number of road/river crossing, urban, rural, etc</td>
</tr>
<tr>
<td>Ammonia Pump Station</td>
<td>7,800 Tonne/Day, 1200 kW</td>
<td>Every 100 km in flat area</td>
</tr>
<tr>
<td>Equivalent power generated</td>
<td>1200 MW</td>
<td>Power generation plant efficiency: 60%</td>
</tr>
</tbody>
</table>
# Transmission Energy Sources Comparison

<table>
<thead>
<tr>
<th>Product</th>
<th>Boiling Point °F (°C)</th>
<th>Density (at 900 psig, 60°F) lb/ft³ (kg/m³)</th>
<th>Energy Density (at 900 psig, 60°F) BTU/ft³ (kJ/m³)</th>
<th>Specific Energy BTU/lb (kJ/Kg)</th>
<th>Mass Flow Rate (lb/hr) (kg/hr)</th>
<th>Pipeline size (in)</th>
<th>Power Required HP (kW)</th>
<th>Relative Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Gas</td>
<td>-260°F @ 0 psig (-160°C @ 0 barg)</td>
<td>3.39 (54.3)</td>
<td>75,600 (2,814,000)</td>
<td>22,300 (51,820)</td>
<td>310,400 (140,800)</td>
<td>16</td>
<td>4,820 (3,600)</td>
<td>Base</td>
</tr>
<tr>
<td>Ammonia</td>
<td>84°F @ 150 psig (29°C @ 62 barg)</td>
<td>38.5 (616)</td>
<td>372,700 (13,860,000)</td>
<td>9,680 (22,500)</td>
<td>716,500 (325,000)</td>
<td>12</td>
<td>1,610 (1,200)</td>
<td>0.5</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>-423°F @ 0 psig (-253°C @ 0 barg)</td>
<td>0.32 (5.16)</td>
<td>19,360 (721,110)</td>
<td>60,130 (139,750)</td>
<td>113,650 (51,550)</td>
<td>18</td>
<td>17,850 (13,320)</td>
<td>2.2</td>
</tr>
</tbody>
</table>

1. Equivalent to 1200 MW power generation fuel supply at 60% efficiency
2. Based on 100 km pipeline
3. All heating values are higher heating values
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