Methanol plotting a course to low carbon pathways

Lloyds Register Future Fuels Workshop
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Methanol is simplest of alcohols

- Simple molecule rich in hydrogen, with only a single carbon bond
- Clear and colourless liquid at room temperature and ambient pressure
- Also known as “wood alcohol,” methanol can be produced from a wide range of feedstocks

Formula: CH$_3$OH
Density: 0.792 g.cm$^{-3}$
Molar mass: 32.04 g mol$^{-1}$
Appearance: colourless liquid
Broad feedstock range, many applications

Feedstock:
- Natural gas (~65%)
- Coal (~35%)
- Biomass & renewables (<1%)

Conversion:

Derivatives:
- Formaldehyde 27%
- Acetic acid 9%
- Gasoline blending 9%
- MTBE 8%
- MTMA 2%
- MTO 18%
- MDE 8%
- Biodiesel 3%
- Methanolamines 3%
- Solvents 4%
- Chloromethanes 2%
- Other 7%

Products:

Markets:
- Appliances
- Automotive
- Construction
- Electronics
- Fuel
- Paint
- Pharma
- Marine

Source: IHS
Increasing use as a marine fuel

### COMBUSTION ENGINE
- 7x +4x chemical tankers
- 1x ROPAX ferry
- 1x Pilot boat
- MOL, WL, Marininvest
- Stena Line
- 2 stroke MAN
- 4 stroke Wärtsila
- new build
- retrofit

### FUEL CELL
- 2x Tourist boat
- 1x Ferry
- Swedish Maritime Admin.
- Innogy, Konstanz Uni
- high speed Scania, Volvo, a.o.
- Serenergy fuel cell stacks
- ‘retrofit’
- retrofit
- retrofit

### PROJECT and R&D
- Cruise ships, fishing boat, barge, dredge, a.o.
- Billion Miles, Summeth/Martec, HyMeth Ship, Lean Ships, Methaship, GMM, a.o.
- SI hybrid, dual fuel, etc.
- new build & retrofit
Toward a low carbon shipping industry

Potential future propulsions solution should ideally be:

- SUSTAINABLE
- SCALEABLE
- STOREABLE
Low carbon pathways exist

Source: The Methanol Institute and Qafq
## Reduces exhaust emissions

<table>
<thead>
<tr>
<th>Emission</th>
<th>Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>SO\textsubscript{x} \textsuperscript{[a]}</td>
<td>99% &lt;</td>
</tr>
<tr>
<td>NO\textsubscript{x} \textsuperscript{[a]}</td>
<td>60% &lt;</td>
</tr>
<tr>
<td>Particulate matter \textsuperscript{[a]}</td>
<td>95% &lt;</td>
</tr>
<tr>
<td>CO\textsubscript{2} (TtW) \textsuperscript{[b]}</td>
<td>17% &lt;</td>
</tr>
</tbody>
</table>

\textsuperscript{[a]} Source: Stena Line

\textsuperscript{[b]} Source: Ford, CO\textsubscript{2} benchmark compared to gasoline

**Assumptions:**

- same mileage, impact due to stoichiometry and heating value
## Putting things in perspective

**LC50 - Lethal dose for fish**

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td></td>
<td>8.2 mg/l</td>
<td>49.9 mg/l</td>
<td>65 mg/l</td>
<td>79 mg/l</td>
<td>15.400 mg/l</td>
</tr>
</tbody>
</table>

**Sources:**

[1] Petrobras/Statoil ASA, Safety Data Sheet, ECHA registration dossier Gasoline
[4] GKG/ A/S Dansk Shell, Safety Data Sheet
## Safer for the environment

<table>
<thead>
<tr>
<th></th>
<th>Maritime accident</th>
<th>Maritime accident</th>
<th>Simulation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ship</strong></td>
<td>Erika</td>
<td>Tanio</td>
<td>-</td>
</tr>
<tr>
<td><strong>Fuel</strong></td>
<td>Heavy Fuel Oil</td>
<td>Heavy Fuel Oil</td>
<td>Methanol</td>
</tr>
<tr>
<td><strong>Released amount</strong></td>
<td>19 000 t</td>
<td>13 500 t</td>
<td>10 000 t</td>
</tr>
<tr>
<td><strong>Affected coastline</strong></td>
<td>400 km</td>
<td>200 km</td>
<td>0 km</td>
</tr>
<tr>
<td><strong>Total damage:</strong></td>
<td>$914M</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Cleaning</strong></td>
<td>$100M</td>
<td>$50M</td>
<td>$0</td>
</tr>
<tr>
<td><strong>Fishing industry</strong></td>
<td>$98.3M</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Tourist industry</strong></td>
<td>$400-500M</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Claim for damages</strong></td>
<td>$120M</td>
<td>$17M</td>
<td>-</td>
</tr>
<tr>
<td><strong>Killed birds</strong></td>
<td>≈ 60,000</td>
<td>≈ 40,000</td>
<td>-&gt; 0</td>
</tr>
</tbody>
</table>

Source: MethaShip
Options to scale and reduce carbon

- Fossil
- Bio-methane
- MSW
- PtX
Methanol is a great energy carrier

H₂: very bad at storing H₂

[Bar chart showing the mass of hydrogen per m³ of compound and the percentage increase over liquid hydrogen for various substances, including Hydrogen, Ammonia, Methane, Methanol, Ethanol, Isopropanol, Isobutanol, Dimethyl Ether, MTBE, ETBE, n-Heptane, Isooctane, Dimethylfuran, and Water.]
Available around the world

Methanol storage capacity estimates (thousand tons)
Methanol...

- is plentiful, available globally
- can be made 100% renewable
- runs well in existing engine technology and has potential for further optimization
- complies with increasingly stringent emission reduction regulations
- requires only minor modifications to current bunkering infrastructure
- is biodegradable!
- safe handling can rely on long history and experience in shipping and industry
- cost are relatively modest and drop as experience mounts
- shows slight regional price variation
A global industry association

- First formed in 1989, the Methanol Institute (MI) serves as the trade association for the global methanol industry.

- MI represents the world’s leading methanol producers, distributors and technology companies from offices around the world.

MI provides value to its members by:
- Ensuring safe handling of methanol and its derivatives.
- Promoting methanol growth by furthering methanol as an essential chemical commodity and an emerging source of clean and renewable energy.
- Influencing global regulatory and public policy initiatives that impact the methanol industry.
2019 members

Tier 1

Tier 2

Tier 3

Tier 4

METHANOL INSTITUTE