Methanol for Marine Applications: A Practical Clean-Burning Marine Fuel Alternative

Gregory Dolan, CEO
Methanol Institute
CMA Shipping 2016
Stamford – 21 March 2017
WHO WE ARE
Global methanol representation

- The Methanol Institute (MI) was first formed in 1989 to represent US methanol producers in Washington.

- 28 years later, MI is truly a global trade association supporting the expansion of the methanol industry in every corner of the world from offices in:

  Singapore | Washington | Brussels | Beijing
02
TRANSITION TO ENERGY RESOURCE
Alternative Fuel Drivers

✓ **Scale**: The feedstock base needs to be large enough to support global transportation market.

✓ **Sustainability**: There needs to be a viable pathway to low- & no-carbon transport, while reducing smog.

✓ **Subsidy**: Can’t rely on government support forever, so someone needs to make money.

✓ **Seamless**: Keep the customer in mind.

✓ **Methanol**: Checks all the drivers!
Feedstock: Abundant/Sustainable

Market: Large/Diverse

Plastic
Paint
Glue
And much more

M3
M15
M85
M100
GEM
MTBE
Biodiesel
DME
Marine
Fuel cell
MTG
Many pathways exist already

Biomass (wood, MSW, a.o.)

- Gasification
- Electrolysis

(Renewable) electricity

CO₂

Carbon capture

Fermentation

- Biogas
- Bio-methane

Reformer

- Syngas

Syngas

H₂

Reactor

- BIO-METHANOL
- RENEWABLE METHANOL
- LOW CARBON METHANOL

Methane
## Project overview

<table>
<thead>
<tr>
<th>Status</th>
<th>Company</th>
<th>Country</th>
<th>Feedstock</th>
<th>Product</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>COMMERCIAL</strong></td>
<td>BioMCN</td>
<td>The Netherlands</td>
<td>Bio-methane</td>
<td>Bio-methanol</td>
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<tr>
<td></td>
<td>CRI</td>
<td>Iceland</td>
<td>Renewable electricity</td>
<td>Renewable methanol</td>
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<tr>
<td></td>
<td>Enerkem</td>
<td>Canada</td>
<td>MSW</td>
<td>Bio-methanol</td>
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<tr>
<td></td>
<td>Methanex</td>
<td>Canada</td>
<td>CO₂</td>
<td>Low carbon methanol</td>
</tr>
<tr>
<td></td>
<td>Oberon</td>
<td>USA</td>
<td>Biogas</td>
<td>Bio-methanol and DME</td>
</tr>
<tr>
<td></td>
<td>QAFaQ</td>
<td>Qatar</td>
<td>CO₂</td>
<td>Low carbon methanol</td>
</tr>
<tr>
<td><strong>R&amp;D and FEASIBILITY</strong></td>
<td>BKW</td>
<td>Switzerland</td>
<td>Renewable electricity</td>
<td>Renewable methanol</td>
</tr>
<tr>
<td></td>
<td>Enerkem</td>
<td>The Netherlands</td>
<td>MSW</td>
<td>Bio-methanol</td>
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<tr>
<td></td>
<td>Infraserve</td>
<td>Germany</td>
<td>Catalylist research</td>
<td>Renewable methanol</td>
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<td></td>
<td>Innogy</td>
<td>Germany</td>
<td>Renewable electricity</td>
<td>Renewable methanol</td>
</tr>
<tr>
<td></td>
<td>Lowlands Methanol</td>
<td>The Netherlands</td>
<td>MSW</td>
<td>Bio-methanol</td>
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<tr>
<td></td>
<td>OPTIMeoH</td>
<td>Germany</td>
<td>Biogas</td>
<td>Bio-methanol</td>
</tr>
<tr>
<td></td>
<td>STEAG</td>
<td>Germany</td>
<td>CO₂ and electricity</td>
<td>Low carbon methanol</td>
</tr>
<tr>
<td></td>
<td>Swerea</td>
<td>Sweden</td>
<td>Steel mill emissions</td>
<td>Low carbon methanol</td>
</tr>
<tr>
<td></td>
<td>ZASSt</td>
<td>Germany</td>
<td>CO₂ and renewable electricity</td>
<td>Renewable methanol</td>
</tr>
<tr>
<td><strong>ON HOLD or STOPPED</strong></td>
<td>BioMCN</td>
<td>The Netherlands</td>
<td>Crude glycerine</td>
<td>Bio-methanol</td>
</tr>
<tr>
<td></td>
<td>Chemrec</td>
<td>Sweden</td>
<td>Black liquor</td>
<td>Bio-methanol &amp; DME</td>
</tr>
<tr>
<td></td>
<td>Varmlandsmetanol</td>
<td>Sweden</td>
<td>Forestry residues</td>
<td>Bio-methanol</td>
</tr>
<tr>
<td></td>
<td>Woodspirit</td>
<td>The Netherlands</td>
<td>Wood residue</td>
<td>Bio-methanol</td>
</tr>
</tbody>
</table>
Oil displacement drives demand growth

2011 Global Methanol Demand by Derivative

- Fuel Derivatives: 35%
- Traditional Derivatives: 65%

Total Methanol Demand = 53 million metric tons

Source: IHS Markit

© 2016 IHS Markit

2016 Global Methanol Demand by Derivative

- MTO/P: 12%
- Fuel Derivatives: 33%
- Traditional Derivatives: 55%

Total Methanol Demand = 75 million metric tons

Source: IHS Markit

© 2016 IHS Markit
Methanol: Essential Chemical Building Block

Source: Methanex

### Methanol In Our Lives

<table>
<thead>
<tr>
<th>Primary Derivatives</th>
<th>Derivatives</th>
<th>Diverse Demand Drivers</th>
</tr>
</thead>
<tbody>
<tr>
<td>FORMALDEHYDE</td>
<td>Urea formaldehyde</td>
<td>Renovation, new building activity, automobile production, panelboard substitution for solid wood, changing wood/panel mix, growth in high technology chemicals.</td>
</tr>
<tr>
<td></td>
<td>Phenol formaldehyde</td>
<td></td>
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<tr>
<td></td>
<td>1,4-butanediol</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Acetal Resins</td>
<td></td>
</tr>
<tr>
<td>ACETIC ACID</td>
<td>Vinyl acetate monomer</td>
<td>Building activity, dyes, surfactants, textile treatments, packaging trends, plastic recycling, paints and coatings.</td>
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<tr>
<td></td>
<td>Acetic anhydride</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Terephthalic acid</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Solvent esters</td>
<td></td>
</tr>
<tr>
<td>CLEAN FUELS</td>
<td>Methanol/water blends</td>
<td>Demand for better health/cleaner environment, clean air legislative goals, displacement of gasoline components (e.g. lead, aromatics), safety and engine performance.</td>
</tr>
<tr>
<td></td>
<td>- fuel cell “hydrogen-carrier”</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Reformulated gasoline - MTBE</td>
<td></td>
</tr>
<tr>
<td>OTHER</td>
<td>Methyl methacrylate</td>
<td>Total chemical production, general economic activity, alternative fuel developments, environmental pressures.</td>
</tr>
<tr>
<td></td>
<td>Methylamines</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chloromethanes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Direct use</td>
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</tbody>
</table>
Methanol is a versatile fuel source

- Out of the ~75 million metric tons of methanol sold globally in 2015, energy and fuel uses represent one-third of total demand
- From 2009-2015, direct methanol fuel blending has increased at an annual rate of nearly 23%

**FUELS**
- Neat fuel
- Low blends
- High blends
- GEM
- MTBE
- Biodiesel
- DME & OME
- MTG

**TECHNOLOGIES**
- SI & CI engines
- Turbines
- Fuel cells
- Stoves

**SEGMENTS**
- Road & non-road transportation
- Power & heat generation, and
- Marine
03  MARINE FUELS
The Clear Alternative Marine Fuel

Diesel Bunker Fuel

Methanol Marine Fuel
Marine Fuel in Transition

- Over 90,000 commercial vessels on world’s oceans, consuming 370 million tons of bunker fuel (Heavy Fuel Oil and Middle Distillates).
- One container ship: SOx = 50 million cars
- 15 largest ships: SOx emissions = 760 million cars in the world

Environmental & Health Hazards

- National Oceanic and Atmospheric Administration: Globally shipping accounts for 60,000 deaths and US$330 billion in health costs.

- Natural Resources Defense Council: Shipping at intersection of high population, choking pollution, and rapid growth.

Source: Natural Resources Defense Council
The International Maritime Organization has adopted regulations for SOx and NOx that are transforming the shipping industry.

While 2020 global SOx reductions may be met with low sulfur fuels, the combination of SOx and NOx reductions driving shipboard solutions.

Next up: Greenhouse gas emissions.
Options available to ship owners

- HFO + scrubbers
- MGO
- LNG
- Methanol
## Methanol fueled vessel projects

<table>
<thead>
<tr>
<th>WFS, MOL, WL, Marinvest</th>
<th>Stena Lines</th>
<th>Swedish Maritime Administration, MI</th>
<th>Methaship, Leanships.</th>
</tr>
</thead>
<tbody>
<tr>
<td>7 chemical tankers</td>
<td>1 RoPax ferry</td>
<td>1 pilot boat</td>
<td>Cruise ship, ferry</td>
</tr>
<tr>
<td>2-stroke MAN</td>
<td>4-stroke Wärtsila</td>
<td>Volvo, Scania, FiTech</td>
<td>Various</td>
</tr>
<tr>
<td>New build</td>
<td>Retrofit</td>
<td>Retrofit</td>
<td>New build</td>
</tr>
<tr>
<td>Operational</td>
<td>Operational</td>
<td>Testing</td>
<td>Design phase</td>
</tr>
<tr>
<td>DNV GL / ClassNK</td>
<td>Lloyds Register</td>
<td></td>
<td>Various</td>
</tr>
</tbody>
</table>
Methanol fuel cells improve electrical efficiency

As part of Germany’s Pa-X-ell project ship builder Meyer Werft installed a Serenergy high temperature PEM 90-kW methanol fuel cell system demonstrator on board the Viking Mariella.

Modular units form basis of a highly efficient and decentralized network on board.
Available in many ports around the world

Methanol storage capacity estimates (thousand tons)

Source: IHS, 2015
Methanol is widely available and easy to handle

- Liquid at atmospheric pressure
- Available in many ports around the world and along rivers
- Low infrastructure cost
- Flexible, modular system
- Environmentally friendly as it’s biodegradable
Recent Studies

EU Joint Research Centre
LNG and Methanol “Most Promising” alternatives to bunker fuel.
May 2016

European Maritime Safety Agency
Investment costs for retrofits and new builds for methanol same range exhaust gas after treatment and less than LNG.
June 2016

European Sea Ports Organisation
Methanol shows promise as an emissions solution for the shipping industry.
July 2016
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
MSF maintains a presence in over 60 countries. Many of these countries have been targeted for methanol poisoning outreach programs. MSF has existing operations, to include:

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