REVOLUTIONIZING METHANOL – FROM CHEMICAL TO FUEL

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ASIAN DOWNSTREAM SUMMIT
2018
SINGAPORE
Contents

- About MI

- Methanol Production and Demand

- Global Methanol Fuel Blending

- New Markets

- Methanol as a Marine Fuel
About MI
The Methanol Institute (MI) formed in 1989
40+ members internationally
MI STRATEGIC PARTNERS

- China Nitrogen Fertilizer Industry Association
- Asian Clean Fuels Association
- Chinese Association of Alcohol & Clean Ether Fuels & Automobiles (CAAEFA)
- Gulf Petrochemicals and Chemicals Association (GPCA)
- International DME Association (IDA)
- International Methanol Producers & Consumers Association (IMPCA)
- Peking University Center for New Global Energy Strategy Studies
- Lloyd’s Register
- International Bunker Industry Association
- Dangerous Goods Advisory Council
- China Classification Society
Methanol Production and Demand
Broad Feedstock Range, many Applications

- Feedstock: natural gas (~65%), coal (~35%), biomass & renewables (<1%)
- Conversion process:
- Derivatives:
  - other 7%
  - solvents 4%
  - chloromethanes 2%
  - MTO 18%
  - methyamines 3%
  - DME 8%
  - biodiesel 3%
  - gasoline blending 9%
  - MTMA 2%
  - MTBE 8%
  - acetic acid 9%
  - formaldehyde 27%
- Products:
- Markets:
  - appliances
  - automotive
  - construction
  - electronics
  - fuel
  - paint
  - pharma
  - and more…

Source: IHS
Renewable Pathways

- Biomass (Wood, MSW, etc)
  - Fermentation
  - Gasification
  - Biogas
  - Biomethane
  - Reformer
  - Syngas
  - Reactor and distillation
    - Bio-methanol
    - Renewable methanol

- (Renewable) Electricity
  - Carbon capture
  - Electrolysis
  - CO₂
  - H₂
Global Methanol Fuel Blending
Methanol is a Versatile Fuel Source

- Out of the ~75 million metric tons of methanol sold globally in 2017, energy and fuel uses represent 40% of total demand.
- From 2009-2016, direct methanol fuel blending 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

**SEGMENTS**
- Road & non-road transportation
- Power & heat generation
- Marine
Global Transport Fuel Progress

Israel
- Cooperation with Italy Fiat to promote M15 Fiat 500 Car (Euro 6)
- Testing M70-85 in Flex fuel vehicles
- 2016 First M15 National Standard Released

Italy
- ENI and FCA cooperation to promote A20 fuel (M15+E5)
- Fiat 500 cars for car sharing service in 2018
- Compliance with Euro 6 standard and 3% tailpipe emission reduction

Denmark
- Methanol Fuel Cell for EV range extension
- Europe’s first methanol filling station in Aalborg, Denmark (Aug. 2015)
India: Roadmap to Methanol Economy

• September 2015, NITI Aayog formed the Methanol Economy Expert Group

• Methanol production from coal and biomass, and utilize methanol and DME as transportation fuels

• September 2016, MI jointly organized a Methanol Economy International Seminar held in Delhi

• Launching Projects:
  o M15 fuel blending
  o methanol/DME buses and trucks
  o railway engines
  o inland waterways
  o cook stoves
  o industrial boilers

Union & Road Transport Minister Nitin Gadkari
New Markets
Methanol Boilers

- Widely used for heating and industrial steam, new-builds and replacing coal and HFO-fired units
- Capacity range from 1 - 20 t/h
- Standards with developed together with MI and Methanex support
- Blends starting as low as 60% (M60)
- *Estimated more than 1,000 units currently, consuming over 2M mtpa of methanol*

Source: Methanol New Energy Applications in China: Boilers and Cook Stoves
Methanol Cook Stoves

- Different types of methanol cook stoves:
  - Single burner heating
  - Stir frying
  - Steaming
- Widely used in restaurants, central kitchens: mainly cost driven
- Simple storage and transportation, filling the deficit of NG pipeline capacity
- Fuel:
  - 100% methanol (M100)
  - 80% and higher blends (emulsified with water)

- Consuming over 3M mtpa of methanol
Methanol as a Marine Fuel
Sources: IMO

**North America**
- SOx established 2009
- Enforced since 2012
- New keels from 2016
- NOx compliant

**Europe**
- SOx established 2005
- Enforced since 2006
- 2015: SOx < 0.1%

**China**
- 2015: HK ECZ established for OGV
- 2016: PRD ECZ
- 2019: China-wide ECZ
• IMO:
  - 0.1% in 2015 in existing ECAs in NA & EU
  - 0.5% in 2020 globally

• Predominant shipping fuel is HFO which does not meet limits – methanol is sulphur free

• China phasing in regulations to reduce sulphur, NOx and PM from marine fuels over next few years

Source: IMO
IMO Strategy to Reduce GHG Emissions

• Member States of the IMO have adopted an initial strategy on the reduction of greenhouse gas emissions from ships earlier this year.
• The initial strategy represents a framework for Member States setting out the vision and level of ambition for GHG reduction within international shipping.

• Level of Ambition:
  • Carbon intensity of ships to decline through implementation of further phases of the energy efficiency design index (EEDI) for new ships;
  • Reduce CO₂ per transport work by at least 40% by 2030, pursuing towards 70% by 2050, compared to 2008 levels; and
  • GHG emissions from international shipping to peak as soon as possible and to reduce by at least 50% by 2050, compared to 2008 levels.
Methanol (MeOH) achieves low emissions & acts as a bridge in lowering CO$_2$ in the future (renewable/bio methanol).
Global Port Terminal Availability

Source: IHS 2017
**Marine Experience**

- March 2015: Stena Germanica – Wärtsilä methanol-fueled marine engine
- Apr 2016: Methanex’s Waterfront Shipping – dual-fuel MAN methanol/diesel engines
- Lloyd’s Register MethaShip project
- LeanShips dual-fuel demo
- Oct 2015: Billion Miles Singapore develops small-marine applications
- Jun 2016: ScandiNAOS Green Pilot Boat conversion
Methaship

- Nationally-funded German research project
- Partners from shipbuilding, ship-safety, OEM manufacturers, methanol trading & production
- Study the use of methanol as a fuel for cruise ships and RoPax ferries
- Study concluded with the following findings:
  - Properties of methanol surpass other alternative fuels in shipping;
  - A major benefit includes storage at ambient temperature and pressure without loss;
  - Methanol offers compelling environmental properties and has the most promising lifecycle analysis when produced from renewable sources; and
  - Widespread availability.
**Flammability and Toxicity**

**Takeaways:**
- Not more toxic than gasoline or diesel
- Methanol poisoning is treated simply and is not carcinogenic
- No GHG potential (methane)
- Miscible in water – a large concentration spill will rapidly decrease with only short term effects
- Far less hazardous to the environment

**Economic Impact - HFO vs Methanol:**

<table>
<thead>
<tr>
<th></th>
<th>Maritime accident</th>
<th>Maritme 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>

Table adapted from Machiel, 1998. *1-No concern. 2 to 3 = Low Level concern. 4 to 6 = moderate concern. 7 to 8 = high level concern. 9 to 10 = extreme hazard.* Numbers in parenthesis reflect hazard reductions resulting from design changes. *Number in parenthesis incorporates the lowered likelihood of ingestion due to the presence of additives. 6"
Safer for the Environment

(LC50, LC=Lethal Concentration):
Concentration in water, at which half the population died within a specified test duration.

Methanol better than
- Diesel by factor 240
- Gasoline by factor 1900

Additional Source: Meyer-Werft
IMO sub-Committee on Carriage of Cargoes and Containers (CCC 5) has completed the draft interim guidelines for the safety of ships using methyl/ethyl alcohol as a fuel, the interim guidelines are on course for formal approval by the IMO’s Maritime Safety Committee in 2020.

The interim guidelines will benefit existing 8 seafaring vessels operating on methanol as well as 4 more that are expected to ply our oceans in 2019.
# Fuel Comparison Model & Online Evaluator

## Total Fuel CAPEX

<table>
<thead>
<tr>
<th>Total CAPEX</th>
<th>M USD</th>
</tr>
</thead>
<tbody>
<tr>
<td>LNG</td>
<td>49.766</td>
</tr>
<tr>
<td>HFO scrubbers</td>
<td>44.167</td>
</tr>
<tr>
<td>Compliant fuel</td>
<td>42.3</td>
</tr>
<tr>
<td>Methanol</td>
<td>44.913</td>
</tr>
</tbody>
</table>

## Price Differentials (USD/MT)

<table>
<thead>
<tr>
<th></th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>LNG</td>
<td>21</td>
<td>260</td>
<td>31</td>
</tr>
<tr>
<td>HFO 3.5</td>
<td>1</td>
<td>185.6</td>
<td>22</td>
</tr>
<tr>
<td>Methanol</td>
<td>1</td>
<td>199.3</td>
<td>23</td>
</tr>
</tbody>
</table>

## Fuel Costs

- LNG price: $315 USD/mt
- HFO 3.5 price: $390 USD/mt
- HFO 0.50 price: $550 USD/mt
- MGO 0.10 price: $600 USD/mt
- Methanol price: $376 USD/mt

## Calorific Value

- Calorific Value LNG: 49 kJ/kg
- Calorific Value HFO 3.5: 41 kJ/kg
- Calorific Value Methanol: 20 kJ/kg
ANNUAL FUEL CONSUMPTION & EMISSIONS

- LNG
- LNG (incl. Methane slip)
- HFO Scrubbers
- Compliant Fuel
- Methanol

**Fuel Consumption**: 4000, 12000, 18000, 20000, 30000
**SOx**: 200, 250, 300
**CO2**: 100, 200, 300

Tonnes (CO2 & Fuel Consumption) vs. Tonnes SOx
Benefits of Methanol as a Fuel

- Capital costs for conversions much less than LNG and after treatment technologies
- New Build dual fuel tankers are only marginally more expensive than traditional fueled vessels
- Methanol is already easily and cost effectively stored at any port in the world
- Methanol is one of the top 5 seaborne chemical commodities accounting for 35% of the world seaborne chemical and vegoil trade
- Major engine OEMs confident engines can meet Tier III (NOx) requirements
- Cost effective to produce, from a variety of feedstocks – as well as renewably
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THANK YOU