9TH RUSSIA & CIS OIL & GAS EXECUTIVE SUMMIT

MONETIZING GAS THROUGH METHANOL

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GORKY GOROD, SOCHI, RUSSIA
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- Summary
WHERE IS METHANOL PRODUCED?

Outside China, methanol is typically produced from natural gas.

Source: Argus
Rest of world methanol production (excluding China) operates to best of abilities. Excess production from the rest of the world is exported to China.

China "generally" represents the high-cost methanol production bloc in the world and operates to meet China demand, less imports received from the rest of the world.

Industrial scale since 1923 (BASF)

* Excludes China's CTO sector
China dominates global methanol industry demand – 54% in 2018

W Europe and N America compete for the 2nd and 3rd spots – top three accounting for 75% of total

Concentrated consumer base, ~30% of demand from top 25 consumers
- Main consumers are large, global chemical companies and China MTO producers: BASF, Momentive, Celanese, BP, Dow/Dow Corning, Lucite, Evonik, LyondellBasell, SABIC, Sinopec, Ningbo Fund, Jiangsu Sailboat, etc

Industry growth expected at 4.5% per year. The equivalent of 2 world scale methanol units

*Excludes China’s CTO sector

Source: Argus
METHANOL INDUSTRY PRODUCTION CASH COST CURVES

- Methanol industry cash cost curves well compressed
  - Cash cost only, no depreciation, capital recovery or return
  - FOB plant gate basis
  - Shipping to destinations can add $20-$60/t, depending on origin and destination

- A slowly rising crude oil forecast drives little change in feedstock costs
  - Industry incremental cash cost of production remains in a narrow band
  - Little opportunity to “drive up” the floor price of the high cost producer increment

- The methanol industry continues to see robust growth
  - ~4-5% into the next decade
  - China continues to dominate industry demand and production
  - Nominal 2-3 “world scale” methanol units needed per year to keep pace with demand growth

Source: Argus
RENEWABLE PATHWAYS ARE RAPIDLY DEVELOPING

Source: The Methanol Institute and Qafaq
E-METHANOL: AN EFFICIENT ENERGY CARRIER

Methanol CH₃OH has, on a volume basis, 40% more H₂ than liquid hydrogen at -253°C, and 140% more H₂ than compressed hydrogen at 700 bars.

Source: Prof. SHIH Choon Fong, NTU, MI
BASF: CO₂ EMISSION FREE METHANOL PRODUCTION

Methanol Synthesis and Distillation Process practically unchanged

Source: BASF
METHANOL AS A CLEAN FUEL
BROADLY, METHANOL IS...

• A cost effective and “future proof” fuel which can be produced from a variety of feedstocks – to include renewables

• One of the top 5 seaborne chemical commodities – safely handled for over 50 years

• A lower cost alternative for converting vessels to methanol – minimal and economically viable without subsidies

• Widely available and alleviates many infrastructure and safety limitations both on land and at sea, trading within a narrower price range than competing fuels

• Not as well understood as a fuel, even though it has similar handling characteristics as distillate fuel
# METHANOL CHARACTERISTICS

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Petrol C_\text{5-12} Hydrocarbon</th>
<th>Diesel C_{10-21} Hydrocarbon</th>
<th>Natural Gas CH_4</th>
<th>Methanol CH_3OH</th>
<th>Ethanol C_2H_5OH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass Fraction</td>
<td>C 85</td>
<td>86</td>
<td>75</td>
<td>37.5</td>
<td>52.2</td>
</tr>
<tr>
<td></td>
<td>H 15</td>
<td>14</td>
<td>25</td>
<td>12.5</td>
<td>13.0</td>
</tr>
<tr>
<td></td>
<td>O 0</td>
<td>0</td>
<td>0</td>
<td>50</td>
<td>34.8</td>
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<tr>
<td>Density (liquid)(kg/L)</td>
<td>0.72-0.78</td>
<td>0.82-0.86</td>
<td>0.42-0.46</td>
<td>0.79</td>
<td>0.81</td>
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<tr>
<td>Boiling point (°C)</td>
<td>30-190</td>
<td>180-360</td>
<td>-162</td>
<td>65</td>
<td>78</td>
</tr>
<tr>
<td>Flash point (°C)</td>
<td>-50 ~-20</td>
<td>&gt;55</td>
<td>-188</td>
<td>11</td>
<td>9</td>
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<tr>
<td>Auto-ignition point (°C)</td>
<td>420</td>
<td>250</td>
<td>650</td>
<td>465</td>
<td>426</td>
</tr>
<tr>
<td>Lower heating value (MJ/kg)</td>
<td>44.0</td>
<td>42.5</td>
<td>50</td>
<td>19.5</td>
<td>25</td>
</tr>
<tr>
<td>Octane number</td>
<td>70-97</td>
<td>20-30</td>
<td>130</td>
<td>111</td>
<td>108</td>
</tr>
<tr>
<td>Cetane number</td>
<td>-15</td>
<td>40-55</td>
<td>Low</td>
<td>3-5</td>
<td>8</td>
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<tr>
<td>Flammability limits (%)</td>
<td>1.1-5.9</td>
<td>1.58-8.2</td>
<td>5-15</td>
<td>6-36.5</td>
<td>4-19</td>
</tr>
<tr>
<td>Vapour pressure at 37°C/kPa</td>
<td>55-103</td>
<td>&lt;1.37</td>
<td></td>
<td>31.6</td>
<td>15.8</td>
</tr>
</tbody>
</table>
Methanol carriers – use cargo as fuel

Source: CCS, Waterfront Shipping
PRACTICAL SOLUTION

• Multi-fuel engines and applications will be the norm going forward

• Methanol can be readily and safely applied in both new build and conversion

• Low Carbon Methanol or Renewable Methanol can be a practical solution for dual fuel applications, to include other alternative fuels such as LPG and LNG

Source: Westfal-Larsen
CONVENTIONAL MeOH EMISSIONS SCORECARD

Methanol (MeOH) achieves low emissions & acts as a bridge in lowering CO₂ now and in the future (blending renewable or bio methanol)

Source: Waterfront Shipping
METHANOL / WATER BLENDING (EMULSIFICATION)

- Approximately 25-40% water is added to the methanol to achieve a Tier III compliant solution
- NOx decreases almost linearly with water content, to approximately 2 g/kWh at 50% and 75% load
- Similar system is being planned for fuel oil
- R&D testing completed - service test is under preparation likely on one of the WFS vessels

Source: MAN
# METHANOL FUELED VESSELS AND PILOTS

<table>
<thead>
<tr>
<th>PROJECT</th>
<th>R&amp;D</th>
</tr>
</thead>
<tbody>
<tr>
<td>DUAL FUEL</td>
<td>FUEL CELL</td>
</tr>
<tr>
<td>Quantity</td>
<td>7</td>
</tr>
<tr>
<td>Vessel Type</td>
<td>Chemical tankers</td>
</tr>
<tr>
<td>Owner</td>
<td>MOL, WL, Marinvest, Mitsui, NYK</td>
</tr>
<tr>
<td>Engine Type</td>
<td>2 stroke MAN</td>
</tr>
<tr>
<td>Design</td>
<td>new build</td>
</tr>
</tbody>
</table>

All projects are based in the EU unless noted otherwise:
- China/SG
- EU/China/SG
- India
- Malaysia
- China
METHANOL IS WIDELY AVAILABLE

Source: IHS
Methanol classified as “not more dangerous” than other fuels such as gasoline or diesel – fuels largely familiar to most people
Easy and reliable treatment to full recovery with either ethanol (orally) or fomepizole (injected)

Source: Malcom Pirnie Inc
**SAFER FOR THE ENVIRONMENT**

**LC50, LC = LETHAL CONCENTRATION FISH**

*Concentration in water, at which half the marine population died within the specified test duration*

- Methanol\(^1\): 15,400 (mg/l)
- Methane\(^5\): 49,9 (mg/l)
- Heavy Fuel Oil\(^3\): 79 (mg/l)
- Diesel\(^4\): 65 (mg/l)
- Gasoline\(^2\): 8,2 (mg/l)

Safer than Diesel by a factor of 240 times

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\(^1\) ECHA, European Chemicals Agency, registration dossier Methanol
\(^2\) Petrobras/Statoil ASA, Safety Data Sheet, ECHA registration dossier Gasoline
\(^3\) GKG/ A/S Dansk Shell, Safety Data Sheet
\(^4\) ECHA, European Chemicals Agency, registration dossier Diesel
\(^5\) ECHA, European Chemicals Agency, registration dossier Methane

Additional Source: Meyer-Werft
Industrial boilers are widely used for heating and industrial stream

Many cities in China prohibiting use of coal and diesel

Capacity ranges from 1 to 20 steam tons/hour

In continuous cycle on full load, one steam ton of capacity consumes 110 kg of methanol

Methanol fuel is used neat or emulsified (typically to 25%)

Standards developed with MI and Methanex support

Now more than 1000 units, consuming over 3M mtpa

Forecasted to 5M mtpa by 2022
METHANOL FUELED CERAMIC KILNS

• China produces:
  o ~60% of world’s glass products
  o ~90% of all ceramics globally
METHANOL FUELED CERAMIC KILNS

- .5M mtpa market in Dehua alone
- Displacing LPG for safety
- More competitive than NG
METHANOL FUELED CERAMIC KILNS – FROM THE SIMPLE
METHANOL FUELED CERAMIC KILNS – TO THE BESPOKE
METHANOL FUELED CERAMIC KILNS – TO MASS MARKETS
METHANOL FUELED CERAMIC KILNS – SMALL KILN

• 3-yr reference

• .5mt/day average consumption

• Underground storage with day tank

• 3cm kiln space

• Retrofit kit includes:
  o Tank
  o Burners
  o Controls
  o CPU
  o Waste Heat Recovery
  o RMB 10,000 (USD$ 1,500)

• Methanol requires less air intake than NG or LPG

• Higher achieved temperatures with methanol – to 1400°C
METHANOL FUELED CERAMIC KILNS – LARGE KILN

- 6cm kiln space
- 3-yr reference
- 3-4 mt/mo consumption
- Price similar to LPG but better quality
- Much safer than LPG, which is registering one LPG tank explosion per week – often with fatalities
METHANOL FUELED COOK STOVES

- Single heating, stir fry, steaming
- Widely used in restaurants, central kitchens, mainly cost-driven
- Simple storage and transportation, filling the gap of pipeline NG supply
- Fuel: 100% methanol to methanol blends usually with water (to 40%)
- AI, ML, IoT enabled
METHANOL FUELED COOK STOVES

• 24/7 on-line monitoring of all installations

• Sensors provide live data streaming of energy delivered and proactively detect technical or safety issues

• Performance and safety are continuously monitored and enhanced

• Block chain enabled

• Infrared flame and gas detection, foam fire suppression
METHANOL FUELED COOK STOVES

- Current market consuming over 5 M mtpa
- Forecast to reach 7-8 M mtpa by 2022
1 out of every 3 cigarettes consumed globally is in China

- RMB1.7 trillion profits + tax collected by government annually
  - Equal to military spending budget
  - More than Sinopec and CNOC combined contributions to state treasury
DISTILLATE & FUEL OIL PRICES EXPECTED TO RISE

Higher demand for gasoil will largely have to be met by higher crude runs, putting upward price pressure on global crude prices, distillate premiums to other fuels, and refining margins in general. This should also tighten distillate markets relative to gasoline, adding to the cost of MGO. Recently, the spread between gasoline and diesel prices has been relatively constant—about $4–$6 per barrel—due to the similar growth rates of the two products. However, history shows that when diesel demand accelerates relative to gasoline, diesel prices shift to premiums of $10–$12 per barrel over gasoline. Timing is critical to fuel choice selection as delays could be costly, even as compliant distillate fuel becomes more widely available.

Source: McKinsey

1Average light product (diesel, gasoline) prices minus fuel oil (3.5% sulfur, 380 centistokes).
Methanex posts reference prices monthly in Asia and North America and quarterly in Europe.

Realized pricing is lower than reference prices due to discounts specified in contracts.

Higher visibility over fuel costs which lowers the risk profile.

Source: Methanex Corporation
METHANOL COMPETITIVE ON ENERGY EQUIVALENT BASIS

• MGO West Coast Avg: LA, San Francisco, Seattle, Vancouver;
• MGO East Coast Avg: New York, Philadelphia, Norfolk, Montreal, Charleston
• Methanol: adjusted to energy equivalent of MGO (2.16 factor)

Source: Platts and IHS Chemical
04 SUMMARY
SUMMARY

- Physics of methanol are highly competitive or surpass other alternative fuels

- Application design, whether retrofit or new build are simple, advantageous, practical and understandable – whether for ships, boilers, kilns, or cars

- Methanol should be treated as a “liquid fuel system” – not to be directly compared with gas (ie; LNG, LPG, NH₃ or H²)

- Compelling environmental properties

- Superior Life Cycle Analysis (LCA) advantage already with CCI technology or when renewably produced

- Infrastructure is a key enabler for methanol’s uptake as a fuel due to storage being no more complicated than other liquid fuels
THANK YOU!!