Agenda

• About the Methanol Institute
• Methanol Overview
• Road Transport
• Marine Fuels
• China Heat Markets
• Hydrogen Carrier
MI History

• The Methanol Institute (MI) was established in 1989
• Three decades later, MI is recognized as the trade association for the global methanol industry
• Facilitating methanol’s expansion from our Singapore headquarters and regional offices in Washington DC, Brussels, and Beijing
Feedstocks and Markets

Feedstocks:
- Natural gas: ~65%
- Coal: ~35%
- Biomass & renewables: <1%

Conversion to Methanol:

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

Source: IHS

Products:

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

2019: Global Methanol Demand = 83 Million Metric Tons or 27.6 billion gallons
Methanol: Net Carbon-Neutral Pathways

Renewable methanol is an ultra-low carbon chemical produced from sustainable biomass, often called bio-methanol, or from carbon dioxide and hydrogen produced from renewable electricity.

Renewable Methanol Emission Reductions: CO2 by up to 95%; NOx by 80%; virtually eliminating SOx and Particulate Matter (PM)
China = More than Half of Global Methanol Demand – 16 Billion Gallons

China: 2019 Methanol Demand by End Use

- MTO/MTP: 24%
- Solvents: 2%
- Acetic Acid: 7%
- Formaldehyde: 23%
- Gasoline Blending: 10%
- MTBE: 9%
- Others: 6%
- All Other: 4%
- Methylamines: 3%
- Chloromethanes: 1%

Domestic Demand = 48.3 million metric tons

Source: IHS Markit © 2019 IHS Markit
# US Methanol Production Resurgence

## Timing Name

<table>
<thead>
<tr>
<th>Timing</th>
<th>Name</th>
<th>Location</th>
<th>Ownership</th>
<th>Capacity '000t</th>
<th>Status</th>
</tr>
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<tbody>
<tr>
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<td></td>
<td></td>
<td></td>
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<td>Toledo, OH</td>
<td>Interstate Chemical</td>
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<tr>
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<td><strong>Total</strong></td>
<td></td>
<td></td>
<td><strong>7,805</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Under/Pending Construction</strong></td>
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<tr>
<td>2020</td>
<td>US Methanol - Liberty ONE</td>
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<td>South Louisiana Methanol</td>
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<td>2,800</td>
<td>From List Below?</td>
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<td><strong>Total</strong></td>
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<td></td>
<td><strong>8,300</strong></td>
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## In Development

<table>
<thead>
<tr>
<th>Timing</th>
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<tbody>
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<td>Celanese/JV</td>
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<td>Zeogas</td>
<td>Lake Charles, LA</td>
<td>Zeogas</td>
<td>1,600</td>
<td>Under Study</td>
</tr>
</tbody>
</table>

**Total existing, under construction, probable and in development**: 38,961
New U.S. Methanol Plants Offer Many Economic Benefits

Economic Impact of a Typical U.S. Methanol

- **Typical capacity**: 1.5 million tons/year
- **Capex**: $1.1 billion
- **State and local taxes**: $35 million
- **Annual natural gas used**: 45 billion cubic feet
- **Construction jobs**: 2,086
- **Direct and indirect jobs**: 592
- **Economic ripple effect**: $1.5 billion
- **Average annual salary**: $72,579
MI Opposes Tariffs

- Reciprocal 25% tariffs on methanol in effect
- 23 August 2018 – MI Testified before U.S. Trade Representative
- Urged USTR to remove methanol from List 3 of 6,000 products of Chinese goods
- Virtually no methanol trade from China to U.S.
- U.S. net methanol exporter and China the world’s largest market for methanol
- Tariffs threaten expansion of U.S. methanol production – risking billions $$ in investment and thousands of jobs

- SIMPLY PUT, CHINA DOESN’T WANT TO SELL US THEIR METHANOL, THEY WANT TO BUY OUR METHANOL
China M100

- Dec 2018: MIIT completes acceptance of all methanol pilot demonstration programs

- **March 2019:** MIIT and 7 other ministries announce methanol policy paper for M100

- MI issues press release and briefing report

- “Paper 61” encourages commercial introduction of M100 vehicles

- Approval of 32 product models from 9 methanol vehicle manufacturers
China consumes 4.8 MMT or 1.6 billion gallons of methanol for road transport.

Currently over 20,000 methanol-fueled taxis operation for total of 125 million kilometers.

Neat methanol fuel or “M100” consumption for taxi is 13.5 litres/100 km, with energy consumption of 237.8 MJ.

| Table 2 Taxi Fuel Cost Comparison of Taxi in Jin Zhong City |
|-----------------------------------------------|----------------|--------------------|
|                                | Gasoline | CNG    | M100                |
| Fuel Price RMB/L                     | 5.51     | 3.5 RMB/m³ | 1.8                |
| Fuel Economy L/100km                 | 8        | 8.8 m³/100km | 13.5               |
| Fuel Cost Saving %                   | 37.5     | 10.6   | --                  |

Note: the fuel price is based on the operation in November of 2015;
GEELY M100 Vehicles

- China’s Geely Automotive Holdings is global leader in the commercialization of M100 vehicles
- Geely has two methanol engine and five methanol vehicle manufacturing bases, with an annual methanol vehicle production capacity of 300,000 - 500,000 cars
- Geely M100 taxi fleet hit 20,000 cars in June 2019, consuming 200,000 MT year
Italy M15/E5 Blending

• 21 November 2017: With Italian Prime Minister, the CEOs of Eni and Fiat Chrysler Automobile sign MOU for joint development of technology reducing CO2 of road transport vehicles

• Eni had developed an “A20” fuel blend of 15% methanol and 5% bioethanol

• New blend demonstrated in 5 FCA Fiat 500 vehicles in Eni’s Enjoy car-sharing fleet

A20: a New Methanol-based Alternative Fuel

15% MeOH

5% bio-EtOH

80% Gasoline

- Formula Cost Reduction
- “Transparent” to all the E10 car vehicles
- No-chemical corrosion problems
- No-phase separation (in the car tank and gas-station)

CUNA specification (NC 627-02 July 2018)

<table>
<thead>
<tr>
<th>Property</th>
<th>Units</th>
<th>Limits MIN - MAX</th>
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<tbody>
<tr>
<td>Research octane number, RON</td>
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<td>100</td>
</tr>
<tr>
<td>Motor octane number, MON</td>
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<tr>
<td>Lead content</td>
<td>mg/l</td>
<td>5.0</td>
</tr>
<tr>
<td>Density (at 15 °C)</td>
<td>kg/m³</td>
<td>720.0 - 775.0</td>
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<tr>
<td>Sulfur content</td>
<td>mg/kg</td>
<td>10.0</td>
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<tr>
<td>Manganese content</td>
<td>mg/l</td>
<td>2.0</td>
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<tr>
<td>Nitrogen content</td>
<td>ppm</td>
<td>100</td>
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<tr>
<td>Oxidation stability</td>
<td>minutes</td>
<td>360</td>
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<tr>
<td>Existent gum content (solvent washed)</td>
<td>mg/100 ml</td>
<td>5</td>
</tr>
<tr>
<td>Water content</td>
<td>% (m/m)</td>
<td>0.2</td>
</tr>
<tr>
<td>Oxygen content</td>
<td>% (m/m)</td>
<td>10.0</td>
</tr>
<tr>
<td>Methanol</td>
<td>% (V/V)</td>
<td>12.0 - 16.0</td>
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<tr>
<td>Ethanol + other Alcohols (C3-C4)</td>
<td>% (V/V)</td>
<td>4.0 - 6.0</td>
</tr>
<tr>
<td>Ethers (5 or more C atoms)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>other oxygenates</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Volume blending of these components is restricted to 10.0 % (m/m) maximum oxygen content including methanol oxygen.

CUNA NC 627-02 include also the evaporative class parameters to prepare A20 grade for summer, winter and transition period.
German C3 Mobility

- C3 Mobility for Closed Carbon Cycle
- Joint public/private partnership with German Ministry of the Economy and Energy and German automotive industry
- Two-year, € 24 million program
# German C3 Mobility

## Project Structure

### Usage of Climate-neutral Fuels

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>C) Optimal Usage of Climate-neutral Fuels in Industry and Transport</td>
<td>Modul II-IV Research, Development of Combustion Processes and Demonstration</td>
</tr>
</tbody>
</table>

## Cylinder Displacement:

- **≤ 0.5 l**
  - 1) Drop-in, Blend, Monovalent (OPEL, RWTH)
    - MIG, C3H6O
  - 2) Drop-in, Blend (BMW, RWTH)
    - CH₂OH, C₂H₄OH
  - 3) Blend (VW)
    - C₂H₄OH, MIG, C₂H₆O

- **≥ 2.0 l**
  - 4) Bi-valent Monovalent (FORD, RWTH, FISE)
    - DME
  - 5) Drop-in (FORD, RWTH)
    - C₂H₆O
  - 6) Blend Dual-Fuel (HMECT, CPT, TUDR)
    - OME
  - 7) Blend Dual-Fuel (FEV, DAIM, DEUT)
    - CH₂OH, OME, C₂H₆O
  - 8) Monovalent Dual-Fuel (RWTH, LIEB)
    - CH₂OH

### Detailed Project Modules

- **1) Fuels/Material Compatibility (T4F/Shell) & Fuel Deterioration/Oil Interaction (OWI)**
- **2) Method Development 3D-CFDR for Fuel Blends (AVL, RWTH)**
- **3) Thermal Management Optimization (OP)**
- **4a) Exhaust Gas Aftertreatment (Components) (TUD, UMI, AVL)**
- **4b) ANB (Strategy) (FEV, FISE)**
- **5) Injection Systems:**
  - 5a) PassCar OME (CPT)
  - 5b) CV + Large Engine (TIF)
  - 5c) PassCar DMF (DPNSO)
- **6) Fuel Sensors (CPT)**
- **7) Model-based Torque Path and Ignition (FEV, WEG, FHAC)**

### D) Cross-sectoral Issues module-spanning Components and Method Development
The International Maritime Organization has adopted emission regulations transforming the shipping industry.

In 2020, global SOx reductions took effect.

By 2050, greenhouse gas emissions must be cut in half.
Methanol Vessels on the Water

DUAL FUEL
- 9x - +2 chemical tankers
  - MOL, WL, Marinvest
  - 2 stroke MAN
  - new build
- 1x ROPAX ferry
  - Stena Line
  - 4 stroke Wärtsila
  - retrofit
- 1x Pilot boat
  - MI/SMA ScandiNaos
  - high speed Scania, Weichai
  - retrofit
- 1x dry bulk
  - Jiang Long
  - DMCC Yuchai
  - new build

FUEL CELL
- 2x Tourist Boat propulsion
  - Innogy HTWG Konstanz
  - SerEnergy fuel cells
  - retrofit
- 1x Ferry hotel load
  - Viking Line
  - retrofit

PROJECT and R&D
- Cruise ships, fishing boat, barge, dredge, a.o.
- SUMMETH/MARTEC, Lean Ships, Methaship, Billion Miles, FiTech, India, PCG Product Vessel, NTU Test Port of Rotterdam Barge, Green Maritime Methanol, FastWater
- SI hybrid, dual fuel, fuel cells
- new build & retrofit
“We developed the ME-LGIM engine in response to interest from the shipping world in alternatives to heavy fuel oil. With the growing demand for cleaner marine fuels, methanol is a sulphur-free alternative that meets the industry’s increasingly stringent emission regulations.” René Sejer Laursen, Promotion Manager at MAN Energy Solutions

https://marine.man-es.com/two-stroke/2-stroke-engines/me-lgim
Methanol Available in Over 100 Ports Today

![Map showing methanol availability in ports](https://public.tableau.com/profile/quantzig#!/vizhome/MethanolAvailabilityDataTopGlobalMaritimePorts/MethanolFuelAvailabilityatPorts)

<table>
<thead>
<tr>
<th>No information on volume of methanol</th>
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<th>Ports with methanol capacity of 100,000 MT to 1,000,000 MT</th>
<th>Ports with methanol capacity of &gt; 1,000,000 MT</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

[Source](https://public.tableau.com/profile/quantzig#!/vizhome/MethanolAvailabilityDataTopGlobalMaritimePorts/MethanolFuelAvailabilityatPorts)
Methanol Discount to Marine Gas Oil

*(Price per unit of energy volumetrically – October 2019)*

*LNG not including delivery cost*
Methanol Bunkering Easy and Clean

- 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
China: Methanol Industrial Boilers

- Industrial boilers are widely used for heating and industrial stream
- Many cities in China prohibiting use of coal and diesel fuels
- Capacity ranged from 1 to 20 ton/hour
- One steam ton capacity consumes 110 kg of methanol, and runs 24/7
- Methanol fuel is used neat or as blend with diesel fuel
- Standards developed with MI and Methanex support
- Estimated more than 1000 units, consuming over 2 MMTs methanol in 2018
- Growing to 5 MMT in 5 years

https://www.methanol.org/energy/boiler-cookstoves/
China: Methanol Cook Stoves

- **Different types methanol 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
- **Market for Cooking Application over 5 MMTs in China in 2018**
- **Growing to 7-8 MMT in 5 years**
• China also developing other new markets for the use of methanol:
  • **Glass/ceramic kilns** – China produced 60% of world’s glass products; methanol uses less air intake and produces cleaner flue gas for superior finish
  • **Tobacco drying** – One in every 3 cigarettes smoked in the world are smoked in China
China: Household Heating

- **Beginning in 2018, China using methanol for home heating**
- Shanxi Province methanol used in 30,000 households in 10 counties, with Jinzong City adding 50,000 households in 2020
- Small heaters for individual families and centralized 2-4 ton steam boilers for larger buildings
- Cities promoting methanol as replacement for coal with government support of 6,000 RMP to furnace providers, free heaters for families and fuel subsidies
METHANOL A HYDROGEN CARRIER FOR FUEL CELLS

- Blue World Technologies (Denmark)
- Palcan (China)
- Horizon Energy Systems (Singapore)
- Oneberry (Singapore)
- Altergy (USA)
- Serenegy (Denmark)
- SFC Energy (Germany)
- Toshiba (Japan)
- Ultracell (USA)
Practical Solution for Battery and Fuel Cell Vehicles

• Reformed Methanol Fuels Cells (RMFC) as range extender for battery electric vehicles

• Increasing range of battery powered vehicles from 300 to 1000 kilometers

• If you really need hydrogen, reform methanol at the fueling station
Denmark’s Blue World Technologies and China’s Palcan

MANUFACTURING PLANTS: 50,000 UNITS/YEAR – 5-15 kw RMFC

Launch/Reception: Blue World Technologies presenting plans for large-scale manufacturing facility

Blue World Technologies today presents plans for the world's largest methanol fuel cell factory located at the Port of Aalborg ready for global export of clean energy technology. Methanol fuel cell components will be produced in high volume enabling electric vehicles to have a 1000km range with 5 minutes refueling time.

Blue World technology is newly founded but has ambitious goals from the start by targeting the most potential markets in form of automotive and electric rail. The challenge is daunting, but also the possibility to really make a difference in the world.

Today the mayor of Aalborg, Mr. Thomas Kastrup Larsen, is attending the launch reception of Blue World Technologies on the Port of Aalborg. Furthermore, plans for the world largest methanol fuel cell manufacturing facility will be presented.

Volume production of methanol fuel cells

Blue World Technologies will establish a state-of-the-art manufacturing plant for automotive fuel cell technology platform utilizing methanol as a fuel. The plant will be highly specialized in the production of materials and components for the fuel cell stack which can be compared to the engine block of a car. The overall effort will require several hundreds of new employees for both development and operations. The factory will be built in three phases, with initial manufacturing activity during 2013.

Our Development Plan II

“Build a 50,000 sets of fuel cell module production base (2018)”

- Industrial Base: Cixi, Zhejiang province
- Total investment of 100 million RMB
- Achieve 50,000 sets of fuel cell module production capacity.

Market target: Electric logistics vehicle, mobile charging vehicle, communication backup power supply, civil-military integration.
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