Fuel Applications for Methanol

Gregory Dolan, CEO
IHS World Methanol Conference -- Berlin
5 October 2019
MI HISTORY

• The Methanol Institute (MI) was established in 1989
• 30 years later, MI 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
MEMBERS

Tier 1

Tier 2

Tier 3

Tier 4

https://www.methanol.org/join-us/
01 METHANOL ECONOMY
BROAD FEEDSTOCK RANGE, MANY APPLICATIONS

feedstock

- ~65%
  - natural gas
- ~35%
  - coal
- <1%
  - biomass & renewables

methanol synthesis

conversion

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%

products

- source: IHS

markets

- appliances
- automotive
- construction
- electronics
- fuel
- paint
- pharma
- and...
- marine
GLOBAL METHANOL FUEL EXAMPLES

- Canada – Waterfront vessels
- USA – motorsport fuel
- UK – EN228 low blend
- Iceland – M100 trials
- Israel – M15 to M100, power generation
- Trinidad – M5
- Africa – cook stoves
- Denmark – fuel cells for vehicles
- Italy – Eni/FCA M15/E5
- Egypt – M15 trials
- India – Methanol Economy roadmap
- Australia – GEM fuels
- Sweden – marine fuel
- China – M15 to M100, boilers, cook stoves
- New Zealand – M3

https://www.methanol.org/energy/
2 February: MI releases *Renewable Methanol Report* prepared by ATA Insights

Contents:

- Executive summary
- Why consider renewable methanol?
- Renewable methanol production
- Case Studies: CRI, Enerkem, BioMCN
- Applications and uses of renewable methanol
- Conclusions and how to find out more

https://www.methanol.org/renewable-methanol/
Renewable Methanol Emission Reductions: CO2 by up to 95%; NOx by 80%; virtually eliminating SOx and Particulate Matter (PM)
# Renewable Methanol Tracker

<table>
<thead>
<tr>
<th>Methanol Category</th>
<th>Commercial</th>
<th>Feasibility and R&amp;D</th>
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<tbody>
<tr>
<td>Bio-methanol</td>
<td>BASF (GER)</td>
<td>Biogeo (GER)</td>
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<td>BioMCN (NL)</td>
<td>ENI (IT)</td>
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<td></td>
<td>Eneco (NL)</td>
<td>Osaka University (JAP)</td>
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<td>New Fuel (DEN)</td>
<td>New Fuel A/S (DEN)</td>
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<td>Nordic Green (DEN)</td>
<td>GasTechno (USA)</td>
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<td></td>
<td>OCI (USA)</td>
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<tr>
<td>Renewable methanol</td>
<td>CRI (IC)</td>
<td>Advanced Chemical Technologies (CAN)</td>
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<td></td>
<td>Innosy (GER)</td>
<td>Asahi Kasei (JPN)</td>
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<td>Air Co (R,SA)</td>
<td>Blue Fuel Energy (CAN)</td>
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<td>Catalytic Innovations (USA)</td>
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<td>CRI (CN/GER)</td>
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<td>Genser (GER)</td>
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<td>Infraserv (GER)</td>
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<td>Liquid Wind (SE)</td>
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<td>MeCO2 (GER)</td>
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<td>Neo-H2 (USA)</td>
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<td>Port of Antwerp (BE)</td>
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<td>Quantum Technologies (CAN)</td>
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<td>STEAG (GER)</td>
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<td>Swiss Liquid Future (CH)</td>
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<td>USC (USA)</td>
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<td>ZAS (GER)</td>
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<td>Low carbon methanol</td>
<td>GPIC (BAH)</td>
<td>Carbon2Chem (GER)</td>
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<td>Methanex (CAN)</td>
<td>BASF (GER)</td>
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<td>QFAC (QAT)</td>
<td>Argonne (USA)</td>
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<td>SABIC (KSA)</td>
<td>Cardiff University (UK)</td>
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WWW.METHANOL.ORG
02 EU E-FUELS/ POWER-TO-X
EU is committed to establish a carbon neutral economy by 2050 – renewable energy account for 95%

European Commission GHG reduction objectives for 2050

- It is assumed, the electricity generation achieves zero net emissions by 2050
- The transport sector target is less than for the overall economy
- The transport sector needs to cut its greenhouse gas emissions by 80% to 95% by 2050 compared to 1990

Source: European Commission, FEV
In 2050 Germany will rely on imported chemical energy carriers – but they have to be synthesized from renewables.

Import of synthetic fuels in 2050 equals up to 50% of today’s mineral oil imports.

- Primary energy use will be shortened by 50% compared to 2008.
- Fossil fuels will provide only 5% of the total primary energy consumption.
- Import of renewable electricity to Germany will increase.
- Up to one third of the total energy consumption might be covered by Power-to-Fuels, thereof:
  - 75% are imported from outside Europe
  - 17% are imported from inside Europe.

Source: European Commission, BMWI Energiedaten, AG Energiebilanzen, ewi gGmbH “Evolution scenario”
POTENTIAL TO STORE EXCESS RENEWABLE POWER

Sources: Laura Nereng, 3M, 2017; Tesla July 2017 announcement extrapolation
GERMAN 2030 CLIMATE PLAN

- Fuel cells and fuels produced with **power-to-x technology** are said to play an important role in future freight transport and the government plans to support "development and large-volume scaling" of electrolysis and other refinery procedures for electricity-based and climate-neutral fuels.

**Merkel's Cabinet agrees 'climate packet,' environmentalists say it's paltry**

20 September 2019

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
METHANOL ALREADY ESTABLISHED PLATFORM
MOLECULE FOR THE CHEMICAL INDUSTRY/ FUEL
PRODUCTION AND AN EXCELLENT FUEL!

METHANOL IS A PROBABLE SOLUTION TO IMPORT RENEWABLE ENERGY TO GERMANY/EUROPE

MeOH is used as fuel already

- First series production M100 truck, claiming 18% costs savings/year
- Methanol is used from M5 to M100
- Applications range from PC to HD

MeOH is promising alternative for SI and commercial engines

- Methanol is cheap to produce
- Established product and building-block (chemical industry)
- Handling and infrastructure is considered to be more complex
- Available applications very limited (EN228 limits MeOH to 3% v/v, but push from Asia)

Methanol utilization in transport will significantly rise

<table>
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<tr>
<th>MeOH</th>
<th>Fuel costs</th>
<th>Availability</th>
<th>Technology Readiness Level</th>
<th>Fuel distribution</th>
<th>Compatibility with existing vehicles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methanol</td>
<td>+/o</td>
<td>0</td>
<td>+/o</td>
<td>0</td>
<td>0/-</td>
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Source: bigwheels.my
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 RESULTS

• “… the new alternative fuel emits up to 3% less in CO2 exhaust emissions quantified using the new Worldwide Harmonized Light Vehicle Test Procedures (WLTP).

• “The formula was designed to reduce direct and indirect CO2 emissions and is compatible with the majority of petrol cars sold from 2001 onwards…”
• 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 commercialization of M100 vehicles

• Approval of 32 product models from 9 methanol vehicle manufacturers

• MI and MIIT Chongqing Methanol Vehicle Conference, 11-13 October
Currently over 20,000 methanol-fueled taxis operation for total of 125 million kilometers

M100 methanol fuel consumption for taxi is 13.5 litres/100 km, with energy consumption of 237.8 MJ

<table>
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<th>Table 2 Taxi Fuel Cost Comparison of Taxi in Jin Zhong City</th>
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<tr>
<td>Fuel Price RMB/L</td>
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<td>Fuel Economy L/100km</td>
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<td>Fuel Cost Saving %</td>
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Note: the fuel price is based on the operation in November of 2015.
Methanol Marine Fuels
• The International Maritime Organization has adopted emission regulations transforming the shipping industry

• In 2020, global SOx reductions take effect

• By 2040 requires 40% GHG reduction, and 50% by 2050
METHANOL VESSELS ON THE WATER

DUAL FUEL

9x - +2
chemical tankers
MOL, WL, Marininvest
2 stroke MAN
new build
1x
ROPAX ferry
Stena Line
4 stroke Wärtsilä
retrofit
1x
Pilot boat
MI/SMA ScandiNaos
high speed Scania, Weichai
retrofit
1x
dry bulk
Jiang Long
DMCC Yuchai
new build
2x
Tourist Boat propulsion
Innogy HTWG Konstanz
SerEnergy fuel cells
retrofit
1x
Ferry hotel load
Viking Line

FUEL CELL

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 are very excited by the performance of our first seven methanol-fuelled vessels that have proven the safety and reliability of the technology. With this second generation of vessels, we will benefit from innovative technological advances that will continue to optimize performance and efficiency,” says Paul Hexter, President, Waterfront Shipping Ltd. “On an energy-equivalent basis, methanol is cost competitive over energy price cycles and we see significant value creation opportunities from using a methanol flex-fuel engine.”


20 August
“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
According to a survey conducted by the Methanol Institute – an industry body whose members include companies involved in methanol production and distribution – methanol is already potentially available from most of the world’s top ports (by tonnage). Chris Chatterton, the institute’s chief operating officer, told ShipInsight on 22 August that its full data will be published “in about a week” but provided a summary that showed its survey had covered 151 ports, of which 97 had “methanol directly in, or in close proximity to, the port.” Those include 88 of the top 100 ports. 23 August

https://shipinsight.com/articles/methanol-fuel-what-you-need-to-know
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
05 CHINA HEAT MARKETS
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 80 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 1500 units, consuming over 3 MMT methanol in 2019.**
- **Growing to 5 MMT by 2022.**

https://www.methanol.org/energy/boiler-cookstoves/
METHANOL COOK STOVES IN CHINA

- 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 2019
- Growing to 7-8 MMT by 2022
China also developing other new markets for the use of methanol:

- **Glass/ceramic kilns** – China produced 60% of world’s glass products; methanol produces cleaner flue gas for superior finish; 4 MT/month average methanol demand; retrofit costs = €1,350

- **Tobacco drying** – One in every 3 cigarettes smoked in the world are smoked in China; Provides state with more revenue than Sinopec and CNOC combined
HYDROGEN CARRIER
METHANOL A HYDROGEN CARRIER FOR FUEL CELLS

- Blue World Technologies (Denmark)
- Palcan (China)
- Advent Technologies (USA)
- Horizon Energy Systems (Singapore)
- Oneberry (Singapore)
- Altergy (USA)
- Serenegy (Denmark)
- SFC Energy (Germany)
- Toshiba (Japan)
- UltraceCell (USA)
COMMERCIAL OFFERINGS FOR STATIONARY POWER
DENMARK’S BLUE WORLD TECHNOLOGIES AND CHINA’S PALCAN

MANUFACTURING PLANTS: 50,000 UNITS/YEAR

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 instilled in high volume existing electric vehicles to have a doubled range with a minutes refueling time.

Blue World Technologies recently founded has an enticing goal from the start by targeting the most potential markets in terms of automotive and electric mobility. The challenge is daunting, but the desire to provide clean and affordable energy for the world.

Today the mayor of Aalborg, Mr. Thomas Ketsby, together with the chairman of Blue World Technologies on the feet of Aalborg. Furthermore, plans for the world’s largest methanol fuel cell manufacturing facility will be presented.

Unique production of methanol fuel cells

Blue World Technologies will establish a state-of-the-art manufacturing plant for a unique fuel cell technology platform utilizing methanol as fuel. The plans 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 effect will create several hundreds of new employment both development and operations. The factory will be built in the strategic manufacturing district 2019.

Our Development Plan II

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

- Industrial base: Jiaxing, 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.
2015: Denmark opens EU’s first methanol fuel pump

Cars/vans use RMFC technology as range extender Increasing range of battery powered vehicles from 200 to 1000 kilometers

April 2019: Beijing Auto Show: AIWays unveils Gumpert RG Nathalie methanol fuel cell electric supercar with a 1,200 km range and a top speed of 300 km/h

2020: Commercial production Nathalie

China now has just 1,500 FCVs and 23 hydrogen fuelling stations

March 2018: MIIT releases plans for hydrogen fuel cell promotion as “new energy vehicles”

Targets: 2020 – 5,000 FCVs; 2025 – 50,000 FCVs; 2030 – 1 million FCVs

Pivot away from EV subsidies and moving support to hydrogen fuel cells

Emphasis on commercial vehicles: buses and trucks, long-haul

Methanol fuel cells included as New Energy Vehicles
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