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- or no-carbon transport, while reducing smog.

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

✅ **Consumer**: Demands seamless transition and ease of use.

✅ **Methanol**: Checks all the drivers!
WHO WE ARE
History

• 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
MI STRATEGIC PARTNERS

- American Chemistry Council
- Solar Fuels Institute
- National Biodiesel Board
- Gasification & Syngas Technologies Council
- Asian Clean Fuels Association
- China Nitrogen Fertilizer Industry Association
- Chinese Association of Alcohol & Clean Ether Fuels & Automobiles
- China Ministry of Industry and Information Technology
- Peking University Center for New Global Energy Strategy Studies
- Gulf Petrochemicals and Chemicals Association
- International DME Association
- European Chemical Industry Council (CEFIC)
- Formacare
- German Regenerative Methanol Network
- International Methanol Producers & Consumers Association
- European Sustainable Shipping Forum (ESSF)
- International Bunker Industry Association
- Dangerous Goods Advisory Council
02 METHANOL PRODUCTION
Conventional Methanol Production

Steam (H₂O) → Reforming → Synthesis gas → Methanol/Water Distillation → Methanol

Natural Gas → Reforming → Synthesis gas = CO + H₂, CO₂ + H₂ → Methanol/Water (CH₃OH/H₂O) → Distillation → Methanol/Water

Fuel Gas → Methanol Converter → Methanol ➔ To Burners

Methanol/Water (CH₃OH/H₂O) ➔ To H₂ consumers

H₂ Purge ➔ To H₂ consumers

Water ➔ Distillation tower

WWW.METHANOL.ORG

8
US Methanol Resurgence

• In 1996, US was world leader in methanol production and demand, with production capacity of nearly 10 MMT, while natural gas was at $2.00 MMBTU.

• With sharp natural gas price increases from late 1990s and 2000s, US went through painful “rationalization” with plant closings, with just three operating plants left by end of decade and just 780,000 metric tons of production capacity.

• The shale gas revolution and the affordability of natural gas has led a resurgence of North American methanol production, with capacity now at 5.75 MMT, and the 1.75 MMT Natgasoline plant on the way.
Many pathways – bio/renewable-methanol

Biomass (wood, MSW, a.o.)
- Fermentation
  - Biogas
  - Bio-methane
- Gasification
  - Syngas
- Electrolysis
  - H₂

Cooker
- Syngas

BIO-METHANOL
- RENEWABLE METHANOL
- LOW CARBON METHANOL

CO₂
- Carbon capture

(Methane)

WWW.METHANOL.ORG
## Status of different technologies

<table>
<thead>
<tr>
<th>Methanol category</th>
<th>Commercial</th>
<th>Feasibility</th>
<th>On hold/stopped</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bio-methanol</strong></td>
<td>BioMCN (biogas), Enerkem (Can), Oberon, NewFuel</td>
<td>Enerkem (NL), LowLands Methanol</td>
<td>BioMCN (glycerine), Chemrec, Range Fuels, Schwarze Pumpe, Värmlands Metanol, Woodspirit</td>
</tr>
<tr>
<td><strong>Renewable methanol</strong></td>
<td>Carbon Recycling International</td>
<td>Port of Antwerp, Infraserv, Innogy, STEAG, Swiss Liquid Future, ZASIt</td>
<td></td>
</tr>
<tr>
<td><strong>Hybrid methanol</strong></td>
<td></td>
<td>OPTIMEoH</td>
<td></td>
</tr>
<tr>
<td><strong>Low carbon methanol</strong></td>
<td>Methanex, QAFAC, SABIC, GPIC</td>
<td>Carbon2Chem, FRESME</td>
<td></td>
</tr>
</tbody>
</table>
Small-Scale Production: Primus Green Energy

- Primus had developed a range of flexible gas-to-liquids systems that can produce methanol, DME or gasoline.
- The systems are simple and economical at scales as low as 500 MMBtu/day.
- Feedstocks: flare gas; stranded ethane; pipeline natural gas; excess syngas from underutilized reformers.
Small-Scale Production: GasTechno

- The GasTechno process is a non-catalytic gas-to-liquids technology that converts methane to methanol in one step.
- The “Methanol in a Box” system is housed in a 40-foot shipping container.
- Designed to monetize flare gas from 50,000 cubic feet per day to 30 million cubic feet per day.
03 FUEL MARKETS
Methanol is a versatile fuel source

- Out of the ~75 million metric tons of methanol sold globally in 2016, energy and fuel uses represent one-third of total demand.

- From 2009-2016, 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
Methanol Fuel Examples Around the World

- **Iceland** – M100 Trials
- **Sweden** – methanol marine fuel
- **Denmark** – methanol fuel cells for vehicles
- **China** – M15 to M100, Industrial Boilers
- **UK** – EN228 low blend
- **USA** – methanol motorsport fuel
- **Israel** – Power generation & M15 Standard
- **Egypt** – M15 Trials
- **New Zealand** – Introducing M3
- **Africa** – cooking stoves
- **India** – Methanol Economy Roadmap
- **Australia** – GEM fuel
- **USA** – methanol motorsport fuel
Various Road Transport Options

**M3 – M15**
- EU allows M3 (EN228) *Blended a.o. in UK and NL*
- China uses M15 *Estimated 7 million metric tons ~75% of cars built by international automakers*
- Trials in Australia, Israel, a.o.

**A20 – A30**
- Automakers call for higher octane to facilitate greater engine efficiency (*higher compression, turbocharging, downsizing*)
- Methanol and ethanol alcohol fuels together at mid-level blends provide needed octane

**M51-100**
- ASTM D5797 standard revision
- M100 dedicated vehicles (*e.g. Geely*)
- Use of SI technologies in Light and Heavy Duty vehicles
- Few changes needed to existing vehicle technologies at low cost
Methanol - Practical Liquid Fuel Alternative
## China Provinces in the Driver Seat

<table>
<thead>
<tr>
<th>Province</th>
<th>Local Methanol Gasoline Standards</th>
<th>Implemented Since</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gansu</td>
<td>M15 &amp; M30</td>
<td>2009</td>
</tr>
<tr>
<td>Guizhou</td>
<td>M15</td>
<td>2010</td>
</tr>
<tr>
<td>Hebei</td>
<td>M15 &amp; M30</td>
<td>2010</td>
</tr>
<tr>
<td>Heilongjiang</td>
<td>M15</td>
<td>2005</td>
</tr>
<tr>
<td>Jiangsu</td>
<td>M45</td>
<td>2009</td>
</tr>
<tr>
<td>Liaoning</td>
<td>M15</td>
<td>2006</td>
</tr>
<tr>
<td>Shaanxi</td>
<td>M15 &amp; M25</td>
<td>2004</td>
</tr>
<tr>
<td>Shandong</td>
<td>M15</td>
<td>2012</td>
</tr>
<tr>
<td>Shanghai</td>
<td>M100</td>
<td>2013</td>
</tr>
<tr>
<td>Shanxi</td>
<td>M5, M15, M85 &amp; M100</td>
<td>2008</td>
</tr>
<tr>
<td>Sichuan</td>
<td>M10</td>
<td>2004</td>
</tr>
<tr>
<td>Xinjiang</td>
<td>M15 &amp; M30</td>
<td>2007</td>
</tr>
<tr>
<td>Zhejiang</td>
<td>M15, M30 &amp; M50</td>
<td>2009</td>
</tr>
<tr>
<td>Ningxia</td>
<td>M15 &amp; M30</td>
<td>2014</td>
</tr>
</tbody>
</table>
China High Proportion Methanol Fuel

2009

China adopted national standards for M85 and M100

2012

MIIT “high proportion” methanol demonstration to serve as the basis for M85 vehicle standards in Shanxi, Shaanxi, and Shanghai, and has expanded to other provinces and cities

2016

7 million tons (2.3 billion gallons/8.7 billion liters) of methanol blended with gasoline, against total gasoline consumption of 2.25 million barrels per day or 34.5 billion gallons/130 billion liters

180,000

Vehicles converted to methanol fuel, mostly taxis
China MIIT’s Methanol Car Demonstration Program - 中国工信部开展的甲醇汽车试点

Till Now

- The methanol cars, including models of taxi, minibus, bus and heavy truck, were put into the demonstration program.
  甲醇车辆包括出租车，面包车，公交车和重卡等车型投入试点示范运行。

- The longest running time of cars participated in the demonstration program has reached 4 years.
  参加甲醇汽车试点车辆单车最长运行时间达到4年。

- The grand total driving distance of cars in 10 demonstration cities was more than 60,000,000km and more than 9600 tons of methanol fuel were consumed.
  10个试点城市试点车辆累计运行里程超过6000万公里，累计消耗甲醇燃料超过9600吨。

Denmark: Methanol Fuel Cell EV Range Extender

- In Denmark the Green Methanol Infrastructure consortium (Serenergy, OK and Hamag) opened the first methanol fuel pump in Europe.

- Cars/vans use Serenergy RMFC technology as range extender and CRI methanol as fuel.

- The consortium reports increasing range of battery powered vehicles from 200 to 800 kilometers.
Israel Methanol Fuels Demonstrations

- Israel fundamentals:
  - Large gas finds in Israel
  - Strategic need to reduce oil dependence
- Prime Minister Netanyahu established Fuel Choices Initiative.
- Driven 1,000,000 kms on M15 fuels with improved power and torque.
- In 2016, Israel adopted national standard for M15 fuels.
- Fiat marketing M15 car in Israel, and Dor Chemicals has introduced M15 retail pumps.
India: Roadmap to Methanol Economy

• On 11 September 2015, NITI Aayog held brainstorming session on possible roadmap for Methanol Economy for India’s long-term energy security

• Formed three Expert Groups:
  • Production of Methanol and DME
  • Utilization of Methanol and DME
  • Research and Development

• The Methanol Institute has committed to assisting the Expert Groups as they look to opportunities to increase methanol production from coal and biomass, and utilize methanol and DME as transportation fuels

• MI jointly organized Methanol Economy International Seminar held in Delhi on 6-7 September 2016
Shifting Policy Landscape
US Renewable Fuel Standard Requirements

![Graph of Renewable Fuel Standard Volumes by Year](image)

- **2008**: Approximately 8 billion gallons
- **2009**: Approximately 10 billion gallons
- **2010**: Approximately 12 billion gallons
- **2011**: Approximately 14 billion gallons
- **2012**: Approximately 16 billion gallons
- **2013**: Approximately 18 billion gallons
- **2014**: Approximately 20 billion gallons
- **2015**: Approximately 22 billion gallons
- **2016**: Approximately 24 billion gallons
- **2017**: Approximately 26 billion gallons
- **2018**: Approximately 28 billion gallons
- **2019**: Approximately 30 billion gallons
- **2020**: Approximately 32 billion gallons
- **2021**: Approximately 34 billion gallons
- **2022**: Approximately 36 billion gallons

- **Other Advanced Fuels**
- **Biomass-based Diesel**
- **Cellulosic**
- **Conventional (starch ethanol)**

Note: The graph shows the increase in Renewable Fuel Standard Volumes from 2008 to 2022, with a particular focus on the contribution of various types of fuels.
No viable pathway to 36 billion gallons

- 2018 Cellulosic Statutory Volume Requirement = 7 billion gallons
- EPA Rule proposes just 238 million gallons of cellulosic ethanol
- Note: 2.1 billion gallons of biodiesel demand = 300 million gallons of methanol demand

Proposed Volume Requirements

<table>
<thead>
<tr>
<th>Proposed Volume Requirements</th>
<th>2018</th>
<th>2019</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cellulosic biofuel (million gallons)</td>
<td>238</td>
<td>n/a</td>
</tr>
<tr>
<td>Biomass-based diesel (billion gallons)</td>
<td>2.1</td>
<td>2.1</td>
</tr>
<tr>
<td>Advanced biofuel (billion gallons)</td>
<td>4.24</td>
<td>n/a</td>
</tr>
<tr>
<td>Renewable fuel (billion gallons)</td>
<td>19.24</td>
<td>n/a</td>
</tr>
</tbody>
</table>

a All values are ethanol-equivalent on an energy content basis, except for BBD which is biodiesel-equivalent.
b The 2018 BBD volume requirement was established in the 2017 final rule (81 FR 89746, December 12, 2016).

EU Renewable Energy Directive II: Main proposed policy changes

<table>
<thead>
<tr>
<th>2020</th>
<th>OBJECTIVE</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>20%</td>
<td>$\text{CO}_2$ reduction</td>
<td>40%</td>
</tr>
<tr>
<td>20%</td>
<td>Renewable energy</td>
<td>27%</td>
</tr>
<tr>
<td>20%</td>
<td>Energy efficiency</td>
<td>27%</td>
</tr>
<tr>
<td>10%</td>
<td>Sustainable biofuels</td>
<td>6.8%</td>
</tr>
<tr>
<td>max. 7%</td>
<td>First generation</td>
<td>max. 3.8%</td>
</tr>
<tr>
<td>0.5%</td>
<td>Advanced biofuels</td>
<td>3.6% min</td>
</tr>
<tr>
<td>yes</td>
<td>Double counting</td>
<td>no</td>
</tr>
</tbody>
</table>
Decreasing 1st gen use, increase of advanced
05 MARINE FUELS
Marine Fuel in Transition

• Bunker fuel – usually made from diesel has been historically used in the shipping industry.

• With over 90,000 commercial vessels moving around the world’s oceans, shipping consumes 370 million tons of fuel (Heavy Fuel Oil and Middle Distillates).

• Bunker fuel has been highly polluting; high SOx, NOx, particulate emissions.
The International Maritime Organization has adopted regulations for SOx and NOx that are transforming the shipping industry.

While SOx reductions may be met with low sulfur fuels, the combination of SOx and NOx reductions driving shipboard solutions.
Options available to ship owners

- HFO + scrubbers
- MGO
- LNG
- Methanol
Methanol fueled vessels on the water today

<table>
<thead>
<tr>
<th>WFS, MOL, WL, Marininvest</th>
<th>Stena Lines</th>
<th>Swedish Maritime Administration, MI</th>
<th>Methaship, Leanships, a.o.</th>
</tr>
</thead>
<tbody>
<tr>
<td>7 chemical tankers</td>
<td>1 RoPax ferry</td>
<td>1 pilot boat</td>
<td>Cruise ship, ferry a.o.</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>
Green Pilot Program - 瑞典绿色示范船项目

The Picture of the ship installed with Methanol Engine
发动机装船后效果图

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.
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
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
06 NEW MARKETS
In 2011, Israel Electric Corp (IEC) & Dor performed trial conversion at power plant located in valley in Eilat

Previously used diesel-fuelled turbine for peak power. Permit limited to 300 hours of operation annually; no pipeline natural gas access

June 2014 commercial operation of 100% methanol-fuelled Pratt & Whitney FT4C Twin Pack 50 MW gas turbine.
IEC/Dor Findings

• Low-cost fuel system retrofits to methanol, with this initial project costing $5 million.
• Yields significant NOx, SO2, and particulates emission reduction, without affecting performance.
• Unit now permitted to operate without restrictions.
• Methanol consumption is **30 tons per hour**.
• This technology (*first of its type in the world*) can be adopted in many other places (mainly Islands) where due to no natural gas supply, are currently using polluting fuels.
Methanol in Cooking Stove Applications

China is Leading the World

- Methanol for cooking applications in China since 1983
- Available for purchase on Internet
- Current market for 3 million metric tonnes/year, with potential for additional 8 million metric tonnes of demand
- Use of alcohol in cooking fuels could reduce annual direct coal burning by 3,172 MW and CO$_2$ emissions decrease of 8.25 billion tons
Methanol Boiler Fuel

- Methanol Boiler in Tianjin, 15 steam ton/hour
- Currently, 1,000 converted boiler units in China consuming 1 million metric tonnes per year of methanol
Primary Applications for Fuel Cells

Charging/Replacement of batteries
- Forklifts
- Camper vans

Provision of off-grid or grid-support power
- Backup power supply to telecoms towers
- Remote communities
- Desalinization plants
- Off-grid mining
Different development stages for fuel applications

- DME
- OME
- MD95
- M100
- GEM
- Turbines
- Generators
- MTBE
- Biodiesel
- M15
- M3
- Boilers
- Cook stoves
- Fuel cell
- Marine
- Fuel cell

- Introduction
- Growth
- Mature
- Decline
07 CONTACTS
MSF MAINTAINS A PRESENCE IN OVER 60 COUNTRIES

MANY OF THESE COUNTRIES MI HAS TARGETED FOR METHANOL POISONING OUTREACH PROGRAMS, MSF HAS EXISTING OPERATIONS, TO INCLUDE:

• • • • • • • •

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