Overview of Global Methanol Fuel Blending

Gregory Dolan, CEO – Methanol Institute
Trinidad and Tobago Methanol Fuel Blending Forum
24 January 2019
01 WHO WE ARE
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
Methanol: Broad Feedstocks and Markets

**Feedstocks**
- Natural gas (~65%)
- Coal (~35%)
- Biomass & renewables (<1%)

**Conversion**
- Methanol synthesis

**Derivatives**
- Other solvents
- Chloromethanes
- MTO
- Methyamines
- DME
- Biodiesel
- Gasoline blending
- MTMA
- MTBE
- Acetic acid
- Formaldehyde

**Products**

**Markets**
- Appliances
- Automotive
- Construction
- Electronics
- Fuel
- Paint
- Pharma
- And more...
Methanol is a versatile fuel source

Out of the ~80 million metric tons of methanol sold globally in 2018, energy and fuel uses represent 40% of total demand.

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 Methanol Fuel Examples

- **Canada** – Waterfront vessels
- **USA** – motorsport fuel
- **UK** – EN228 low blend
- **Iceland** – M100 trials
- **Sweden** – marine fuel
- **Denmark** – fuel cells for vehicles
- **China** – M15 to M100, boilers, cook stoves
- **New Zealand** – M3
- **Africa** – cook stoves
- **Israel** – M15, power generation
- **India** – Methanol Economy roadmap
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03 Methanol Blending
Solutions for gasoline and diesel engines

Gasoline:
- Low blends
- Mid-level blends
- High blends

Diesel:
- FAME
- SI/CI HDVs
- DME/OME
Various Gasoline/Diesel Blend Options

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

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

**M51-100**
- ASTM D5797 standard M51-M85
- M100 dedicated vehicles (e.g. Geely)
- Use of SI technologies in light duty vehicles
- Both SI and CI for heavy duty vehicles
Methanol - Practical Liquid Fuel Alternative

A Practical alternative

Low energy density
High on board storage costs

Dominant global transportation fuels, high energy density
### Fuel Properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Gasoline</th>
<th>Diesel</th>
<th>Ethanol (E85)</th>
<th>Methanol (M85)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical Structure</td>
<td>C₄ to C₁₂</td>
<td>C₈ to C₂₅</td>
<td>CH₃CH₂OH</td>
<td>CH₃OH</td>
</tr>
<tr>
<td>Feedstocks</td>
<td>Crude Oil</td>
<td>Crude Oil</td>
<td>Corn</td>
<td>Natural Gas, Coal, Biomass, CO₂</td>
</tr>
<tr>
<td>Gasoline Gallon Equivalent</td>
<td>100%</td>
<td>113%</td>
<td>75%</td>
<td>65%</td>
</tr>
<tr>
<td>Energy Content (LHV)</td>
<td>116,090 Btu/gal</td>
<td>128,450 Btu/gal</td>
<td>76,330 Btu/gal</td>
<td>57,250 Btu/gal</td>
</tr>
<tr>
<td>Energy Content (HHV)</td>
<td>124,340 Btu/gal</td>
<td>137,380 Btu/gal</td>
<td>84,530 Btu/gal</td>
<td>65,200 Btu/gal</td>
</tr>
<tr>
<td>Pump Octane</td>
<td>84-93</td>
<td>n/a</td>
<td>110</td>
<td>112</td>
</tr>
</tbody>
</table>
Newer Model Year Vehicles Can Manage Higher Alcohol Blends

Ethanol vs Methanol Gasoline Blend Vehicle Performance

- CRC - E20 performed well for Model Year 1997+ Vehicles
- China Introduced M15 starting in 2005
- E15 Waiver for Model Year 2000+ Vehicles
- China Introduced M15 in 2004
- E10 Gasohol since 1978
- E5 in EU
- M3, M5, M7, M10, M14, M15
Global Fuel Standards Allowable Methanol Content

- Earlier commercial Fuel Standards started with nominal 3 vol % methanol in gasoline

- Higher methanol content in gasoline allowed as global automotive fuel system technology and materials continue to improve in global vehicle fleets

| Approved Methanol Gasoline Blends with Requirements for Co-solvent Alcohols and Additives |
|-----------------------------------------------|-----------------|-----------------|----------------|----------------|----------------|
| Market Region                               | Introduction Year | Maximum Volume % Methanol | Minimum Volume % Co-solvent | Maximum Wt % Oxygen | Corrosion Additives |
| Europe                                      | EC Directive     | 1985             | 3.0              | ≥ Methanol      | 3.7 %          |
| U.S.A                                       | Sub Sim *        | 1979             | 2.75             | ≥ Methanol      | 2.0 %          |
| U.S.A                                       | Fuel Waiver      | 1981             | 4.75             | ≥ Methanol      | 3.5 %          | Required        |
| U.S.A                                       | Fuel Waiver      | 1986             | 5.0              | ≥ Methanol      | 3.5 %          | Required        |
| China, Shanxi                                | M15 Standard     | 2007             | 15.0             | For Water Tolerance | ~7.9 %          | Required        |

* U.S. EPA’s Substantially Similar Regulation for commercial gasoline

Other countries evaluating introduction of methanol blending standards in gasoline:
Egypt, India, Israel, Italy, New Zealand, Trinidad, Others
Methanol Blending Benefits

Ultra-high Efficiency Characteristics:

- Methanol use in spark ignition engines allows higher efficiencies by increasing the engine knock limit.

- Methanol has much higher flame speed, which allows for tighter combustion control and more precise torque management.

- Improving knock performance is important to help avoid undesired detonation while also allowing for highly effective recovery of energy from exhaust heat.

<table>
<thead>
<tr>
<th>Properties</th>
<th>Methanol</th>
<th>Gasoline</th>
</tr>
</thead>
<tbody>
<tr>
<td>High heat of vaporization</td>
<td>1100</td>
<td>325</td>
</tr>
<tr>
<td>(kJ/kg)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High octane number</td>
<td>109</td>
<td>95</td>
</tr>
<tr>
<td>RON</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High flame speed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laminar burning velocity at NTP (cm/s)</td>
<td>45</td>
<td>30</td>
</tr>
</tbody>
</table>
Methanol Has Superior RON Blending Property
## Key Performance Property Contribution To Gasoline Blending

**Per Unit Volume** and **Per Unit of Energy** Delivered to Gasoline Supplies

<table>
<thead>
<tr>
<th></th>
<th>Ethanol</th>
<th>Methanol</th>
<th>% over Ethanol</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RON</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oct-BBLs</td>
<td>10.5</td>
<td>11.5</td>
<td>+ 10</td>
</tr>
<tr>
<td>Oct-BBLs / GJ</td>
<td>3.12</td>
<td>4.60</td>
<td>+ 48</td>
</tr>
<tr>
<td><strong>HoV (cooling)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GJ / m³</td>
<td>0.66</td>
<td>0.91</td>
<td>+ 38</td>
</tr>
<tr>
<td>GJ / GJ</td>
<td>0.03</td>
<td>0.06</td>
<td>+ 86</td>
</tr>
</tbody>
</table>

Methanol delivers much more octane and evaporative cooling to gasoline blending than Ethanol.
Material Compatibility With Methanol Blends Well Understood

- Elastomer Compatibility with Methanol Blends well studied in the 1980’s
- Society of Automotive Engineers (SAE) Compatibility Guidelines established M15 as fuel standard for selecting materials used in vehicle fuel systems starting 1993

![Elastomer Volume Swells of Gasoline Methanol Blend](chart)

Base gasoline with 10% Methanol Swells Similar to High Aromatic Gasoline

- Natural Rubber
- Ethylene-propylene diene terpolymer
- Polyacrylate
- Chlorosulfonated Polyethylene
- Butadiene-acrylonitrile
- Fluorosilicone

![Graph](chart)
<table>
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<tr>
<th>Material</th>
<th>Compatibility</th>
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<th>Compatibility</th>
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<tbody>
<tr>
<td>304 stainless steel</td>
<td>A-Excellent</td>
<td>Hypalon</td>
<td>A-Excellent</td>
</tr>
<tr>
<td>316 stainless steel</td>
<td>A-Excellent</td>
<td>Hytrel</td>
<td>B-Good</td>
</tr>
<tr>
<td>Acetal (Delrin)</td>
<td>A-Excellent</td>
<td>Kalrez</td>
<td>A-Excellent</td>
</tr>
<tr>
<td>Aluminum</td>
<td>A¹-Excellent</td>
<td>Kel-Fr</td>
<td>A¹-Excellent</td>
</tr>
<tr>
<td>Brass</td>
<td>A-Excellent</td>
<td>LDPE</td>
<td>A-Excellent</td>
</tr>
<tr>
<td>Bronze</td>
<td>A-Excellent</td>
<td>Natural rubber</td>
<td>A-Excellent</td>
</tr>
<tr>
<td>Buna N (Nitrile)</td>
<td>A-Excellent</td>
<td>Neoprene</td>
<td>A-Excellent</td>
</tr>
<tr>
<td>Carbon graphite</td>
<td>A-Excellent</td>
<td>NORYLr</td>
<td>A-Excellent</td>
</tr>
<tr>
<td>Carbon Steel</td>
<td>A-Excellent</td>
<td>Nylon</td>
<td>B¹-Good</td>
</tr>
<tr>
<td>Carpenter 20</td>
<td>A-Excellent</td>
<td>Polycarbonate</td>
<td>B¹-Good</td>
</tr>
<tr>
<td>Cast iron</td>
<td>A-Excellent</td>
<td>Polyetherether Ketone (PEEK)</td>
<td>A-Excellent</td>
</tr>
<tr>
<td>Ceramic Al203</td>
<td>A-Excellent</td>
<td>Polypropylene</td>
<td>A²-Excellent</td>
</tr>
<tr>
<td>Ceramic magnet</td>
<td>A-Excellent</td>
<td>PPS (Ryton®)</td>
<td>A-Excellent</td>
</tr>
<tr>
<td>ChemRaz (FKM)</td>
<td>A-Excellent</td>
<td>PTFE</td>
<td>A-Excellent</td>
</tr>
<tr>
<td>Copper</td>
<td>B¹-Good</td>
<td>PVC</td>
<td>A¹-Excellent</td>
</tr>
<tr>
<td>CPVC</td>
<td>A-Excellent</td>
<td>PVDF (Kynar®)</td>
<td>A-Excellent</td>
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<tr>
<td>EPDM</td>
<td>A-Excellent</td>
<td>Silicone</td>
<td>A-Excellent</td>
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<tr>
<td>Epoxy</td>
<td>B¹-Good</td>
<td>Titanium</td>
<td>B-Good</td>
</tr>
<tr>
<td>Fluorocarbon (FKM)</td>
<td>C-Fair</td>
<td>Tygon</td>
<td>A¹-Excellent</td>
</tr>
<tr>
<td>Hastelloy-Cr</td>
<td>A-Excellent</td>
<td>Viton</td>
<td>C-Fair</td>
</tr>
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Footnotes for Previous Table:

2. Explanation of Footnotes
   1. Satisfactory to 72°F (22° C)
   2. Satisfactory to 120°F (48° C)

Ratings -- Chemical Effect
A = Excellent.
B = Good -- Minor Effect, slight corrosion or discoloration.
C = Fair -- Moderate Effect, not recommended for continuous use. Softening, loss of strength, swelling may occur.
D = Severe Effect, not recommended for ANY use.
N/A = Information Not Available.

3. The only severe defect (level D) noted were for ABS plastic and polyurethane. However, neither of these materials is likely used in fuel wetted parts in vehicles, since aromatic compounds such as benzene, toluene and xylene each have an equivalent rating of severe defect level D for both ABS plastic and polyurethane. Thus, these specific material incompatibilities have no practical significance in the context of low level methanol blended transportation fuels.
Monitoring For Water Maintains Quality / Stability of Methanol Blends

- Good operating practices in gasoline distribution system maintain quality gasoline
Inherently lower NOx and PM due to low temperature combustion properties;

C1 compounds in M85 compared to the much higher carbon content of reformulated gasoline

A lack of carbon-carbon bonds results in ultra-low particulate emissions;

The atmospheric reactivity of methanol is recognized to have lower ozone forming potential compared to the olefins and aromatics present in gasoline.
Methanol Provides Environmental Benefits

- Blending clean burning methanol also adds oxygen and volatility to gasoline which:
  - reduces vehicle exhaust emissions that reduces air pollution from Mobile Sources
  - improves combustion efficiency that raises methanol's net energy contribution from 50% of gasoline energy equivalent up to ~60% which further lowers vehicle's CO2/km
Fuel safety comparing apples to apples

<table>
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<tr>
<th>Hazard pictograms (CPL)</th>
<th>METHANOL</th>
<th>DIESEL</th>
<th>GASOLINE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><img src="image" alt="Methanol Icon" /></td>
<td><img src="image" alt="Diesel Icon" /></td>
<td><img src="image" alt="Gasoline Icon" /></td>
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<th>Signal word: (CPL)</th>
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<th>DIESEL</th>
<th>GASOLINE</th>
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<tr>
<td>Danger</td>
<td><img src="image" alt="Methanol Icon" /></td>
<td><img src="image" alt="Diesel Icon" /></td>
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<th>GASOLINE</th>
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<td>H225 Highly flammable liquid and vapour</td>
<td><img src="image" alt="Methanol Icon" /></td>
<td><img src="image" alt="Diesel Icon" /></td>
<td><img src="image" alt="Gasoline Icon" /></td>
</tr>
<tr>
<td>H331 Toxic to contact with skin</td>
<td><img src="image" alt="Methanol Icon" /></td>
<td><img src="image" alt="Diesel Icon" /></td>
<td><img src="image" alt="Gasoline Icon" /></td>
</tr>
<tr>
<td>H370 Causes damage to organs</td>
<td><img src="image" alt="Methanol Icon" /></td>
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<td><img src="image" alt="Gasoline Icon" /></td>
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<th>Precautionary statements (CLP)</th>
<th>METHANOL</th>
<th>DIESEL</th>
<th>GASOLINE</th>
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</thead>
<tbody>
<tr>
<td>Follow special instructions before use</td>
<td><img src="image" alt="Methanol Icon" /></td>
<td><img src="image" alt="Diesel Icon" /></td>
<td><img src="image" alt="Gasoline Icon" /></td>
</tr>
<tr>
<td>Use only in well-ventilated area</td>
<td><img src="image" alt="Methanol Icon" /></td>
<td><img src="image" alt="Diesel Icon" /></td>
<td><img src="image" alt="Gasoline Icon" /></td>
</tr>
<tr>
<td>Protect from direct sunlight</td>
<td><img src="image" alt="Methanol Icon" /></td>
<td><img src="image" alt="Diesel Icon" /></td>
<td><img src="image" alt="Gasoline Icon" /></td>
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**METHANOL INSTITUTE**

[WWW.METHANOL.ORG](http://WWW.METHANOL.ORG)
Methanol has lower fire risk than gasoline

Methanol
- evaporates slowly
- needs lots of vapour to burn
- confined fire zone; fires less likely

Gasoline
- evaporates fast
- needs little vapour to burn
- broad fire zone; fires more likely
Methanol is less dangerous than gasoline

Table 6-1

<table>
<thead>
<tr>
<th>Hazard Summary</th>
<th>M100</th>
<th>Gasoline</th>
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<tbody>
<tr>
<td>Flammability</td>
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<tr>
<td>Ease of Occurrence</td>
<td>4</td>
<td>9</td>
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<tr>
<td>Open &amp; Restricted Areas</td>
<td>8 (2-4)*</td>
<td>2</td>
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<tr>
<td>Enclosed Spaces</td>
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<tr>
<td>Relative Hazard if Fire</td>
<td>3</td>
<td>10</td>
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<tr>
<td>Fire Severity</td>
<td>7</td>
<td>10</td>
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<tr>
<td>Ease of Extinguishing</td>
<td>8</td>
<td>1</td>
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<tr>
<td>Flame Visibility</td>
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<td></td>
</tr>
<tr>
<td>Toxicity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inhalation-Low Conc.</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>Toxicity</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Inhalation - High Conc.</td>
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<td>4</td>
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<tr>
<td>Toxicity</td>
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<td>10</td>
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<tr>
<td>Ease of Occurrence</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Skin Contact</td>
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<tr>
<td>Toxicity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ease of Occurrence</td>
<td>8(2)*</td>
<td>10</td>
</tr>
<tr>
<td>Ingestion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toxicity</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Ease of Occurrence</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table adapted from Machiele, 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.**

Source: Malcolm Pirnie, Inc., Technical Memorandum
SAFER FOR THE ENVIRONMENT

LC50, LC = LETHAL CONCENTRATION
Concentration in water, at which half the population died within specified test duration

- Safer than Diesel by a factor of 240 times
  - Methane\(^5\) 49.9 (mg/l)
  - Heavy Fuel Oil\(^3\) 79 (mg/l)
  - Diesel\(^4\) 65 (mg/l)
- Safer than Gasoline by a factor of 1900 times
  - Methanol\(^1\) 15,400 (mg/l)
  - Gasoline\(^2\) 8.2 (mg/l)

- Methane\(^5\)
- Heavy Fuel Oil\(^3\)
- Diesel\(^4\)
- Gasoline\(^2\)

\(^1\) 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
04
40 Years of Experience
40+ Years of Global Experiences with Methanol/Gasoline Blends

- German Automakers and Oil Refiners conducted small vehicle fleet trials of methanol/gasoline fuels in mid-1970’s

- Germans selected M15 as highest methanol content for use in vehicles with 1980’s carburetor fuel systems and material compatibility

- Number of larger methanol/gasoline blend fleet trials conducted in late 1970’s / early 1980’s

  - Germany ~ 1,000 vehicles
  - Sweden ~ 1,000 vehicles
  - New Zealand ~ 950 vehicles
  - China ~ 500 vehicles

  *Results: Methanol with corrosion inhibitors and co-solvent alcohols provided stable gasoline fuel, and protected fuel system metals in vehicles*

- The State of California managed extensive methanol/gasoline fuel programs in 1980’s/1990’s

- Some China Provinces initiated commercial M15 market trials in 2004
The California Methanol Experience

Methanol Deployment in Light Duty Vehicles

California Demonstrated Methanol as a Transportation Fuel in Light- and Heavy Duty Vehicles

mdj Research
California Methanol Programs in the 1980s-90s, was fundamentally a technical success.

- Sixty retail fuelling stations
- 17,500 M85-compatible vehicles - first large scale production of Flexible Fuel Vehicles
- Over 200 million miles of successful vehicle operating experience along with a zero-incident health & safety record
However, despite the establishment of a California Fuel Methanol Reserve (CFMR), the low oil price during that period presented major competitive challenges…
POSITIVE OUTCOMES

+ Distillation Properties
+ Water Solubility
+ Material Compatibility in FFVs
+ Vehicle Emission Impacts (e.g., HCHO standard adopted and easily complied with via close coupled catalysts)
+ Octane Effects
+ Blending Vapor Pressure
+ Toxicity of Vapors
+ Risk Mitigation (e.g., flame arrestors, anti-siphoning devices)
UK BioMethanol Blending

- UK Department of Transport: Renewable Transport Fuel Obligation Report – 1 February 2018
- Averages 1% methanol in summer, and 1.5% in winter
- Biomethanol 57 Million liters, or 4% of UK total renewable fuel use
- “The supply of biomethanol has been increasing in recent years to an all-time high in 2016/2017”

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 being demonstrated in 5 FCA Fiat 500 vehicles in Eni’s Enjoy car-sharing fleet

### A20: a New Methanol-based Alternative Fuel

#### CUNA specification (NC 627-02 July 2018)

<table>
<thead>
<tr>
<th>Property</th>
<th>Units</th>
<th>Limits MIN – MAX</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research octane number, RON</td>
<td></td>
<td>100</td>
</tr>
<tr>
<td>Motor octane number, MON</td>
<td></td>
<td>86</td>
</tr>
<tr>
<td>Load 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>
</tr>
<tr>
<td>Sulfur content</td>
<td>mg/kg</td>
<td>10.0</td>
</tr>
<tr>
<td>Manganese content</td>
<td>mg/l</td>
<td>2.0</td>
</tr>
<tr>
<td>Nitrogen content</td>
<td>ppm</td>
<td>100</td>
</tr>
<tr>
<td>Oxidation stability</td>
<td>minutes</td>
<td>300</td>
</tr>
<tr>
<td>Existing 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>% (V/V)</td>
<td>10.0</td>
</tr>
<tr>
<td>Methanol</td>
<td>% (V/V)</td>
<td>12.0</td>
</tr>
<tr>
<td>Ethanol + other Alcohols (C3,C4)</td>
<td>% (V/V)</td>
<td>16.0</td>
</tr>
<tr>
<td>Ethers (5 or more C atoms) other oxygenates</td>
<td>Volume blending of these components is restricted to 10.0 % (m/m) maximum oxygen content including methanol oxygen.</td>
<td></td>
</tr>
</tbody>
</table>

CUNA NC 627-02 include also the evaporative class parameters to prepare A20 grade for summer, winter and transition period.
A20: Overall Transparency

After 1000 hours of test No evidence of corrosion-related criticalities for A20.

For all types of tube tested, the ageing of A20 fuel does not lead to criticality in the mechanical behavior of the materials.

The results of the tests carried out so far confirm the compatibility of the fuel with FCA vehicles compliant with E10.

Next step: Ongoing process to check the compatibility to other carmakers and motorcycle manufacturers.
Fleet Test is On-going in Milan

Eni got approval from Italian Ministers to use A20 fuel for fleet tests as first step for selling into Italian market

In November 2017 the fleet tests started on Enjoy car sharing vehicles (n.5 Fiat 500) constantly monitored and refueled by the Enjoy team on a Eni station c/o Milan

Endurance test

- The car subjected to accumulation has run 100,000 km. All the controls (emissions, etc.) have been successful
EU Rally Racing with GEM Fuels

• Methanol Institute, Methanex and OCI NV (Natgasoline) sponsored GEM fuels in 2013, 2014, and 2015 World Rally Championship.

• GEM Fuels: 37% Gasoline; 21% Ethanol; 42% Bio-Methanol

• 2013 Junior WRC and 2014 Fiesta Trophy Results:
  • 24 young drivers in 10 Rally Race events across Europe drove 16,000 km
  • Consumed 38,000 liters of GEM fuels
  • Saved 66,000 kilograms of CO2
Green Methanol Infrastructure consortium opened the first methanol fuel pump in Europe.

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

Increasing range of battery powered vehicles from 200 to 800 kilometers.

Serenergy fuel cells also in Gumpert RG Nathalie, a methanol fuel cell powered electric supercar with a 1,200 km (745 mile) range and a top speed of 300 km/h (186 mph).
Methanol Fuels being commercialized in Australia
- Project led by Coogee. Methanex is a partner
- Methanol excise tax free status for 10 years (~A38c/litre)
- Successful road trials and testing programs completed
- Commercial roll out of GEM 8 (M5/E3) on hold pending methanol plant restart: GEM15 & GEM56 in the future

**Selected Test Fuel Properties for ULP and Alcohol Blends**
Israel Methanol Fuels Demonstrations

• 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 retails pumps
China Leading World in Methanol Fuel Use

China methanol consumption in fuel products
thousand barrels per day


other fuel uses
methanol derivatives to gasoline
direct methanol blending to gasoline

https://www.eia.gov/todayinenergy/detail.php?id=30072
China Methanol Fuel Status

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.

2014
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.
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.
- Now introduced M100 bus, long-haul truck and medium-duty truck.
India: Roadmap to Methanol Economy

- September 2015, NITI Aayog formed Methanol Economy Expert Group
- September 2016, MI jointly organized Methanol Economy International Seminar held in Delhi
- M15 rollout in January 2019
- NITI Aayog has plan to replace 20% of crude imports from methanol, reducing fuel costs by 30%
05 MARINE FUELS
The International Maritime Organization has adopted emission regulations transforming the shipping industry.

- In 2020, global SOx reductions take effect.
- By 2050, greenhouse gas emissions must be cut in half.
Examples of vessels running on methanol

**DUAL FUEL**
- **7x** - +4
  - chemical tankers
  - MOL, WL, Marininvest
  - 2 stroke MAN
  - new build
- **1x**
  - ROPAX ferry
  - Stena Line
  - 4 stroke Wärtsila
  - retrofit

**FUEL CELL**
- **2x**
  - Pilot boat
  - MI/SMA ScandiNaos
  - high speed Scania, Weichai
  - retrofit
- **1x**
  - Tourist boat
  - Innogy HTWG Konstanz
  - Serenergy fuel cell stacks
  - retrofit

**PROJECT and R&D**
- **1x**
  - Cruise ships, fishing boat, barge, dredge, a.o.
  - SUMMETH/MARTEC, Lean Ships, Methaship, Billion Miles, FiTech, India
  - PCG Product Vessel, NTU Test Bed
  - Port of Rotterdam Barge
  - SI hybrid, dual fuel, etc.
  - new build & retrofit
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
OTHER MARKETS
Methanol Industrial Boilers in China

- 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 2017**
- **Growing to 5 MMT in 5 years**

https://www.methanol.org/energy/boiler-cookstoves/
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 estimated over 5 MMTs in China in 2017
- Growing to 7-8 MMT in 5 years
Methanol a Hydrogen Carrier for Fuel Cells

- Horizon Energy Systems (Singapore)
- Oneberry (Singapore)
- Altergy (USA)
- Palcan (China)
- Serenegy (Denmark)
- SFC Energy (Germany)
- Toshiba (Japan)
- Ultracell (USA)
- Blue World Technologies (Denmark)
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