Methanol fuel drivers: Public policy, economics, energy and the environment

Gregory Dolan
Methanol Institute
About the Methanol Institute

- Members include:
  - World’s leading methanol producers
  - Distributors
  - Technology companies

- Provides market support:
  - To traditional markets & derivatives
  - Leads the development of new emerging markets and applications
  - Delivers safe handling tools to global distribution chain
2013 members
Methanol basics

- The simplest of all alcohols $\text{CH}_3\text{OH}$
- A pure clean burning liquid fuel with the highest available hydrogen to carbon ratio
- A high octane blending component for gasoline that allows for higher engine compression, decreases hydrocarbon, toxic, and carbon monoxide emissions
- A globally marketed commodity with a distribution system similar to gasoline
Methanol basics

- A fuel made from non-petroleum feed stocks such as natural gas, coal and residue/biomass/renewable
- A fuel with has a long history of use in racing vehicles, that is rapidly expanding in China, and being tested in various parts of the world
- A much less flammable fuel than gasoline
- A fuel competitive with gasoline, and a biofuel competitive with ethanol
Polygeneration

- Natural gas
- Coal
- Biomass
- CO₂

Synthesis gas → Methanol → Fuels
  - Methanol
  - Gasoline
  - DME
  - MTBE
  - Ethanol
  - Olefins
  - Formaldehyde
  - Acetic Acid
  - Chemicals

Synthesis gas → Chemicals
  - Formaldehyde
  - Acetic Acid
  - Chemicals
Achieving transportation energy policies

Transition to Sustainable Fuels

- Total of Sustainable Fuels
- Synthetic Fuels from Air CO2
- Synthetic Fuels from Fluegas CO2
- 2nd Biofuels
- 1st Biofuels

Time - Years

%
Methanol basics – chemical applications
Global methanol demand

2000 - 2011 CAGR: 4.6%
2012 - 2016 CAGR: 8.6%

Note: Excludes integrated methanol demand for methanol to olefins and propylene which is forecast to grow from 2.2 million tonnes in 2011 to 18.1 million tonnes in 2016.

Source: IHS, June 2012
Methanol basics
transportation fuel applications

• Out of the ~60 million metric tons of methanol sold globally in 2012, energy and fuel uses represents ~35%
• MTBE
• TAME
• Low blends
• High blends
• Biodiesel
• DME
• MTG
• Diesel blends
• Fuel cells
• Best known example of gasoline blending is China.
• Other countries with increasing use for blending include: Australia, Israel, UK, Netherlands and Iceland
Methanol basics
transportation fuel applications

Direct fueling -
- Blended with gasoline (M3 – M85)
- 8 million metric ton annual demand (2.6 billion gallons)
- Biomethanol is 2\textsuperscript{nd} Generation biofuel

Dimethyl ether -
- Either DME or BioDME
- Can be used neat or blended with propane
- Low-carbon, no-sulfur, diesel replacement
- Transport market is emerging with partners like Volvo and Nissan. Pilots in EU, Japan and China
Methanol basics
transportation fuel applications

Biodiesel -
• Key ingredient in esterification
• Renewable methanol can make ultra-clean biodiesel
• Roughly 15-20% of oil source by mass

MTBE/BioMTBE -
• Extensive world markets remain for MTBE
• Up to 15% MTBE content allowed in EU, compliance with Renewable Energy Directive with BioMTBE attractive
Methanol basics
transportation fuel applications

Methanol-to-olefins -
• A 600,000 tonnes/year MTO project requires 1.8m tonnes/year of methanol
• MTO eases burden of petroleum supply by diversifying feedstocks for light olefins

Methanol-to-gasoline -
• ExxonMobil MTG technology produces sulphur-free 92 Research Octane drop in gasoline
• Better yields than Fischer-Tropsch fuels at lower costs
Blend properties

- Methanol contains oxygen for cleaner fuel combustion
- High blending octane for smoother burning
- Lower boiling temperature for better fuel vaporization
- Highest hydrogen to carbon ratio for lower carbon intensity
- Lower atmospheric reactivity to reduce smog
- No sulphur that can poison catalytic converter
Blending benefits

• Blending methanol allows refiners to expand gasoline production
• Upgrade regular gasoline to higher premium grades
• Ethanol acts as an excellent co-solvent with methanol
• Meet environmental requirements by reducing ozone, CO, toxics and particulates
Methanol economics

Methanol upgrades coal and gas to oil products value

**Energy prices: a massive premium for crude**
USD per mm BTU, 6-month moving average

- Brent Crude Oil
- Natural Gas
- Coal

China policy drivers

- Methanol determined to be energy security priority for China to reduce imports
  - Abundance of coal as feedstock
- Methanol represents 7-8% of China’s transportation fuel pool
  - Primarily in inner provinces/coal regions, not yet widespread in largest cities
  - Central government developing standards for methanol fuel
  - Central government and key provinces conducting pilot program on high-proportion methanol fueled vehicles

12th 5 year plan
- Seeks to capitalize on infrastructure development and promote domestic consumerism
- Focus on energy security and economics, creating more pragmatic path forward
## China methanol production

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<tr>
<th></th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
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<tbody>
<tr>
<td>Company</td>
<td>276</td>
<td>291</td>
<td>295</td>
</tr>
<tr>
<td>Production Capacity (KT)</td>
<td>26280</td>
<td>38400</td>
<td>46540</td>
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<tr>
<td>Capacity year-on-year</td>
<td>12.4</td>
<td>46.1</td>
<td>21.2</td>
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<tr>
<td>Production Output (KT)</td>
<td>11300</td>
<td>17520</td>
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<tr>
<td>Production up</td>
<td>-12.1</td>
<td>55</td>
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Source: CNFIA
## China methanol consumption

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<tr>
<td>Apparent consumption (KT)</td>
<td>16570</td>
<td>22700</td>
<td>31958</td>
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<tr>
<td>Apparent consumption on year (KT)</td>
<td>19.1</td>
<td>37</td>
<td>40.8</td>
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</table>

Source: CNFIA
China methanol industry

- According to CNFIA, the concentration of the methanol industry has been further enhanced in 2011/2012
- 15 methanol companies have annual production capacity of over 600,000 tons, taking up 32.6% of the total production capacity of China
- 33 methanol companies have annual production capacity of over 300,000 tons, representing 47.4% of the total production capacity of China
- 80% of capacity uses coal/coke as feedstock
Methanol economics

Competitive pricing in China

China Domestic Methanol Prices + Methanol Energy and Volume Equivalences for Gasoline Blending

- East China Domestic Price
- Methanol Equivalent Price - Volume Basis
- South China Domestic Price
- Methanol Equivalent Price - Energy Basis

Source: MMSA
Shanxi setting the pace

- China’s Shanxi Province has been demonstrating methanol fuels for 30 years
- Methanol capacity at 6 million tons, by end 2015 could be 20 million tons
- Over 1500 stations selling M15 (650 Sinopec branded), and 60 dispensing M85-M100
- 80,000 methanol flexible fuel vehicles, mainly taxis
  - 15,000 taxis consume 120,000 tons M85/year providing operators with 100 million RMB in annual fuel cost savings
- Building 7 blending centres, each blend 1.5 million tons methanol gasoline/year
U.S. policy drivers

- Detractors: Chamber of Commerce, American Petroleum Institute, Alliance of Automobile Manufacturers
- Shale gas developments open path for methanol production in North America
- Looking towards re-introduction in the House and the Senate in 113th Congress, with new provisions

Open Fuel Standard Act 112th Congress -
- Required starting in 2014, 50% of all new cars warranted to operate on non-petroleum fuels
- Goes up to 80% by 2016, and 95% by 2017
- Includes alcohol FFVs, and vehicles running on CNG, propane, plug-in battery electrics, and fuel cells
North American expansion - high probability

### North America Methanol Expansion Forecast 2012-2016

<table>
<thead>
<tr>
<th>Name</th>
<th>Location</th>
<th>Ownership</th>
<th>Capacity (000 Metric Tons)</th>
<th>Timing</th>
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<tr>
<td><strong>Restarts</strong></td>
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<td>OCI- Beaumont</td>
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<td>Lyondell</td>
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<td><strong>Relocations</strong></td>
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<td>Former Coastal Plant</td>
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<td>3,855</td>
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## North America Methanol Capacity Expansion 2011-2017

(000) Metric Tons

<table>
<thead>
<tr>
<th>Name</th>
<th>Location</th>
<th>Ownership</th>
<th>Capacity</th>
<th>Timing</th>
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<td>South Louisiana Meth</td>
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<td>G2X Energy</td>
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<tr>
<td><strong>Total</strong></td>
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### Relocations

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<td>Methanex</td>
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### Unannounced, In Planning

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<td>U.S. Gulf Coast</td>
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<td>U.S, East Coast</td>
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<td>In Planning</td>
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<tr>
<td><strong>Total</strong></td>
<td>6,272</td>
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<tr>
<td><strong>Grand Total</strong></td>
<td>12,322</td>
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EU policy drivers

• **Bio-methanol**
  - A feedstock for
    • biodiesel
    • bio-MTBE
  - A blend component for gasoline
  - Showing ~73% life cycle GHG emission reduction compared to gasoline

**Fuel Quality Directive**
- Allows for 3% methanol fuel blending with stabilizing agent
- 6% reduction of life cycle GHG emission per unit of energy by 2020 compared with 2010
- Biofuels must be sustainable
- Potential ILUC issue
- Varying incentives and mandates across MS
EU policy drivers

Renewable Energy Directive -
Renewable energy to represent 10% of the energy used in transport by 2020
Biofuels must be sustainable
Potential ILUC issue. 5% first generation cap proposed by EC

• Biomethanol
  – Produced from residues & waste, bio-methane and CO₂
  – Energy content counts double towards RED target, quadruple counting proposed by EC
  – 1 Ton biomethanol = 1.5 Ton bioethanol
  – No concerns over ILUC
  – No competition with food
  – Made from residues; no competition with food and no ILUC concerns
Global methanol fuel developments

- Low blends and racing in UK and NL
- UK & NL fuel blenders supply RON95 EN228 gasoline containing 5% ethanol and (bio-)methanol
- Bio-methanol offers double counting benefit at low cost
- Further opportunities in combination with E10 identified
- EC awarded Euro 199 mio NER300 subsidy for wood-based methanol project
- BioMCN 350Z challenge competes on GEM fuel; FIA strong interest
Achieving transportation energy policies

- EU developments: Promoting the use of Tri-flex-fuel vehicles
- Tri-flex-fuel vehicles are capable of operating on any combination of gasoline/ethanol/methanol and do not require specific refuelling infrastructure
- Hence they allow for an acceleration of gasoline displacement
- Ethanol and methanol generating less CO₂/km emission than gasoline and are more energy efficient
- Relatively few changes required to existing engines at cost estimated not to exceed US$100/vehicle
- for running high methanol/ethanol blends

Lotus Ethos hybrid drive Tri-flex-vehicle
Achieving transportation energy policies

- Fuel mixtures that perform like E85 in an E85 FFV
Newer vehicles can manage higher alcohol blends

CRC - E20 performed well for model Year 1997+ Vehicles. China Introduced M15 starting in 2005

E15 waiver for model year 2000+ vehicles

E10 Gasohol since 1978

E5 in EU

China introduced M15 in 2005
## China vehicle sales by source

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<td>56.4</td>
<td>72.8</td>
<td>95.5</td>
<td>103.8</td>
<td>145.9</td>
<td>199.7</td>
<td>239.1</td>
<td>63.2</td>
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<td>Japanese</td>
<td>76.8</td>
<td>103.8</td>
<td>145.7</td>
<td>169.3</td>
<td>216.8</td>
<td>269.8</td>
<td>281.7</td>
<td>71.1</td>
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<td>59.6</td>
<td>69.9</td>
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<td>349.0</td>
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<td>28.5</td>
<td>39.0</td>
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<td>17.6%</td>
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<td>19.4%</td>
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<td>20.0%</td>
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<tr>
<td>Japanese</td>
<td>24.1%</td>
<td>25.1%</td>
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<td>26.2%</td>
<td>24.3%</td>
<td>23.6%</td>
<td>23.3%</td>
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<tr>
<td>US</td>
<td>13.5%</td>
<td>14.4%</td>
<td>13.8%</td>
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<td>12.3%</td>
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<td>29.3%</td>
<td>28.9%</td>
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<td>3.4%</td>
<td>3.5%</td>
<td>3.5%</td>
<td>3.6%</td>
</tr>
</tbody>
</table>

Source: China State Information Center
High octane fuels - increased engine efficiency

- Methanol contains oxygen which improves fuel combustion
- Methanol has a high blending octane (anti-knocking), which allows for a higher gasoline compression in engines, making engines more efficient
- Dedicated alcohol engines can give up to 35% efficiency improvement compared with gasoline engines
- Ford and other automakers have been discussing the need for mid-range alcohol fuel blends (20-30% ethanol/methanol) as a means to increase the octane of the transportation
- Increasing octane allows the use of higher compression ratio engines, greater turbocharging, direct fuel injection, and engine downsizing
Methanol distribution

• Transportation
  – Methanol is transported by vessels, barges RTC’s and trucks like gasoline
  – Cleaning procedures to be followed to ensure integrity of methanol
  – Mingling issues make the use of long distance pipeline for methanol difficult, unless dedicated
  – Methanol subject to substantially the same precautions as are routinely exercised for gasoline transport
  – USEPA/USDOE report costs for terminal, blending operations, truck fleet operations are US$7.25 million for each 250 million gallons of methanol fuel
Methanol distribution

• **Storage**
  – For storage at retail service stations, the underground tank is preferred
  – Tanks for methanol can be made from stainless steel, carbon steel, or methanol-compatible fiberglass
  – In the U.S., methanol tanks placed underground must have secondary containment because methanol is classified as a hazardous chemical
  – Cost for underground storage tanks/pumps US$62,000 station
Product stewardship – fuel blends

- Communicates best practices to handle methanol at fuel blending locations
- Supports the growing use of methanol in energy applications
Conclusions

• There are no technical hurdles to using methanol as a transportation fuel
• There are significant economic advantages to methanol fuel use
• Methanol fuels increase octane, and can help global auto manufacturers improve vehicle efficiency and reduce greenhouse gas emissions
• Global methanol fuel use is increasing rapidly
• Methanol has a wide range of feedstocks, natural gas, coal, biomass (non-food), and CO₂ making methanol a long-term sustainable fuel option
Contact

Thank you for your time and attention!

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