A NEW LOOK AT METHANOL:

Accelerating Petroleum Reduction and the Transition to Low Carbon Mobility

Paul Wuebben, MI Consultant
Senior Director, Renewable Fuels
Carbon Recycling International

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OUR BASIC MESSAGE:

Methanol Deployment in Light Duty Vehicles *GHG Reduction Pathways*

Alcohol fuels-vehicle technologies may be the most cost effective GHG reduction strategies

- Higher octane fuels enable higher IC engine efficiency
  - Ethanol and methanol blends
  - Refining HC processing
- High efficiency ICE coupled with electrification provides a cost effective pathway to achieving GHG reductions
  - DI, turbocharged, downsized, down speed, high compression
- Need to minimize future fuel and vehicle costs
  - High octane gasoline an option but possibly more expensive if hydrocarbon processing used
  - Ethanol or methanol may be the best fueling options either in lower level blends or in higher level blends
  - Need also to minimize battery storage

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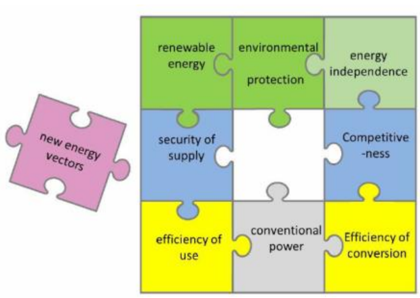
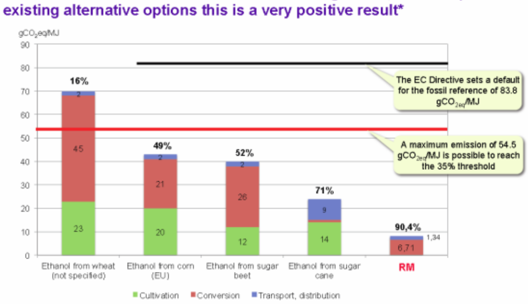
Renewable Methanol:

The Key to the Sustainable Fuel Puzzle



The Renewable Methanol achieves GHG savings of 90,4 %. Compared to existing alternative options this is a very positive result*



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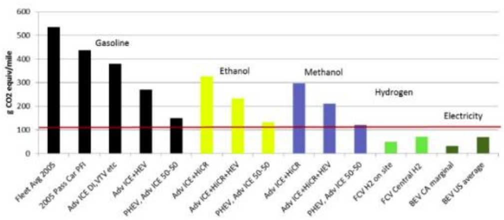
Methanol Deployment in Light Duty Vehicles *GHG Reduction Pathways*

Fuels and vehicle technologies achieving 80% reduction in LDV GHG emissions are needed



SOURCE: Mike Jackson, CRI / GEELY Methanol Symposium, Iceland, Feb. 23, 2016

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Methanol's Key Advantages to Build On:

- The chemical simplicity of methanol is one of its important strengths:
  - *Unlike gasoline, there are no carbon-carbon bonds in methanol, which translates directly into low particulate matter or "soot" formation potential;*
- GEM blends offer an elegance direct path to market as they can be readily formulated to achieve the equivalent octane, latent heat, Btu content and air-fuel stoichiometry of E85 used in current flexible fuel vehicles (FFVs);
- Moving past low volume ethanol blends would provide a more favorable and broader mix of benefits and synergies
- Methanol have been shown to reduce polycyclic aromatic hydrocarbons (PAH) which drives diesel toxicity.

Robust Knowledge Base to Build On:

- Successive generations of methanol vehicle development have yielded key insights on how to leverage methanol's advantages:
  - VW dedicated vehicles in 1980s
  - FFVs by many OEMs in the 1990s
    - Including Volvo's 940 Environmental Concept Car
  - Lotus and Coogee GEM vehicle in the 2000s
  - Geely M100 production vehicles this decade!
  - Serenergy FCV Prototypes

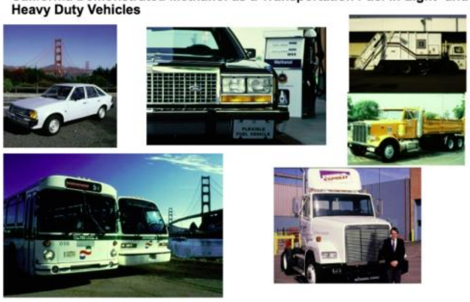
Recent Assessment by Volvo:

Both Methanol and DME Show the Highest Promise

Source: Volvo Sustainability Report 2013

Methanol Deployment in Light Duty Vehicles *Methanol Experience*

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



mdj Research

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Methanol Vehicles:

Deep Roots + Exciting Horizons

THE CALIFORNIA & U.S. NATIONAL CONTEXT

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

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Geely's World 1st M100 OEM Production Vehicle Aimed at the EU Market

CRI Demonstration: Iceland, 2016

- Geely
- Chairman:

- Methanol-Fueled Car is Promising

LI Shufu, who is chairman of the Geely Group and Volvo stated that methanol fuel is safety, economy and environmentally friendly.
http://autonews.gasgoo.com/china-news/geely-chairman-methanol-fueled-car-is-promising-140715.shtml

Geely has been conducting research on methanol fuels since 2005, with 27 patents.

Geely's plant in Jinzhong, Shanxi Province capable of producing 250,000 methanol-fueled cars per year.

China Provinces in the Driver Seat

Province	Local Methanol Gasoline Standards	Implemented Since
Gansu	M15 & M30	2009
Guizhou	M15	2010
Hebei	M15 & M30	2010
Heilongjiang	M15	2005
Jiangsu	M45	2009
Liaoning	M15	2006
Shaanxi	M15 & M25	2004
Shandong	M15	2012
Shanghai	M100	2013
Shanxi	M5, M15, M85 & M100	2008
Sichuan	M10	2004
Xinjiang	M15 & M30	2007
Zhejiang	M15, M30 & M50	2009
Ningxia	M15 & M30	2014

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• China Methanol Fuel Status

2009	2012	2014	160,000
China adopted national standards for M85 and M100	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.	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	Vehicles converted to methanol fuel, mostly taxis.

China Dual-Fuel HD CI Engines

	Emissions	HC	CO	NOX	PM
ESC	China IV	0.46	1.5	3.5	0.02
	DMDF	0.026	0.010	3.108	0.014
ETC	China IV	0.55	4.0	3.5	0.03
	DMDF	0.006	0.006	3.347	0.026
ELR	Emissions	China IV		DMDF	
	Soot	0.5		0.201	

- Researchers at China's Tianjin University have field-tested more than 70 heavy-duty compression ignition trucks in dual-fuel methanol/diesel conversion.
- Methanol displaces 30% of diesel consumption.
- Demonstrated compliance with China IV.

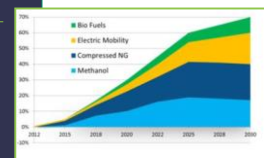
SERENERGY PEM FC Vehicle:

An Ideal Platform for Renewable Methanol

First Methanol station in Europe

INSERO methanex HAMAG OK

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 900,000 kms on M15 fuels with improved power and torque.
- Emissions of HC, CO, NOx, CO2, methanol, and formaldehyde all lower or similar to gasoline and all under EU standards

Australia Methanol Fuel Blending

- Methanol Fuels being commercialized in Australia
  - Project led by Coogee. Methanex is a partner
  - Path to energy security
  - Methanol excise tax free status for 10 years (~A38c/litre, ~$US 480/t)
  - Successful road trials and testing programs completed
  - **Commercial roll out of GEM 8 planned in 2016; GEM15 & GEM56 in the future**

CoogeeChemicals Gem Driven by the pure power of methanol

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

METHANEX ABENGOA natgasoline PURE GEM FUEL

A Closer Look at Methanol Benefits (1):

- High thermal efficiency due to the use of higher compression ratio enabled by methanol's high octane, which can be leveraged by engine downsizing;
- Ultra-low knock limit due to its high octane and latent heat properties, further enhancing turbo-charged high compression DI technology;
- Higher power and greater engine down-sizing potential than gasoline technology;
- Higher torque and power response for a given engine size, due to its faster flame propagation coupled to its high octane value;
- Inherently lower NOx and PM due to its low temperature combustion properties.

A Closer Look at Methanol Benefits (2):

- Strong synergy and reinforcement of hybridization and electric drive train utilization in electric and fuel cell vehicles;
- Low incremental cost of flexible fuel technology capable of running on gasoline-ethanol-methanol (GEM) blends;
- High margins of in-use catalyst performance due to lower combustion and exhaust temperatures, in contrast to gasoline DI
- ***Potential for ultra-low well-to-wheel GHG emissions from the use of renewable methanol;***
- No equivalent "clean diesel" certification risk, complexity and reliance on consumer behavior to maintain system compliance
  - *Avoidance of diesel engine complex selective catalytic reduction (SCR) and Lean NOx Trap (LNT) with very narrow or non-existent margins of compliance (e.g., VW worse case);*

Methanol Lean Boosted Technology:

Likely Superior to Atkinson Cycle Alone

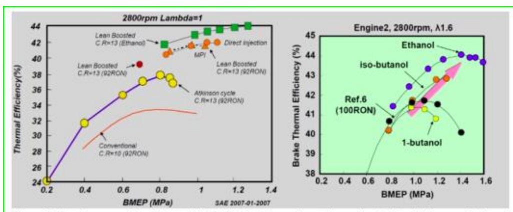


Figure 6. SI engine research at Toyota [24,25]. The left figure shows the merits of using Atkinson cycle, lean boost and high RON fuels. The right figure shows a comparison between 1-butanol, iso-butanol and ethanol at lean operation.

Source: "The Impact of RON on SI Engine Thermal Efficiency" Nakata, K., Uchida, D., Ota, A., Utsumi, S. et al., Toyota Motor Corp., SAE Technical Paper 2007-01-2007.

Leveraging GEM and FFV technology

- Methanol-based GEM blends offer an un-leveraged opportunity to extend the reach of the existing 14+ billion gallons of conventional ethanol, while also creating a clear market signal to OEMs and fuel providers to make long term investment in alcohol compatible infrastructure.
- Both alcohols – ethanol and methanol – offer major advantages to auto manufacturers when facing difficult emissions in-use compliance challenges associated with gasoline or diesel direct injection technology
- The deployment of over 17 million flexible fuel vehicles in the U.S. represents the largest alternative fuel compatible fleet ever achieved, and while ethanol demand for FFVs has remained flat at just 200 million gallons per year, it is essential that this deployment be continued and leveraged fully.


Department of
Mechanical
Engineering
UNIVERSITY OF BATH
PVR
Powertrain & Vehicle
Research Centre
GEM Fuels Development – New Ways of
Introducing Methanol into Transport Fuel
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Edward Goossens – GUTTS Motorsport
Kjell ac Bergström and Kenth Johansson – Saab Automobile
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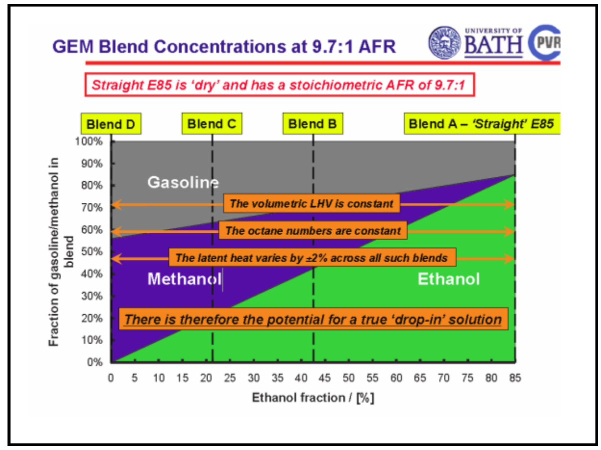
Zeyuan Liu
University of Bath, UK


GEM Blend Concentrations at 9.7:1 AFR
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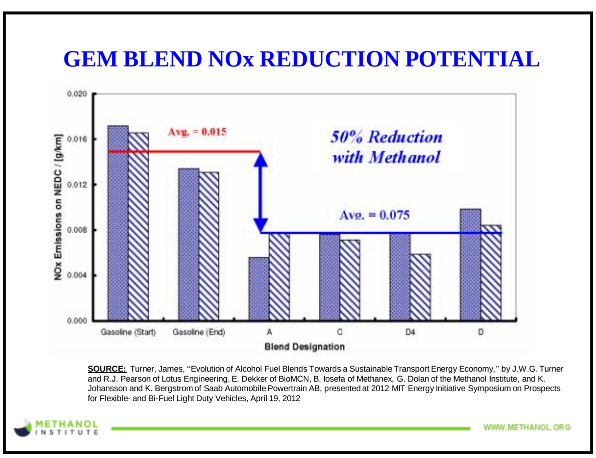
PVR
Straight E85 is 'dry' and has a stoichiometric AFR of 9.7:1
Blend D
Blend C
Blend B
Blend A – 'Straight' E85
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Fraction of gasoline/methanol in blend
Gasoline
The volumetric LHV is constant
The octane numbers are constant
The latent heat varies by ±2% across all such blends
Methanol
Ethanol
There is therefore the potential for a true 'drop-in' solution
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85
Ethanol fraction / [%]


GEM BLEND NOx REDUCTION POTENTIAL
0.020
0.016
0.012
0.008
0.004
0.000
NOx Emissions on NEDC / [g/km]
Avg. = 0.015
50% Reduction
with Methanol
Avg. = 0.075
Gasoline (Start)
Gasoline (End)
A
C
D4
D
Blend Designation
SOURCE: Turner, James, "Evolution of Alcohol Fuel Blends Towards a Sustainable Transport Energy Economy," by J.W.G. Turner and R.J. Pearson of Lotus Engineering, E. Dekker of BioMCN, B. Iosefa of Methanex, G. Dolan of the Methanol Institute, and K. Johansson and K. Bergstrom of Saab Automobile Powertrain AB, presented at 2012 MIT Energy Initiative Symposium on Prospects for Flexible- and Bi-Fuel Light Duty Vehicles, April 19, 2012
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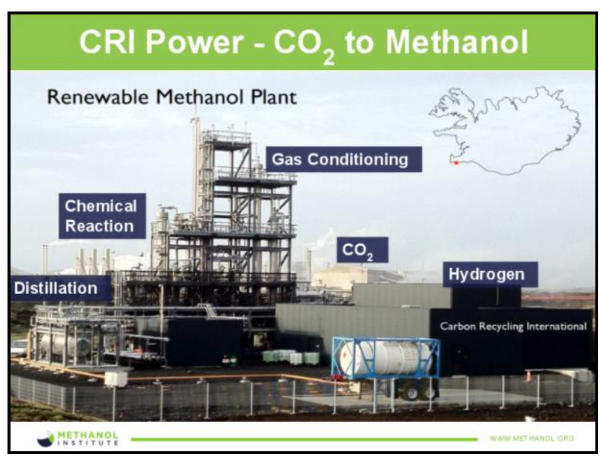
CRI Power - CO2 to Methanol
Renewable Methanol Plant
Gas Conditioning
Chemical
Reaction
CO2
Hydrogen
Distillation
Carbon Recycling International
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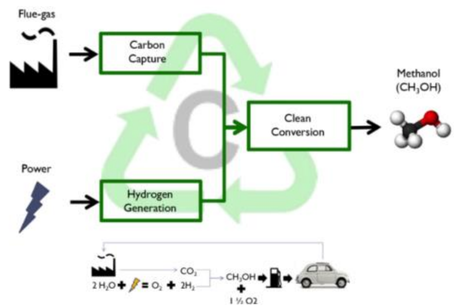
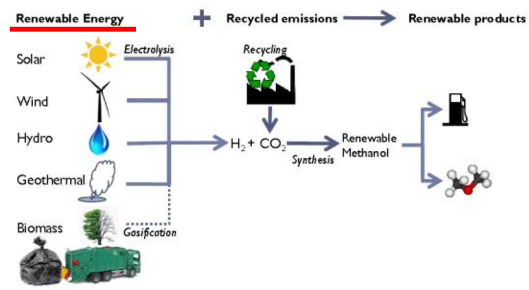
CRI's Renewable Methanol Production

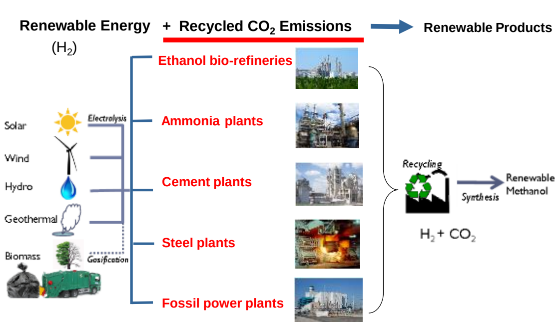
Process Summary



Diversity of Renewable Energy Sources:



And Diversity of CO_2 Sources



Power to Methanol:

More Efficient than Power to Methane

Thermodynamic Efficiency Calculations for the Conversion of Syngas to Synfuels

	SYNGAS CO / H_2		SYNGAS CO_2 / H_2	
	ΔH_{298} [kJ/mol]	$\eta = 1 - \frac{\Delta H_{298}}{LHV_{Syngas}}$	ΔH_{298} [kJ/mol]	$\eta = 1 - \frac{\Delta H_{298}}{LHV_{Syngas}}$
CH_3OH	-90,625	0,882	-49,943	0,931
CH_3OCH_3	-204,932	0,866	-121,682	0,916
CH_4	-206,158	0,796	-165,475	0,829
C_5H_{12}	-802,865	0,803	-602,450	0,844

SOURCE: Center for Solar Energy and Hydrogen Research (ZSW), Stuttgart, Germany

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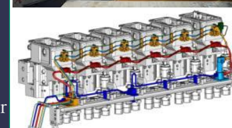
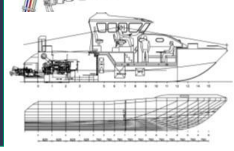
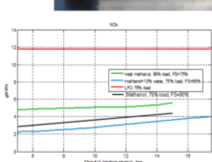
Methanol Marine Fuels

- Launched in March 2015, Stena *Germanica* features Wärtsilä methanol-fueled marine engine in EU-sponsored effort.
- Methanex's Waterfront Shipping 2016 delivery of seven new vessels with MAN dual-fuel methanol/diesel engines.
- MethaShip project led by Lloyd's Register designing cruise ship and ropax ferry over next three years.
- 2016 Pilot Boat conversion by ScandiNAOS with support from MI, and Swedish Maritime Administration.

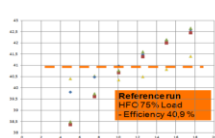




Stena Germanica Methanol Conversion



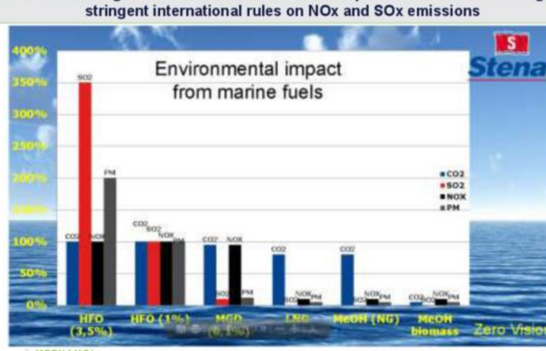
Reduced NOx (-70%)



Same efficiency as diesel

Stena Marine Fuels Assessment

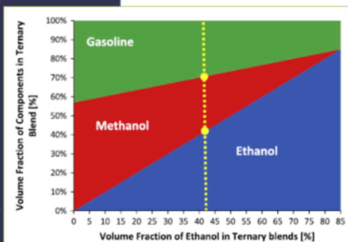
Stena sees long term role for methanol as viable path to address increasingly stringent international rules on NOx and SOx emissions



THE WAY FORWARD

A TRANSITION PATH TO REINTRODUCING METHANOL

- The development of GEM fuels can be readily formulated to achieve equivalent octane, latent heat, Btu content and air-fuel stoichiometry to E85 used in current flexible fuel vehicles.
- The use of GEM blends would directly enhance the gasoline displacement potential of ethanol.
- GEM blends offer an opportunity to increase octane levels while extending the reach of the existing 14+ billion gallons of conventional ethanol to a larger number of vehicles.



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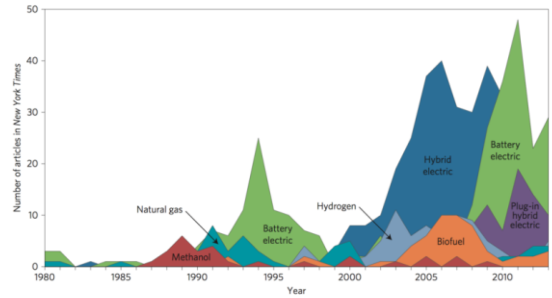
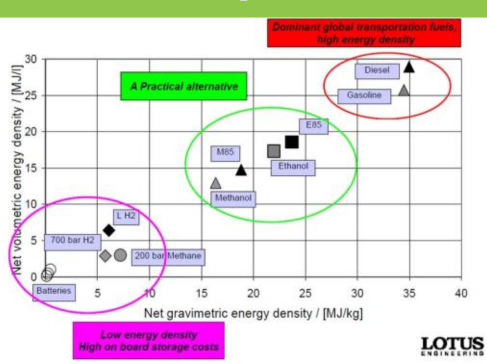
Concluding Thoughts:

No Single 2050 "Wedge" is a Guaranteed Success



Source: Simon Fraser University

Methanol - Practical Liquid Fuel Alternative



The Infrastructure Costs of 100% BEV of H_2FCV Deployment is Much Higher Than Liquid Refueling:

	Liquid Fuels	Level 3 BEV	Hydrogen
Miles of Mobility Provided per Average Station	119,000	4,800	4,800**
Stations Needed to Achieve Energy Equivalent Throughput	1	25	25
Cost per station	150,000	80,000	2,000,000
Cost per equivalent station		2,000,000	50,000,000
Cost for a 10,000 station-equivalent network	$1.5 billion	$20 billion*	$500 billion

* *Assumes 100% 24 hour constant utilization of available capacity*

** *80 kg per day capacity, 60 miles/kg*

H2 Refueling Infrastructure Object Lesson:

- Space Shuttle External Tank H2 Capacity: 106,000 kg
- Underground H2 Tanks are not allowed
- A 10 story tank with a 27' diameter would be needed to match liquid refueling capacity at the average station

CONCLUSIONS:

- Methanol leading to Renewable Methanol offers a "3rd Wedge" to meet CARB 2050 goals
- Optimized ICEs coupled to RM + electric drive + MIT innovations can achieve FCV-equivalence
- Liquid renewable fuels, including RM, are relevant for CA for decades
  - *Integrates well with hybridization*
  - *Methanol-based FCVs are in use today*
  - *FFVs and GEM FFVs offer a key transition path*
- Heavy duty and marine applications are maturing
  - *Zero S, low NOx, globally mature infrastructure*
- CA support for an Open Fuel Standard could revolutionize and expedite the path to sustainable alcohol fuels untethered to any land use or food market impacts

SUPPLEMENTAL SLIDES

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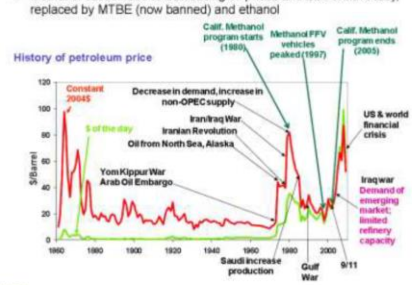
However, despite the establishment of a California Fuel Methanol Reserve (CFMR), the low oil price during that period presented major competitive challenges…

US experience with Methanol

- Methanol succumbed to decreasing oil prices and lack of advocacy, replaced by MTBE (now banned) and ethanol



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NOT ALL WAS LOST…

…Extensive technical literacy gained in the following areas

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)*

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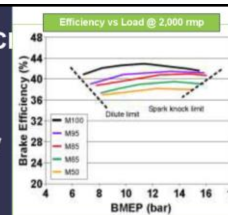
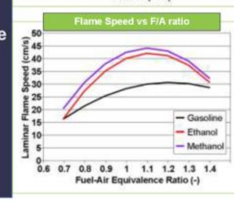
METHANOL AS A MOTOR VEHICLE FUEL

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





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Properties MeOH ↔ gasoline & implications

Properties: Methanol / Gasoline

- High heat of vaporization
  - Methanol 1100, Gasoline 325 (kJ/kg)
- High octane number
  - Methanol 109, Gasoline 95 RON
- High flame speed
  - Laminar burning velocity at NTP (cm/s)
  - Methanol 45, Gasoline 30

Potential

- Even for gasoline-optimized engine max. achievable engine load higher when using alcohols
  - Increase in volumetric eff. due to high degree of charge cooling
  - Spark timing less knock limited due to elevated knock resistance and higher flame speeds
- Options for dedicated engines:
  - High compression ratio
  - High EGR ratios
  - Lean operation

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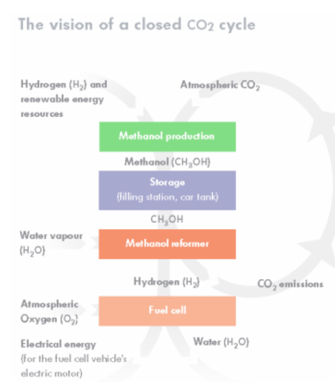
VW VISION
(1996)



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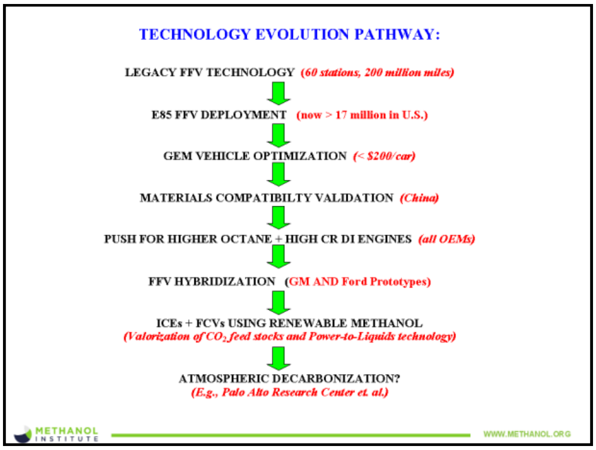
TECHNOLOGY EVOLUTION PATHWAY:
LEGACY FFV TECHNOLOGY (60 stations, 200 million miles)
E85 FFV DEPLOYMENT (now > 17 million in U.S.)
GEM VEHICLE OPTIMIZATION (< $200/car)
MATERIALS COMPATIBILTY VALIDATION (China)
PUSH FOR HIGHER OCTANE + HIGH CR DI ENGINES (all OEMs)
FFV HYBRIDIZATION (GM AND Ford Prototypes)
ICEs + FCVs USING RENEWABLE METHANOL
(Valorization of CO2 feed stocks and Power-to-Liquids technology)
ATMOSPHERIC DECARBONIZATION?
(E.g., Palo Alto Research Center et. al.)
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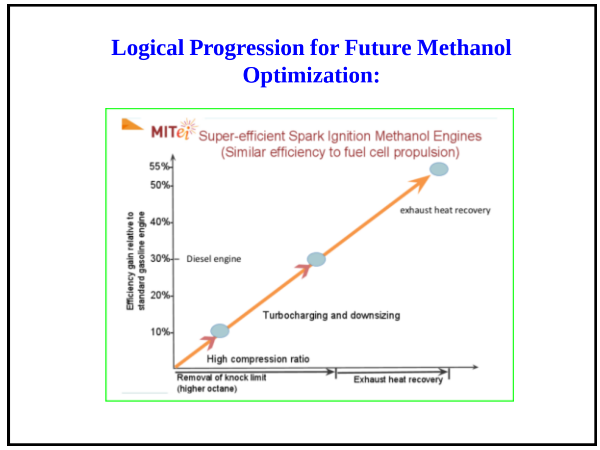
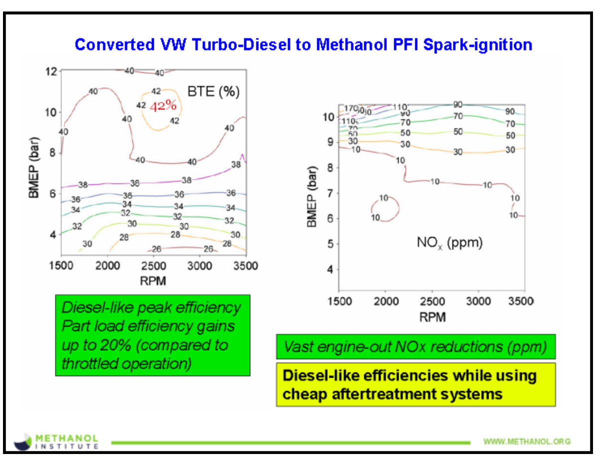

Logical Progression for Future Methanol Optimization:
MITei Super-efficient Spark Ignition Methanol Engines
(Similar efficiency to fuel cell propulsion)
Efficiency gain relative to standard gasoline engine
55%
50%
40%
30%
20%
10%
Diesel engine
exhaust heat recovery
Turbocharging and downsizing
High compression ratio
Removal of knock limit
(higher octane)
Exhaust heat recovery


Converted VW Turbo-Diesel to Methanol PFI Spark-ignition
BTE (%)
42%
BMEP (bar)
RPM
NOx (ppm)
Diesel-like peak efficiency
Part load efficiency gains up to 20% (compared to throttled operation)
Vast engine-out NOx reductions (ppm)
Diesel-like efficiencies while using cheap aftertreatment systems
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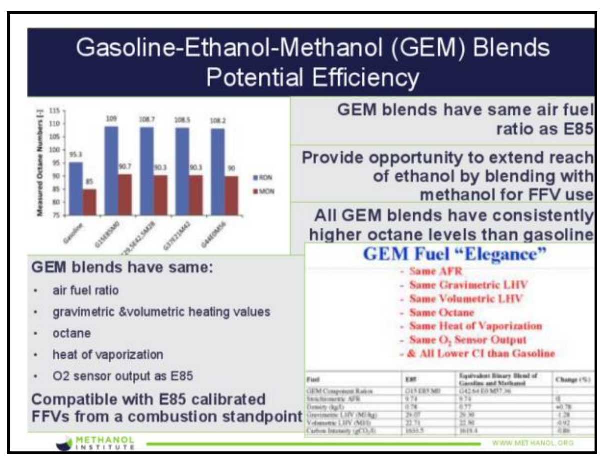
Gasoline-Ethanol-Methanol (GEM) Blends
Potential Efficiency
Measured Octane Numbers [-]
RON
MON
GEM blends have same air fuel ratio as E85
Provide opportunity to extend reach of ethanol by blending with methanol for FFV use
All GEM blends have consistently higher octane levels than gasoline
GEM Fuel "Elegance"
- Same AFR
- Same Gravimetric LHV
- Same Volumetric LHV
- Same Octane
- Same Heat of Vaporization
- Same O2 Sensor Output
- & All Lower CI than Gasoline
GEM blends have same:
air fuel ratio
gravimetric &volumetric heating values
octane
heat of vaporization
O2 sensor output as E85
Compatible with E85 calibrated FFVs from a combustion standpoint
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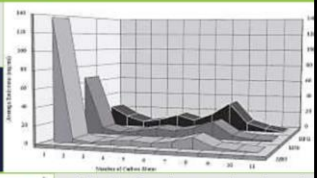
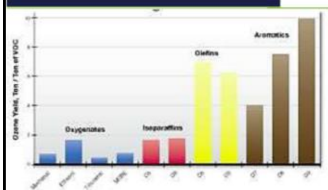
Methanol Air Quality & GHG Benefits

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

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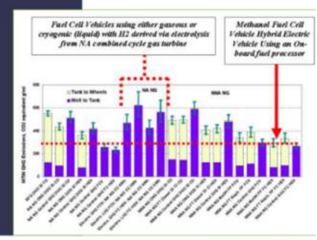
Methanol & Fuel Cells

- Methanol is used in fuel cell applications as a high density source of hydrogen for PEM fuel cells, and in direct methanol fuel cells
- Methanol-based fuel cell vehicles are in current demonstration in Denmark by Serenegy
- Argonne National Lab found methanol fuel cells coupled to hybridized electric drivetrains would have significantly lower GHG emissions compared to fuel cell vehicles using hydrogen derived via electrolysis using natural gas



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Enerkem – Waste to Methanol

Renewable Methanol

Will bring Edmonton's recycling rate from 60% to 90%.

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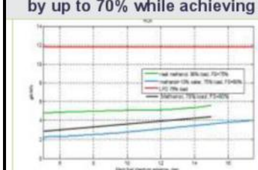
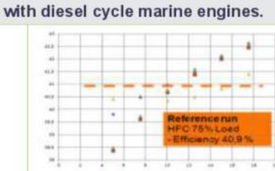
Methanol Marine Fuels

Launched in March 2015, Stena Germanica features Wärtsilä methanol-fueled marine engine in EU-sponsored effort.

Recent testing by Stena demonstrated NOx emissions can be decreased by up to 70% while achieving parity with diesel cycle marine engines.



Reduced NOx (-70%)



Same efficiency as diesel

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mdj Research

cleaner fuels and vehicles now

Methanol Deployment: FFVs, GEM and Electric Drive Strategies for LDVs

Presented at
METHANOL ENGINE ADVANCEMENT FOR SUSTAINABLE TRANSPORT SYMPOSIUM
February 22-24, 2016
Reykjavik, Iceland

California Methanol Program Legacy

- CAFE Incentives developed for alternative fuel vehicles
  - First for methanol and then for ethanol flexible fuel vehicles (FFVs)
  - U.S. FFV population around 20 million vehicles
  - Low incremental vehicle costs easy for OEMs to produce
- Most gasoline soled in U.S. is E10 at 87 octane (r+m/2)
  - 10% ethanol blended in reformulated blend for oxygen blends
  - Reformulated E10 reduces air pollution
  - Small but growing E85 infrastructure
  - Little E85 used due to unfavorable pump pricing
  - ASTM D5798-13a defines E85: 51-83% ethanol

Recent work for Fuel Freedom Foundation has shown methanol can be a viable alternative to meet goals of petroleum displacement and lower emissions of Greenhouse Gas (GHG), criteria, and toxic emissions1

- Substantial increase in U.S. Natural Gas Supply due to shale exploration and production
- Gasoline, Ethanol, Methanol (GEM) Blends have been demonstrated in existing ethanol FFVs
- Meeting Climate Change objectives will require large GHG emissions reductions

1Jackson, Michael D. and Peter F. Ward, "Demonstrating the Feasibility of Methanol Gasoline Blends to Reduce Petroleum Use in the United States, mdj Research and Alternative Fuels Advocates, prepared for Fuel Freedom Foundation, February 2013

GEM Fuels used in Fuel Flexible Vehicles (FFVs) and converted gasoline FFVs could provide a cheaper fuel at the pump

Fuel	Gasoline	Blend A	Blend B	Blend C	Blend D
GEM Component Ratios	G100 E0 M0	G15 E85 M0	G29.5 E42.5 M28	G37 E21 M42	G44 E0 M56
Stoichiometric AFR	14.18	9.69	9.69	9.71	9.69
Density (kg/l)	0.731	0.781	0.773	0.769	0.765
Gravimetric LHV (MJ/kg)	43.12	29.09	29.38	29.56	29.66
Volumetric LHV (MJ/l)	31.52	22.71	22.70	22.71	22.69
Carbon Intensity (gCO_2/l)	2297.3	1627.9	1624.2	1623.9	1620.2
Carbon Intensity (gCO_2/MJ)	72.88	71.69	71.56	71.49	71.41
RON	95.3	109.0	108.7	108.5	108.2
MON	85.0	90.7	90.3	90.3	90.0
Sensitivity	10.3	18.3	18.4	18.2	18.2

source SAE 2012-01-1279

- GEM fuels transparent to FFVs with possible exception of material compatibility with methanol blends and evaporative emissions at low blend levels (M10)
- GEM fuels may also operated in modern gasoline technology vehicles—some conversion software and/or hardware may be needed

Methanol Deployment in Light Duty Vehicles *Outlook*

Methanol has the potential to compete in the LDV market

- Price competitive at the pump
  - Need consumer value proposition
- Market methanol to existing and converted FFVs to establish fuel demand
  - Solve any material and evaporative emission issues
  - ASTM 5797-13 defines methanol as M51-M85
- Introduce dedicate high efficiency ICEs using methanol
  - High compression, DI, Turbocharged, downsized and downspeed
  - Take advantage of methanol fuel properties
- Integrate high efficiency ICE with electric vehicle platforms
  - Hybrid electric vehicles
  - Plug-in hybrid electric vehicles

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