Methanol Institute’s 30th Year Anniversary

Gregory Dolan, CEO
Ray Lewis – Founder/Past President
Argus Methanol Forum -- Houston
10 September 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
OUR TEAM

Greg Dolan, CEO
- Joined MI in 1996 and held a variety of senior management positions within MI before being named CEO in 2013
- 10 years as a press officer for the State of New York and 2 years as legislative assistant in the US Senate
- Has authored or co-authored many works on the topic of methanol and is based in Washington, D.C.

Chris Chatterton, COO
- Joined MI in 2015 with more than 20 years executive level experience in energy, oil & gas and petrochemicals
- Led several, successful energy and agriculture initial public offerings (IPOs) and cross-border private placements
- Based in Singapore

Tim Chan, Manager of Government & Public Affairs – Asia Pacific/Middle East
- Joined MI full-time staff in 2018, after serving as an intern in 2016/2017
- Has also worked for Singapore Ministry of Transport and GR firm Burson-Marsteller
- Based in Singapore

Larry Navin, Director of Government & Public Affairs – Americas/Europe
- Extensive multi-lateral experience to include US-India Business Council, US Dept of Commerce Int’l Trade Administration
- Prior to joining MI, Mr Navin also held roles with the Overseas Private Investment Corporation (OPIC) and the US Senate
- Based in Washington, D.C.

Eelco Dekker, Chief EU Representative
- Joined MI in 2014 with an extensive background in European fuel blending, energy applications and regulatory affairs
- Former Chief Marketing Officer at BioMCN, with over 10 years in commercial roles with DSM and Ciba Specialty Chemicals
- Based in Brussels

Kai Zhao, Chief China Representative
- Joined MI in 2015 and serves concurrently as Director and project researcher at the Academic Board Office of the Centre for Global New Energy Strategy Studies (CGNESS) at Peking University, a position he has held for the last 8 years
- Based in Beijing

Belinda Pun, Executive Assistant
- Joined MI in 2018 after 17 years of experience as Executive Assistant and Administrative Manger
- Previously worked as office manager for Siemens Postal, Parcel & Airport Logistics
- Based in Singapore

Novpreet Bajwa, Operations and Web/Media Coordinator
- Joined MI in 2018
- Background in social media campaigns, web site optimization, web quality assurance, and office administration
- Based in Washington, DC
AMERICAN METHANOL INSTITUTE FOUNDER AND PAST PRESIDENT – RAY LEWIS
Methanol as an Energy Source: New Markets for Methanol

Gregory Dolan, CEO – Methanol Institute
Argus Methanol Forum -- Houston
10 September 2019
01 METHANOL ECONOMY
BROAD FEEDSTOCK RANGE, MANY APPLICATIONS

feedstock

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

methanol synthesis

conversion

derivatives

products

markets

other 7%
solvents 4%chloromethanes 2%
MTO 18%
methyamines 3%
DME 8%
biodiesel 3%
gasoline blending 9%
MTMA 2%
MTBE 8%
acetic acid 9%
formaldehyde 27%
source: IHS

appliances
automotive
construction
electronics
fuel
paint
pharma
and...
marine
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
Israel – M15 to M100, power generation
Trinidad – M5
Africa – cook stoves
Sweden – marine fuel
Denmark – fuel cells for vehicles
Italy – Eni/FCA M15/E5
Egypt – M15 trials
India – Methanol Economy roadmap
Australia – GEM fuels
China – M15 to M100, boilers, cook stoves
New Zealand – M3
Iceland – M100 trials

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

Renewable Methanol Emission Reductions: CO2 by up to 95%; NOx by 80%; virtually eliminating SOx and Particulate Matter (PM)

Renewable methanol is an ultra-low carbon chemical produced from sustainable biomass, often called bio-methanol, or from carbon dioxide and hydrogen produced from renewable electricity.
# RENEWABLE METHANOL TRACKER

<table>
<thead>
<tr>
<th>Methanol category</th>
<th>Commercial</th>
<th>Feasibility and R&amp;D</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bio-methanol</strong></td>
<td>BASF (GER)</td>
<td>Biogeo (GER)</td>
</tr>
<tr>
<td></td>
<td>BioMCN (NL)</td>
<td>Eneco (NL)</td>
</tr>
<tr>
<td></td>
<td>Eneco Tech (CAN)</td>
<td>New Fuel (DEN)</td>
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<td></td>
<td>Nordic Green (DEN)</td>
<td>OCI (USA)</td>
</tr>
<tr>
<td><strong>Renewable methanol</strong></td>
<td>CRi (IC)</td>
<td>Advanced Chemical Technologies (CAN)</td>
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<tr>
<td></td>
<td>Innovex (GER)</td>
<td>Asahi Kasei (JPN)</td>
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<td></td>
<td>Air Co (UK)</td>
<td>Blue Fuel Energy (CAN)</td>
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<td></td>
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<td>bsec Engineering (GER)</td>
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<td></td>
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<td>Catalytic Innovations (USA)</td>
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<td></td>
<td>CRI (CN/GER)</td>
<td>CRI (CN/GER)</td>
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<td></td>
<td>Genetec (GER)</td>
<td>Genetec (GER)</td>
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<td></td>
<td>InfraServ (GER)</td>
<td>InfraServ (GER)</td>
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<td></td>
<td>Liquid Wind (SE)</td>
<td>MefCO2 (GER)</td>
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<td></td>
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<td>Neo-H2 (USA)</td>
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<td></td>
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<td>Port of Antwerp (BE)</td>
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<td></td>
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<td>Quantum Technologies (CAN)</td>
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<td>STEAG (GER)</td>
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<td></td>
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<td>Swiss Liquid Future (CH)</td>
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<td>thyoensknapp (GER)</td>
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<td>USC (USA)</td>
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<td></td>
<td></td>
<td>ZAS (GER)</td>
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<tr>
<td><strong>Low carbon methanol</strong></td>
<td>GPIC (BAH)</td>
<td>Carbon2Chem (GER)</td>
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<td></td>
<td>Methanex (CAN)</td>
<td>HESME (SE)</td>
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<td></td>
<td>QAPA (QAT)</td>
<td>GasTechno (USA)</td>
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<td></td>
<td>SABIC (KSA)</td>
<td>Haldor Topsoe (DEN)</td>
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<tr>
<td></td>
<td></td>
<td>Maverick Synfuels (USA)</td>
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<td></td>
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<td>NCFC (CN)</td>
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<td>OPTIMECH (GER)</td>
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<td>BASF (GER)</td>
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<td>Argonne (USA)</td>
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<td></td>
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<td>Cardiff University (UK)</td>
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</tbody>
</table>
SOLAR METHANOL ISLANDS

• Researchers from Norway and Switzerland have proposed using “solar methanol islands” as tool for reducing greenhouse gas emissions
• Use photovoltaic cells to convert solar energy into electricity, then powering hydrogen production and CO2 extraction from seawater to produce liquid methanol
• Requires wave height less than seven meters and water depth less than 600 meters
• 70 artificial islands cover one kilometer square
• 3.2 million floating islands would produce enough methanol to exceed total global emissions of fossil fuels

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

CO₂ emission in the EU in million tons

- 1990
- 2015
- 2050
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
CHINA M100

- 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 commercial introduction of M100 vehicles
- Currently over 20,000 methanol-fueled taxis operation for total of 125 million kilometers
- Approval of 32 product models from 9 methanol vehicle manufacturers
M100 methanol fuel consumption for taxi is 13.5 litres/100 km, with energy consumption of 237.8 MJ

<table>
<thead>
<tr>
<th></th>
<th>Gasoline</th>
<th>CNG</th>
<th>M100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel Price RMB/L</td>
<td>5.51</td>
<td>3.5 RMB/m³</td>
<td>1.8</td>
</tr>
<tr>
<td>Fuel Economy L/100km</td>
<td>8</td>
<td>8.8 m³/100km</td>
<td>13.5</td>
</tr>
<tr>
<td>Fuel Cost Saving %</td>
<td>37.5</td>
<td>10.6</td>
<td>--</td>
</tr>
</tbody>
</table>

Note: the fuel price is based on the operation in November of 2015.
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.
- Geely M100 taxi fleet to hit 20,000 cars in June 2019, consuming 200,000 MT year.
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: a New Methanol-based Alternative Fuel

<table>
<thead>
<tr>
<th>Property</th>
<th>Units</th>
<th>Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>MIN - MAX</td>
</tr>
<tr>
<td>Research octane number,RON</td>
<td></td>
<td>100</td>
</tr>
<tr>
<td>Motor octane number,MON</td>
<td></td>
<td>85</td>
</tr>
<tr>
<td>Lead 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>360</td>
</tr>
<tr>
<td>Existent gum content</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>% (m/m)</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)</td>
<td></td>
<td></td>
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<tr>
<td>C3-C4 other oxygenates</td>
<td></td>
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</tr>
</tbody>
</table>

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

- Formula Cost Reduction
- “Transparent” to all the E10 car vehicles
- No-chemical corrosion problems
- No-phase separation (in the car tank and gas-station)
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…”
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)

<table>
<thead>
<tr>
<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>+/o</td>
<td>o</td>
<td>+/o</td>
<td>o</td>
<td>o/–</td>
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</tbody>
</table>

Methanol utilization in transport will significantly rise

Source: bigwheels.my
C3-Mobility - Climate-neutral Fuels for Future Traffic

Usage of Climate-neutral Fuels

C) Optimal Usage of Climate-neutral Fuels in Industry and Transport Modul II-IV
Research, Development of Combustion Processes and Demonstration

<table>
<thead>
<tr>
<th>Cylinder Displacement</th>
<th>≤ 0.5 l</th>
<th>≥ 2.0 l</th>
</tr>
</thead>
<tbody>
<tr>
<td>1)</td>
<td>MEG, C_H_2O</td>
<td>MEG, C_H_3N_3</td>
</tr>
<tr>
<td>2)</td>
<td>Drop-in, Blend, Monovalent (DPEL, RWTH)</td>
<td>Drop-in, Blend (BMW, RWTH)</td>
</tr>
<tr>
<td>3)</td>
<td>Blend (SME)</td>
<td>Blend (DPEL, RWTH, PISE)</td>
</tr>
<tr>
<td>4)</td>
<td>Blend-Diesel (BMW, DPEL, PISE)</td>
<td>Blend-Diesel (FEV, DAIM, DEUT)</td>
</tr>
<tr>
<td>5)</td>
<td>Blend-Diesel (DPEL, RWTH)</td>
<td>Blend-Diesel (FEV, DAIM, DEUT)</td>
</tr>
<tr>
<td>6)</td>
<td>Monovalent Diesel (BMW, DPEL, PISE)</td>
<td>Monovalent Diesel (RWTH, LIEB)</td>
</tr>
</tbody>
</table>

1) Fuels/Material Compatibility (TG/Shell) & Fuel Deterioration/Oil Interaction (CWI)
2) Method Development 3D-CFD for Fuel Blends (AVL, RWTH)
3) Thermal Management Optimization (CWI)
4a) Exhaust Gas Aftertreatment (Components) (TUD, UMI, AVL)
4b) ANB (Strategy) (FEV, PISE)
5) Injection Systems:
   5a) PassCar DME (DENSO)
   5b) PassCar OME (CPT)
   5c) CV + Large Engine (LIEB)
6) Fuel Sensors (CPT)
7) Model-based Torque Path and Ignition (FEV, WEG, FAAC)

D) Cross-sectoral Issues module-spanning Components and Method Development

Benedikt Hueser, 2010
04 Methanol 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
OPTIONS AVAILABLE TO SHIP OWNERS

- HFO + scrubbers
- MGO or HFO/MGO Hybrid
- LNG
- Methanol

https://www.methanol.org/marine-fuel/
“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

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
“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
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
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/
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 2017**
- **Growing to 7-8 MMT in 5 years**
China also developing other new markets for the use of methanol:

- **Glass/ceramic kilns** – China produced 60% of world’s glass products; methanol uses less air intake and produces cleaner flue gas for superior finish
- **Tobacco drying** – One in every 3 cigarettes smoked in the world are smoked in China
06 HYDROGEN CARRIER
METHANOL A HYDROGEN CARRIER FOR FUEL CELLS

- Blue World Technologies (Denmark)
- Palcan (China)
- Horizon Energy Systems (Singapore)
- Oneberry (Singapore)
- Altergy (USA)
- Serenegy (Denmark)
- SFC Energy (Germany)
- Toshiba (Japan)
- Ultracell (USA)
COMMERCIAL OFFERINGS REFORMED METHANOL FUEL CELLS FOR STATIONARY POWER
**METHANOL FUEL CELL EV RANGE EXTENDER**

- 2015: Denmark opens EU’s first methanol fuel pump
- 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
- 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
DENMARK’S BLUE WORLD TECHNOLOGIES AND CHINA’S PALCAN

MANUFACTURING PLANTS: 50,000 UNITS/YEAR – 5 kw RMFC
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

October 2019: MI and MIIT holding methanol seminar in Chongqing
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