Rebecca Boudreaux, Ph.D.
President, Oberon Fuels
2014 Washington Methanol Policy Forum
Dimethyl ether (DME)

- NO carbon-carbon = NO soot/particulate matter
- No sulfur, low NO$_x$
- *Not* tied to the price of crude oil
- Multiple feed stocks (biogas, natural gas)
- Handles like propane
Sweden
1st BioDME plant
(2011)

China
11 mtpy capacity
30 – 50% in operation

India
265 ktpy planned

Uzbekistan
100 ktpy planned

Vietnam
Project announced

Indonesia
800 ktpy planned

Japan
80 ktpy operational

Trinidad & Tobago
100 KTA plant planned
Mitsubishi Corp. & Mitsubishi Gas Chemical

United States
12,000 liter/day modular plant producing (2013)

Papua New Guinea
200 ktpy planned (2016)

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Gaining Traction

Transport Topics
SPECIAL REPORT

ALTERNATIVE FUELS
SAFETY • MAINTENANCE • INFRASTRUCTURE
EFFICIENCY • ENVIRONMENT • REGULATION
Mack to Begin Production of DME-Powered Vehicles in 2015

GREENSBORO, NC (June 20, 2013) – Mack Trucks will begin production of dimethyl ether (DME)-powered MACK® Pinnacle™ Axle Back models in 2015. DME, a non-toxic, clean-burning alternative fuel, offers many environmental and societal benefits, including that it can be made from multiple sustainable feedstocks.

One of the most significant advantages of the fuel is that it produces no soot, eliminating the need for a diesel particulate filter (DPF). DME can provide up to a 95 percent CO2 reduction compared with diesel when produced from biomass or biogas.

Furthermore, DME can be made from North America’s plentiful domestic natural gas, municipal waste, animal waste, grass clippings and other sustainable sources, offering the potential to reduce dependency on foreign oil.

“The benefits of DME are numerous,” said Kevin Flaherty, president of Mack Trucks Sales & Marketing. “It’s better for the environment because it burns clean, and it’s produced from sustainable sources that are domestically available. Mack trucks are built in the U.S.A., and we’re proud to be powering our vehicles with a fuel made in America as well.”

The Pinnacle Axle Back model powered by DME will be equipped with a 13-liter engine to easily handle heavy workloads. The Pinnacle Axle Back model is ideal for highway van trailer applications, bulk hauling, flatbed and dump trailer jobs.
Oberon Fuels Project with Volvo Trucks and Safeway Receives Grant from San Joaquin Valley Air Pollution Control District for Production of First North American Fuel-grade DME

Companies partnering to test heavy-duty commercial vehicles powered by clean-burning dimethyl ether produced from biomass.

SAN DIEGO, June 6, 2013 /PRNewswire/ -- Oberon Fuels, the first company to bring dimethyl ether (DME), a clean burning diesel alternative to market, has received a $500,000 grant from the San Joaquin Valley Air Pollution Control District (SJVAPCD) to produce fuel-grade DME at its facilities in California. Working with its partners, Volvo Trucks in North America and Safeway, Inc., one of the largest food and drug retailers in North America, Oberon Fuels will provide DME produced from biogas for Safeway's trucking operations.

(Logo: http://photos.prnewswire.com/prnh/20130412/LA94212LOGO)

The approved project focuses on using DME as a near-zero emission solution for heavy-duty trucking. Oberon Fuels has developed a patented, skid-mounted, modular design for DME production. This small-scale process enables the development of regional fuel markets that
How do you make it?

Made from methane and CO$_2$

- *Not* tied to the price of crude oil
- Multiple feedstocks
- Pipeline natural gas, stranded gas, biogas
Feedstocks: DME Production

• **Natural Gas** key for:
  – Fast deployment
  – Large-scale production
  – Increasing or stabilizing methane content

• **Renewable & Wasted Resources** key for:
  – DME’s sustainability
  – Long-term price stability

*Using 2 greenhouse gases to make cleaner burning fuel*
Flared Gas
Landfill Gas
Feedstocks: Renewable Sources

- Cow Manure: 25 m³ per ton
- Pig Manure: 30
- Potato Waste: 29
- Chicken Manure: 80
- Brewery Waste: 120
- Green Clippings: 175
- Grass Silage: 185
- Corn Silage: 190
- Food Scraps: 265
- Bakery Waste: 714
- Fats & Grease: 961

Cost-effectively converts methane and CO$_2$ to DME
Skid-mounted Fuel Production

April 15, 2013
Chicago, IL

May 17, 2013
Brawley, CA
Phase 1: Pilot Plant

- Pilot Plant Online
- Converts methanol to DME (last process step)
- 1\textsuperscript{st} Fuel-grade DME in North America
- **Location:** Brawley, California
DME Infrastructure: Hub & Spoke Model

DME Centrally Produced

SYNGAS  METHANOL  DME

DME Delivered to Customers

10,000 gallons per day
Fuels ~100 trucks per day

On-site Fueling at Customer Terminal
Fueling Infrastructure
DME Summary

No C-C bond = No soot

Made from
Methane + CO₂

Excellent Diesel Replacement

...Another Market for Methanol
## DME Properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Propane</th>
<th>Methanol</th>
<th>DME</th>
<th>Diesel Oil</th>
<th>Methane</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boiling Point (°C)</td>
<td>-42</td>
<td>64.6</td>
<td>-25.1</td>
<td>180-360</td>
<td>-161.5</td>
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<tr>
<td>Vapor Pressure @ 20 °C, bar</td>
<td>8.4</td>
<td>--</td>
<td>5.1</td>
<td>--</td>
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<tr>
<td>Liquid Density @ 20 °C, gm/cm³</td>
<td>0.509</td>
<td>0.79</td>
<td>0.67</td>
<td>0.84</td>
<td>--</td>
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<tr>
<td>Sp. Gravity of gas (vs. Air)</td>
<td>1.52</td>
<td>--</td>
<td>1.69</td>
<td>--</td>
<td>0.55</td>
</tr>
<tr>
<td>Flammability Limits in Air, vol.%</td>
<td>2.1-0.4</td>
<td>5.5-36</td>
<td>3.4-17</td>
<td>0.6-7.5</td>
<td>5-15</td>
</tr>
<tr>
<td>Wobbe Index, kJ/m³</td>
<td>69,560 *</td>
<td>--</td>
<td>46,198</td>
<td>--</td>
<td>48,530</td>
</tr>
<tr>
<td>Cetane Number</td>
<td>5</td>
<td>5</td>
<td>55-60</td>
<td>40-55</td>
<td>0</td>
</tr>
<tr>
<td>Calorific value, LHV, Kcal/kg</td>
<td>11,100</td>
<td>4,800</td>
<td>6,900</td>
<td>10,200</td>
<td>12,000</td>
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<tr>
<td>Calorific value, LHV, Kcal/nm³</td>
<td>21,800</td>
<td>--</td>
<td>14,200</td>
<td>--</td>
<td>8,600</td>
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