
Alternative diesel fuels: renewable diesel and dimethyl ether, DME

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Alternative Diesel fuels

- **Biodiesel**
 - Feedstocks, vegetable oils, animal fats
 - React with methanol to make fatty acid methyl ester (FAME)
- **Synthetic diesel**
 - Feedstocks, natural gas, coal, biomass
 - Fischer-Tropsch or related thermochemical process
 - Similar to petroleum diesel, very high quality, low emission
- **Natural gas**, not a diesel fuel but used in converted diesel engines
- **Ethanol**, gasoline replacement, poor diesel fuel except in dual fuel modes
- **Butanol**, gasoline replacement, may be used as diesel fuel in low blends
- *Renewable diesel*
- *Dimethyl ether*

Renewable diesel – also called HVO, hydrotreated vegetable oil

- Conversion process
 - Usual feedstock vegetable oil or animal fat.
 - Reaction with hydrogen in hydrotreating process, large scale at oil refinery
- Properties
 - A pure hydrocarbon, like a very high grade diesel fuel
 - May be blended and used in any proportion with petroleum diesel
 - Long shelf life
 - Good low temperature operation
- Emissions compared to petroleum diesel
 - Substantial reductions in all regulated emissions, particulate matter (PM), CO, hydrocarbons, NO_x
 - Substantial reductions in well to wheel greenhouse gas emissions
- Compared to biodiesel
 - Typically produced in much **larger scale facilities, refinery**
 - Similar greenhouse emissions
 - Higher PM but lower NO_x emissions
 - Better shelf life and low temperature characteristics

A second generation biofuel – dimethyl ether, DME

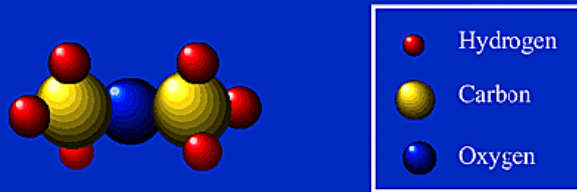
- Recent U of M study on DME
 - Potential for production of bio DME in Minnesota
 - Performance and emissions in a diesel engine
- Co-Investigators
 - David Kittelson, Win Watts, David Bennett, Will Northrop, Kathleen Vignali, Mechanical Engineering
 - Steven Taff, Applied Economics
- Sponsors
 - University of Minnesota Initiative for Renewable Energy and the Environment (IREE)
 - Addition support from General Motors, Chemrec (Sweden), and USEPA
- Informal collaborators
 - Pennsylvania State University
 - Johnson-Matthey
 - Volvo
 - Rational Energies

DME basics

- What is DME?

Dimethyl Ether

Dimethyl ether has the chemical formula, CH_3OCH_3 . Its name is derived from the two methyl groups (CH_3) attached to oxygen, followed by the word *ether*.



For comparison, methane (natural gas) and methanol have the following structures.



Methane



Methanol

- DME Properties

- Physical properties similar to propane
- Virtually non-toxic
- Not a carcinogen or mutagen
- Very low greenhouse emissions

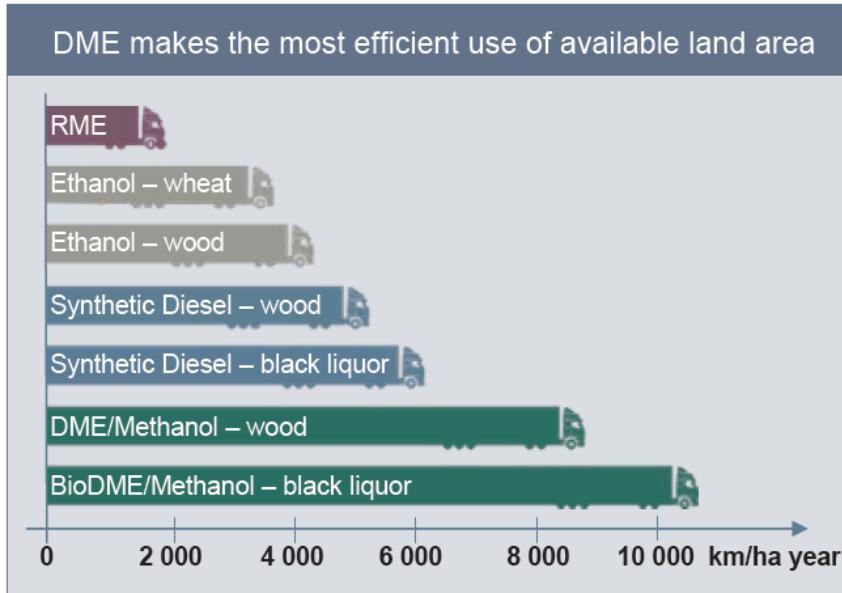
- DME Uses

- Cosmetic propellant
- Propane replacement
- Diesel fuel
 - High efficiency
 - Soot free combustion
 - Fuel system modifications required

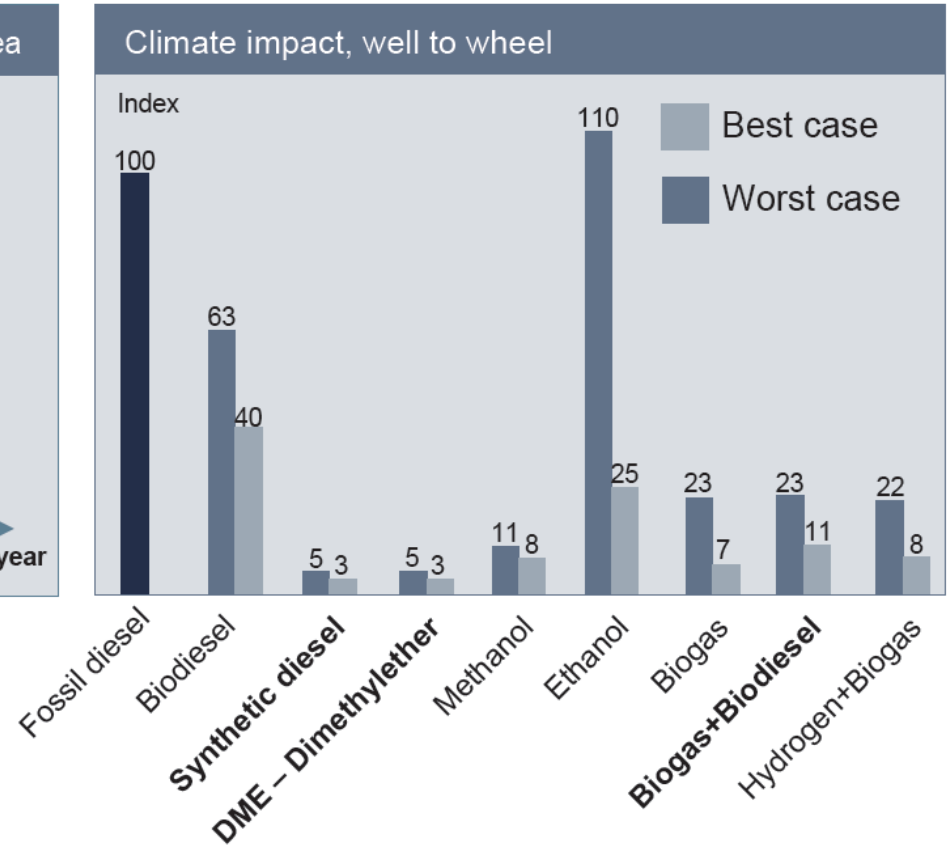
Source: International DME Association

Efficiency in focus

Efficient use of land area



Minimal greenhouse gas emissions



AB Volvo
Heavy duty DME vehicles
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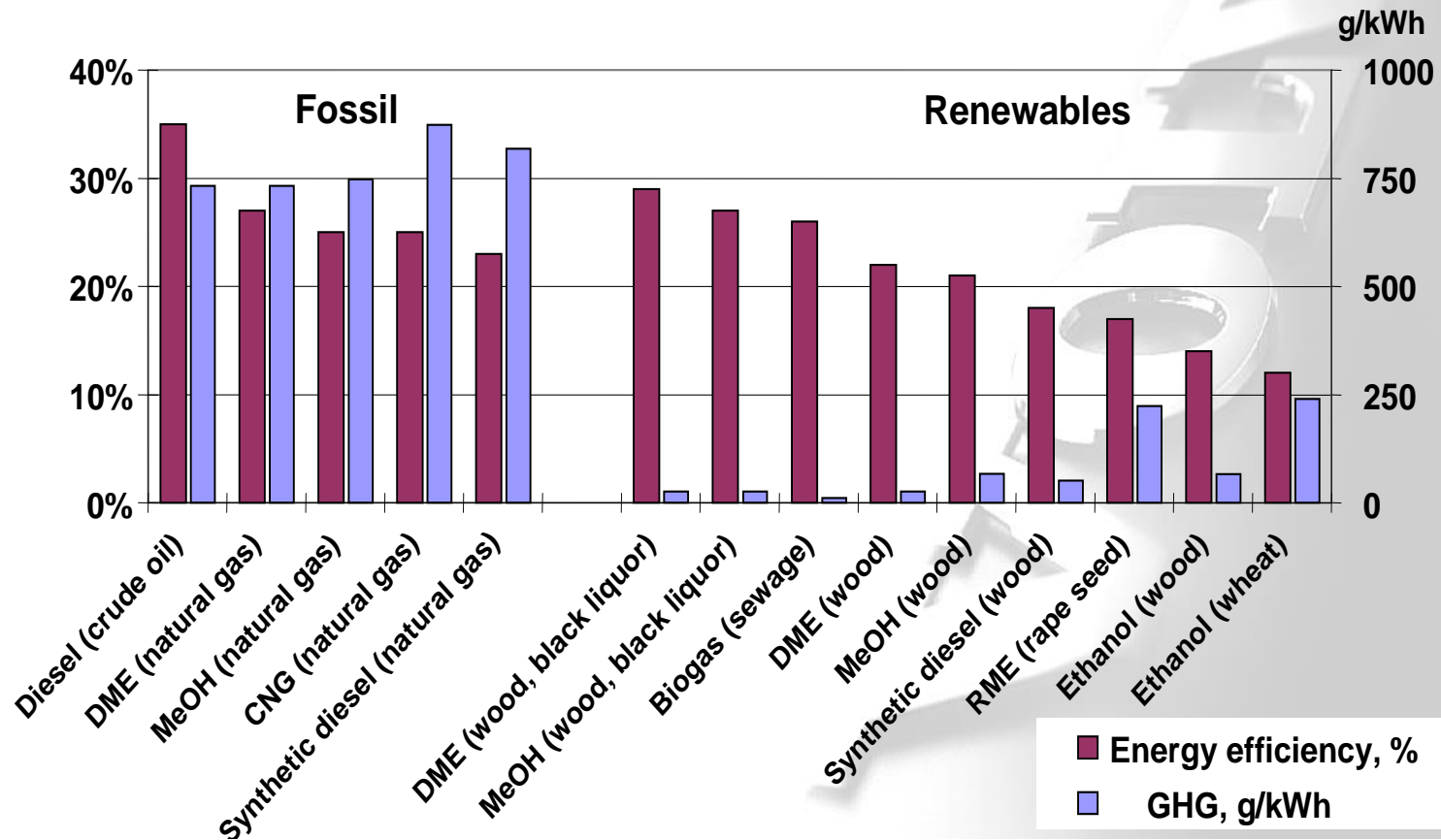


Heavy duty DME vehicles -from advanced engineering to customer field test, Niklas Gustavsson, Environmental & Public Affairs, AB Volvo

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Fuel comparison - efficiency and greenhouse emissions



Source: Volvo Technology Corporation. These estimates include production, transport, and end use GHG emissions. KEY: DME dimethyl ether; MeOH methanol; CNG compressed natural gas; RME rapeseed methyl ester; GHG greenhouse gas.

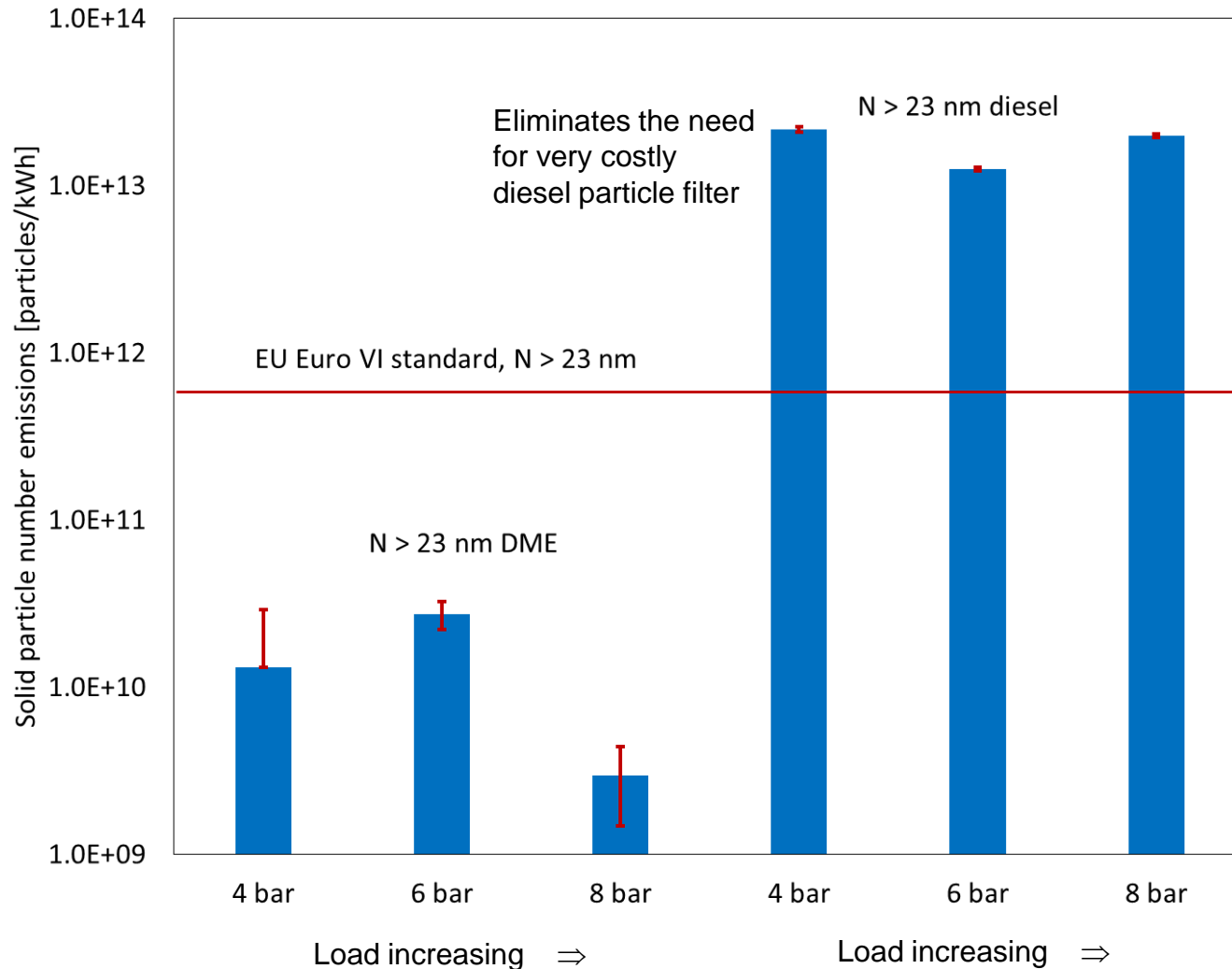
Current status

- Most of the DME worldwide is made from natural gas or coal
- In the US, DME is used as a nontoxic, non-ozone depleting cosmetic propellant
- DME is widely used in China as a propane replacement for cooking and heating
 - Current production about 40 million gallons/year
 - Planned production by 2020 about 800 million gallons/year, this corresponds to about, nearly half the current US use
- The first bio DME pilot plant was built by Chemrec at a paper mill in Piteå, Sweden.
- Oberon fuels has announced small scale plants (3000-10,000 gal DME /day) for conversion of biomass, solid waste, methane/CO₂ to DME
- Volvo, Isuzu, Shanghai Diesel and Nissan, have been testing prototype DME vehicles for several years
 - Shanghai announced plans to introduce fleets of DME trucks, buses, and taxis
 - Volvo has announced production of DME fueled trucks in the U.S. starting 2015

Projected bio DME yield from Minnesota pulpmills

- DME potential daily production: 139,000 – 315,000 gallons/day
- If both mills adopts DME production
 - DME could displace 2-6% of our current Diesel fuel use
 - Or 8-25% our propane needs
- Going beyond pulpmills in Minnesota - if existing cellulosic biomass resources were used to produce DME
 - We could produce about 1.2 times our current Diesel fuel need or
 - Or nearly 5 times our propane needs.

Regulated solid particle number emissions much lower with DME



If DME is so good why aren't we using it more widely?

- Unlike ethanol, biodiesel, natural gas, there are no natural production lobbies, advocates
- Stored and a liquid under moderate pressure like LP gases - propane and butane, but could use their distribution infrastructure
- Unlike biodiesel or renewable diesel, it is not practical to gradually phase in blended with petroleum diesel
- Excellent diesel fuel but some engine modifications required
 - Pressurized fuel system
 - Different elastomers
 - Lubricity additive
 - Potential issues with extremely tiny unregulated particles
- China already has large production capacity
 - Initial use as a propane replacement for heating and cooking
 - Expansion into diesel buses and trucks
- Volvo has made huge investments – we will see....

Questions?

- Contact information for further questions - kitte001@umn.edu