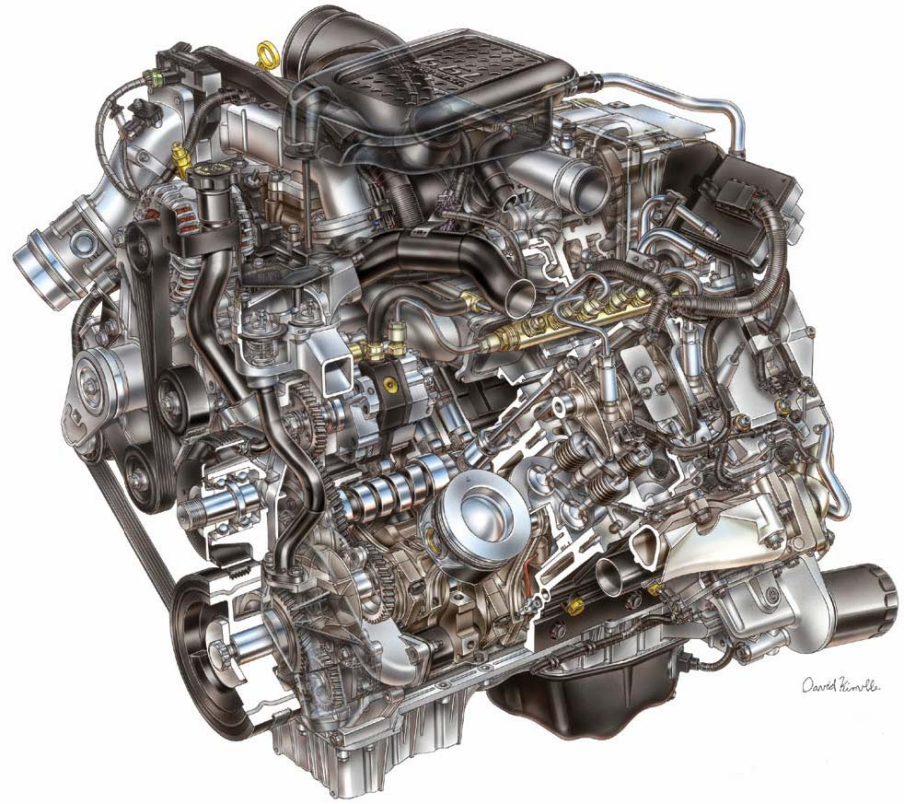
Systems Approach to New Transportation Fuels



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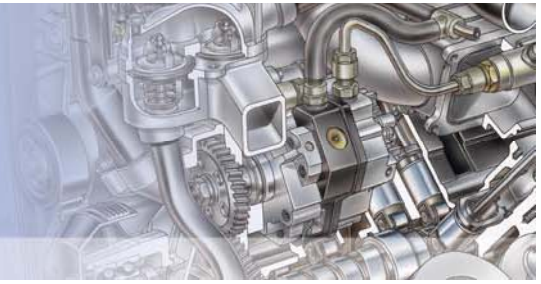
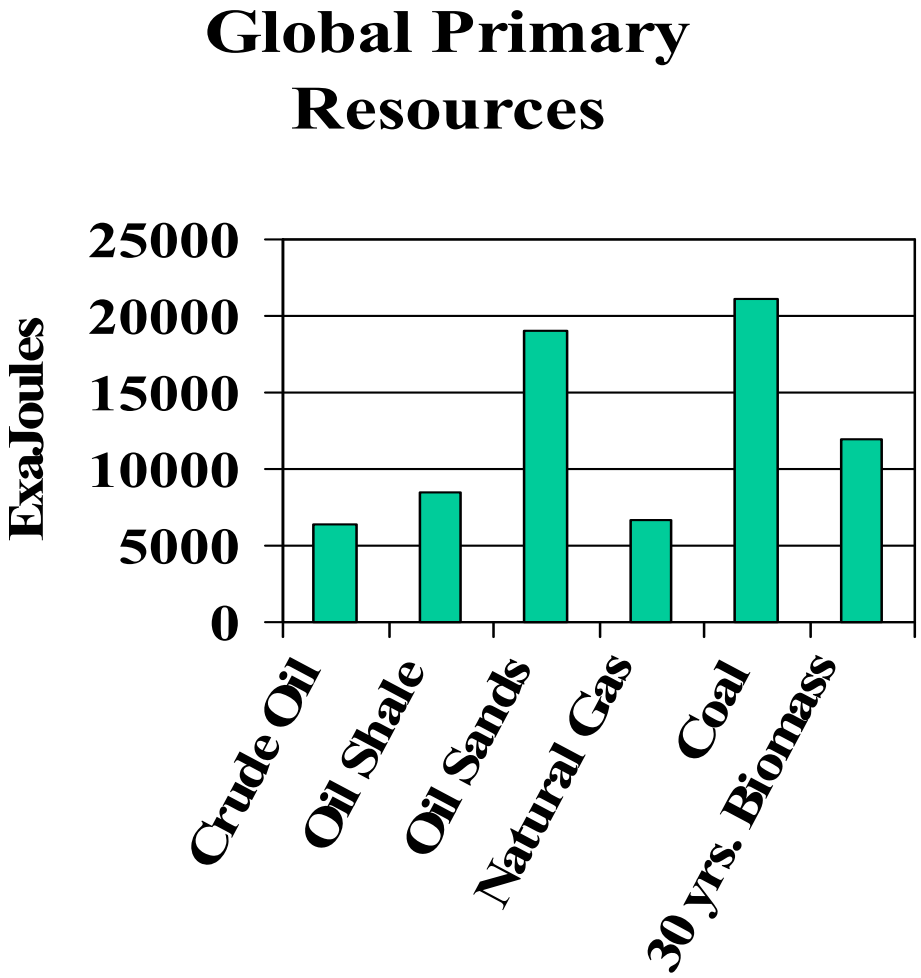
DEER Workshop Fuels Panel
August 23, 2006

Critical issues for transportation today?



- Transportation is highly dependent on petroleum
  - Petroleum prices have risen rapidly
  - U.S. imports have increased
  - Much of the global petroleum supply is concentrated in politically-sensitive regions
  - Conventional petroleum availability will diminish some time in the future
- Rising costs for high efficiency engines and aftertreatment systems that meet emissions standards

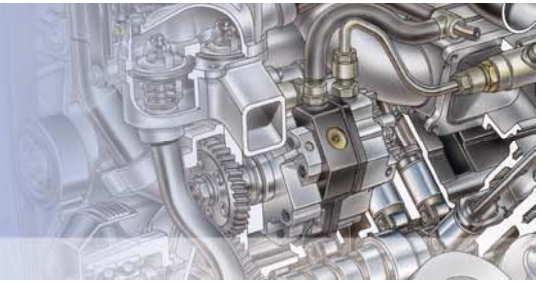
Primary resource availability



Source: World Business Council for Sustainable Development, 2002

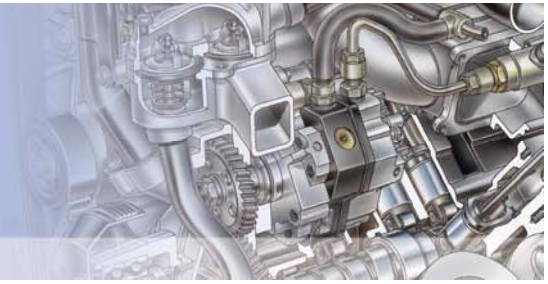
- Over 75000 EJ of global primary energy resource
  - Current consumption 440 EJ/year (BP review)
- The amount of global resources is not the issue

Fuel alternatives differ for each propulsion system

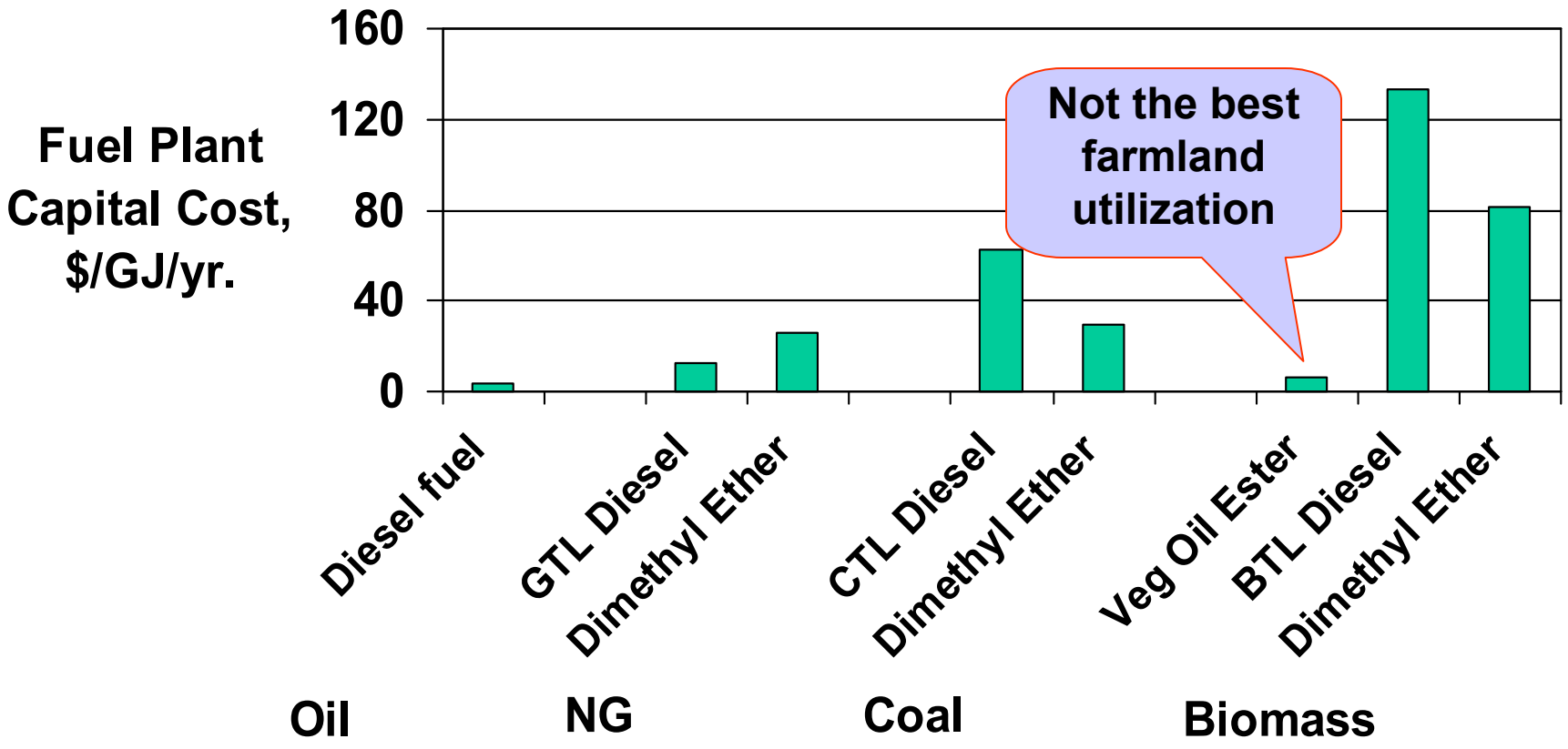


- Hydrogen a clear winner for fuel cell vehicles
- Ethanol blends and E85 good for spark ignition engines
  - Optimization still required
- What about compression ignition engines?
  - High efficiency over wide engine operation range
  - Existing technologies present some interesting possibilities
    - Biodiesel derived from vegetable oils
    - Gas to liquids, coal to liquids, and biomass to liquids, using the Fischer Tropsch process
    - Dimethyl ether
  - Significant barriers to implementation of alternatives

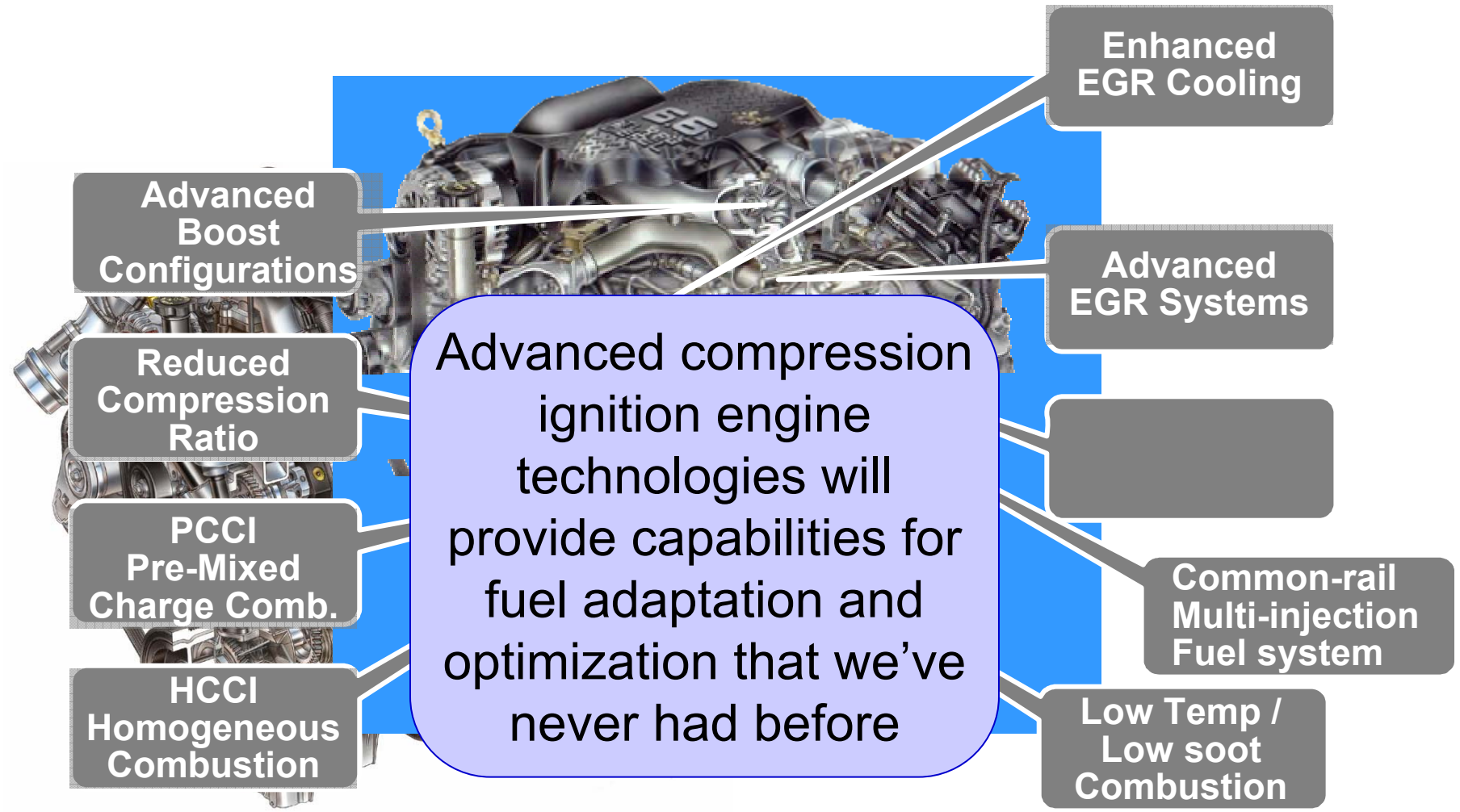
Most diesel fuel alternatives require large capital investment



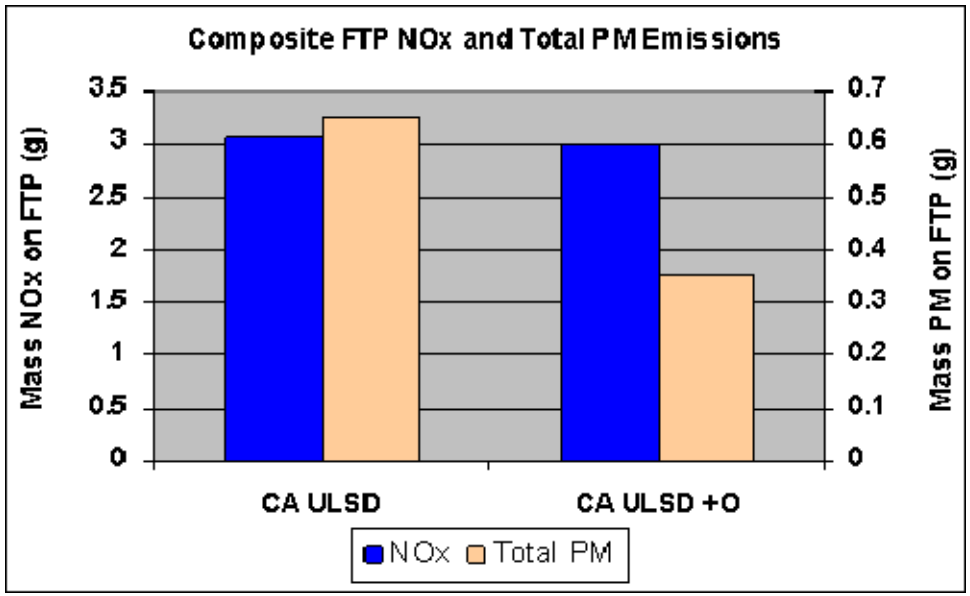
Concawe-EUCAR-JRC, 2006



New diesel technologies may open the door to new fuel compositions



Example of fuel oxygenate effect



Based on composite results from SAE 2005-01-3880:

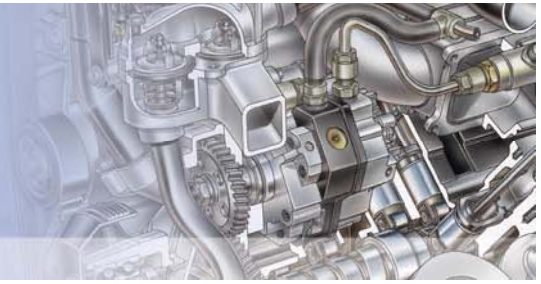
- **Oxygen in diesel has little direct effect on NOx**
- **It has major impact on PM**

Implication:

PM benefit can be traded off

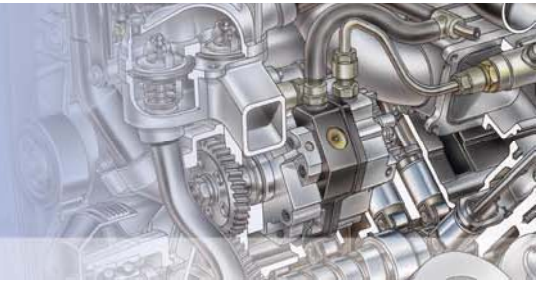
- **produce lower NOx using high EGR (permitted by low PM)**
- **Improve fuel economy with reduced DPF loading (and reduce plugging of EGR coolers)**
- **Combination of NOx and EGR benefits**

What should be done?



- Government and industry should partner to find the best fuel-engine system based on
  - potentially available resources
  - energy, emissions, and economics of fuel production
  - investment required in fuel distribution infrastructure
  - high efficiency, low emissions combustion characteristics in engines
- We should not be constrained by a history of incremental changes to conventional diesel fuel for use in past engines

Future fuels can come from a variety of sources



Current

Petroleum

Conventional Diesel Fuel
For Today's Diesel Engines

Future

Petroleum

Oil Sands

Oil Shale

New Fuel for
Future CI Engines

Coal

Biomass

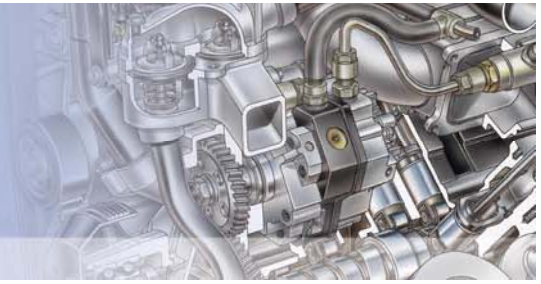
Vegetable Oil

Questions:

How should the use of these other resources be balanced to provide the most economical compression ignition fuel for future CI engines?

Should it be today's conventional diesel fuel or something different?

Vision



- Industry and government will partner to develop a fuel-engine system that is robust to future energy and environmental constraints
- The partnership will find an optimized compression ignition fuel that is
    - Available from multiple resources
    - Economic to produce and distribute
    - An enabler for low cost engine emissions control systems
    - Unconstrained by the existing petroleum-based fuel system

- This vision will be very challenging, but we need to try