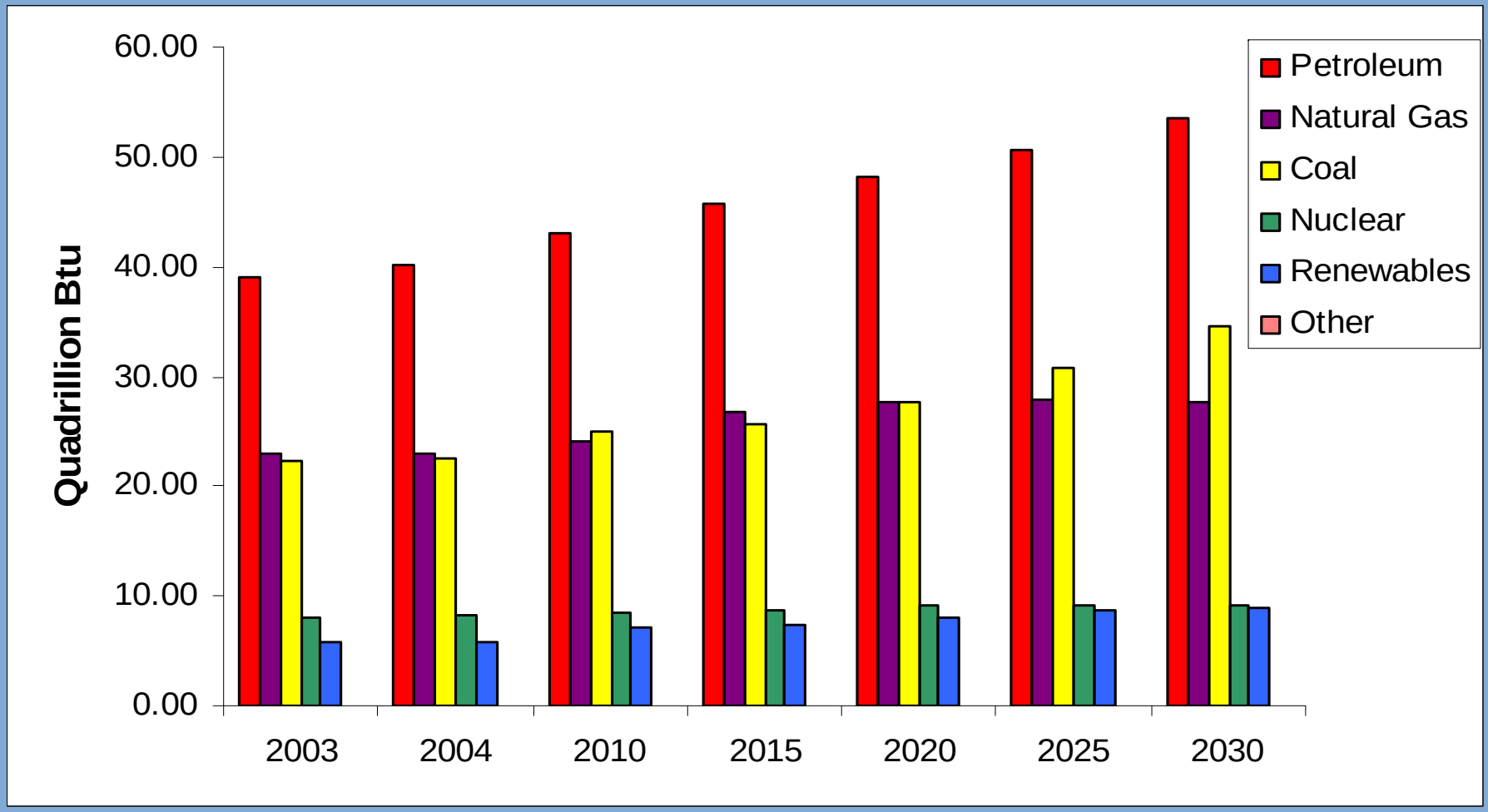
Alternative Fuels Overview

Sample Presentation

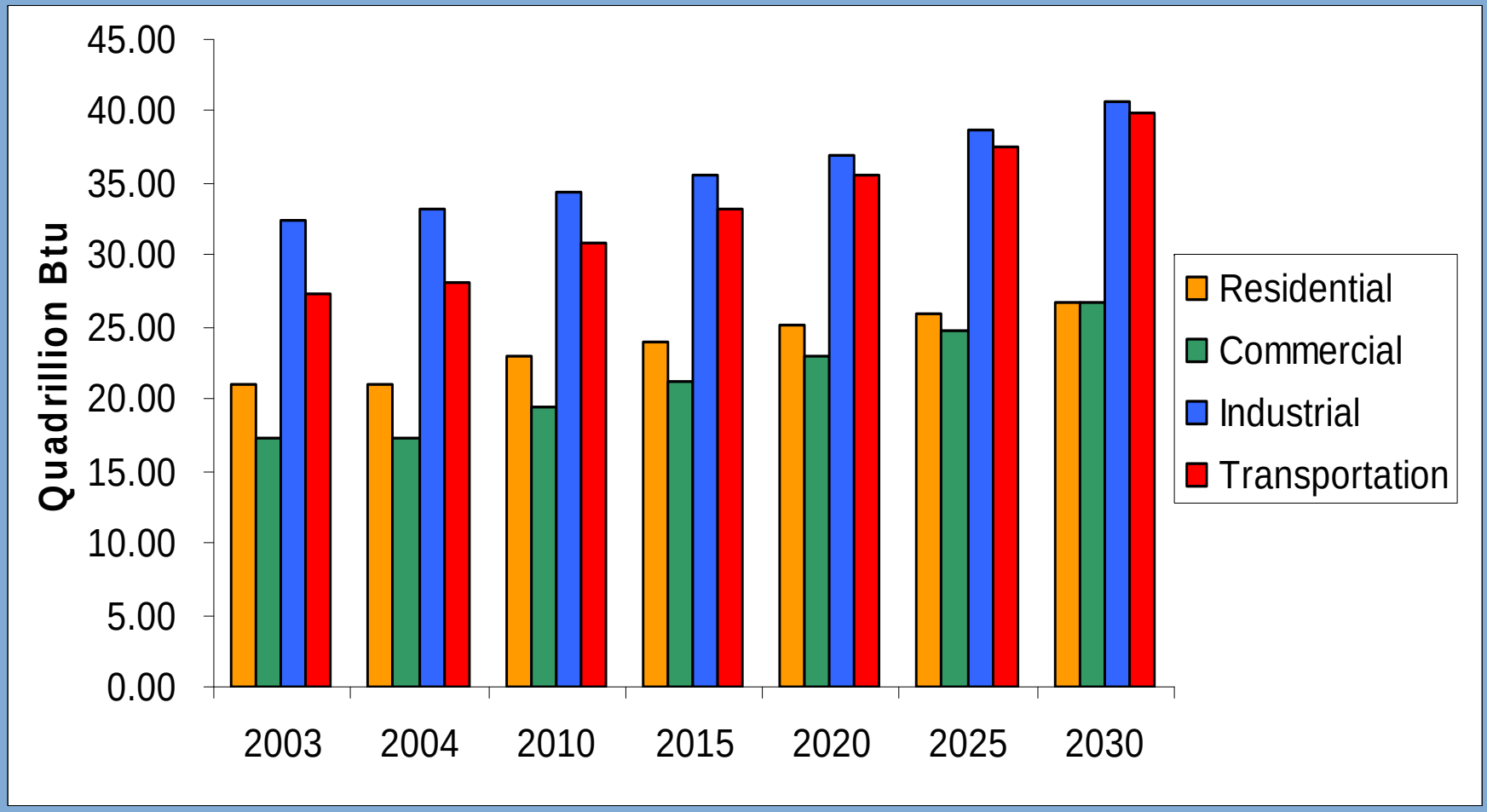
1/11/07

U.S. Energy Consumption



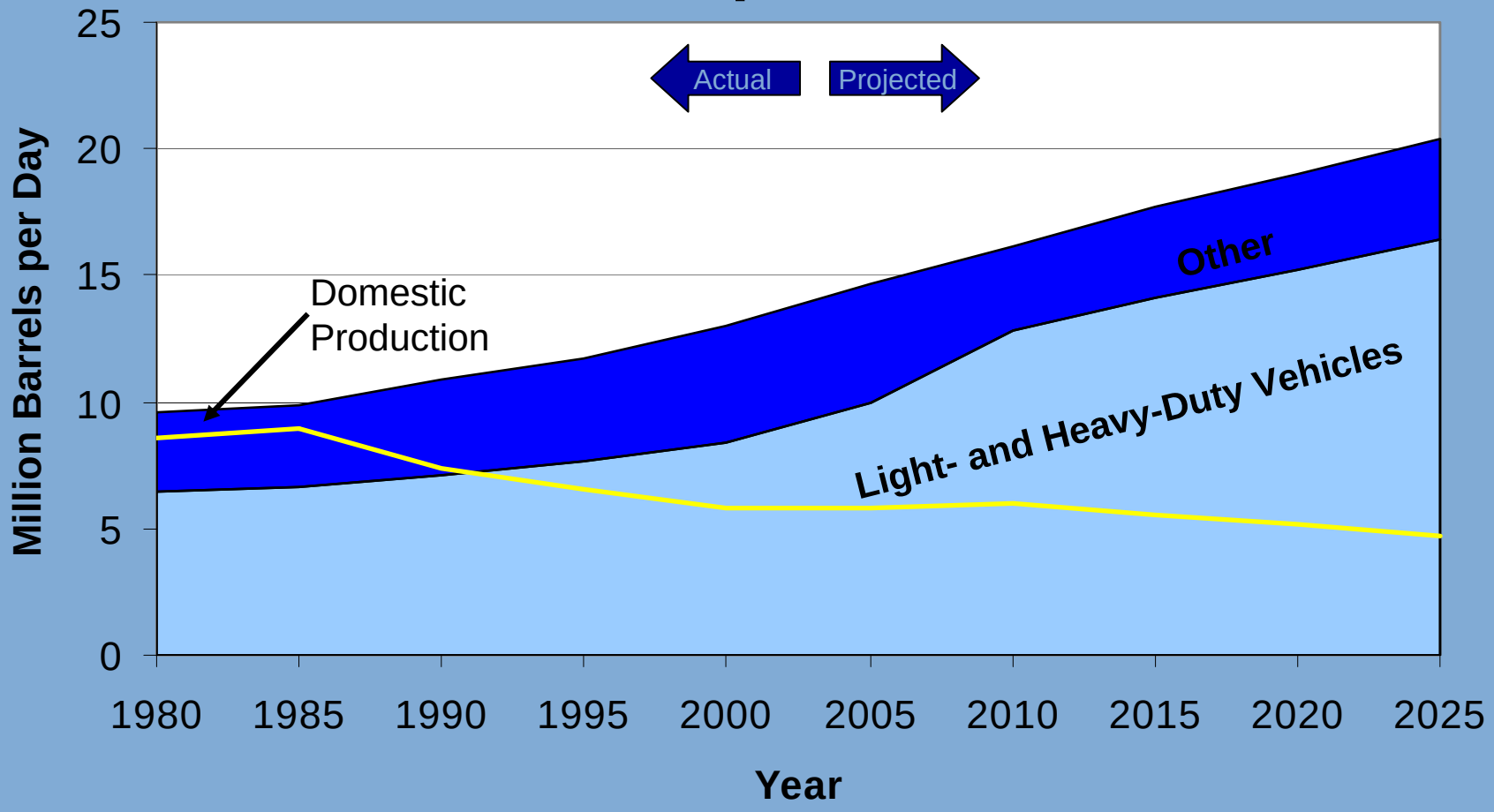
Source: Annual Energy Outlook 2006, Energy Information Administration.

U.S. Energy by Sector



Source: Annual Energy Outlook 2006, Energy Information Administration.

U.S. Oil Consumption



Source:Transportation Energy Data Book Edition 24, Oak Ridge National Laboratory Center for Transportation Analysis, http://cta.ornl.gov/data and Annual Energy Outlook 2005, Energy Information Administration.

Alternative Fuels—One Solution

- Domestically produced.
- Derived from renewable sources.
- Reduces harmful pollutants, exhaust emissions, and CO_2 emissions.

Ethanol Properties

- Alcohol-based fuel produced from starch crops or cellulosic biomass (trees and grasses). Currently, corn is primary feedstock.
- High octane (100+); enhances octane properties of gasoline and used as oxygenate to reduce CO emissions.
- 27% - 36% less energy content than gasoline. OEM's estimate 15% - 30% decrease in mileage.
- E85 vehicles demonstrate a 25% reduction in ozone-forming emissions compared to gasoline.
- As an alternative fuel, most commonly used in a blend of 85% ethanol and 15% gasoline (E85).

Ethanol Uses

- Mostly used in light-duty vehicles called flexible fuel vehicles (FFVs). FFVs can use 100% unleaded fuel or any mixture of E85 and unleaded fuel.

- Several manufacturers offer FFVs in car and pickup configurations. See the AFDC Web: www.eere.energy.gov/afdc

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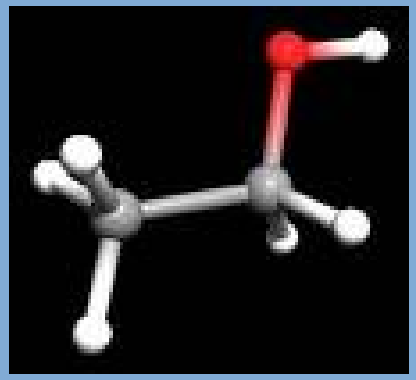
Ethanol Considerations

- Decreased mileage.
- High level of fuel pricing volatility until demand and supply balance.
- Refueling infrastructure not in place in all areas (1003 stations in the U.S. offered E85 in 2006).
- Ongoing debate: energy balance, land mass, food vs. fuel, and water required.

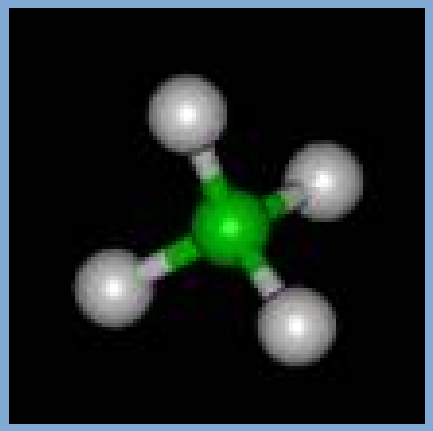


Natural Gas Properties

- Recovered from underground reserves.
- Used in two forms: CNG (compressed natural gas) and LNG (liquefied natural gas).
- CNG and LNG vehicles can demonstrate reduced ozone-forming emissions compared to gasoline. May have increased hydrocarbon emissions.
- Contains 59% - 69% less energy content per gallon at 3000 - 3600 psig than gasoline.
- Widespread distribution infrastructure (737 CNG and 32 LNG refueling stations in operation in 2006).

CNG/LNG Uses

- CNG used in light- and medium-duty vehicles.
- LNG used in heavy-duty trucks and all natural gas fueled locomotives.
- CNG stored onboard at 3000 - 3600 psig.
- LNG stored at 50 psig and fuel temperature at -220^{0}F.



CNG/LNG Considerations

- CNG refueling stations are either slow-fill (several hours to fill) or fast-fill (2 - 5 minutes).
- Additional safety modification for maintenance facilities required by NEC (National Electrical Code) and NFPA (National Fire Protection Association).
- Higher vehicle costs because of required tank configuration.
- Shorter vehicle range for CNG vehicles.
- Availability of refueling stations.

Biodiesel Properties

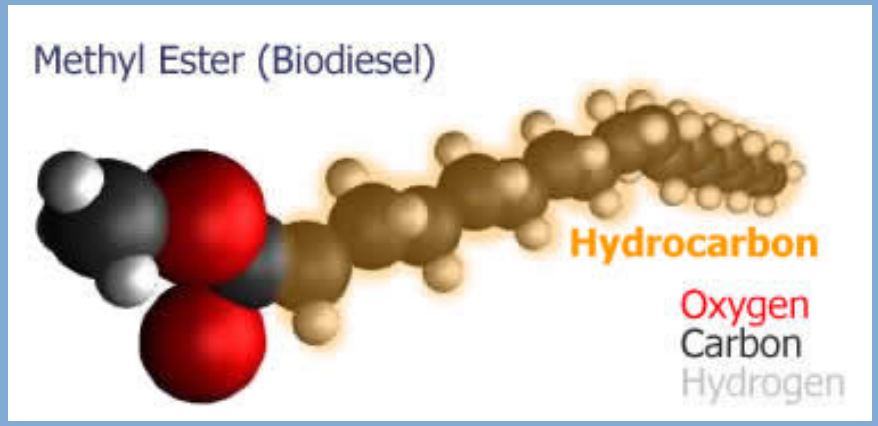
- Manufactured from vegetable oils, animal fats, or recycled restaurant greases; reacted with alcohol to produce fatty acid alkyl ester.
- Nontoxic, biodegradable, and reduces serious air pollutants.
- B20 (20% biodiesel, 80% petroleum diesel) can generally be used in unmodified diesel engines.
- Can be used in pure form (B100), but may require engine modifications.
- Has a higher cetane number and provides more lubricity.
- B20 contains 9% less energy content per gallon than #2 diesel.

Biodiesel Uses

- B20 can generally be used in all unmodified diesel engines.
- Using biodiesel maintains the same payload capacity and range and provides similar horsepower, torque, and fuel economy.

Biodiesel Considerations

- Potential issues with cold starting. Also, cold weather storage requires additional steps to keep biodiesel usable.
- Fuel related failures may not be covered by some OEM warranties if greater than B5 is used.
- Limited production and availability. At the end of 2006 there were 635 stations offering biodiesel.

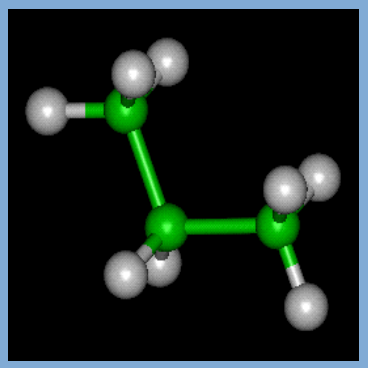


Propane (LPG) Properties

- By-product of natural gas processing and crude oil refining.
- HD5, the automotive propane standard, a mixture of 90% propane and other hydrocarbons.
- Contains 33% - 41% less energy content per gallon than gasoline.
- LPG vehicles can demonstrate a 60% reduction in ozone-forming emissions compared to gasoline.
- High octane properties (~104) allow LPG vehicles to operate with higher compression ratios; leads to higher efficiency/fuel economy.

Propane (LPG) Uses

- Used in light- and medium-duty vehicles, heavy-duty trucks and buses.
- Popular choice for non-road vehicles such as forklifts and agricultural and construction vehicles.
- Many propane vehicles are converted gasoline vehicles. (Conversion kits include regulator/vaporizer, air/fuel mixer, oxygen-monitoring closed-loop feedback system, and special fuel tank.)

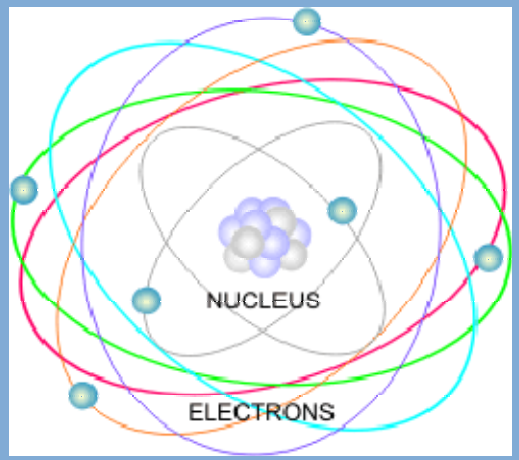


Propane (LPG) Considerations

- Widespread infrastructure of pipelines, processing facilities, and storage (2,499 stations in U.S. offered LPG in 2006).
- For vehicles, need to balance range vs. payload reduction caused by larger fuel tanks.
- Increased vehicle costs.

Electricity Properties

- Recharges batteries in electric vehicles.
- Electricity sources for battery recharging (electrical outlet, gasoline engine on-board vehicle, regenerative braking).
- Electricity sources for power outlets (coal, natural gas, nuclear, wind, other renewables).



Electricity Uses

- Two categories include EVs or plug-ins (externally charged) and HEVs or hybrid vehicles (self-charged). Both use battery storage.
- Available in neighborhood electric vehicles, bicycles, light-duty vehicles, medium- and heavy-duty trucks and buses.
- Hybrids use an electric motor or a combination of a gasoline engine and electric motor to drive the wheels. Hybrids use batteries to store electricity produced by regenerative braking and the onboard generator.
- Range of a dedicated electric is typically 50-130 miles.

Electricity Considerations

- Fuel savings (10% - 100% depending on application and vehicle).
- Payback on investment.
- Possible federal and state tax credits for purchase of hybrid.

Hydrogen Properties

- Does not occur to any significant extent on earth in its free, elemental form.
- Found in chemical compositions such as water and hydrocarbons, and dry coal.
- Pure hydrogen contains no carbon thus burns to form water with no CO_2 or CO emissions.
- One kg of hydrogen contains roughly equivalent energy to one gallon of gasoline.
- Can be stored as compressed hydrogen at 5,000 – 10,000 psi or liquid hydrogen (cooled to -423^0F).

Hydrogen Uses

- Emerging fuel for transportation fuel cells.
- Used in modified internal combustion engines.
- Fuel cells use a direct electrochemical reaction to produce electricity on board the vehicle. This electricity is used to power electric motors.
- Ongoing demonstration projects in select U.S. areas.

Hydrogen Considerations

- Vehicles not available for commercial sale.

- Infrastructure extremely limited (31 demonstration-level refueling stations in the U.S in 2006).

October 2006 Average Fuel Prices

	Nationwide Average Price This Report	Nationwide Average Price Last Report (6/06)	Change in Price	Units of Measurement
Gasoline (Regular)	$2.22	$2.84	($0.62)	per gallon
Diesel	$2.62	$2.98	($0.36)	per gallon
CNG	$1.77	$1.90	($0.13)	per GGE
Ethanol (E85)	$2.11	$2.43	($0.32)	per gallon
Propane	$2.33	$2.08	$0.25	per gallon
Biodiesel (B20)	$2.66	$2.92	($0.26)	per gallon
Biodiesel (B2-B5)	$2.75	$2.97	($0.22)	per gallon
Biodiesel (B99-B100)	$3.31	$3.76	($0.45)	per gallon

Clean Cities Alternative Fuel Price Report
October 2006