

Biofuels

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Why Biofuels?

- Our dependence on energy
- Fossil Fuels
 - Non-renewable
 - Destructive to the earth

What are Biofuels?

- Biomass
 - From plants, animals and waste
- Biofuel
 - Produced from biomass
 - Renewable
 - Carbon-neutral

Uses of Biofuels

- Humans have used biofuels since the discovery of fire
- Defining moments in the transportation industry
 - Internal combustion engine
 - Diesel engine
 - Ford Model T
- Fossil fuel became an abundant resource

Making a comeback

- Renewed interest in Biofuels
 - Fossil fuels becoming scarce
 - Countries thriving for energy independence
 - Instability in the Middle East, oil prices

Biodiesel

Vegetable Oils

- Similar properties to Biodiesel (“unwashed biodiesel”)
- 1900 World’s Fair, diesel engine demonstration
- Elsbett company allows vehicles to run vegetable oil
- Inexpensive engine modification has same effect
- Transesterification process

Biodiesel

- Biodiesel is an incremental technology
- Hard to judge a standard for the technology
- Biodiesel as an additive
 - Has not replaced petroleum diesel, it is mixed in
 - B20 means it is 20% biodiesel and 80% petroleum
- Pure Biodiesel (B99 & B100)

Biodiesel

Adoption

- Biodiesel has not had the quickest adoption
- Railroad Industry
 - 2001, Virgin Group Ltd. Class 220 Voyager
 - First diesel-electric high-speed train
 - Used B20 blend of biodiesel
 - Saved 14% in direct emissions

Biodiesel

Adoption

- Airplane Industry
 - Slow adoption due to risks
- 2008, Virgin Group Ltd.'s Virgin Atlantic
 - Flew “BioJet” Boeing 747 from London to Amsterdam
 - Used B20 biodiesel provided by Imperium Renewables
 - Touted as major step towards “greener flying”

Biodiesel

Pros

- Greatly reduces carbon dioxide, carbon monoxide and sulfur dioxide emissions
- Fully biodegradable
- Can be produced from many waste materials, many different industries can participate

Biodiesel

Cons

- Generally more expensive than petroleum diesel
- Can result in higher levels of nitrogen oxides and hydrocarbon emissions in existing diesel engines
 - New engines would have to be produced to eliminate
- Pure biodiesel (B99 & B100) thicken into solids at low temperatures

Biodiesel

Looking Forward

- Increased attention due to ease of production and integration into existing engines
- Better performance through tweaks and better engines
- Increasing market share; likely to replace pure petroleum diesel in the coming years

Bioalcohols

- Biologically synthesized alcohols → bioalcohols
 - Methanol, ethanol, propanol and butanol
 - Characteristics allow for use in existing engines
 - Mostly only ethanol is used and researched further
- Incremental technology, improving on petroleum based gasoline

Bioalcohols

Ethanol

- Best known bioalcohol in use today
- Consists of same type of alcohol found in beverages, just in higher concentrations
- “Ethanol” here refers to bio-ethanol; ethanol can be derived from petroleum as well
 - Chemically identical
- Low on technology s-curve

Bioalcohols

Ethanol Adoption

- Ethanol as an additive
 - Most popular in the US is E85 Ethanol, 85% ethanol & 15% petroleum gasoline
 - “FlexFuel” vehicles excel with E85, most modern engines can be converted to use E85
 - E10 represents majority of fuel consumed in the U.S.
- E100 used in Brazil and Argentina

Bioalcohols

Pros

- Emits less pollution
- Good performance
- Renewable, biodegradable
- Produced from agricultural feedstock
- Allows for energy independence

Bioalcohols

Cons

- Non-neutral net carbon output
- Fuel vs. Food issue
- Problems running high concentration in existing engines

Bioalcohols

Looking Forward

- Improved production methods looks to reduce carbon footprint
- Engineering crops that result in higher energy yields
- Government incentives for farmers producing bioalcohols

Biogas

- Biogas is produced from biodegradable materials
- Anaerobic digestions process captures gas produced from breakdown of matter
- Biogas consists mostly of methane and carbon dioxide
- Biogas can be combusted with oxygen, allow it to be used as fuel

Biogas

History

- 10th century BC, used to heat bath water
- First anaerobic digester was built in 1859 in India
- Septic tank was used to power street lamps in 1895, London

Biogas

Production

- Biogas can be produced from swamps, landfills, sewage treatment and farm waste
- Anaerobic digestion
 - Works by compressing the material so that anaerobic microbes thrive
 - Methane and other gases are captured and compressed for later use

Biogas

Adoption

- Used for heating in existing gas networks
- Internal combustion engines
 - Bates had biogas powered car that came from processed pig manure in 1974
- Volvo Group has been offering biogas powered cars since 1995
 - Volvo Bi-Fuel S80 gets 186 miles to a tank of biogas, cost to operate is 20-60% less than of petroleum based gasoline

Biogas Adoption

- Waste Management Inc. is the largest hauler and landfill operator in the U.S.
- 1/3 of landfills have methane-to-energy capabilities
- \$400 million investment to further biogas capture capabilities
- Marks the largest and most ambitious renewable energy project to date

Biogas

Pros

- Renewable, non-polluting
- Landfill methane is 20 times more potent as a greenhouse gas than carbon dioxide
- Footprint is nearly zero when we capture and reuse this methane
- Production scales well from small to large

Biogas

Cons

- Little control of the rate of production

Biogas

Looking Forward

- Technology and its benefit are becoming widespread
- Compressed biogas widely available in Europe
- U.S. federal agencies promote biogas production
- Least amount of disadvantages indicate its strength as an alternative fuel

