



Biodiesel



What is Biodiesel?

- Biodiesel consists of alkyl-esters derived from a biological source
- Biodiesel can be used as a fuel in compression ignition engines (i.e. diesels)
- Can be blended with petroleum diesel in any ratio (e.g. B2, B20, B100)

What is Biodiesel?

- Vegetable oils (soy, canola, palm) are the most commonly used oils for biodiesel production.
- All common oils can be converted (i.e. plant oils, animal fats, waste cooking oil)



Why Biodiesel?

IT'S RENEWABLE!

Why Biodiesel?

- **Non-toxic**
 - LD50 of 17.4 g/kg
 - ten times less toxic than table salt
 - Less skin irritation than a 4% soap solution
 - very mild irritation
 - Insignificant aquatic toxicity
 - 1000mg/L is lethal to bluegill

[illegible]

- **Reduced air pollution**
 - Sulfur emissions are greatly reduced
 - Equivalent to ultra low sulfur diesel now required by EPA
 - EPA Criteria pollutants are reduced
 - unburned hydrocarbons
 - carbon monoxide
 - particulate matter

Effects on Air Quality

- Reduced air pollution
 - Reduces health risks associated with petroleum diesel:
 - 75-85% reduction of polycyclic aromatic hydrocarbons (PAH)
 - 90% reduction of nitrated polycyclic aromatic hydrocarbons (nPAH).
 - These have been identified as carcinogens

AVERAGE BIODIESEL EMISSIONS COMPARED TO CONVENTIONAL DIESEL, ACCORDING TO EPA

Emission Type	B100	B20
<u>Regulated</u>		
Total Unburned Hydrocarbons	-67%	-20%
Carbon Monoxide	-48%	-12%
Particulate Matter	-47%	-12%
Nox	+10%	+2% to -2%
<u>Non-Regulated</u>		
Sulfates	-100%	-20%*
PAH (Polycyclic Aromatic Hydrocarbons)**	-80%	-13%
nPAH (nitrated PAH's)**	-90%	-50%***
Ozone potential of speciated HC	-50%	-10%

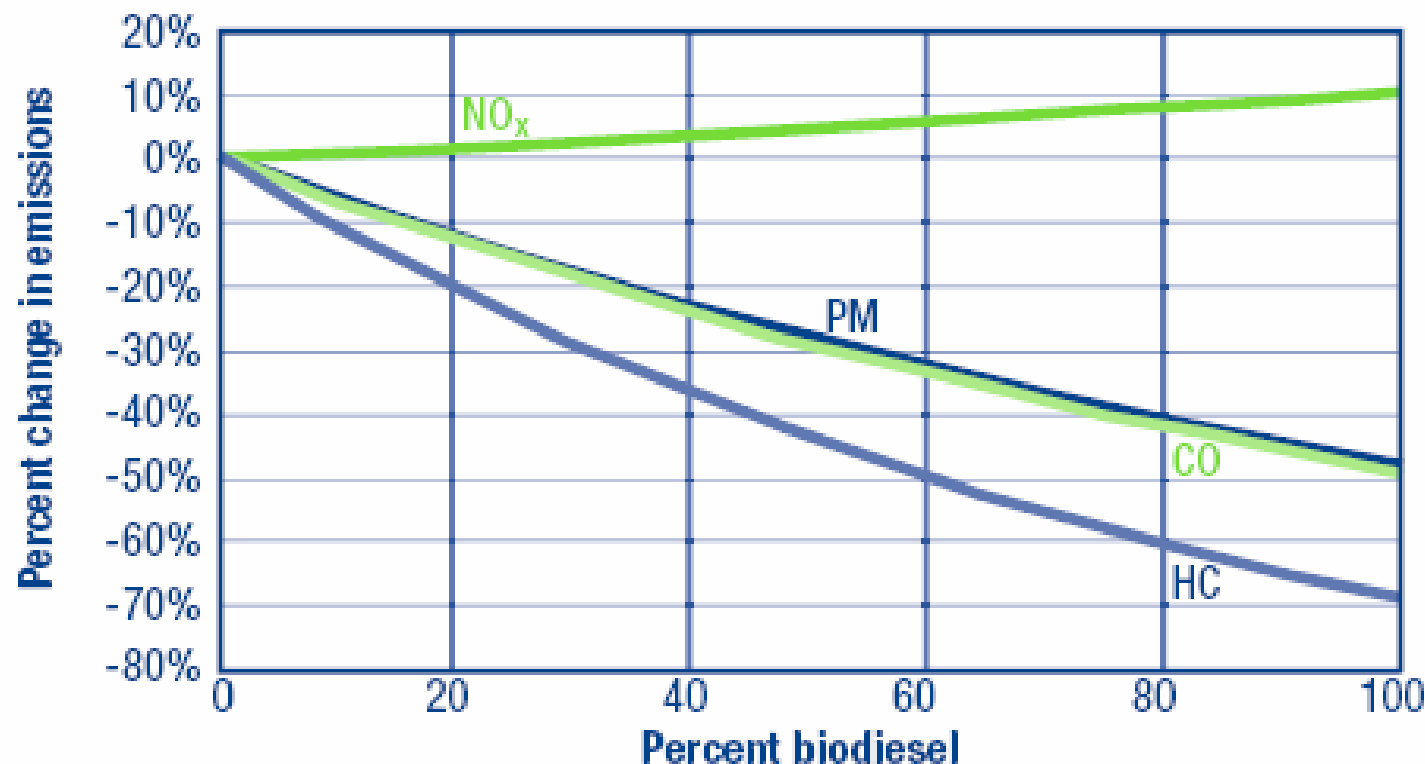
* Estimated from B100 result

** Average reduction across all compounds measured

*** 2-nitrofluorine results were within test method variability

Source: EPA Emissions Evaluation for the National Biodiesel Board

Biodiesel Vs Petrodiesel



Basic Emission Correlation. Average emission impacts of biodiesel for heavy-duty highway engines. Source: U.S. EPA².

Environmental Benefits

- Homegrown
 - Can be grown from local oil crops
- Biodegradable
 - Biodiesel degrades at ~the same rate as dextrose
 - Environmentally positive (no oil spill disasters)



Some other important considerations

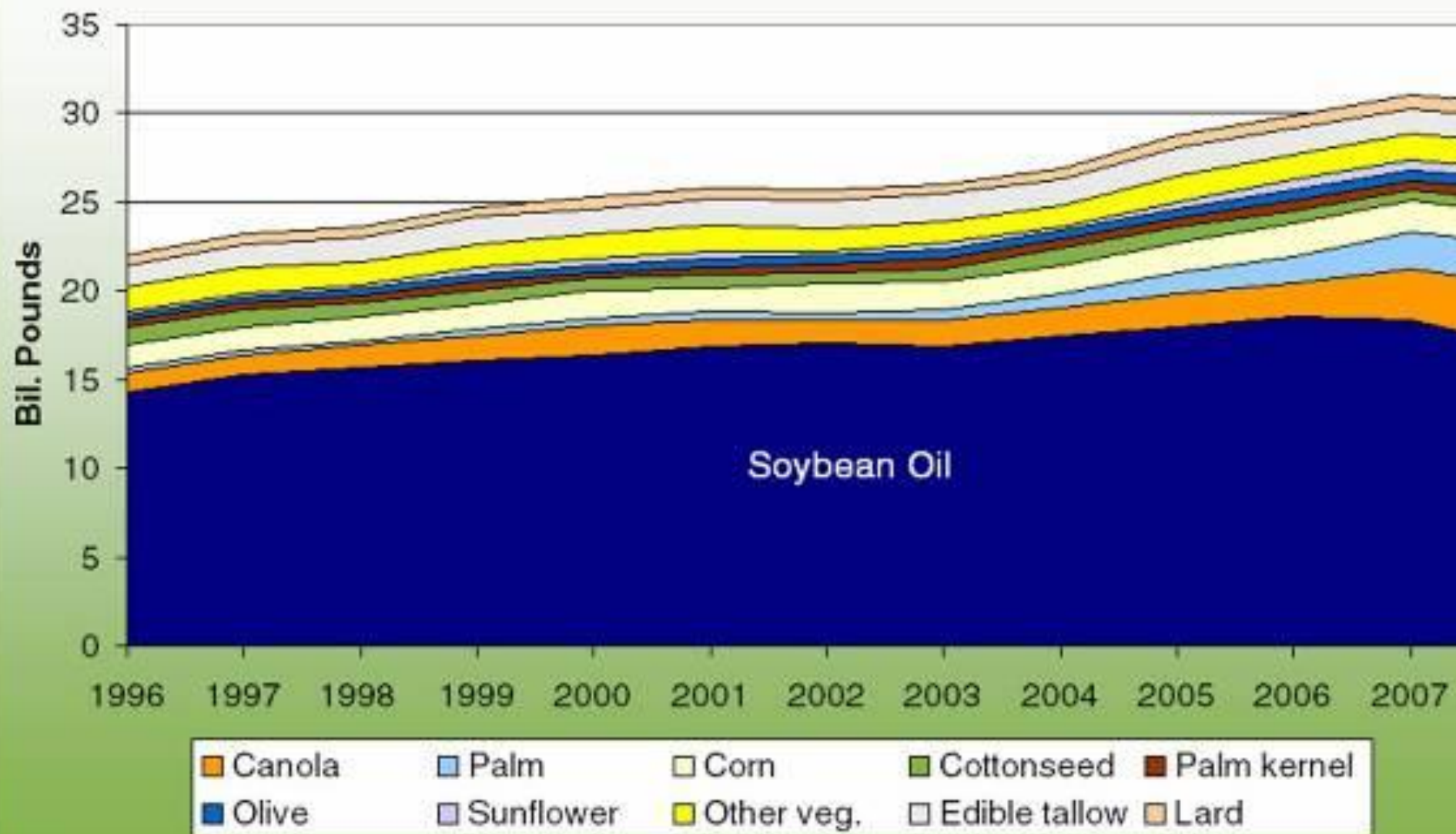
- Fits existing fuel infrastructure
 - Runs in current diesel engines
 - Can be stored at existing petrol stations
 - Can be transported like petroleum diesel
- Higher flashpoint than petroleum diesel
 - Classified as non-flammable by OSHA (150 °C)
 - Safer to handle and transport, safer in accidents
- Provides lubricating properties
 - Reduces engine wear
 - Extends engine life

What's the Catch?

Feedstock Supply

There simply isn't enough oil to turn into biodiesel!

Figure 1. U.S. Domestic Vegetable Oils and Animal Fat Usage



Feedstock Supply

- Devoting all 2005 U.S. soybean production to biodiesel would have offset 6.0% of U.S. diesel demand.

Source: Hill et al. 2006. Environmental, economic, and energetic costs and benefits of biodiesel and ethanol biofuels. Proceedings of the National Academy of Sciences, 103:30 11206-11210

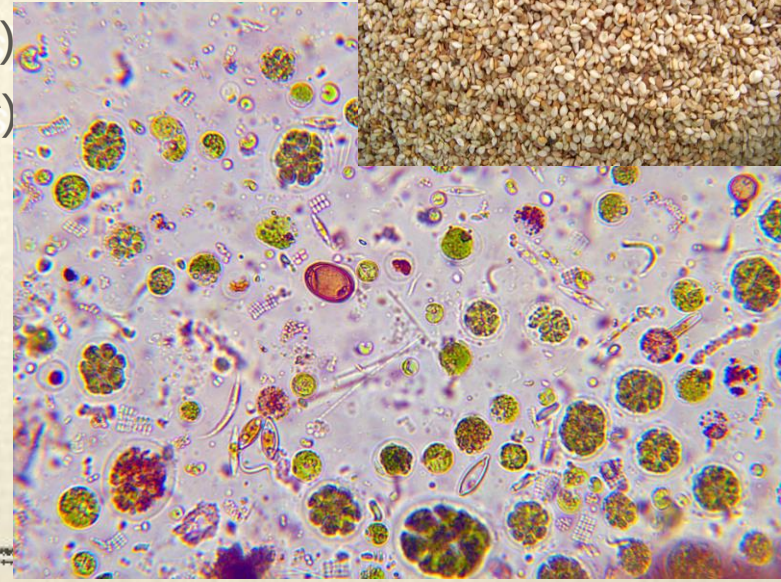
Feedstock Supply

- However, because of the fossil energy required to produce biodiesel, this change would provide a net energy gain equivalent to just 2.9%.

Source: Hill et al. 2006. Environmental, economic, and energetic costs and benefits of biodiesel and ethanol biofuels. Proceedings of the National Academy of Sciences, 103:30 11206-11210

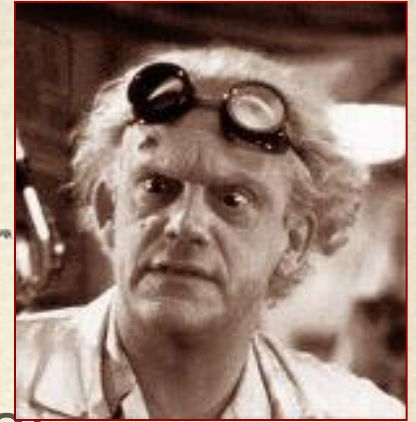
Feedstock Supply Solutions

1. Use less fuel by increasing efficiency
2. Recycle waste cooking oil
3. Get creative in oil crops!
 - Tremendous botanical potential
 - ✓ Sesame (*Sesamum indicum*)
 - ✓ Camelina (*Camelina sativa*)
 - ✓ Jatropha (*Jatropha curcas*)
 - ✓ Castor (*Ricinus communis*)
 - ✓ Tallow (*Sapium sebifera*)
 - ✓ Algae (~40,000 species)



The Biodiesel Production Process

How is Biodiesel Made?



- A TRANSESTERIFICATION reaction of **vegetable** (or **animal**) lipids with a low molecular weight alcohol (**methanol**) produces biodiesel
- This reaction is catalyzed by a **base**, typically: Sodium Hydroxide (NaOH) or Potassium Hydroxide (KOH)

Transcendental Transesterification

- TRANS= CHANGE
- ESTERIFICATION= CREATING AN ESTER
- OIL + ALCOHOL = GLYCEROL + ALKYL ESTERS (BIODIESEL)

A BASE AND HEAT ARE REACTION CATALYSTS

- In the context of biodiesel transesterification is:
 - the replacment of the glycerol portion of the oil with methanol or ethanol

A Note on Safety

- An alcohol is required in the production of Biodiesel
 - methanol is typically used
- Methanol is a **flammable neurotoxin**
 - However, so is gasoline (a quite common fuel)

- **Safety precautions** must be used when handling, transporting, or producing methanol:

- no sparks
- no smoking
- proper ventilation
- proper safety equipment: gloves, goggles, etc.