



Introduction to Biofuels: Biodiesel and Straight Vegetable Oil



Biofuels Program
Central Carolina Community College
Pittsboro, NC

Welcome to Biofuels!

During this course we will read about, discuss, and work on projects that all have to do with vegetable oil and how it can be used as an alternative to diesel fuel.



Who are Rachel & Leif?

- Rachel is a former automotive technology instructor, biodiesel activist, and loves her new job building a biodiesel plant.
- Leif is a community organizer, biofuels entrepreneur, and general tinker.

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Class Nuts & Bolts

- This class meets every Monday from 6 to 9 PM in automotive classroom 111 (unless otherwise noted--sometimes we move over to the Biology lab, Auto shop, or off-site field trip).
- We will use course material from Iowa State University, the Homebrew Guide, Journey to Forever and other readings as text.
- Last night of class bring food for potluck dinner.
- Prepare for class by doing the assigned reading. Our discussions and lessons will rely on an understanding of the readings.
- Some class presentations and handouts are also available on our website.

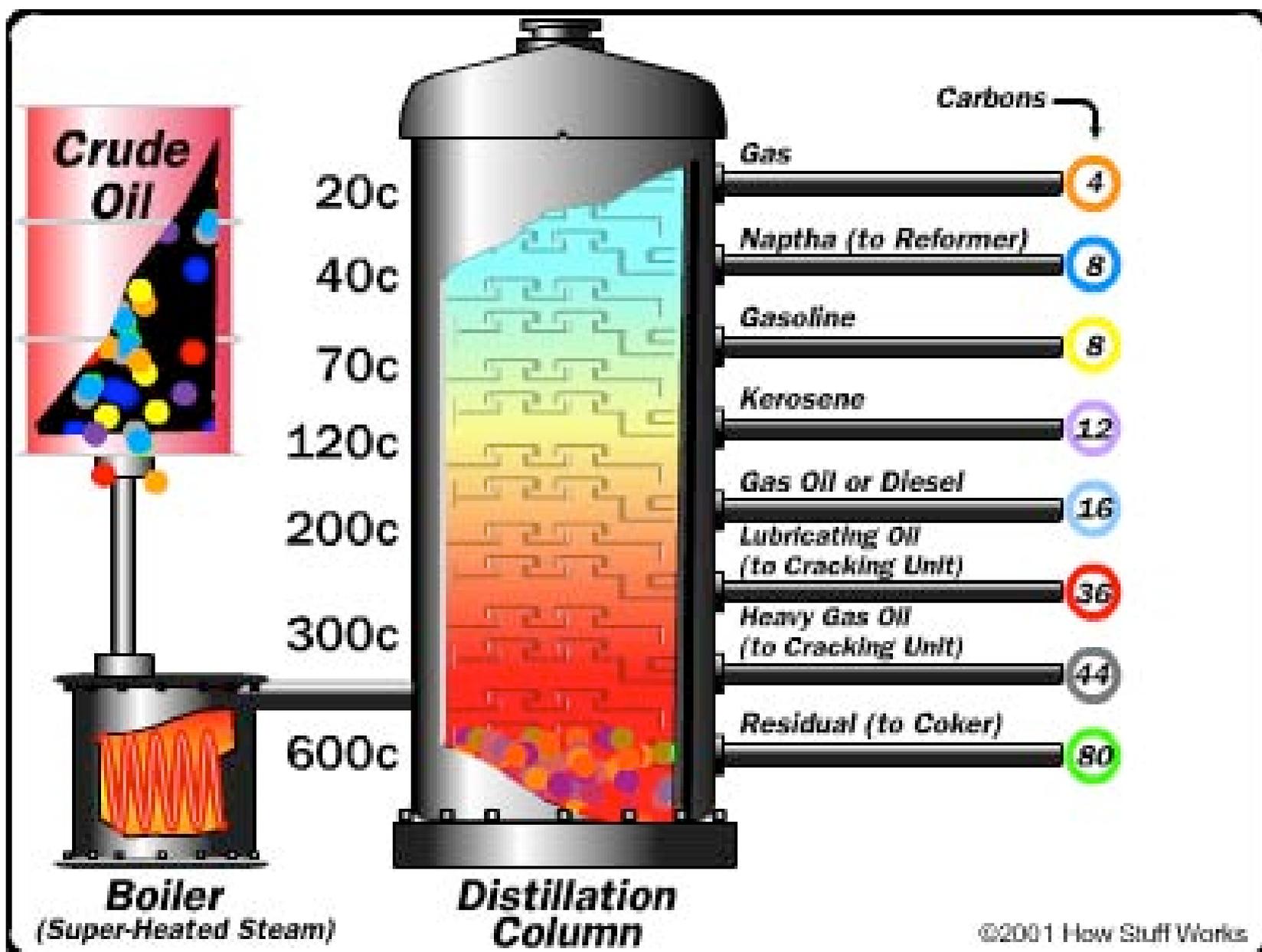
www.biofuels.coop

**Where does our fuel come
from?**

How is diesel made?

- Petroleum coke is heated up to separate the complex mixture of hydrocarbons into usable products like diesel.
- Each petroleum derived product is distinguished by its boiling point.
- Diesel fuel undergoes a hydro-treating process to remove sulfur.





Typical Refinery Products

Product	Boiling Range Deg. C	Boiling Range Deg. F
LPG	-40 - 0	-40 - 31
Gasoline	30 - 200	80 - 400
Kerosene, Jet Fuel, #1 Diesel	170 - 270	340 - 515
#2 Diesel, Furnace Oil	180 - 340	350 - 650
Lube Oils	340 - 540	650 - 1000
Residual Oil	340 - 650	650 - 1200
Asphalt	540 +	1000 +
Petroleum Coke	Solid	

From: Schmidt, G.K. and Forster, E.J., "Modern Refining for Today's Fuels and Lubricants," SAE Paper 861176, 1986.

How much fuel do we use?

13.62 million barrels of petroleum for
transportation/day in 2004 (U.S.)
(572 mil gal)

60 Billion gallons of on-road diesel fuel in 2003

30 million gallons of biodiesel in 2004

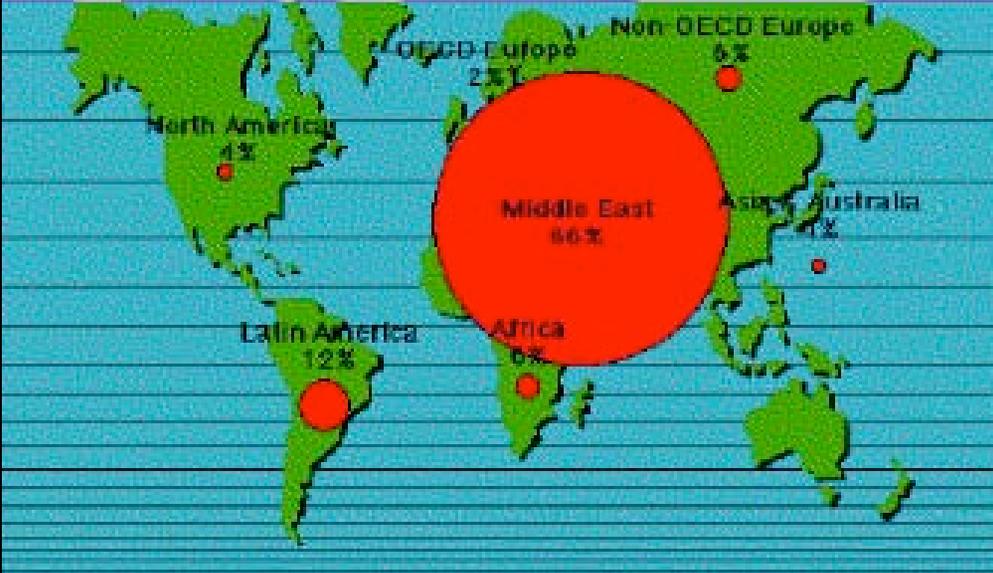
What are the impacts of the Oil and Petroleum-Based Industries?

Impacts of the Oil and Petroleum-Based Industries

- Social
- Economic
- Environmental
- Cultural
- Medical

How much oil is left?

Oil Reserves



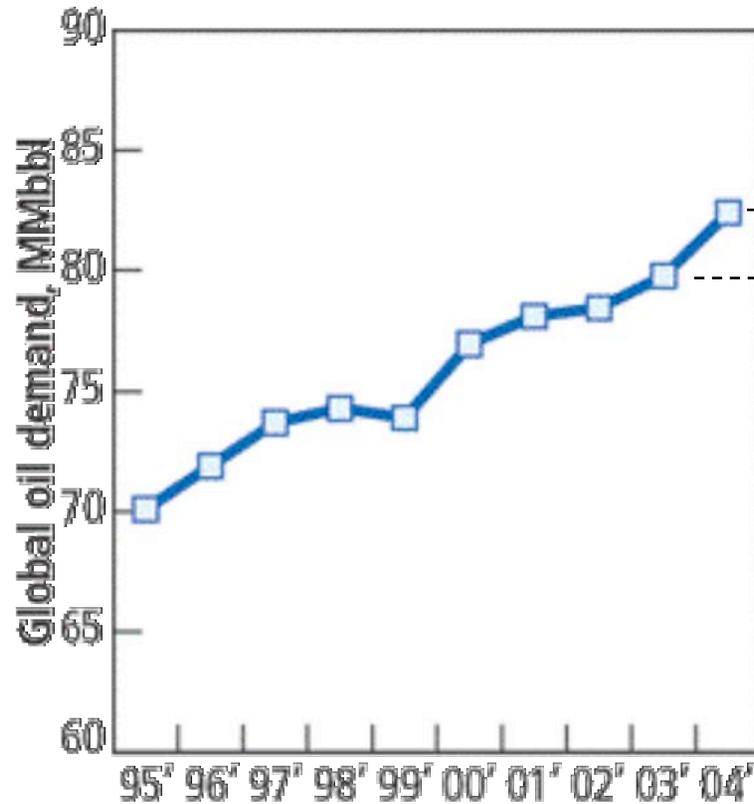
Major oil trade movements

Trade flows worldwide (million tonnes)



Last year's increase more than Iraq's output

***Global oil demand
1995-2004***



***One-year (2004)
increase in world
oil usage (2.5
million
barrels/day, 3%)***

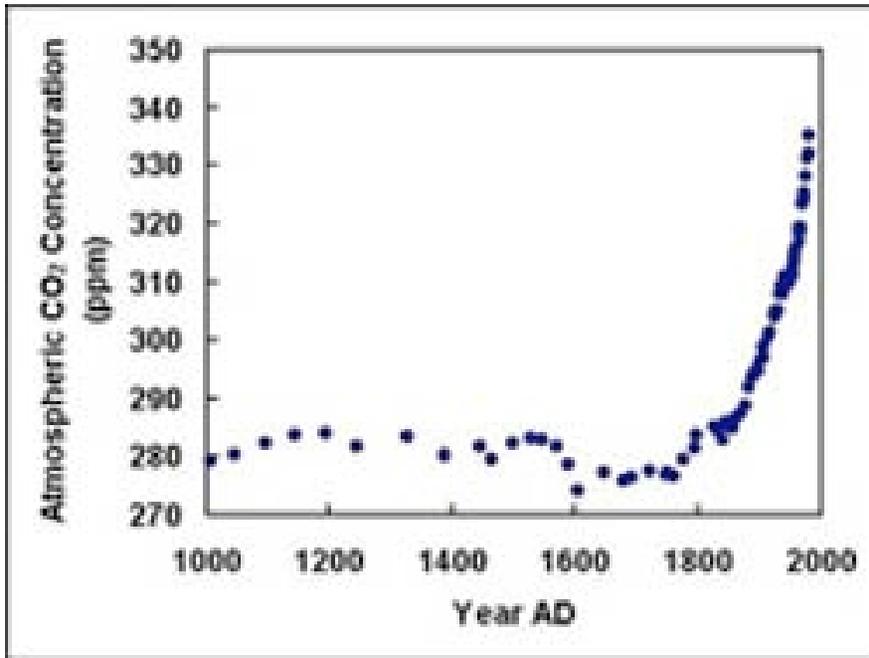
***One-year (2004)
total Iraqi oil
production
(1.5 million
barrels/day)***

*Iraq assumed
to retain 12% of
world reserves,
(maximum Iraqi
yearly production
during 1980's: ~3.5
million barrels/day)*

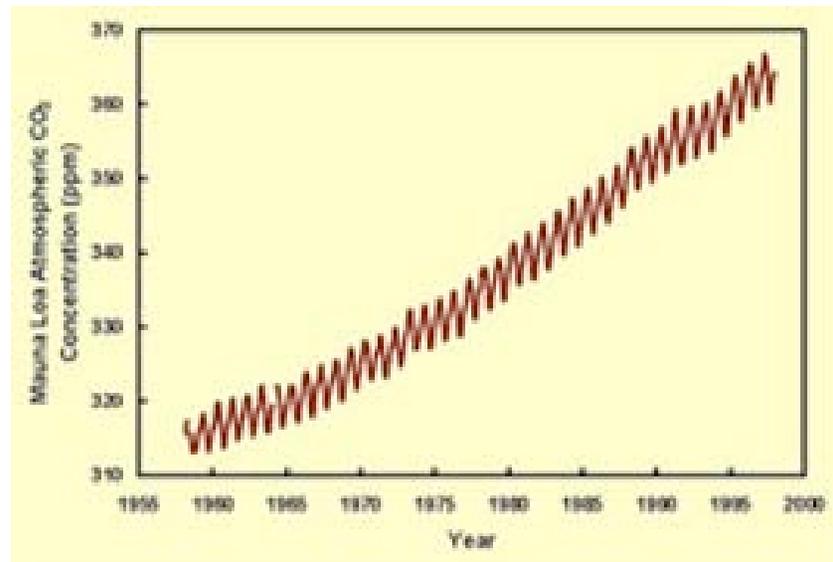
***[This 3.0% increase in consumption of oil in
2004 was matched by a 3.3% increase in natural
gas consumption and a 6.3% increase in coal]***

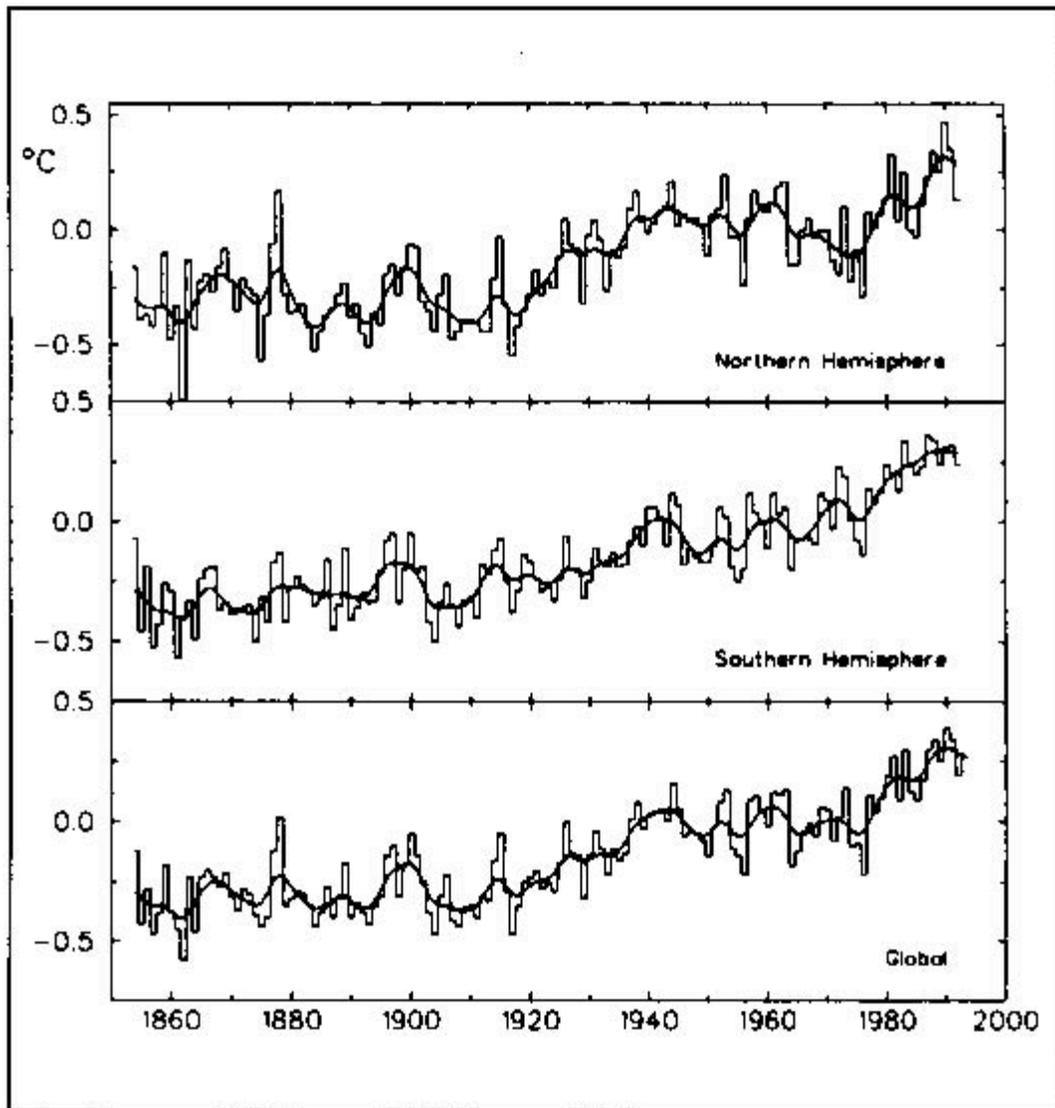
- total oil used since 1850 – **about 1000 billion barrels (Gb)**
- total world reserves remaining – **about 1000 billion barrels**
- percent oil currently in use discovered before 1973 – **70%**
- time left, current world usage (29 billion/year) – **33 years**
- time left, US uses only oil still left in US fields – **3 years**
- time left, US grabs/uses all of Iraq's oil for itself – **15 years**
- time left, whole world uses oil at US's current rate – **6 years**
- percent US oil used in food production (*not* including packaging, refrigeration, trucking, cooking) – **25%**
- physical human work equivalent of energy used to generate US diet for 1 person, 1 day – **3 weeks**
- oil in US strategic reserves (0.66 billion) – **1 month US usage**

Atmospheric CO₂ Concentration



The data for the graph on the left was taken from ice-core samples at Law Dome, Antarctica by Etheridge et al. (1998). The data on the right represents direct CO₂ measurements taken at Mauna Loa by Keeling and Whorf (1998).





Hemispheric and mean global temperature trends, 1854 to the present

Source: Climatic Research
Unit University of East
Anglia
Norwich, UK

Sustainability

- Sustainability means that a process can be continued indefinitely without depleting the energy or material resources on which it depends
- Ecosystem means a grouping of plants, animals, or other organisms interacting with each other and their environment in such a way as to perpetuate the grouping more or less indefinitely
- Principles of Sustainability
 - Ecosystems recycle their own waste and reuse the nutrients of all elements
 - Ecosystems use sunlight as their energy source
 - Consumer population size is maintained such that overuse of resources does not occur
 - Biodiversity is maintained

**What makes petroleum
sustainable?**

Renewable Energies

- Renewable energies are replenishable, they come back after they are used
- All forms of renewable energy come from the sun (directly or indirectly). Some believe that the sun could easily provide all of our energy needs if we just knew how to better capture its energy .
- Biofuels like biodiesel and SVO are two types of renewable energies. Not all renewable energies are biofuels.
- Other types of renewable energies are:
 - Photovoltaics: Solar panels that generate electricity from the sun
 - Wind: Machines like turbines that generate electricity from wind
 - Hydropower: Any energy produced from flowing water
 - Hydrogen: Produces electricity when used in conjunction with a fuel cell powered generator
 - Biomass & Producer gas: Gaseous energy made from waste wood

Vegetable-Based Fuel History

- Dr. Rudolph Diesel developed a unique engine in 1895
- This engine was designed to operate on peanut oil or other vegetable-based fuels
- Dr. Diesel demonstrated his engine at the 1900 World Exhibition
- Dr. Diesel mysteriously died in 1913. After his death, Diesel's engine was adapted to use a by-product of the gasoline refining process. The petroleum industry called it diesel fuel.
- (Knothe points out that Diesel was describing a test conducted by another company)
- March 18th- Biodiesel Action Day



The use of vegetable oils as engine fuels may seem insignificant today but the such oils may become, in the course of time, as important as petroleum and the coal tar products of the present time.

-Rudolph Diesel, 1912

What is SVO?

- SVO is an abbreviation for Straight Vegetable Oil and simply means: vegetable oil
- Soybean oil, corn oil, canola (an edible variety of rapeseed) oil, cottonseed oil, mustard oil, palm oil, sunflower oil, linseed oil, Jatropha oil, etc.
- Restaurant waste oils such as frying oils
- Animal fats such as beef tallow or pork lard
- Trap grease (from restaurant grease traps), float grease (from waste water treatment plants), etc.



What is Biodiesel?

- Biodiesel is a liquid fuel, technically known as a mono alkyl ester, made from fats or oils and alcohols.
- Biodiesel is a renewable fuel that can be produced in any climate using already developed agricultural practices.
- Biodiesel is made from renewable resources such vegetable oils, animal fats, or other types of biomass.
- B100 is 100% biodiesel.
- Biodiesel is widely available in both its neat form (B100) and in blends with petroleum diesel (for example: B2, B5, B20).
- In Europe rapeseed oil is the primary feedstock used to make biodiesel.
- In the USA soybean oil is the primary feedstock used to make biodiesel because it is the largest soy producer in the world.



Why Use Biofuels?

- **It provides a market for excess production of vegetable oils and animal fats.**

There is increasing demand around the world for soybean meal to provide the protein for human and animal consumption. If new markets are not found for the soybean oil, then the price will be low and farmers will have even more difficulty producing a profit.

- **It decreases the country's dependence on imported petroleum.**

Though the percentage of the country's fuel supply that can be replaced with biodiesel would be small, an additional source of fuel can have a surprising impact on fuel price stability.

- **It is renewable and does not contribute to global warming due to its closed carbon cycle.**

Carbon in the fuel was originally removed from the air by plants so there is no net increase in carbon dioxide levels.



Why Use Biodiesel?

- **It provides substantial reductions in carbon monoxide, unburned hydrocarbons, and particulate emissions from diesel engines.**

Some emissions tests have shown a slight oxides of nitrogen (NOx) increase with biodiesel.

New research on real-time vehicles has shown
A decrease in Nox emissions.

Biodiesel has excellent lubricating properties.

Even when added to regular diesel fuel in an amount equal to 1-2%, it can convert fuel with poor lubricating properties, such as modern ultra-low-sulfur diesel fuel, into an acceptable fuel.



Biodiesel Life-cycle

- Biodiesel (B100) yields 3.2 units of fuel product energy for every 1 unit of fossil energy consumed in its life cycle.
- The production of B20 yields 0.98 units of fuel product energy for every unit of fossil energy consumed.
- Substituting 100% biodiesel (B100) for petroleum diesel in buses reduces the life cycle consumption of petroleum by 95%.
- This benefit is proportionate with the blend level of biodiesel used.
- When a 20% blend of biodiesel and petroleum diesel (B20) is used as a substitute for petroleum diesel in urban buses, the life cycle consumption of petroleum drops 19%.
- Petroleum diesel takes 1.2 units of fossil resources to produce 1 unit of petroleum diesel.
- Overview of Biodiesel & Petroleum Life cycles-
www.ott.doe.gov/biofuels/docs/lifecycle.html
- Pimentel and Patzek study

What makes biodiesel sustainable?

- Reduced reliance on petroleum & crude oil products, all *finite* resources
- Reduced emissions of greenhouse gases.
- Economic growth in the form of employment in regional & rural areas.
- Diversification of income & economy in these regional & rural sectors.
- Improved air quality, particularly in high smog & population dense areas.
- Reduced production of waste oil
- Positive environmental impacts with sustainable production of feedstocks
- Reduced pollution for water and soil sources .
- Decreased reliance on external/foreign supplies of oil → increased security for energy supplies

Greenhouse Gas Emissions

Fuel	Greenhouse Gases	Particulates	Nitrous Oxides	Volatile Organic Compounds	Carbon Monoxide
Gasoline	+35	-70	-55	+170	+415
CNG	+20	-80	-45	-30	+190
LPG	+20	-80	-60	0	+210
Ethanol 85%	0	-75	-55	+130	+210
Diesel	0	0	0	0	0
Biodiesel 20%	-15	-20	0	-10	-15
Hybrid	-30	-20	-20	-20	-20
Electric	-45	-80	-95	-100	-100
Biodiesel 100%	-70	-55	+5	-55	-45

GHG Emissions / Mile for a Passenger Car

- Compared to a mile driven on diesel.

Class Objectives

What can you expect to learn in this class?

- How to make and test biodiesel.
- How to build a small batch biodiesel reactor
- How Straight Vegetable Oil (SVO) conversions work.
- How collection, filtration, & storage of SVO and Biodiesel work.
- How a diesel engine works.
- How a fuel delivery system works.
- What is the future for biodiesel in the U.S. and worldwide.
- What sustainability and renewable energy means to you.

Links

- Iowa State Biodiesel Program www.me.iastate.edu/biodiesel/
- National Biodiesel Board: <http://nbb.org>
- Journey to Forever: <http://journeytoforever.org/biofuel.html>
- NREL Biodiesel Handling and Use Guidelines:
<http://www.afdc.doe.gov/pdfs/5845.pdf>
- Collaborative Biodiesel Tutorial www.biodieselcommunity.org
- Our Class: <http://www.biofuels.coop>
- Please sign up for the Biofuel Interest Group listserve for announcements related to biofuels!

Good Night!

Thank you for coming to learn about the wonderful world of biofuels. If you have any questions please do not hesitate to contact Rachel or Leif.

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