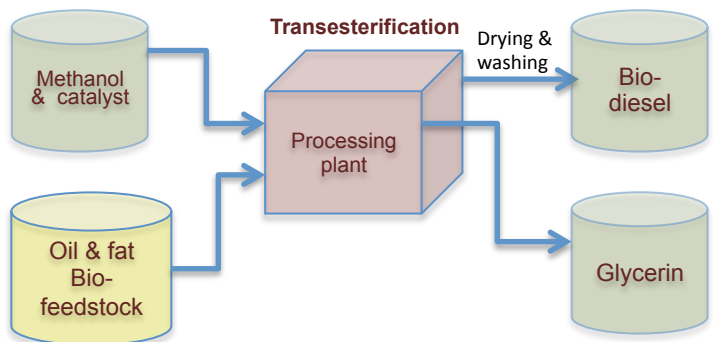




Bio-diesel Process Diagram



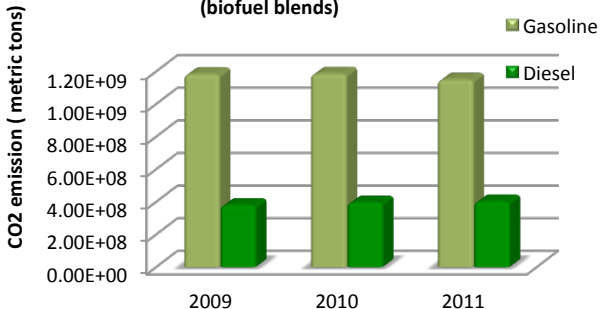
Overview:

- ✧ Biodiesel is made through a chemical process called trans-esterification, whereby the fat or vegetable oil is reacted with an alcohol catalyst (usually methanol) to produce biodiesel and glycerin.
- ✧ Biodiesel is renewable, biodegradable, and nontoxic to the environment.
- ✧ Glycerin as a byproduct then can be used in soap, and e-cigarettes juice.
- ✧ Biodiesel and Ethanol can be blend with petroleum fuel and used with minimal if any modifications in traditional gasoline/ diesel engine.

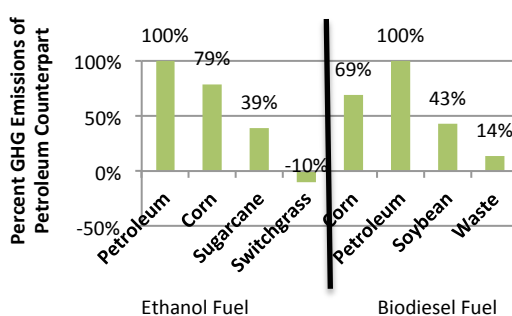
Bio-feedstock (Benefits and drawbacks):

- ✧ Biodiesel can be produced with oil and other types of lipid rich vegetation: such as algae, corn oil, peanut oil, sunflower oil, etc..
- ✧ Competition with food and fiber production for use of arable land; cost; regional market structure, lack of well managed agricultural practices in emerging economies; water and fertilizer use; conservation of bio-diversity
- ✧ Algae so far is the best source of feedstock available that has one of the highest lipid content with least use of resources (58,7000 L/ hectare)

Total CO2 emission from US highway vehicle by fuel (biofuel blends)



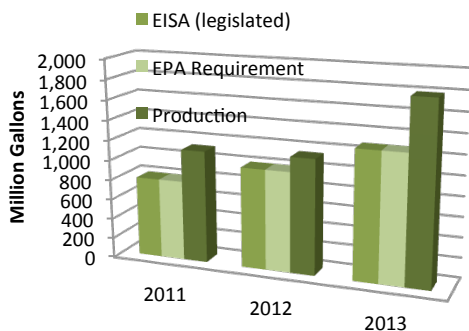
Lifecycle GHG Emissions from Biofuels, Compared to their Petroleum Substitutes



Environmental Benefits / Impact:

- ✧ Biodiesel reduces net emission of CO2 by 78.45% compared to petroleum diesel. For B20, CO2 emissions from urban buses drop 15.66% (DOE)
- ✧ Some plant species that are being used for feedstock can become invasive if not native to the local ecosystem.

Biomass-based Diesel RFS2 Mandates and Production



Mandates and policy in the US:

- ✧ The United States is the only country so far to have adopted a blending mandate for second-generation biofuels – the Renewable Fuels Standard (RFS) – which is part of the Energy Independence and Security Act of 2007 (EISA). It defines the volume of different biofuels that have to be blended with conventional fuel between 2006 and 2022.
- ✧ Ethanol can be blended in traditional gasoline with up to 10% (E5, E10 fuel)
- ✧ Biodiesel can be blended in about the same ratio 5% ~ 10% with no change to traditional diesel engine (B5, B10 fuel)

U.S. Biodiesel Production, Exports, and Consumption

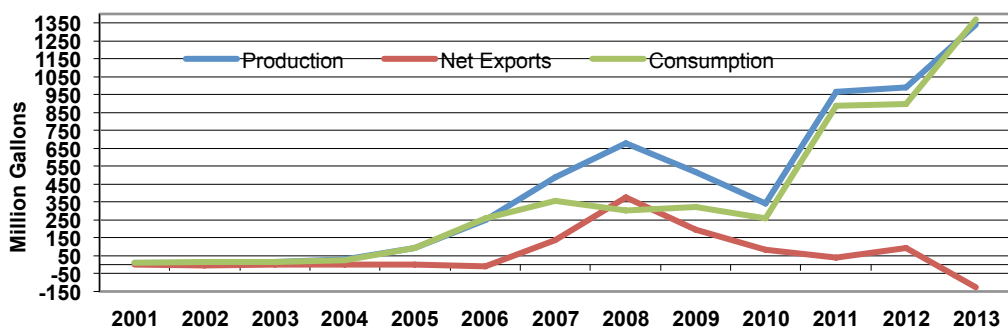


Figure overview:

- ✧ In this figure, we can see the trend in which biodiesel has progress in the recent decade. Production has increase significantly with the total production of 1339 million gallons in 2013. The consumption rate is also high, with net export rate dips in the negatives which indicate that there is a demand for import in 2013.



Processing figure is self-made with information from:

IEA Energy Technology Essentials Report (Jan 2007)

Overview and bio feedstock:

Biodiesel from microalgae

<http://www.journals.elsevier.com/biotechnology-advances>

JOURNAL OF BIOSCIENCE AND BIOENGINEERING:
Biodiesel fuel production by trans esterification of oils
HIDEKI FUKUDA,* AKIHIKO KONDO,2 AND HIDEO NODA,
2001)

Emission figure is self-made from compiled data from the IEA from 1999 to 2011 that includes biofuel blends.

Carbon content is acquire through EPA: Emission Fact:
<http://pbadupws.nrc.gov/docs/ML1204/ML120440122.pdf>

Figure is self-made with data from:

Chapter 2.6 of the EPA's Renewable Fuel Standard Program (RFS2) Regulatory Impact Analysis. February 2010. EPA-420-R-10-006. at www.epa.gov/otaq/renewablefuels/420r10006.pdf

Emission reduction facts are from: Life Cycle Inventory of Biodiesel and Petroleum Diesel for Use in an Urban Bus .

Figure is selfmade with data from the IAE:

Data Source: EIA Monthly Energy Review, Table 10.4 (<http://www.eia.gov/totalenergy/data/monthly/#renewable>)
<http://www.afdc.energy.gov/data/10681>

Policy and mandate: IEA
Sustainable Production of Second-Generation biofuels

Production, consumption and exports figure is generated with data from:
Data Source: EIA Monthly Energy Review, Table 10.4 (<http://www.eia.gov/totalenergy/data/monthly/#renewable>)

<http://www.afdc.energy.gov/data/10325>