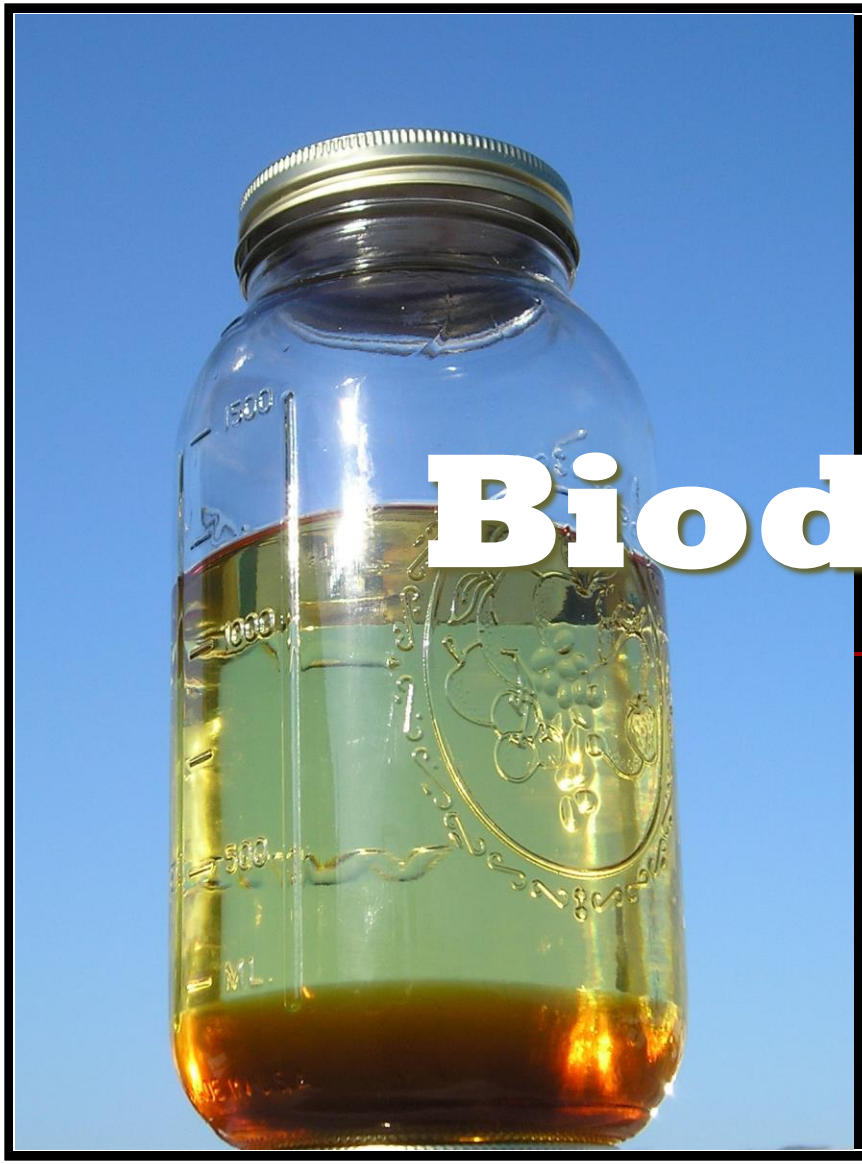


Biodiesel

A Sustainable Fuel

What is Biodiesel?

- Biodiesel consists of alkyl-esters derived from a biological source.
- Biodiesel can be used as a diesel fuel in any existing diesel engine.
- Can be blended with petroleum diesel in any ratio.

What is Biodiesel?

- Almost any oil can be converted; hydrogenated oils and animal fats do not work as well.
- Vegetable oils, such as soy and jatropha, are the most commonly used commercial oils.
- Oil from algae grown on waste water is a highly sustainable possibility.

Why Biodiesel?

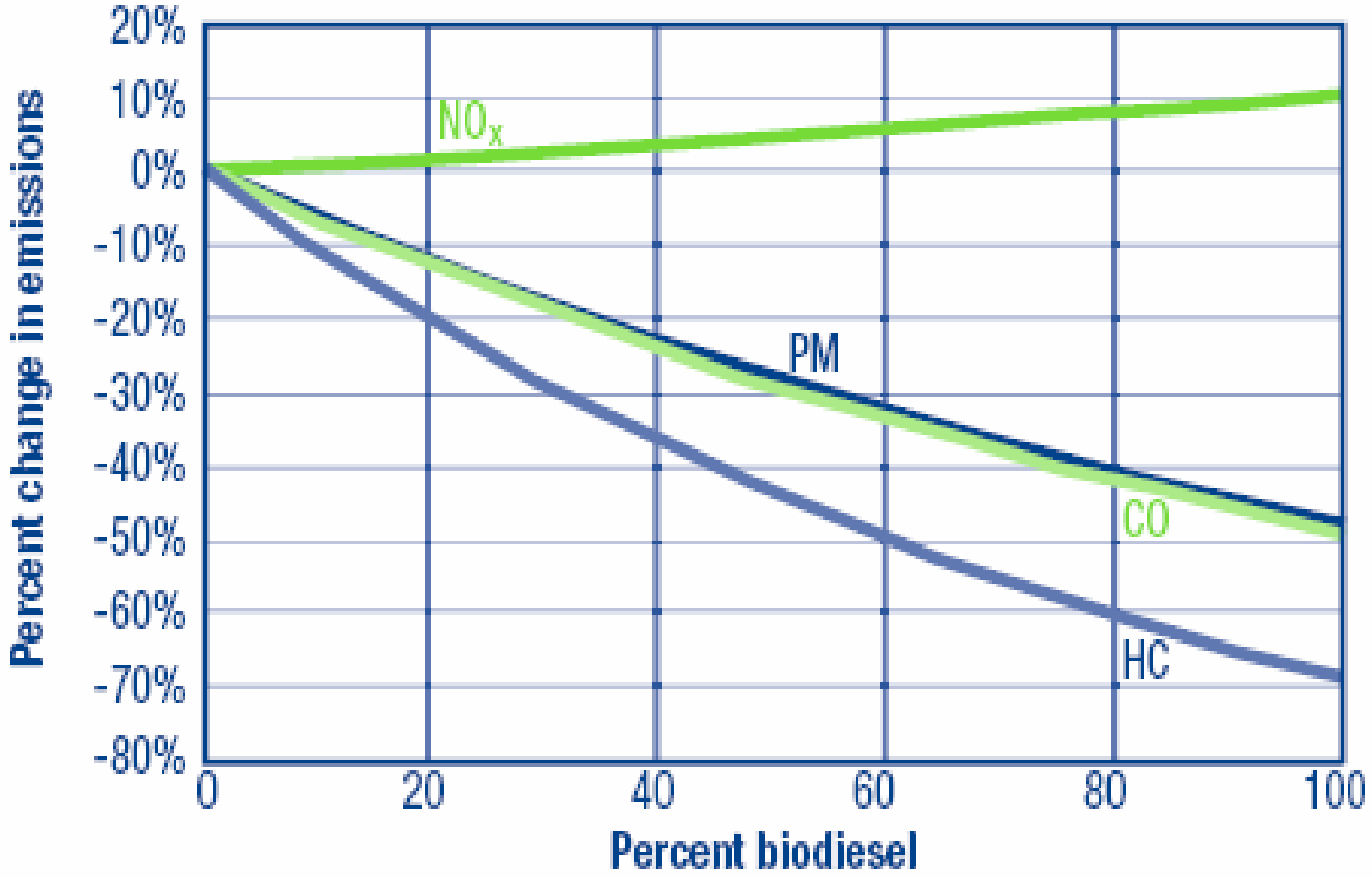
- Reduced air pollution
- Renewable
- Non-toxic
- Biodegradable
- Fits existing fuel infrastructure
- Homegrown
- Higher flashpoint than petroleum diesel

Biodiesel Vs Petroleum

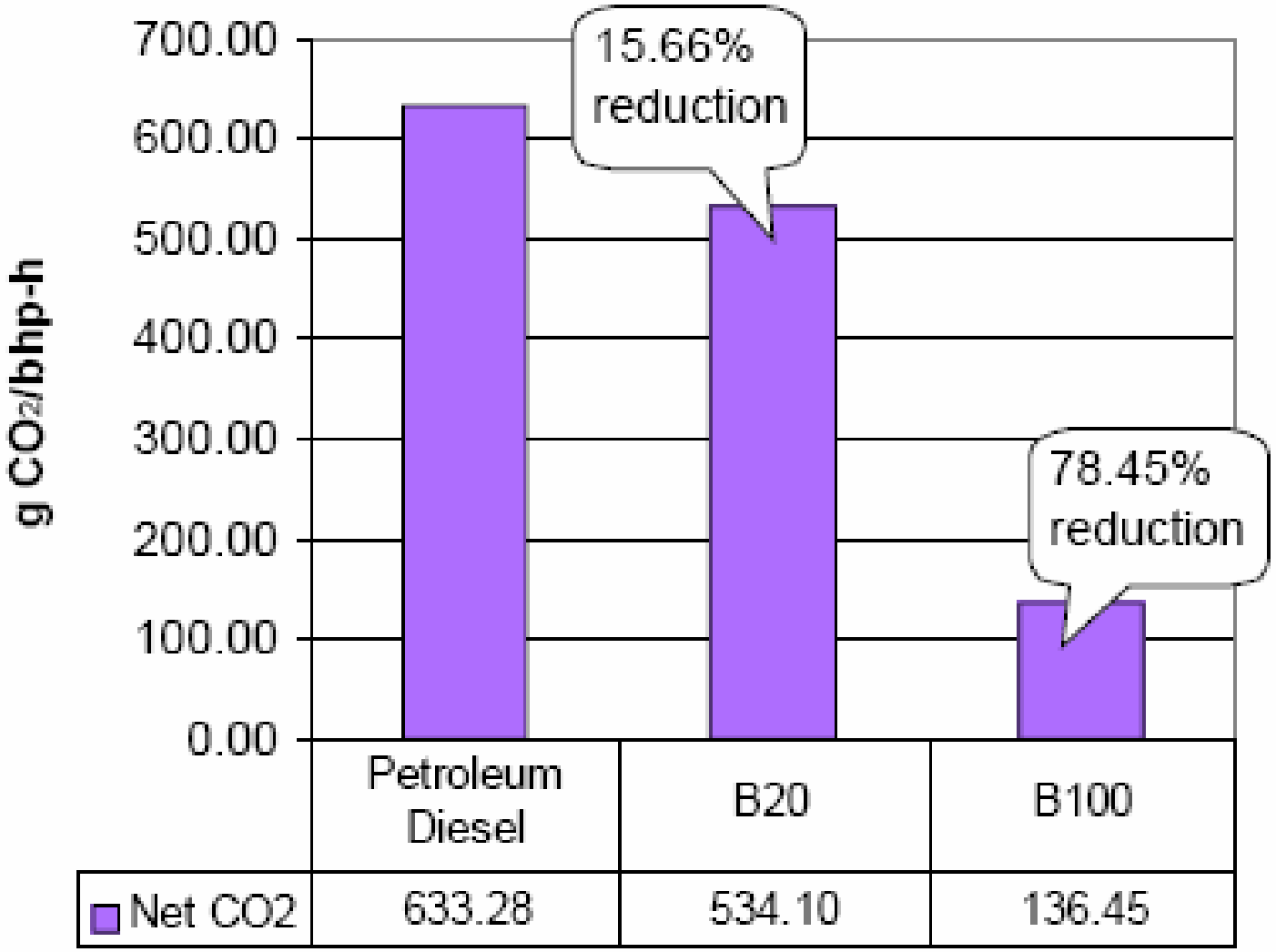
AVERAGE BIODIESEL EMISSIONS COMPARED TO CONVENTIONAL DIESEL, ACCORDING TO EPA

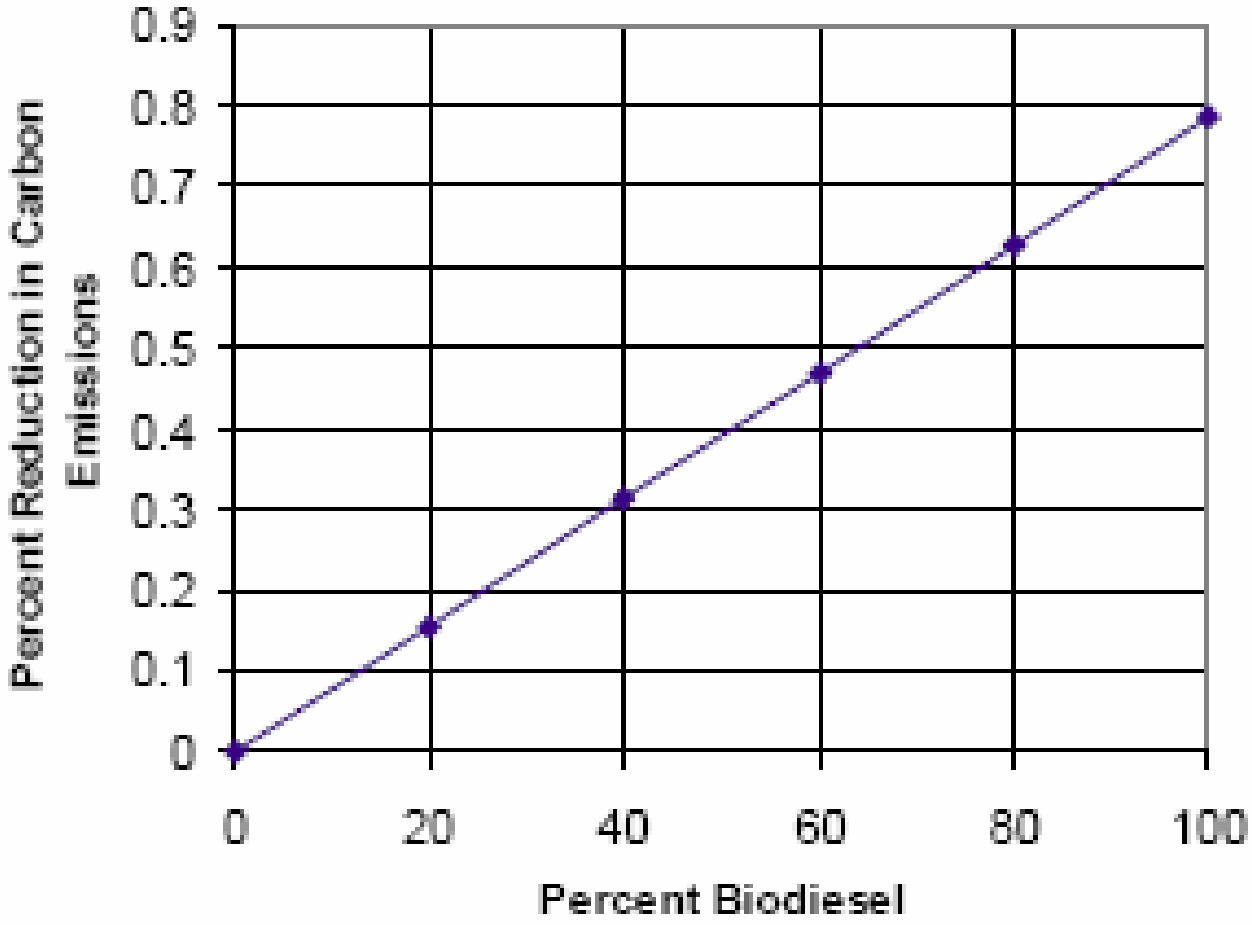
Emission Type	B100	B20
Regulated		
Total Unburned Hydrocarbons	-67%	-20%
Carbon Monoxide	-48%	-12%
Particulate Matter	-47%	-12%
Nox	+10%	+2% to -2%
Non-Regulated		
Sulfates	-100%	-20%*
PAH (Polycyclic Aromatic Hydrocarbons)**	-80%	-13%
nPAH (nitrated PAH's)**	-90%	-50%***
Ozone potential of speciated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

* Estimated from B100 result
** Average reduction across all compounds measured
*** 2-nitroflourine results were within test method variability

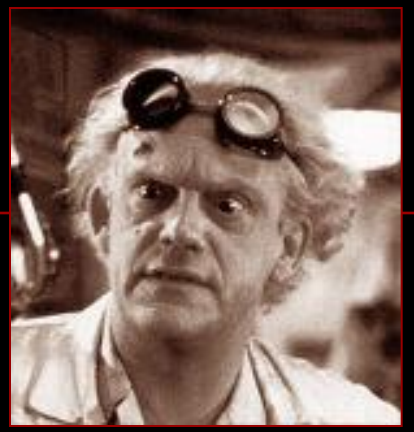


Basic Emission Correlation. Average emission impacts of biodiesel for heavy-duty highway engines. Source: U.S. EPA[2].


700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
g CO2/bhp-h
15.66% reduction
78.45% reduction
Petroleum Diesel
B20
B100
Net CO2
633.28
534.10
136.45


Percent Reduction in Carbon Emissions
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
20
40
60
80
100
Percent Biodiesel

How is Biodiesel Made?



- It is produced by a **TRANSESTERIFICATION** or **ESTERIFICATION** reaction of vegetable (or animal) oils with a low molecular weight alcohol such as ethanol or methanol.
- This reaction is catalyzed by a base, Sodium Hydroxide (NaOH) or Potassium Hydroxide (KOH)

What the Heck is Transesterification?!

- So, Basically you have the reaction:
- Oil + Alcohol = glycerol + Alkyl esters (Biodiesel)
- (It must be catalyzed with a base and heat)
- This is the process of transesterification: **replacing the glycerol portion of the oil with methanol/ethanol**