



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?

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

Why Biodiesel?

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

Biodiesel Vs Petroleum

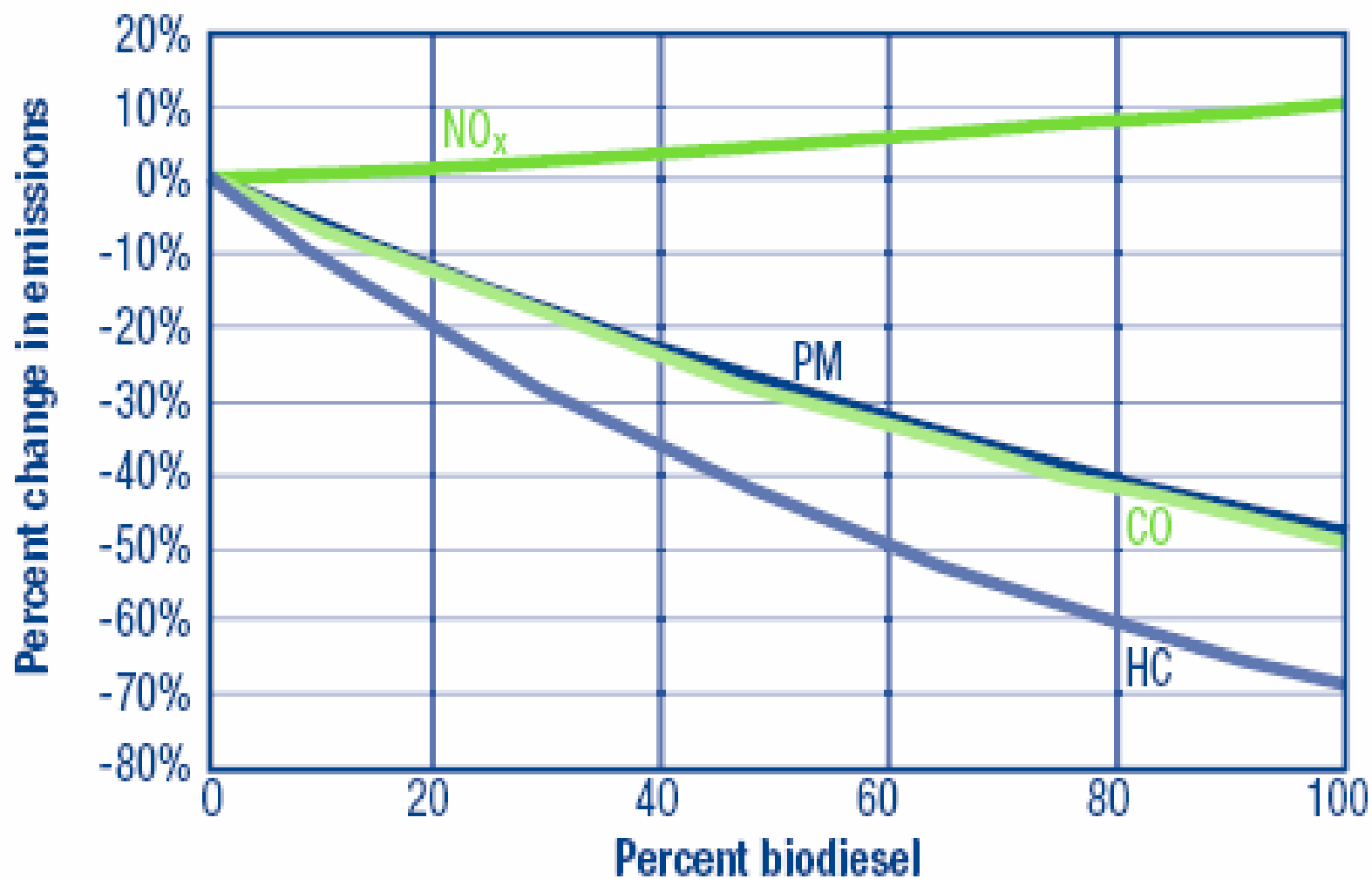
AVERAGE BIODIESEL EMISSIONS COMPARED TO CONVENTIONAL DIESEL, ACCORDING TO EPA

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%

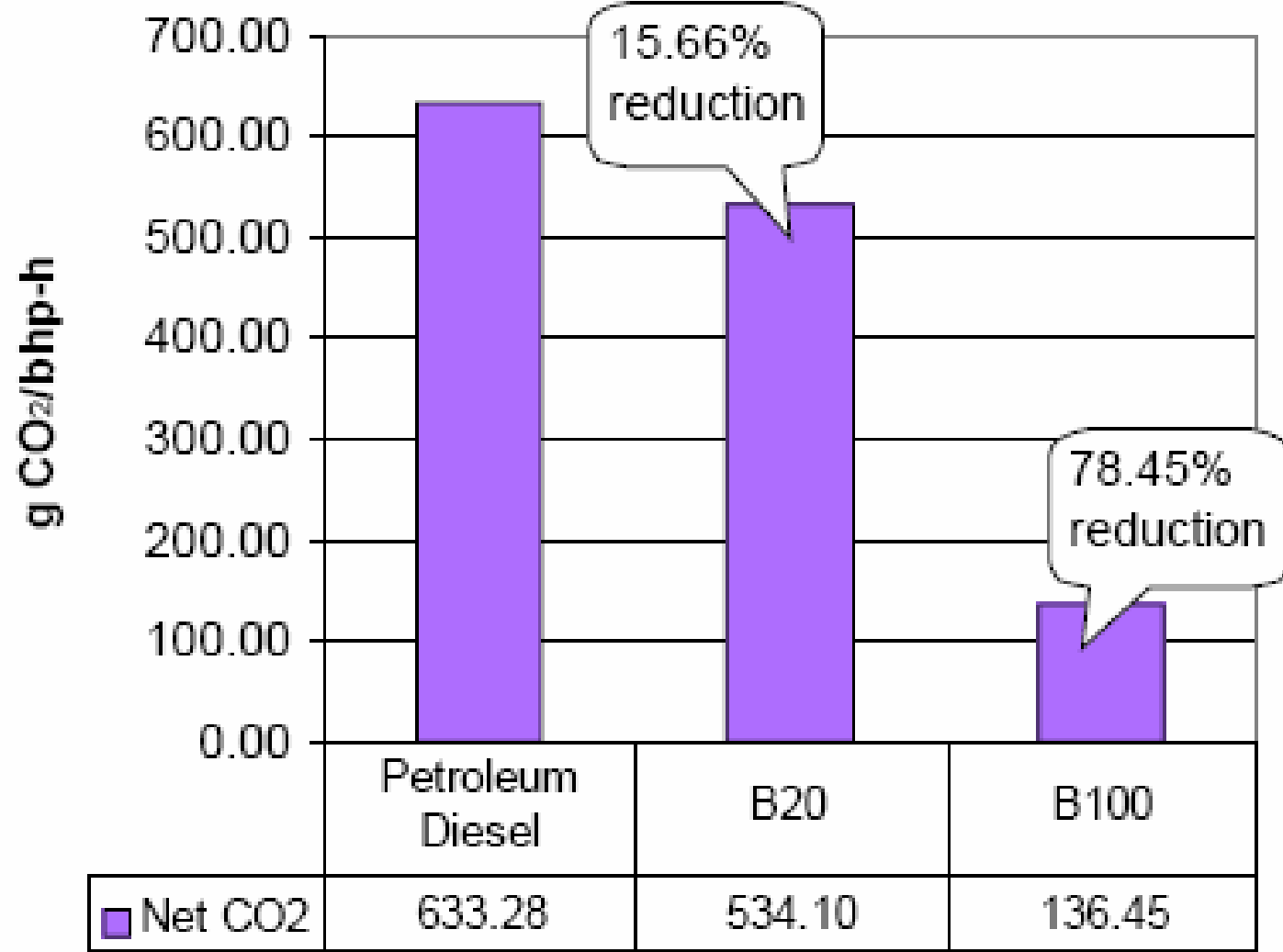
* Estimated from B100 result

** Average reduction across all compounds measured

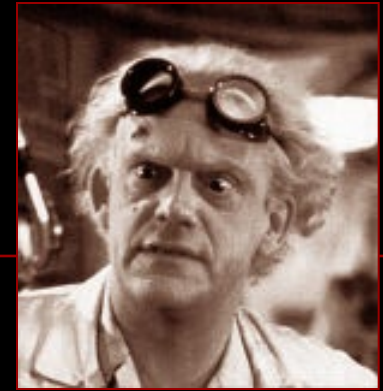
*** 2-nitroflourine results were within test method variability



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



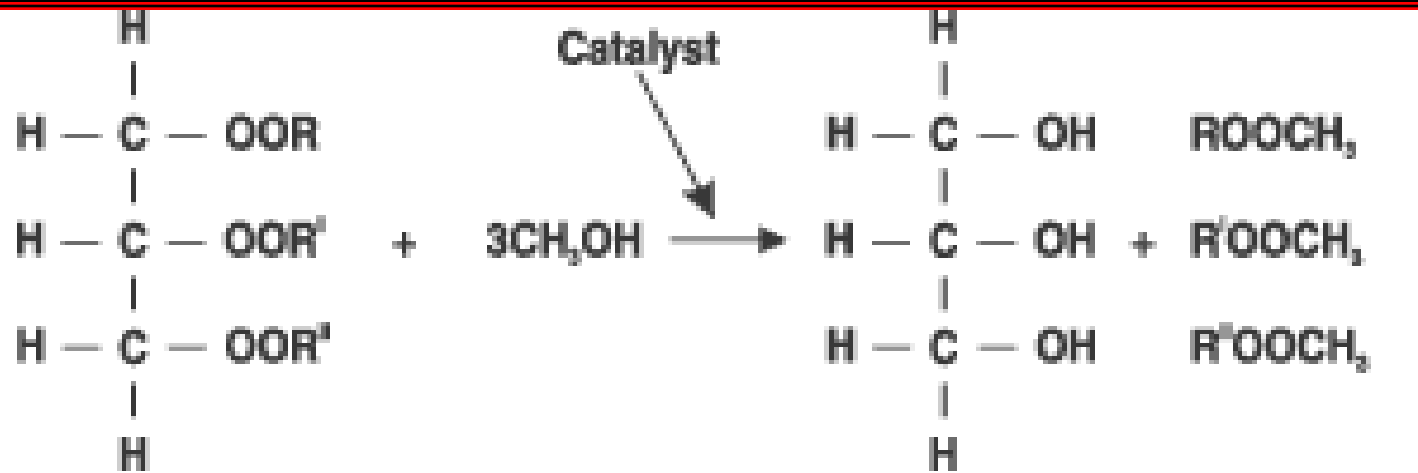
How is Biodiesel Made?



- 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**



Vegetable Oil + Methyl Alcohol \longrightarrow Glycerol + Methyl Ester