

Biodiesel Emissions ...



Why is 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

Emissions Benefits

- Biodiesel reduces tailpipe particulate matter (PM), hydrocarbon (HC), and carbon monoxide (CO) emissions from most modern four-stroke CI engines.
- These benefits occur because the fuel (B100) contains 11% oxygen by weight.
- The presence of fuel oxygen allows the fuel to burn more completely, so fewer unburned fuel emissions result.
- This same phenomenon reduces air toxics, because the air toxics are associated with the unburned or partially burned HC and PM emissions.
- Testing has shown that PM, HC, and CO reductions are independent of the feedstock used to make biodiesel.

Emissions

- Nitrogen gas (N₂)** - Air is 78-percent nitrogen gas, and most of this passes right through the car engine. •
- **Carbon dioxide (CO₂)** - This is one product of combustion. The carbon in the fuel bonds with the oxygen in the air. •
 - **Water vapor (H₂O)** - This is another product of combustion. The hydrogen in the fuel bonds with the oxygen in the air.
 - **Carbon monoxide (CO)** - a poisonous gas that is colorless and odorless. •
 - **Hydrocarbons (HC) or volatile organic compounds (VOCs)** - produced mostly from unburned fuel that evaporates Sunlight breaks these down to form oxidants, which react with oxides of nitrogen to cause ground level ozone (O₃), a major component of smog. •
 - **Nitrogen oxides (NO and NO₂, together called NO_x)** - contributes to smog and acid rain, and also causes irritation to human mucus membranes

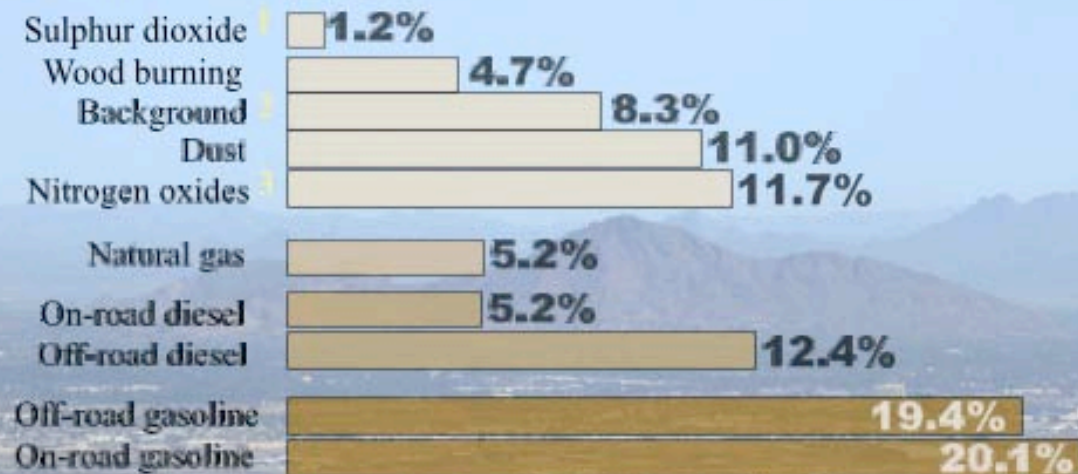
Diesel particulate matter

- Diesel engines produce emissions of diesel particulate matter (DPM), commonly known as soot.
- most complex and troublesome diesel emission.
- solid as well as liquid material.
- Chemical and physical compositions of the various particles differ, the basic fractions of DPM are elemental carbon, heavy hydrocarbon, and hydrated sulfuric acid.
- The amount of sulfuric acid emitted is directly related to the sulfur content of the diesel fuel.
- Some of these particles are large or dark enough to be seen as soot or smoke.
- Others are so small that several thousand of them could fit on the period at the end of this sentence.
- Recent interest in the smallest diesel particles of diameters below 50 nanometers (a nanometer is one million times smaller than the head of a pin) was sparked by the finding that **new diesel engines emit higher numbers of small particles than the old engine technology.**

Content of the Brown Cloud

There are many sources for the makeup of the Brown Cloud over the Valley. Exhaust fumes form the largest percentage, with diesel fumes contributing more than their fair share.

Brown Cloud Sources for 60% of Fall & Winter Days



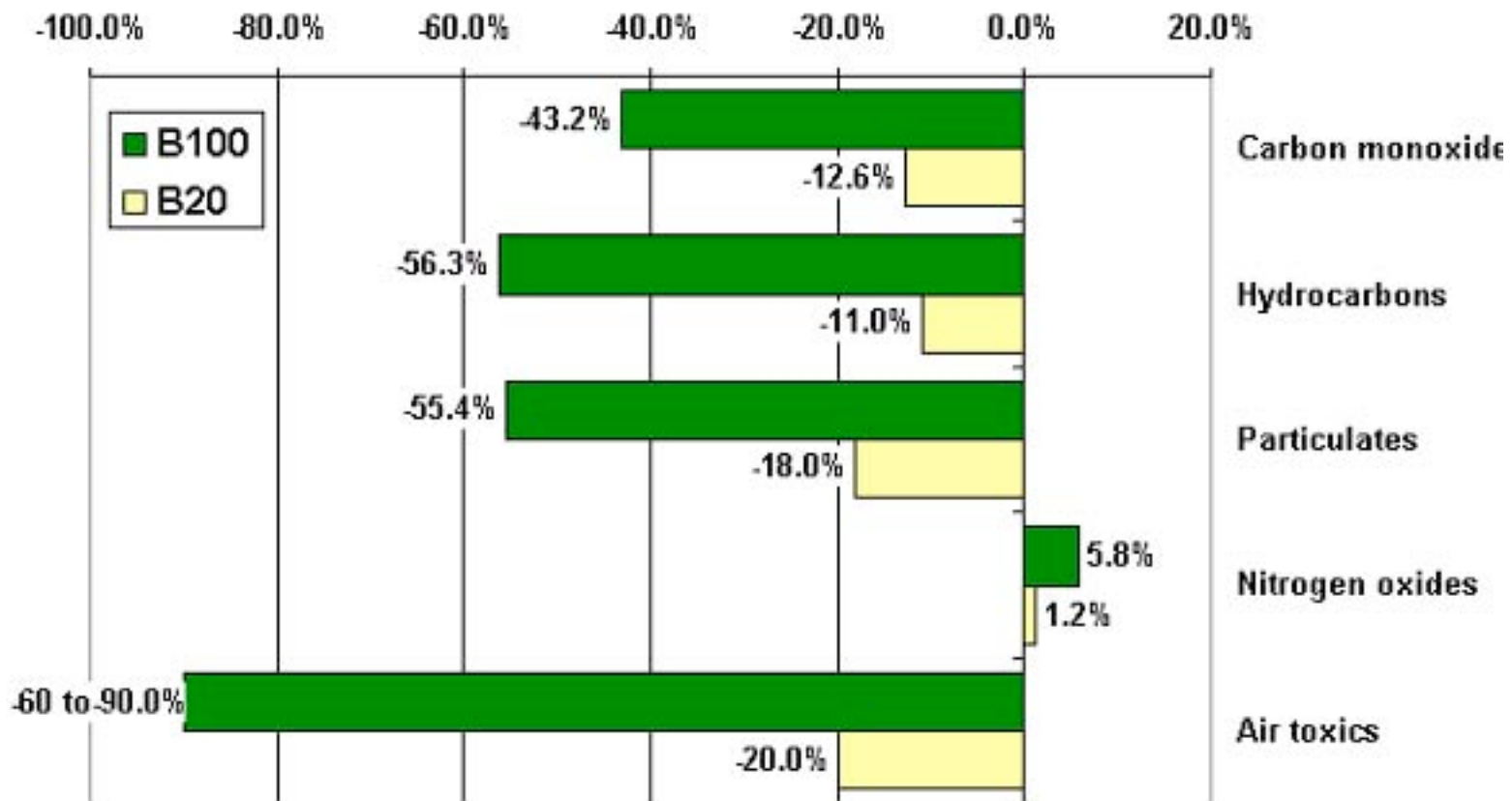
- 1 - Power plant emission and some diesel exhaust.
- 2 - Pollutants that have drifted into the metro area from outside.
- 3 - Components of vehicle exhaust

Note: Figures do not equal 100% due to rounding

Source: Arizona Department of Environmental Quality

Emissions of Biodiesel Blends

Biodiesel emission reduction compared to EPA certification diesel fuel



Changes in Emissions

(B20 & B100)

Table 21: Relative Change in Life Cycle Air Emissions for Fuels Containing 20% and 100% Biodiesel

Pollutant	B20	B100
CO	-6.90%	-34.50%
PM	-6.48%	-32.41%
HF	-3.10%	-15.51%
SO _x	-1.61%	-8.03%
CH ₄	-0.51%	-2.57%
NO _x	2.67%	13.35%
HCl	2.71%	13.54%
HC	7.19%	35.96%

Emissions from Boilers

- But when biodiesel is used in boilers or home heating oil applications, NO_x tends to decrease.
- The fuel is burned in very different ways in these dramatically different applications
- open flame for boilers, enclosed cylinder with high pressure spray combustion for engines and results in different effects.
- Heating oil and diesel fuel that is dyed red for off-road use (agriculture, power, boiler fuels, construction, forestry, mining, etc.) can contain as much as 5,000 ppm sulfur today.

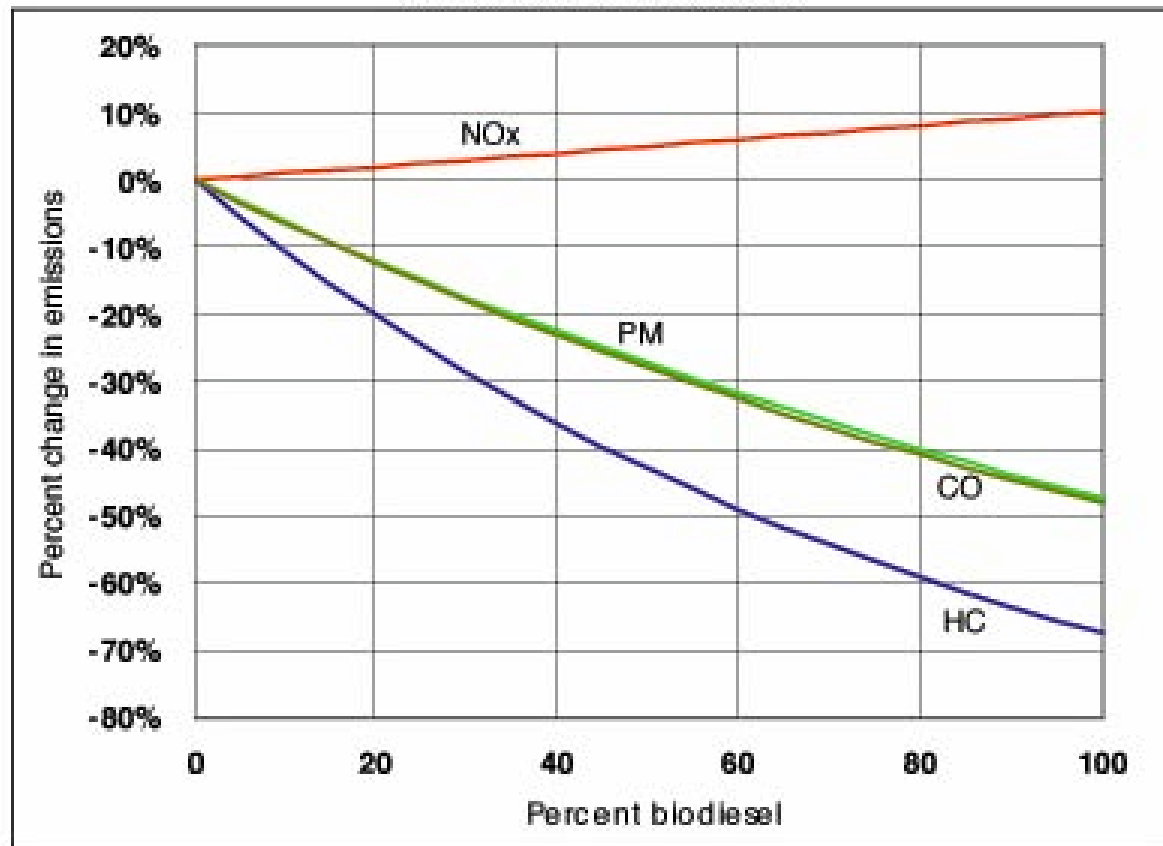
BIODIESEL REDUCES HARMFUL EMISSIONS

EMISSION TYPE	100% BIODIESEL	20% BIODIESEL
Carbon Monoxide	-43.2%	-12.6%
Hydrocarbons	-56.3%	-11.0%
Particulates	-55.4%	-18.0%
Nitrogen Oxides (NOx)	+5.8%	+1.2%
Air Toxics	-60% to -90%	-12% to -20%
Mutagenicity	-80% to -90%	-20%
Carbon Dioxide *	-78.3 %	-15.7 %

Source: National Renewable Energy Laboratory (NREL)

Exhaust Emissions

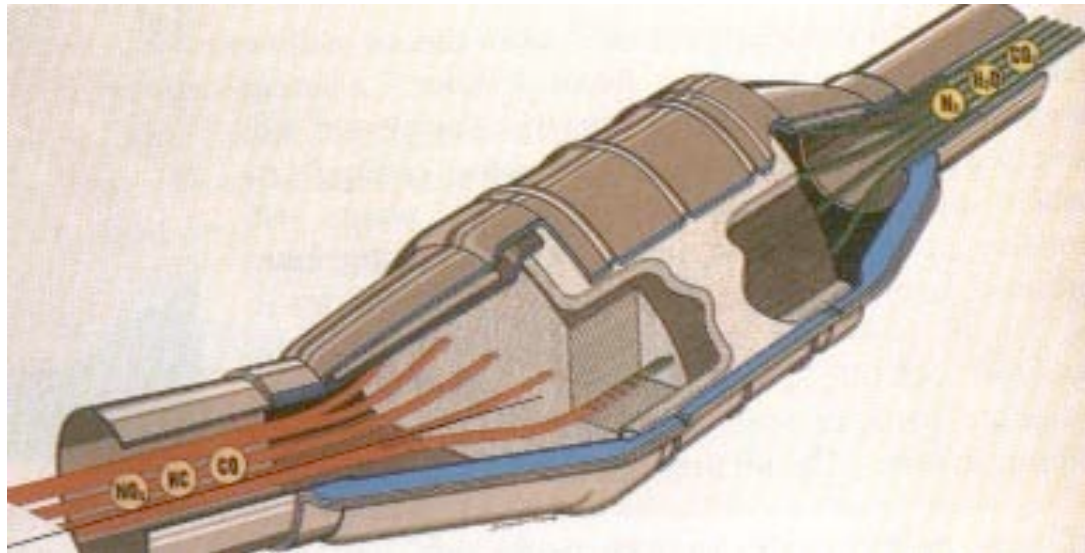
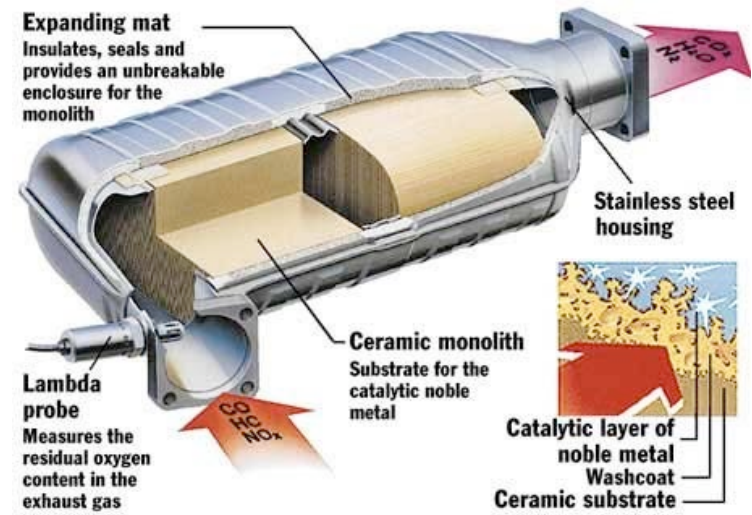
Figure IV.A.1-1
Basic emission correlations



Source: A Comprehensive Analysis of Biodiesel Impacts on Exhaust Emissions, Draft Technical Report, Assessment and Standards Division Office of Transportation and Air Quality, U.S. Environmental Protection Agency. October 2002. EPA420-P-02-001

Catalytic Converters

- The **reduction catalyst** is the first stage of the catalytic converter.
- It uses platinum and rhodium to help reduce the NO_x emissions.
- When an NO or NO₂ molecule contacts the catalyst, the catalyst rips the nitrogen atom out of the molecule and holds on to it, freeing the oxygen in the form of O₂.
- The nitrogen atoms bond with other nitrogen atoms that are also stuck to the catalyst, forming N₂. For example:
- The **oxidation catalyst** is the second stage of the catalytic converter.
- It reduces the unburned hydrocarbons and carbon monoxide by burning (oxidizing) them over a platinum and palladium catalyst. This catalyst aids the reaction of the CO and hydrocarbons with the remaining oxygen in exhaust gases.



Diesel Emission Controls

- Donaldson's DOC (Diesel Oxidation Catalyst) muffler is a new retrofit solution that reduces diesel engine emissions.
- The DOC muffler is a direct replacement for most Original Equipment muffler
- meets the requirements of the U.S. Environmental Protection Agency (EPA) and California Air Resources Board (CARB).



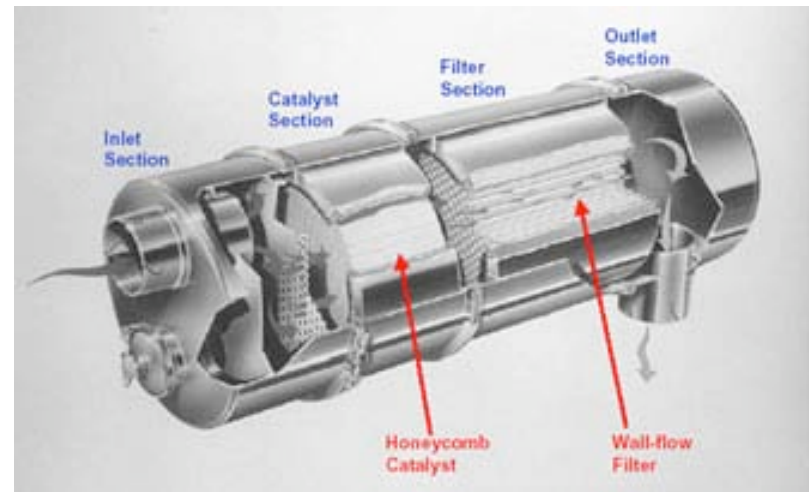
EGR: Exhaust Gas Recirculation

Exhaust Gas Recirculation:
used to reduce combustion
temperature and pressure to
control Oxides of Nitrogen
emissions



Diesel Particulate Matter Filters

- Diesel [particulate matter](#) (PM) filters are ceramic devices that collect PM in the exhaust stream.
- The high temperature of the exhaust heats the ceramic structure and allows the particles inside to break down (or oxidize) into less harmful components.
- They can be installed on new and used buses, but must be used in conjunction with [ultra-low sulfur diesel](#) (ULSD) - fuel with a sulfur content of less than 15 parts per million.
- The combination of PM filters and ULSD can reduce emissions of PM, [hydrocarbons](#) (HC), and [carbon monoxide](#) (CO) by 60 to 90 percent.



Diesel Particulate Filter

- Bosch's latest diesel particulate filter is made of sintered metal instead of ceramic, and features wedge-shaped slices packed in a cylinder.
- They are thinner at their leading edge, and the circumference of the cylinder decreases in the direction of the exhaust gas flow for more even filling.
- It should last for the life of the car.



Alternative Fuel Emissions

(Non- bus, heavy duty vehicles)

