

Americans have grown increasingly concerned about U.S. dependence on oil imports and greenhouse gas emissions in recent years, resulting in greater interest in fuels like biodiesel and ethanol that can be produced from domestic feedstocks rather than petroleum. The first diesel engine ran on peanut oil, and today there is renewed interest in alternatives to pure petroleum-derived diesel fuel.

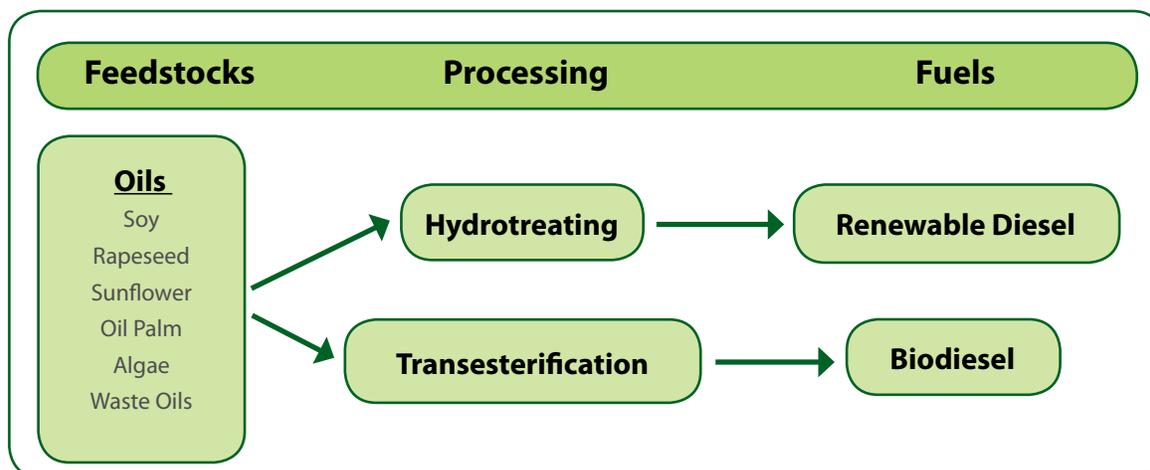


Biodiesel production has grown substantially in recent years, from just 25 million gallons in 2004 to an estimated 300 million gallons in 2007; a twelve-fold increase in just three years, yet still representing only 0.5 percent of total annual diesel fuel use in the United States. As experience with renewable fuels grows, the search for solutions to early challenges related to biodiesel quality, performance and availability continue with the development of second and third generation renewable diesel fuels. At the same time, cost-benefit assessments are becoming more comprehensive, providing more accurate estimates of the full economic and life-cycle environmental implications of using various renewable fuels.

## What are renewable fuels?

According to the Environmental Protection Agency's new Renewable Fuel Standard, renewable fuels are defined as motor vehicle fuels produced from plant or animal products or wastes. Within this definition, two distinct forms of diesel fuel are specified: biodiesel and renewable diesel. Each is defined according to the process by which it is produced. The term "biodiesel" is often used very broadly to refer to any blend of conventional petroleum diesel with any renewable diesel product. In order to avoid confusion, the term biodiesel should be used in reference to pure biodiesel fuel meeting the ASTM D6571 standard. Mixtures of biodiesel with petroleum should be referred to as biodiesel blends (i.e. B20).

## Renewable Fuels Creation Process



MeetCleanDiesel

## 1. Biodiesel

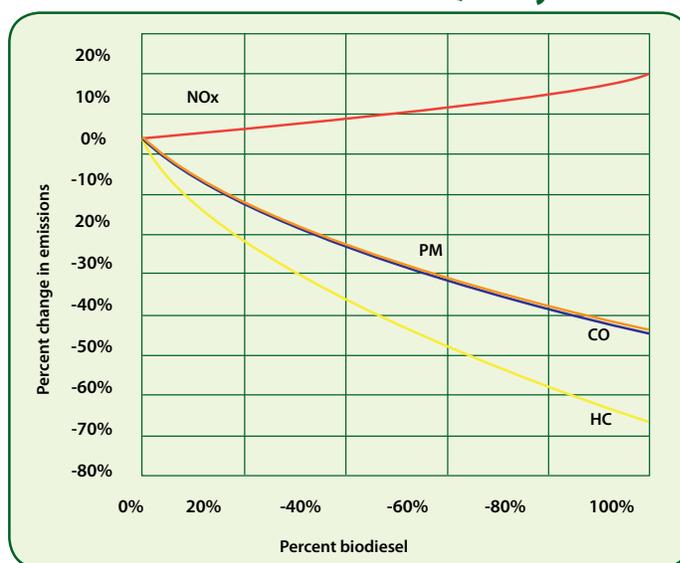
Biodiesel is chemically referred to as a Fatty Acid Methyl Ester (FAME). It is produced by processing raw vegetable oil or animal fats through a chemical process called transesterification. Biodiesel is chemically distinct from petroleum diesel and has a separate ASTM standard, specifying the properties of biodiesel which can effectively be blended with petroleum diesel (i.e. B20 represents a blend of 80 percent petroleum diesel fuel and 20 percent pure biodiesel). The most common feedstock in the U.S. has been soybean oil, while rapeseed (canola) oil is used more frequently in Europe. A byproduct of this chemical refining process is the production of glycerin, which can be used in some other compounds. The use of refined and recycled restaurant 100 percent vegetable oil is also gaining attention on a local community level, but production is limited due to inadequate and unstable supplies of waste vegetable oil. These oils are often a mix of various oils and they must still go through the transesterification process in order to be classified as biodiesel.

## 2. Renewable diesel

Renewable diesel is a broad class of fuels derived from biomass feedstocks, including oils or animal fats, but processed through other chemical processes and commonly referred to as non-esterified renewable diesel (NERD). The most advanced of these alternatives is produced through hydrotreating, a process which is being utilized in today's petroleum refineries. During this process hydrogen replaces other atoms such as sulfur, oxygen and nitrogen and converts the oil's triglyceride molecules into paraffinic hydrocarbons. While existing petroleum refineries could blend the renewable and petroleum fuels during the hydrotreating process to create a renewable diesel blend, stand alone facilities can produce 100 percent renewable diesel to be used directly or to be blended with petroleum diesel. The resulting renewable diesel or renewable diesel blend offers several advantages over fuel produced with the FAME process including reduced waste and by-products, higher energy density and improved cold flow properties. This process also enhances the blended fuel storage and stability of the finished biofuel product. Several manufacturers have announced their intent to commercialize this technology and begin producing renewable diesel this way in the United States between 2007 and 2010.

Other methods under consideration for creating renewable diesel fuel include biomass-to-liquid (BTL) and thermal conversion process (TCP) technologies. The former converts biomass (predominantly cellulosic material such as certain grasses or other plants) through high-temperature gasification into synthetic gas or "syngas" and then uses a Fischer-Tropsch process to catalytically convert the syngas to liquid fuel. TCP processing converts biomass or other carbonaceous material into a "bio-oil" which is then refined into diesel-like fuel. Both BTL and TCP offer tremendous potential to convert large volumes of cellulosic biomass into liquid fuels, but need further development and remain far from being economical for large scale fuel production.

### Biodiesel and Air Quality



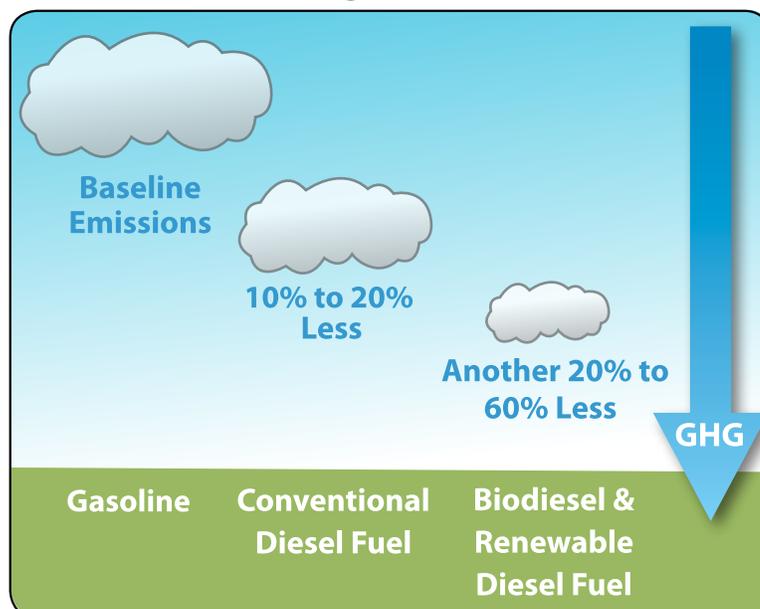
Source: EPA Biodiesel Emissions Analysis Program — [www.epa.gov/OMS/models/biodsl.htm](http://www.epa.gov/OMS/models/biodsl.htm)

## What are the benefits of biodiesel and renewable diesel fuels?

Biodiesel and renewable diesel fuels offer a variety of energy security, economic and environmental benefits. One of the most frequently cited benefits is their ability to help the United States offset its need for foreign oil imports and move toward energy independence. They have also drawn strong support from the agricultural community which would benefit from increased farm income.

From an environmental perspective, biodiesel and renewable diesel fuels can reduce emissions of hydrocarbons, carbon monoxide and particulate matter. Diesel vehicles are naturally 20-40 percent more energy efficient than gasoline vehicles resulting in a 10-20 percent reduction in GHG emissions. Using biodiesel and renewable diesel fuels can further reduce carbon dioxide emissions anywhere from 20-60 percent.

## The Diesel Advantage: Lower GHG Emissions



## Are there special considerations in using biodiesel or renewable diesel fuels in diesel vehicles?

Vehicle owners should review the individual engine and equipment manufacturers' specific warranty provisions and policies regarding the use of renewable diesel or biodiesel blends in their equipment. Current and future production diesel engines use advanced emissions control technology such as particulate filters and oxidation catalysts, and the effects of biodiesel on these systems is still being explored, especially at blends higher than B5.

Special attention to fuel system (filters, injectors, etc.) maintenance is required particularly with the first use of biodiesel blends which can release deposits into the fuel system. Other considerations for vehicle owners and operators involve assuring the quality and stability of the biodiesel blend. Biodiesel tends to attract water in fuel tanks and storage systems and may require replacement of hose and sealing equipment due to incompatibility with some older engines. Because most biodiesel is produced locally or regionally, there can be substantial variations in quality and cold weather performance. Additionally, biodiesel typically costs more than traditional diesel fuel.

Though there is less experience with NERD renewable diesel compared to biodiesel, its use should alleviate many of the challenges related to the fuel system and injectors. NERD fuels are pure hydrocarbons which have similar performance to petroleum diesel and in some cases, even meet petroleum diesel's ASTM D975 standard.

## What additional benefits do next generation renewable diesel fuels offer?

Thanks to heightened publicity from celebrity supporters and a beneficial production tax credit, biodiesel production has grown significantly in the last several years. However on an overall basis, biodiesel production still remains miniscule relative to national diesel consumption levels, making the implementation of a nationwide B2 or B5 standard an impossibility in the near term. Other complications from using higher biodiesel blends raise challenges for the widespread use of biodiesel even if production levels could be met.

Second-generation hydrotreating technologies may provide solutions to these problems and greater promise for substantial replacement of petroleum diesel with renewable alternatives. Non-FAME renewable diesel fuel's similarity to petroleum diesel is likely to minimize engine performance complications from blending and enable the use of existing pipelines and trucking infrastructure to deliver the fuel on a widescale basis. Other possible advantages over biodiesel include improved ignition (higher cetane level), less susceptibility to freezing in cold weather (lower cloud point), higher renewable content, greater fuel stability which enhances storage abilities, a larger choice of feedstock, and lower NOx and GHG emissions.

## How do renewable diesel fuels contribute to reductions in greenhouse gases and environmental improvements?

With greater experience and continued technological advances, the entire family of renewable diesel fuels will be able to displace an increasing amount of petroleum diesel. California's Air Resources Board (CARB) recently found renewable diesel to be one of the lowest carbon-intensity fuels available today. Scientists who examined the draft Low Carbon Fuel Standard (LCFS) on behalf of the state found that use of these fuels is the most readily available means to reduce a vehicle's GHG emissions and thus, its contribution to climate change. Growing interest in renewable diesel fuel was further strengthened by the California Energy Commission's recent support for promoting the use of renewable diesel fuel as a means of reaching the state's energy and environmental goals. A greater nationwide use of light duty diesel cars and light trucks with biodiesel and renewable fuel blends would further magnify this benefit.

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