



## **Biodiesel: A Renewable, Domestic Energy Resource**

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**I**n 2004, the United States used an average of 20 million barrels of oil per day, which is one-fourth of the 80 million barrels pumped per day worldwide. The worldwide pumping capacity is near the predicted peak with an anticipated decline in peak capacity within the next decade or several decades. Today, the U.S. imports 60% of all the oil that is used for our domestic consumption, whereas as recently as 35 years ago, the U.S. imported just 30%. Our dependency on imported oil is a significant threat to our homeland security as well as our economic well-being, especially during an oil embargo.

The use of biofuels holds real promise to: 1) decrease our country's dependency on foreign nations for energy; 2) improve environmental conditions; and 3) provide an additional income stream to the agricultural sector. Biofuels are derived from biological materials such as food crops, crop residues, forest residues, animal wastes, and landfills. Major biofuels are biodiesel, ethanol, and methane. Biofuels—by their very nature—are renewable over a period of less than one year for those based on crops, crop residues, and animal wastes or about 35 years for those based on forest residues, as compared to the hundreds of millions of years for fossil fuels. This fact sheet explores biodiesel as one of our nation's "home-grown" energy sources.

### **What is Biodiesel?**

Biodiesel is a renewable alternative to petroleum-based diesel fuel (hereafter referred to as "petrodiesel"). Biodiesel contains no petroleum, but it can be blended at any level with petrodiesel. Biodiesel can be made from any plant oil, animal oil, or even used cooking oil. Animal oils (tallow and lard) and used cooking oil are generally the least expensive feedstocks to purchase; however, there may be considerable additional expenses for the logistics to transport and handle these materials.

In the U.S., soybean oil is used for about 90% of the biodiesel that is produced today. Canola oil and rapeseed oil are the most common feedstocks for making biodiesel in Canada and Western Europe, respectively.

Biodiesel works very well as fuel for any diesel engine with only minor, if any, required modifications. Diesel engines made before the early 1990's may need some modifications since many have seals and other components made with natural rubber, which degrades when in contact with biodiesel. Biodiesel has a lower energy content (124,000 BTU/gallon) compared to petrodiesel (136,000 BTU/gallon). Biodiesel has a slightly higher cetane number than petrodiesel, resulting in improved ignition properties.

Biodiesel in its pure form is known as "neat" biodiesel. A biodiesel blend is pure biodiesel blended with petrodiesel with the notation of Bxx where the xx indicates the amount of biodiesel (by volume) in the blend. For example, B20 is a blended volume mixture of 20% biodiesel and 80% petrodiesel. Neat biodiesel (B100) can be used to totally replace petrodiesel, but more commonly, biodiesel is used in blends varying from B2 to B20.

Before blending biodiesel with petrodiesel, one must always make sure that the biodiesel meets the industry standard (ASTM D-6751) to be classified as a fuel. **Never purchase biodiesel or a biodiesel blend from a fuel dealer, jobber, or broker who cannot provide certification that the biodiesel meets the ASTM D-6751 standard.**



## **How is Biodiesel Made?**

Biodiesel is produced by mixing the feedstock oil (usually soybean oil in the U.S.), with methyl or ethyl alcohol, and a lye catalyst (sodium hydroxide or potassium hydroxide). This process - known as transesterification - breaks the glycerin from the fatty acid molecules of the feedstock oil and then each fatty acid molecule attaches itself to an alcohol molecule. If methyl alcohol is used as one of the ingredients along with soybean oil and a catalyst, then the more technical name for biodiesel is soy methyl ester; if ethyl alcohol is used, then the name is soy ethyl ester. Biodiesel (the ester) will rise to the top and glycerin with alcohol will settle to the bottom. After several scrubbing with water, the biodiesel (B100) can be marketed as a fuel and the glycerin can be used as an ingredient for making soaps, detergents, shampoos, and cosmetics. Glycerin must be disposed of properly as a waste product or used as a coproduct.



The transesterification process is not new. For hundreds of years, long before the advent of diesel engines, a similar process was used for soap-making with the biodiesel liquid fraction discarded as a waste by-product. The soap-making process, known as saponification, originally relied almost exclusively on tallow and lard as the feedstocks.

Biodiesel fuel must not be confused with crude, untransesterified vegetable oil. Some people have reported successful use of filtered and clarified crude vegetable oil as a diesel fuel supplement. These advocates are quick to point out that when Rudolph Diesel invented his engine in the 1890s, the fuel often used was peanut oil – not peanut-based biodiesel, but just plain peanut oil. Peanut oil was gradually

replaced by petrodiesel as it became more readily available. Even though crude vegetable oil could be used in the early diesel engines, modern diesel engines require the use of transesterified oil for long-term performance. The fuel injection systems used today are especially vulnerable to gum deposits if the oil is not properly transesterified. More information concerning the use of soy oil versus biodiesel is available at the web site <http://energy.cas.psu.edu/soydiesel.html>

Biodiesel from soybeans yields 3.2 units of fuel energy for each unit of fossil fuel energy consumed in its life cycle. Biodiesel is really concentrated solar energy or “liquid sunshine” because it is based on the solar-powered photosynthesis process during the growth phase of the plant feedstock. On the other hand, petrodiesel relies on fossil fuel reserves which are finite and declining. Biodiesel is an alternative, renewable fuel currently available that has a high overall positive life-cycle energy balance. Since the soybean plant is a legume, a crop of soybeans requires less nitrogen fertilizer than required by some other renewable energy crops.

Soybean oil is extracted from soybeans by crushing and pressing the beans to expel the oil. In some cases, a chemical solvent is used to obtain a greater oil yield. One bushel of soybeans (60 pounds) yields about 1.4 - 1.5 gallons of crude oil which can be processed into about 1.2 – 1.4 gallons of B100 biodiesel. One bushel of soybeans also yields about 44 pounds of soybean meal, a valuable co-product used as a protein source in animal feed rations. A typical soybean yield of 50 bushels per acre results in the production of about 60 – 75 gallons of B100 and about 1.1 tons of soybean meal per acre.

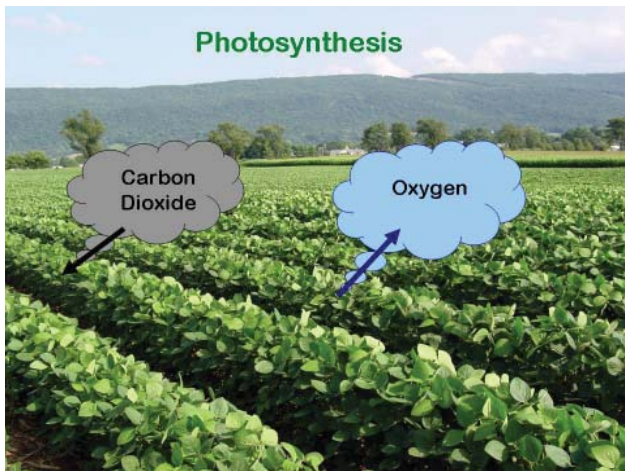


## **Environmental Benefits of Biodiesel**

Emissions from burning biodiesel in a conventional diesel engine have significantly lower levels of un-

burned hydrocarbons, carbon monoxide, carbon dioxide, particulate matter, sulfur oxides (SO<sub>x</sub>), odor, and noxious “smoke” compared to emissions from petrodiesel. The SO<sub>x</sub> are practically eliminated with the use of B100. However, using biodiesel results in a slight increase in the nitrogen oxides (NO<sub>x</sub>). Reduction of the SO<sub>x</sub> is significant because the SO<sub>x</sub> gases are largely responsible for acid rain and for impeding the performance of catalytic converters on diesel engines.

Carbon dioxide emissions from combustion of biodiesel are reduced by about 10% when compared to petrodiesel, but there is a more significant carbon dioxide benefit with biodiesel made from plant oils. During the photosynthesis process as the plants are growing and developing, carbon dioxide is drawn from the environment into the plant tissues; the plants are really carbon dioxide scrubbers. Biodiesel processed from plant oils is carbon dioxide neutral. In addition, the plants release beneficial oxygen into the environment.



Accidental spills of biodiesel are far less of a problem compared to petrodiesel. Pure biodiesel is fully biodegradable; in fact, about 98% of biodiesel degrades in about three weeks. The biodegradable property of biodiesel makes it an especially attractive fuel choice for environmentally sensitive areas such as national parks, forests, and marinas.

The cleaner environment resulting from biodiesel benefits public health issues in this country and worldwide. Increasing incidences of allergies and respiratory ailments, such as asthma, have been linked at least partially to the steadily increasing levels of contaminants in the environment from burning fossil fuels in engines and power plants.

The environment is a clear winner if more biodiesel fuel is used! The U.S. Environmental Protection

Agency (EPA) has been testing biodiesel for compliance with the Clean Air Act. The testing concluded that emissions from biodiesel are non-toxic and impose little or no health risks to humans. Tests have shown that the cancer-causing potential of particulate matter from pure biodiesel is about 94% less than that from petrodiesel.

## **Biodiesel Fuel Performance and Management Considerations**

Rudolph Diesel designed and built the compression ignition engine or diesel engine in the 1890's. Since then, diesel engines have provided enormous benefits throughout the world. But the continuing use of petrodiesel has substantial implications for environmental and public health issues. The challenge is how to optimize the use of diesel engines in a more compatible manner with the environment. Biodiesel holds such promise but certain precautions must be noted.

B100 is seldom used as a fuel because of cost factors and availability. Furthermore, no engine manufacturers at this time warrant their engines and engine components if B100 is used as the fuel. Biodiesel blends of B2 to B20 are most common. Even at low blends of B1 or B2, biodiesel provides environmental benefits and greatly improves the lubricity of low-sulfur diesel fuel. Lubricity of a fuel is the ability of the fuel to provide lubrication to reduce wear between moving parts of the diesel engine.

EPA requires that sulfur levels in petrodiesel be reduced. Before 1993, the allowable sulfur level in diesel fuel was 5,000 parts per million (ppm). Since 1993, allowable sulfur was 500 ppm. Starting June 2006, sulfur is being reduced gradually to 15 ppm for “on-road” transportation fuel. Whenever sulfur is removed from petrodiesel, lubricity of the fuel is greatly reduced. Biodiesel has virtually no sulfur content but has excellent lubricity properties. Just using B1 improves lubricity of low-sulfur petrodiesel by as much as 65%.

Whenever switching to biodiesel or a biodiesel blend fuel in an engine that had been running on petrodiesel, it is recommended to change fuel filters on a more frequent basis at least for the first six months after the transition. Biodiesel is an excellent solvent and, as such, it will readily dissolve many of the deposits in a diesel engine, fuel injectors, fuel supply lines, and storage tanks that have accumulated over the years of engine operation with petrodiesel. Continue changing fuel filters on an as-needed basis until the system has been cleaned of the petrodiesel deposits. Since biodiesel is a good solvent, it is necessary to quickly wipe

any biodiesel spills from painted surfaces to avoid paint removal.

With a flash point temperature of about 300°F (compared to about 140°F for diesel fuel), biodiesel presents a very low fire hazard and is much safer to store and handle than other petroleum-based fuels.

Most of the standard storage and handling procedures used for petrodiesel can also be used for biodiesel. The fuel should be stored in a clean, dry, dark environment. Recommended materials for storage tanks include aluminum, steel, polyethylene, polypropylene and Teflon, but not concrete-lined storage tanks. The storage tank should not include any copper, brass, lead, tin, zinc or rubber fittings. Since biodiesel is an organic liquid, the use of an algaecide or fungicide additive is recommended whenever the fuel is stored during warm weather. B100 has a tendency to gel during cold weather as indicated by its higher cloud point and pour point temperatures than petrodiesel. Additives are available to prevent gelling, but gelling is generally not a problem for blends of B20 or lower. Storage time for biodiesel and petrodiesel should be limited to six months for best performance.

### **Biodiesel Implications on World Hunger**

Utilizing food crops as fuel does not compete with the food needed for nourishment throughout the world. Although malnutrition is a serious global problem affecting 800 million people, the world is not experiencing a food production problem. Instead the world faces political challenges associated with providing infrastructure for effective food distribution and storage.

Contemporary agricultural systems can and do produce sufficient quality and quantity of food for the world's population, with additional resources available so that agricultural products can be used for processing into fuel, pharmaceuticals, and chemical feedstocks.

### **Where is Biodiesel Available?**

The most reliable way to get up-to-date information is to check the web site for the National Biodiesel Board at <http://www.biodiesel.org>. Click on "Guide to Buy-

ing Biodiesel." Then under the heading of DISTRIBUTORS, click on "Click here for a national map of biodiesel distributors." Then click on your state on the map. An additional web site to locate suppliers within Pennsylvania is available at <http://ibfuels.com> and then click on "Find a Distributor."

Make sure that you are buying biodiesel and not just crude, unprocessed vegetable oil. Insist on certification that the biodiesel meets ASTM D6751 standards.

### **Summary**

Biodiesel is an alternative, renewable fuel with significant promise for addressing major energy problems. While biodiesel is not a "silver bullet" solution to our energy problems, it can provide 3 – 6 % of the energy required in this country. Effective energy management systems are needed to optimize energy use throughout all sectors of our economy. Using biodiesel as a fuel:

- Reduces our nation's dependency on foreign oil
- Increases our homeland security
- Promotes rural and agricultural economic development
- Improves environmental quality and public health
- Increases lubricity of petrodiesel fuel
- Conserves our fossil fuels

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1st Edition 08/05  
Rev. 08/06

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