

## Biodiesel

### What is Biodiesel?

- A substitute for or an additive to diesel fuel that is derived from the oils and fats of plants
- An alternative fuel that can be used in diesel engines and provides power similar to conventional diesel fuel
- A biodegradable transportation fuel that contributes little, if any, net carbon dioxide or sulfur to the atmosphere, and is low in particulate emissions
- A renewable, domestically produced liquid fuel that can help reduce U.S. dependence on foreign oil imports.

### The Resource

Up to 50% of the total U.S. diesel fuel consumption (amounting to 190 billion liters or 50 billion gallons in 1991) could be replaced with biodiesel made from animal, vegetable, and microalgal oils. In the 1990/1991 growing season, the United States produced approximately 10.1 billion kilograms (22.3 billion pounds) of bio-oil (soybean, corn, cottonseed, peanut, sunflower, canola, and rendered tallow). If this oil was used solely for biodiesel production, it would be equivalent to 12.1 billion liters (3.2 billion gallons) of fuel. Because several animal and vegetable oils are being displaced in the U.S. food market as a result of health issues, biodiesel from these resources could offer a high-value alternative market for U.S. oil seed and tallow producers.



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distribution on the Internet.

*A scientist at the National Renewable Energy Laboratory tests ponds containing microalgae bred for high lipid (oil) content.*

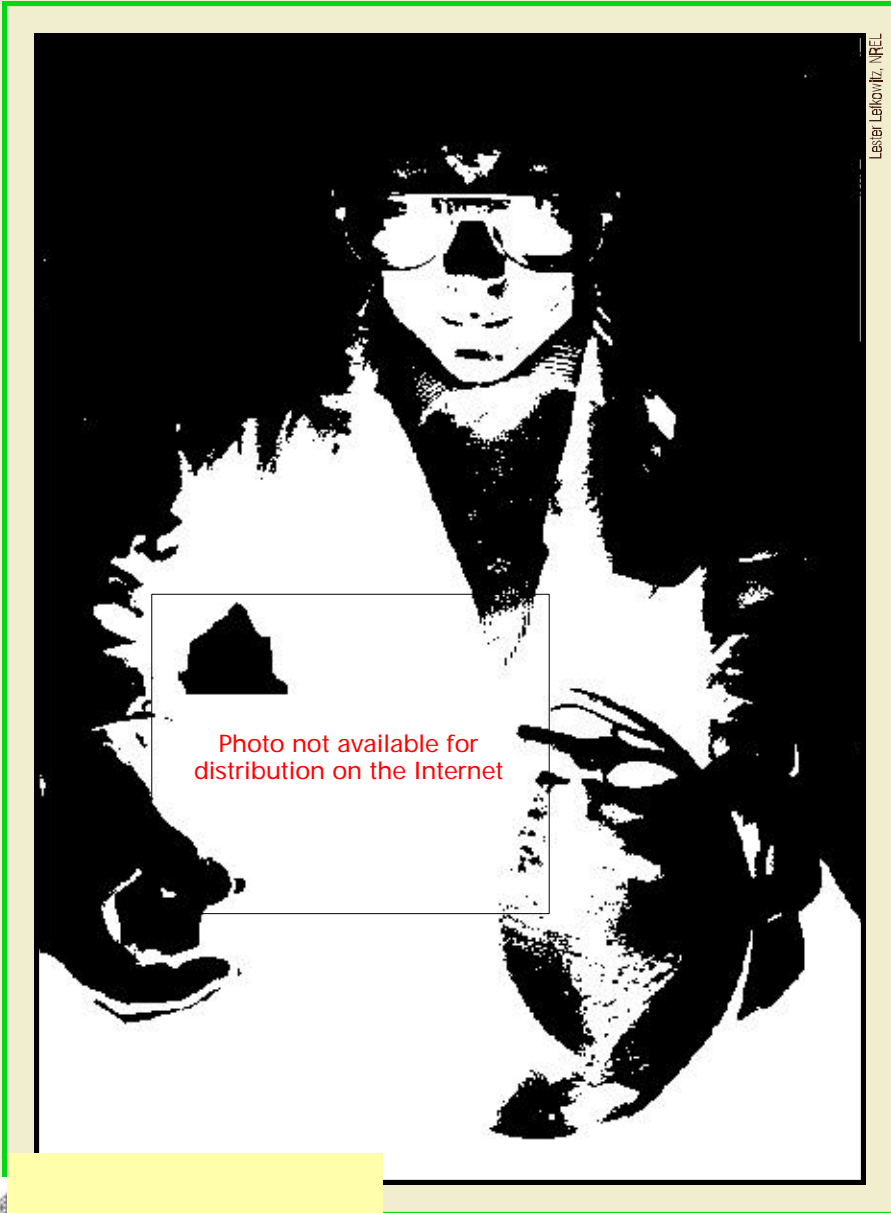


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*Oils called lipids can be extracted from microalgae and converted into biodiesel. Microalgae ponds could satisfy more than half the nation's demand for diesel.*

Additional biodiesel could be derived from aquatic plants such as microalgae. Looking toward the long term, researchers are working to optimize the growth and lipid (oil) production of microalgae for biodiesel conversion. This resource has the potential to supply 50% or more of the U.S. diesel market.

## History

Biodiesel was introduced in South Africa before World War II to power heavy-duty vehicles. Recent environmental and domestic economic concerns have prompted a resurgence in the use of biodiesel throughout the world. In 1991, The European Community (EC) proposed a 90% tax deduction for the use of bio-fuels, including biodiesel. Biodiesel plants are now being built by several companies in Europe; each of these plants will produce up to 5.7 million liters (1.5 million gallons) of fuel per year.

In the United States, biodiesel is also being commercialized. Procter & Gamble Co. is currently the only U.S. manufacturer of biodiesel (primarily made from soybean oils); several U.S. demonstration programs, however, use biodiesel to fuel more than 200 vehicles, including buses, trucks, construction/maintenance equipment, and motor boats.

## The Process

Biodiesel can be produced through "transesterification," a process that combines vegetable oils, animal fats, and/or microalgal oils with alcohol in the presence of a catalyst to form fatty esters. Product recovery is separated into phases, which provides for easy removal of glycerol, a valuable industrial by-product, in the first phase. The remaining alcohol/ester mixture is then separated, and the excess alcohol is recycled. Then the esters are sent to the cleanup or purification process, which consists of water washing, vacuum drying, and filtration.

## The DOE & USDA Programs

The U.S. Department of Energy (DOE) and the U.S. Department of Agriculture (USDA) have major research and development

programs under way to reduce the cost of biodiesel production. These agencies have jointly funded research to identify high oil-content crops with diesel market potential. DOE programs include long-term research for producing algal strains with high lipid content and development of biodiesel conversion technologies using algal lipids and higher plant oils.

The USDA has proposed a major research and development initiative to achieve lower crop production costs. Through advanced chemical engineering processes, the USDA anticipates improvements in conversion yields and environmentally sound, cost-effective crop management techniques. Several USDA biochemistry and advanced plant breeding projects could also help increase crop yields and thus reduce fuel costs.

The DOE Alternative Fuels Utilization Program has plans to conduct several biodiesel emissions and engine testing projects with the expectation that the fuel will meet the requirements of the U.S. Environmental Protection Agency's Clean Air Act Amendments of 1990. Preliminary results of tests conducted by engine manufacturers suggest that biodiesel may significantly lower several key exhaust emissions, especially those of problematic particulate matter. Also, DOE will expand its alternative fuels utilization research to include biodiesel in support of the comprehensive national Energy Policy Act of 1992.

### Cost

The cost of biodiesel is largely dependent on the choice of feedstock. According to a recent market analysis, if soybeans are used, the fuel will cost approximately \$0.66/liter (\$2.50/gallon) on a

small-market scale. However, large-scale commercial use of biodiesel produced using today's technology could reduce the cost of biodiesel to \$0.40 to \$0.45/liter (\$1.50 to \$1.60/gallon). Additional research advances using existing feedstock technologies or innovative feedstocks such as microalgae could further reduce costs. The goal of the DOE/NREL program is to produce biodiesel from microalgae at a cost of \$0.26/liter (\$1.00/gallon).

### Utilization

In general, no major engine, ignition system, or fuel injector modifications are needed for standard diesel engines to operate on biodiesel. The solvent characteristics of the fuel may require substitutions of certain hose and fuel line materials that contact the fuel, however.

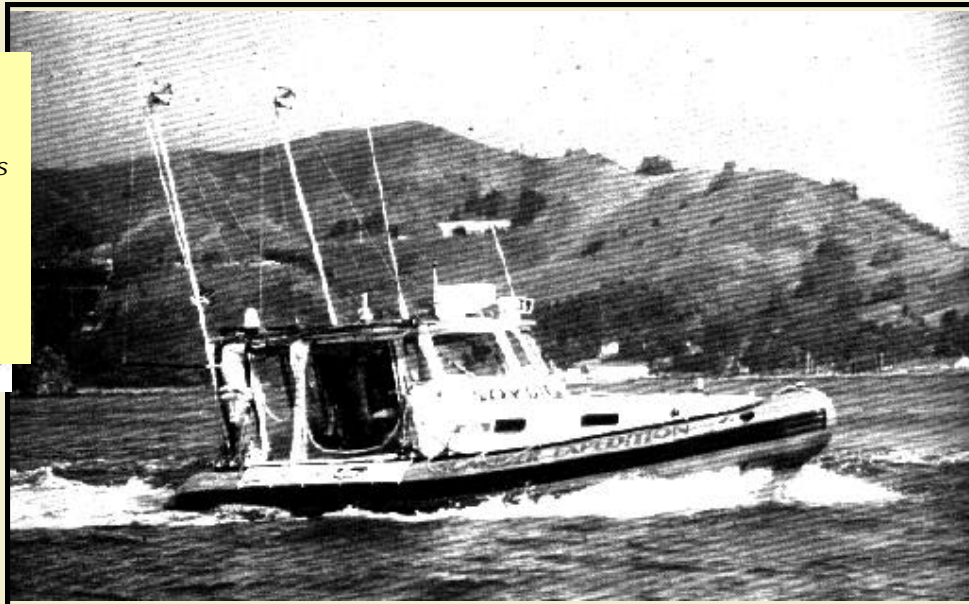
*Biodiesel is expected to meet the requirements of the U.S. Environmental Agency's Clean Air Act Amendments of 1990.*



North Strawn, NREL



*Adventurer Bryan Peterson circumnavigated the Earth in this biodiesel-powered boat. The trip was filled with tense moments and adventure, but not because of his fuel.*



Noni Strawn, NREL

Based on limited testing conducted to date, biodiesel provides fuel economy comparable to conventional diesel fuels. Recent tests done by Mercedes-Benz indicate that highway fuel mileage is essentially the same. In addition, engine performance tests at the Austrian Institute of Agricultural Engineering show lubricant consumption and engine wear with biodiesel operation to be comparable to operation with conventional diesel fuel.

### **Safety**

Biodiesel offers enhanced safety characteristics compared with other diesel alternatives, including petroleum, methanol, and natural gas. Biodiesel has a high flash point, it does not produce explosive air/fuel vapors, it has very low mammalian toxicity if ingested, and it is biodegradable. The emissions are also expected to be less toxic, however, no definitive data on this point are currently available.

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