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BIODIESEL: A BRIEF OVERVIEW

CURRENT TOPIC

By Karen Faupel and Al Kurki,
NCAT Agriculture Specialists, May 2002

As the national debate over reducing U.S. dependence on foreign oil heats up, discussion of alternative fuels is more and more prevalent. One of the most commonly mentioned is biodiesel, a 100% agriculturally derived liquid fuel, often called B100. Most often used to fuel diesel vehicle engines, biodiesel can also be used as heating oil. Biodiesel is made from virgin vegetable oils, from waste fryer oils, or from waste animal fats and oils. It can be used alone or blended with petroleum diesel in any percentage without major modifications to the engine. Biodiesel blends are making their way into government fleets, municipal transit systems, and personal vehicles—most commonly as B20, a blend of 20% biodiesel and 80% petroleum diesel.

Biodiesel has many benefits and some drawbacks. The benefits include:

- Reduced vehicle emissions
- Reduced engine wear because of the fuel's excellent *lubricity* (ability to lubricate the engine and fuel system)
- Increased safety in storage and transport because the fuel is nontoxic and biodegradable
- Increased value for American farm products
- Reduced dependence on foreign oil suppliers and associated price fluctuations

Contents

Photo courtesy of National Biodiesel Board (NBB) and the U.S. Department of Energy/National Renewable Energy Laboratory

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Possible drawbacks include:

- The need in older engines to replace rubber fuel hoses and gaskets with synthetics because of biodiesel's tendency to deteriorate rubber
- Possible concerns with engine warranties
- Special measures that must be taken to use biodiesel, particularly B100, in cold climates
- Higher per-gallon cost than petroleum diesel in the current market
- Limited commercial availability of fuel if you are not going to process it yourself

EMISSIONS

Recent reports point to evidence that petroleum diesel exhaust causes cancer and other human health problems (1, 2). However, diesel engines were designed to run not only on petroleum fuels but also on vegetable oils. In fact, Joshua Tickell reports in his book *From the Fryer to the Fuel Tank* (3) that when Rudolf Diesel showcased his engine at the World Exhibition in Paris in 1900, he used peanut oil for the demonstration.

Biodiesel has completed both the Tier I and Tier II Health Effects testing requirements of the Clean Air Act Amendments of 1990. With the exception of oxides of nitrogen, all regulated and non-regulated pollutants showed a 40% or more decrease in emissions when B100 was compared to petroleum diesel (4). According to the U.S. Department of Energy, "Tests have shown that the cancer-causing potential of particulate matter from pure biodiesel is about 94% less than that of regular diesel and the risk from B20 is 27% less" (5). See the enclosed *Health Effects Testing* and *Biodiesel Emissions* fact sheets from the National Biodiesel Board for detailed emissions data.

PRODUCTION

As defined in legislation introduced last summer in the U. S. Congress(6), biodiesel includes fuel derived from corn, soybeans, sunflower seed, cottonseed, canola and rapeseed, crambe, safflower, flaxseed, and mustard seed. Soybeans are the most commonly used feedstock in the U.S. today; rapeseed is the primary feedstock in Europe. Many other crops as well as animal fats can be used. See Table 1 for a list of crops and their oil production potential. The choice of feedstock is much more critical to the economics of the venture than to the manufacturing process.

Biodiesel can be made at several scales of production. A chemical process called transesterification is used to transform the raw vegetable oil into biodiesel and glycerin. This process is not as complicated as it may sound, though it does require the use of toxic chemicals—most commonly methanol and lye. Ethanol and potassium hydroxide, which are less hazardous, can be used instead, but they generally take more time and yield less fuel. In diesel fuel blends of less than 10 percent vegetable oil to petroleum, the vegetable oil may not require processing.

Veggie van pulling a trailer (Green Grease Machine) that produces fuel from used cooking oil for about $0.80 per gallon.

SMALL-SCALE PRODUCTION

With care and practice, biodiesel can be produced on-farm using a variety of oils as feedstocks. Farmers can produce their own fuel for tractors and other farm equipment from their own oilseeds or from waste fryer oil collected in neighboring communities. For small-scale production, Joshua Tickell's book *From the Fryer*

Table 1. Oil-producing Crops

Plant	Latin Name	Kg Oil/ Hectare	Plant	Latin Name	Kg Oil/ Hectare
corn	*Zea mays*	145	tung oil tree	*Aleurites fordii*	790
cashew nut	*Anacardium occidentale*	148	sunflower	*Helianthus annuus*	800
oat	*Avena sativa*	183	cocoa	*Theobroma cacao*	863
palm	*Erythea salvadorensis*	189	peanut	*Arachis hypogaea*	890
lupine	*Lupinus albus*	195	opium poppy	*Papaver somniferum*	978
rubber seed	*Hevea brasiliensis*	217	rapeseed	*Brassica napus*	1000
kenaf	*Hibiscus cannabinus L.*	230	olive tree	*Olea europaea*	1019
calendula	*Calendula officinalis*	256	piassava	*Attalea funifera*	1112
cotton	*Gossypium hirsutum*	273	gopher plant	*Euphorbia lathyris*	1119
hemp	*Cannabis sativa*	305	castor bean	*Ricinus communis*	1188
soybean	*Glycine max*	375	bacuri	*Platonia insignis*	1197
coffee	*Coffea arabica*	386	pecan	*Carya illinoensis*	1505
linseed	*Linum usitatissimum*	402	jojoba	*Simmondsia chinensis*	1528
hazelnut	*Corylus avellana*	405	babassu palm	*Orbignya martiana*	1541
euphorbia	*Euphorbia lagascae*	440	jatropha	*Jatropha curcas*	1590
pumpkin seed	*Cucurbita pepo*	449	macadamia nut	*Macadamia terniflora*	1887
coriander	*Coriandrum sativum*	450	brazil nut	*Bertholletia excelsa*	2010
mustard	*Brassica alba*	481	avocado	*Persea americana*	2217
camelina	*Camelina sativa*	490	coconut	*Cocos nucifera*	2260
sesame	*Sesamum indicum*	585	oiticia	*Licania rigida*	2520
crambe	*Crambe abyssinica*	589	buriti palm	*Mauritia flexuosa*	2743
safflower	*Carthamus tinctorius*	655	pequi	*Caryocar brasiliense*	3142
buffalo gourd	*Cucurbita foetidissima*	665	macauba palm	*Acrocomia aculeata*	3775
rice	*Oriza sativa L.*	696	oil palm	*Elaeis guineensis*	5000

Tickell, Joshua. 2000. *From the Fryer to the Fuel Tank*, reprinted with permission (3)

to the Fuel Tank (3) offers clear, step-by-step production instructions. His associated website <http://www.veggievan.org> offers information and discussion forums among small-scale producers, many of whom are making fuel for their personal vehicles. For those who wish to press their own oilseeds, ATTRA's *Small-Scale Oilseed Processing* publication contains useful information about generating the raw oil.

A word of caution is in order here, however. Homemade biodiesel fuel that is used in vehicles *operating on public roads* is not exempt from federal and state taxes, which can be as high as $0.48 per gallon. Federal and state revenue departments have a set fine structure for failure to pay these taxes. These taxes can be waived if one applies for and receives a research permit. In some states, biodiesel packaged in small quantities and sold as a standard diesel fuel additive is untaxed. If you're planning to use biodiesel exclusively on-farm or off-road, taxation is not an issue.

Production permits, taxation, and proper processing and disposal of biodiesel by-products are important factors to consider in biodiesel production at any scale.

In addition, it is important to learn about permitting issues associated with biodiesel production. It appears that the Environmental Protection Agency (EPA) will require a production permit if annual production exceeds 1,000 gallons. Check with your state environmental protection office to get the final ruling on this matter if you are considering making biodiesel in larger quantities for vehicles (6).

Medium-scale Production

Medium-scale production may present the greatest opportunity for value-added agriculture for family farmers, but this is also the scale on which the least amount of information is currently available. Lots of folks are tinkering around in their garages and barns with small-scale production, and there are several industrial-scale processors on-line, but thus far there is no farmers' cooperative producing biodiesel on a medium scale to supply a local farming community's fuel needs. To the authors' knowledge, there is no "turn-key" processing system available for purchase on the market today; this is potentially an opportunity for entrepreneurs, if the economics of production prove favorable.

For initial investigation into medium-scale production, the University of Idaho's research may be a good resource. The university produced biodiesel from rapeseed, non-food-grade canola, and mustard for Yellowstone National Park's Truck in the Park project for several years and through that effort developed a medium-scale continuous-production process.

Industrial-scale Production

There are several industrial-scale production facilities on-line in the United States today, from which biodiesel is available for purchase throughout the country. Contact the National Biodiesel Board for a current listing of suppliers and manufacturers (see the **Resources** section below for contact information). Industrially processed fuel should be produced in accordance with the provisional ASTM (American Society for Testing and Materials) specifications. Biodiesel fuel specifications are also available from the National Biodiesel Board.

Conclusion

Biodiesel production presents American farmers with a vast field of opportunity for adding value to oilseed crops, waste oils, and animal fats. Much of the opportunity hinges on beneficial economics and an increase in demand. A number of incentives included in legislation before Congress seem likely to advance efforts to commercialize biodiesel (7).

State governments are also taking action to increase biodiesel use and production. For example, legislation in Minnesota will require that all diesel fuel contains 2 percent biodiesel once state production reaches 8 million gallons per year. In Idaho biodiesel receives a fuel tax discount. Other state incentives can be found across the country (8).

From a technological standpoint, there is little doubt that biodiesel can help fuel the transition to a more sustainable transportation system. In the coming years, the promise of reduced emissions and the potential to produce fuel crops sustainably could generate great public and political support for biodiesel.

Use of rapeseed as a feedstock that can also be a biofuel.

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2) School buses and diesel exhaust (television broadcast). February 7, 2002. Good Morning America. ABC. Unedited transcript available at <http://more.abcnews.go.com/sections/gma/goodmorningamerica/gma020207_hunterbuses.html>.

3) Tickell, Joshua. 2000. From the Fryer to the Fuel Tank: The Complete Guide to Using Vegetable Oil as an Alternative Fuel, 3rd ed. Tickell Energy Consulting, Tallahassee, FL. 162 p.

4) National Biodiesel Board. No date. Health Effects Testing. 1 p.

5) National Renewable Energy Laboratory. 2001. Biodiesel Offers Fleets a Better Alternative to Petroleum Diesel. U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy. NREL/FS-540-30136. 4 p.

6) Haines, Howard. Montana Department of Environmental Quality. Telephone conversations with co-author Al Kurki, April 2002. It appears at this point that EPA's permitting will be tied to the quantity of methanol or ethanol used in the biodiesel production process. The maximum-1,000-gallon figure quoted here is based on extrapolations of the maximum amount of methanol (not requiring a permit) used in making biodiesel.

7) Senate Bill S. 1058 (Hutchinson (R-AR) and Dayton (D-MN)). 2001. 107th Congress, 1st Session. Accessed July 2001. <http://thomas.loc.gov/>.

8) Written comments provided by Howard Haines, bio-energy engineering specialist, Montana Department of Environmental Quality, April 2002.

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RESOURCES

National Biodiesel Board
P.O. Box 104898
Jefferson City, MO 65110-4898
1-800-841-5849
email: info@nbb.org
http://www.biodiesel.org

The National Biodiesel Board provides a wealth of information on their website.Call their toll-free number for a free printed information kit.

From the Fryer to the Fuel Tank: The Complete Guide to Using Vegetable Oil as an Alternative Fuel, 3rd ed. 2000. By Joshua Tickell. Tickell Energy Consulting, Tallahassee, FL. 162 p.

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Small-Scale Oilseed Processing. NCAT/ATTRA Value-Added & Processing Guide. 2001. By Janet Bachmann. National Center for Appropriate Technology, Fayetteville, AR. 21 p.

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Biodiesel Development: New Markets for Conventional and Genetically Modified Agricultural Products. 1998. By James Duffield, Hosein Shapouri, Michael Graboski, Robert McCormick, and Richard Wilson. United States Department of Agriculture, Economic Research Service, Washington, DC. 31 p.

Available for download free of charge from <http://www.ers.usda.gov/publications/aer770/> or by phone at 1-800-999-6779 (Stock Number: ERSAER770) for $25.50 + handling.

WEB RESOURCES

National Biodiesel Board
http://www.biodiesel.org

DOE Alternative Fuels Data Center
http://www.afdc.doe.gov/altfuel/biodiesel.html

Veggie Van Home Page
http://www.veggievan.org/biodiesel/

University of Idaho
http://www.uidaho.edu/bae/biodiesel/

DOE Office of Transportation Technologies
http://www.ott.doe.gov/

DOE Energy Efficiency and Renewable Energy Network
http://www.eren.doe.gov/RE/bio_fuels.html

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