

# ENERGY MANAGERS' QUARTERLY

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## FEATURE

### The Biodiesel Advantage

*Neil Kolwey*

Many organizations, including the U.S. military, the National Aeronautics and Space Administration, dozens of commercial fleets, and hundreds of school districts and local and state governments, are using biodiesel. Biodiesel fuel in trucks and buses is by far the largest potential commercial and industrial application, but it can also be used in other types of diesel equipment.

Biodiesel's main benefits are reduced air emissions (including particulates, hydrocarbons, sulfur dioxide, and carbon dioxide) and in many cases reduced maintenance costs or other benefits. The municipal transit and parking authority in Cedar Rapids, Iowa, has found that biodiesel contributes to longer intervals between engine over-

hauls. The University of Colorado at Boulder has found a 2 percent increase in fuel efficiency with biodiesel use.

### Biofleets

For most organizations using biodiesel, the main motivation is reduced air emissions, but many are also discovering maintenance or performance benefits. Most organizations using biodiesel in their vehicles use a blend of 20 percent biodiesel and 80 percent petroleum diesel (B20) rather than pure biodiesel (B100) or other blends higher than 20 percent. B20 is used by more organizations because it presents fewer challenges to unmodified engines.

**Environmental benefits.** Many organizations are setting voluntary goals to reduce emissions of CO<sub>2</sub>, and using biodiesel in fleet vehicles is one emissions reduction option. Considering the life cycle of biodiesel (including farming, distillation, and use) versus that of petroleum diesel, CO<sub>2</sub> emissions are reduced by about 80

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## Corporate Energy Managers' Consortium

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percent for B100 and 16 percent for B20. In the U.S., biodiesel is produced mainly from soybeans. The CO<sub>2</sub> sequestered from the air during the growth of the soybeans is released again during combustion of the fuel, so the net CO<sub>2</sub> emissions from using biodiesel are reduced compared to those from petrodiesel. However, the net CO<sub>2</sub> emissions for biodiesel use are not zero because some fossil fuels are consumed during the soybean farming and fuel distillation processes. Another indicator of the life-cycle environmental benefits of biodiesel is the fossil energy ratio (FER), which is defined as units of energy in the fuel produced per unit of fossil energy input. Biodiesel has an FER of 3.2:1, compared to only 0.83:1 for petroleum diesel. By comparison, corn ethanol has an FER of 1.4:1 compared to gasoline's FER of 0.83:1.<sup>1</sup>

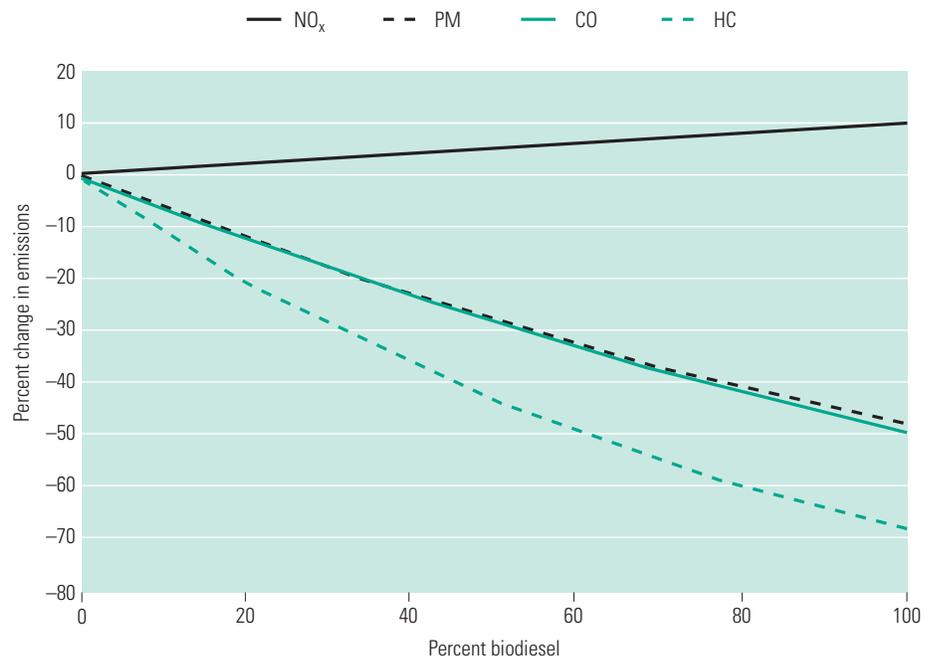
Emissions of conventional pollutants, with the exception of nitrogen oxides, are also reduced significantly through biodiesel use. (See **Figure 1**.)<sup>2</sup>

**Performance and reduced maintenance costs.** There are many large truck and bus fleets using biodiesel with good success. A growing number of organizations are also finding that blends of biodiesel up to 20 percent (B20) actually reduce maintenance costs and help extend engine life by reducing the amount of dirt that builds up in the fuel system and in the engine in general.

There are a few challenges to be aware of in using biodiesel. Biodiesel does not flow as well as petrodiesel in cold temperatures and can possibly form wax crystals and begin to gel (solidify). The wax crystals can potentially clog fuel injectors.

Figure 1: Emission reductions for biodiesel blends

Emissions of particulate matter (PM), carbon monoxide (CO), and hydrocarbons (HC) decrease significantly with biodiesel use. Nitrogen oxide (NO<sub>x</sub>) emissions increase by about 10 percent for B100 and by about 2 percent for B20.



Source: U.S. Environmental Protection Agency [2]

Preventing these problems may require special additives or fuel heating systems. Care must also be taken in storing 100 percent biodiesel. If it is stored for longer than a few months, it can turn rancid.

Second, biodiesel has greater solvent properties, and use of B100 or other high-percentage biodiesel blends may cause rubber seals and gaskets in fuel systems to wear faster or to fail, especially in vehicles made prior to about 1994. In addition, when first switching to a biodiesel blend, fuel filters need to be changed more frequently because biodiesel dissolves soot and other deposits that tend to build up in the fuel tank and fuel system from using petroleum diesel. After the adjustment period, the fuel lines should stay cleaner if the vehicle continues to burn biodiesel. Also, because of biodiesel's greater affinity to water vapors, the fuel tank should be kept as full as possible to minimize the amount of condensation. Water drains on engine-mounted fuel filters should also be drained more frequently. (See sidebar, page 4, for more guidelines on biodiesel use.)

Biodiesel also offers a few clear advantages over petroleum diesel. Biodiesel has a higher lubricity (an indicator of lubricating properties) than petroleum diesel. The higher lubricity can contribute to longer life for the fuel pump and other fuel system components that rely partially on the fuel for lubrication. Another important fuel property is the cetane rating, a measure of ability to autoignite. Biodiesel has a higher cetane rating than petroleum diesel, which is one reason for its lower emissions of unburned hydrocarbons. (The other reason is biodiesel's higher oxygen content.)<sup>3</sup>

On the other hand, biodiesel has a lower energy content per gallon (by about 10

percent) than petroleum diesel, which theoretically would result in a 2 percent loss of fuel efficiency (miles per gallon) for vehicles using B20. However, the higher cetane rating and higher oxygen content at least partially offset the lower energy content, and some organizations have actually found a slight increase in fuel efficiency with B20 use. The University of Colorado has seen the overall fuel efficiency of its fleet improve by about 2 percent with the use of B20. (See the "Case Studies" section.)

New Holland is the first diesel equipment manufacturer to extend its warranty to cover the use of blends up to B20. Many others, while officially endorsing only blends up to B5 currently, are working with the National Biodiesel Board to improve standards and guidelines for the use of B20. The National Biodiesel Board is optimistic that this collaboration will eventually lead these companies to extend their warranties to include B20 use. (See sidebar, page 4.)

### **Case Studies**

Many organizations have experienced benefits from using B20 or higher blends. The city of Berkeley, California, is successfully using 100 percent biodiesel in about 90 percent of its diesel fleet vehicles, including fire trucks. A school district in Michigan found through monitoring engine oil (a practice used by many fleet managers to determine when oil changes are necessary) that buses using B20 could be driven more miles between oil changes because of less soot from the fuel being deposited in the oil. The school district also reported fewer required fuel pump changes.<sup>4</sup> The transit authority of Cedar Rapids, Iowa, reported that its maintenance costs were significantly reduced, in part because of its use of B20.

## Technical Recommendations for B20 Fleet Use

The following recommendations, dated June 2005, were written by the National Biodiesel Board (see [www.biodiesel.org](http://www.biodiesel.org)) and diesel equipment manufacturers making up the B20 Fleet Evaluation Team.<sup>5</sup> (Team members are listed at end of sidebar.)

- *Ensure the biodiesel meets the ASTM [American Society for Testing and Materials] specification for pure biodiesel (ASTM D 6751) before blending with petrodiesel. Purchase biodiesel and biodiesel blends only from companies that have been registered under the BQ-9000 fuel quality program.*
- *Ensure the B20 blend meets properties for ASTM D 975, Standard Specification for Diesel Fuel Oils, or the ASTM specification for B20 once it is approved.*
- *Ensure your B20 supplier provides a homogeneous product.*
- *Avoid long-term storage of B20 to prevent degradation. Biodiesel should be used within six months.*
- *Prior to transitioning to B20, it is recommended that tanks be cleaned and free from sediment and water. Check for water and drain regularly if needed. Monitor for microbial growth and treat with biocides as recommended by the biocide manufacturer. See the NREL [National Renewable Energy Laboratory] Biodiesel Storage and Handling Guidelines for further information: [www.nrel.gov/vehiclesandfuels/npbf/pubs\\_biodiesel.html](http://www.nrel.gov/vehiclesandfuels/npbf/pubs_biodiesel.html).*
- *Fuel filters on the vehicles and in the delivery system may need to be changed more frequently upon initial B20 use. Biodiesel and biodiesel blends have excellent cleaning properties. The use of B20 can dissolve sediments in the fuel system and result in the need to change filters more frequently when first using biodiesel until the whole system has been cleaned of the deposits left by the petrodiesel.*
- *Be aware of B20's cold-weather properties and take appropriate precautions. When operating in winter climates, use winter blended diesel fuel. If B20 is to be used in winter months, make sure the B20 cloud point is adequate for the geographical region and time of year the fuel will be used.*
- *Perform regularly scheduled maintenance as dictated by the engine operation and maintenance manual. If using B20 in seasonal operations where fuel is not used within six months, consider storage-enhancing additives or flushing with diesel fuel prior to storage.*

These recommendations on use of B20 are preliminary and are not provided to extend or supplant warranty limitation provided by an individual engine or equipment supplier. Use of B20 blends is solely at the discretion and risk of the customer, and any harmful effects caused by the use of B20 are not the responsibility of the engine or equipment maker.

**B20 Fleet Evaluation Team members.** Cummins, John Deere, International Truck and Engine Corp., DaimlerChrysler, Caterpillar, Ford Motor Company, General Motors, Department of Defense, Siemens, Delphi Automotive Systems, Volkswagen, Engine Manufacturers Association, MARC-IV Consulting, ASG Renaissance, Bosch, FleetGuard, NREL, BMW of North America, Mack Trucks, Stanadyne Automotive Corporation, Suncor, CNH Global, Parker-Hannifin-Racor Division, and DENSO International America.

**University of Colorado at Boulder.** The University of Colorado (CU) at Boulder has a fleet of 17 buses, 2 garbage trucks, 2 dump trucks, and a “high ranger” truck (equipped with a bucket-lift system for uses such as tree trimming). CU began using biodiesel about three years ago. It uses B100 in the garbage trucks in the summer months, switching back to B20 in the winter, and uses B20 in all other vehicles year-round.

Overall, CU’s maintenance costs are about the same now as they were with petroleum diesel. However, CU has seen a 2 percent increase in fuel economy with biodiesel. To adjust to using biodiesel, the maintenance staff changed the fuel filters more frequently at first, but they anticipated this adjustment, and there were no problems. They also drain the water separators on the fuel filters more frequently than with petroleum diesel, which is an easy routine maintenance task.

CU has not had any problems with using B20 in the winter. To avoid any cold-weather problems, Bryan Flansburg, CU’s Director of Transportation Services, recommends using a high-quality biodiesel. CU uses Blue-Sun biodiesel, which includes an additive in the winter months to reduce the chances of any coagulation or crystallization. Flansburg explained that it is especially important to be careful with biodiesel made from recycled oils. If they contain any animal fat, this will definitely increase the chances of coagulation problems in the winter.

CU is purchasing two brand-new buses later this year, and it specified in the bid for the new buses that the warranty had to cover the use of B20. CU also uses B20 in two other newer vehicles (2004 and 2005), and Flansburg explained that he is not concerned about any warranty issues with these vehicles. “If a problem devel-

ops, the manufacturer would have to prove that it was caused by the fuel—otherwise, they would have to cover it under the warranty.”

CU began using biodiesel because of the environmental benefits. Three years ago, CU students voted to pay \$.50/student per semester to fund biodiesel use. Since there are about 30,000 students, this fee raises about \$30,000 per year. In Boulder, B20 still costs slightly more than petroleum diesel, but the price differential has narrowed in the past year with increasing prices of petroleum diesel. Most of the \$30,000 is being channeled into an outreach program to teach middle and high school students about biodiesel and its benefits.<sup>6</sup>

**Five Seasons Transportation.** Five Seasons Transportation and Parking, the municipal transit authority in Cedar Rapids, Iowa, has been using biodiesel (B20 or B10) in its bus fleet consistently since 2000. The main initial motivation was to reduce emissions of conventional pollutants (and smoke, which consists of particulate matter and hydrocarbons), for which it had received several fines from the Iowa Department of Environmental Quality. In addition to using biodiesel, Five Seasons installed an innovative system on its buses to inject 80-proof alcohol (40 percent ethanol and 60 percent water) into the engines along with diesel fuel. The 80-proof alcohol costs about \$1.30/gallon. Each bus has a computerized fuel-injection system that controls the amount of alcohol versus diesel that is injected into the cylinders. The average mixture is about 18 percent alcohol and 82 percent diesel, but the percentage of diesel increases as the engine speed (rpm) increases.

Using this combination of alcohol and biodiesel has substantially reduced both

diesel air emissions and engine maintenance costs. The alcohol helps reduce NO<sub>x</sub> emissions, more than offsetting the slight increase in NO<sub>x</sub> emissions caused by using biodiesel. Diesel engines such as the ones used in buses normally need to be rebuilt approximately every 150,000 miles. Remarkably, for Five Seasons the combination of alcohol and biodiesel usage has doubled this to 300,000 to 400,000 miles between rebuilds. Engine rebuilds normally cost about \$14,000 to \$15,000 (or about \$10,000 if done in-house). Thus, Five Seasons has avoided one rebuild and saved approximately \$14,000 per each ~300,000 vehicle miles. The initial cost per bus of installing the alcohol-injection system is about \$3,500.

Bill Hoekstra, the transportation and parking director, commented, “We have never had any problems with biodiesel.” Hoekstra explained that Five Seasons avoided any fuel gelling problems in cold

weather by making sure the biodiesel blend is high quality (by choosing a good supplier) and by making sure the biodiesel does not remain in storage too long before being used. If the fuel remains stagnant in cold weather, it can get cloudy, indicating that it is starting to solidify. Keeping the fuel moving avoids this problem. “We have never had a problem with gelling, even as cold as it can get in Cedar Rapids in the winter.”

Hoekstra explained that the alcohol fuel-injection idea originally was developed for gasoline engines on Boeing B-17 and B-25 bomber planes used in World War II to help them run cooler, and was later applied to diesel farm tractors. Hoekstra met a vendor in Radcliff, Iowa, in 1987 who claimed that alcohol would reduce emissions and improve the performance of bus engines; he convinced Hoekstra to give the idea a try.<sup>7</sup>

## Other Biodiesel Applications

Other potential applications of biodiesel include backup generators, other types of diesel equipment, and boilers. For boilers and backup generators that are operated frequently, the benefits of biodiesel should also be compared with the option of converting to natural gas. Natural gas conversion involves an initial cost, but natural gas is cheaper and has even lower emissions of most pollutants than biodiesel. The exception is that B100 produces much lower net CO<sub>2</sub> emissions than natural gas. For backup generators, proper storage of the biodiesel could present challenges.

**Underground mining equipment.** The Hutchinson Salt Company in Hutchinson, Kansas, converted all of its underground mining equipment to burning 100 percent biodiesel in 2003. The company now uses over 30,000 gallons of biodiesel per year. The main benefit so far has been the significant reduction in air emissions, especially particulates, which has made the workers happier.<sup>8</sup>

**Backup generators.** In 2001, a 6-megawatt portable backup generator system was installed at the University of California at Riverside to deal with the power crisis of 2001. The system was fueled with 100 percent biodiesel to reduce emissions.<sup>9</sup>

**Price.** Biodiesel in the U.S. currently costs an average of about \$.10/gallon more than petroleum diesel.<sup>10</sup> However, prices vary regionally, and in some locations such as Oregon biodiesel is slightly cheaper. Biodiesel is likely to become price-competitive in more locations as the price of petroleum diesel continues to increase.

**Finding biodiesel at a station near you.** There are currently about 600 retail sites in the U.S. that sell biodiesel in one or more blends. It's easy to find locations of biodiesel stations in your state by using a web site developed by the National Biodiesel Board (see [www.biodiesel.org/buyingbiodiesel/retailfuelingsites/showstate.asp?st=IA](http://www.biodiesel.org/buyingbiodiesel/retailfuelingsites/showstate.asp?st=IA)). By clicking on your state, you are provided with a list of retail sites that sell biodiesel, including the blends (for example, B20 or B100) that are available at each site.

As production increases, the number of sites selling biodiesel will increase. Biodiesel production in the U.S. has already increased dramatically in the past several years in response to new tax incentives and the increasing price of petroleum diesel. Production tripled from 2003 to 2005 to over 75 million gallons<sup>11</sup> and is expected to double again in 2006 to over 150 million gallons.

### **Tuning Up Your Fleet**

As the price of biodiesel becomes more competitive, it will become difficult to argue against it. With public pressure building to address the challenge of climate change, using blends up to at least B20 could help reduce your CO<sub>2</sub> emissions and improve your environmental image. You may also discover happier, healthier diesel engines at the same time.

## Notes

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