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Senior University garage supervisor Keith Johnson holds a sample of virgin feedstock envirodiesel. The envirodiesel, which is made from soybean oil, is mixed with regular diesel feul and used in University buses. (TREVOR CAMPBELL/Daily)

Exploring the potential of biodiesel technology

'U' buses already run on biodiesel, and the technology is becoming increasingly available for wider use

By: A.J. Hogg, Daily Science Writer

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Every time you step on a University bus, at least 20 percent of the fuel it burns is already renewable, sustainable and domestically produced.

All University vehicles with diesel engines run on B20 biodiesel, a blend of 20 percent biodiesel and 80 percent petroleum diesel, said Renee Jordan, University Fleet Manager. Biodiesel is a diesel fuel made from soybean oil, recycled waste cooking oils, or any other vegetable oil and even oil produced by algae.

If an engine can run on petroleum diesel, it can run on biodiesel.

"Biodiesel is a renewable, sustainable, environmentally friendly option that's already a mature technology," said Steven Bertman, professor of chemistry at Western Michigan University. In order to be used, biodiesel doesn't require a huge push of research and development.

"I keep hearing 'hydrogen fuel,' keep hearing 'future,' keep hearing '2030,' " Bertman said, exasperated. "We can use biodiesel now."

Biodiesel's huge advantage as a fuel comes from its renewability. The carbon dioxide emitted by burning biodiesel was taken from the atmosphere just a year earlier, when the soybean plant removed it to photosynthesize sugars for food. This means that there is no net year-to-year change in atmospheric CO2 due to biodiesel combustion.

Increased atmospheric CO2, a greenhouse gas, is a major cause of climate change. By not producing CO2 from long-stored fossil fuels, biodiesel helps keep atmospheric CO2 from rising, mitigating climate change.

In 1895, Rudolph Diesel designed his eponymous engine to run on a variety of fuels, which include nearly any hydrocarbon from gasoline to peanut oil.

"Diesels have the advantage of being inherently more efficient," Bertman said.

This is due to the use of compression ignition, which ignites the fuel without a spark plug, and higher fuel compression ratios than gasoline engines.

However, running on biodiesel is not without problems.

"It's not a perfect solution," Bertman conceded. "It's still internal combustion, and emits carbon monoxide and nitrogen oxide."

Both compounds are pollutants that affect air quality.

"But compared to the gas engine, it's a huge step forward," he said.

An October 2002 EPA study reported that emissions from soy-based B20 biodiesel, compared to petroleum diesel, have 21 percent fewer hydrocarbons, 11 percent less carbon monoxide and 10 percent less particulate matter - the black smoke you see coming out of diesel engine tailpipes. These benefits increase with increasing amounts of biodiesel in the blend. The only downside is that nitrogen oxide emission - a key step in creating ozone pollution - increased by 2 percent.

Biodiesel challenges

Bertman said there are three major challenges to revving up biodiesel use: the availability of the biodiesel in retail locations, cold weather limitations and the supply of raw oil to be converted into biodiesel.

According to the Alternative Fuel Data Center at the United States Department of Energy, there are currently nearly three times as many biodiesel pumps in Michigan as ethanol pumps. Engines do not need to be modified for biodiesel use as they do for ethanol. Ethanol has only 60 percent of the energy density of regular gas, which means poorer fuel efficiencies, whereas biodiesel is within a few percentage points of the energy density of petroleum diesel.

At cold temperatures during Michigan winters, biodiesel, like petroleum diesel, can become more viscous and resist flow. However, these problems have been solved in petroleum diesel with additives and by the way the fuel is handled.

Bertman drives a diesel Volkswagen Jetta, and runs it year-round on B50 (a 50 percent biodiesel, 50 percent petroleum diesel blend). In the summer, when cold temperatures are not a problem, he uses 100 percent biodiesel, or B100.

He praises biodiesel for being non-flammable, biodegradable, non-toxic and an excellent engine lubricant. Many people make their own small-batch biodiesel for personal use, and Bertman often demonstrates how easy this is by making it in two-liter plastic bottles during public talks on the topic.

Biodiesel is made via a chemical reaction called transesterification. You start with fresh vegetable oil or waste grease, chemically known as triglycerides. You add methanol and, as a catalyst, potassium hydroxide. After mixing this solution, you end up with glycerine, which can be composted, and fatty acid methyl esters, also known as biodiesel. You then separate out the glycerine and heat the biodiesel to remove any unreacted alcohol and water.

Triglycerides are "nature's answer to storing solar energy," Bertman said. "They're chock full of energy."

"That's why there is oil in seeds - the plant is trying to pack as much energy in as small a space as possible."

Using cropland to cultivate seed oil for biodiesel would cause domestic fuel production to compete with food production. This conflict might be avoided by using algae, which can grow in salt water, to produce triglycerides that can be converted into biodiesel. Some algae are up to 60 percent oil by mass and grow very quickly.

The Department of Energy's National Renewable Energy Laboratory issued a report in 1998, summarizing the research done from 1980 to 1996 with an emphasis on algae for biodiesel production. It concludes: "These analyses indicate that significant potential land, water and CO2 resources exist to support this technology." Algae could supply enough oil to meet our transportation and home heating needs with biodiesel.

Despite indications that using algae to produce oil for renewable, environmentally friendly, sustainable biodiesel production, the research was shut down in 1996 due to budget cuts.

"These are technological hurdles - not deal breakers," Bertman concluded. "Biodiesel has the potential of being a really important near-term solution - we could have the production capability if we tried."

Walter Weber, director of the College of Engineering academic program of concentrations in environmental sustainability agreed. "Quite frankly, biodiesel mixed with petroleum diesel will transition us very well into a hydrogen economy. We can't just leap into the hydrogen economy."

The hydrogen economy is based on using hydrogen in fuel cells for sustainable energy. Currently, there are problems in distributing hydrogen, and the technology is not readily available in vehicles.

Biodiesel supply

Meanwhile, the University is contributing to renewability and energy independence by using commercially distributed biodiesel. Last fiscal year, the University used 353,443.6 gallons of B20. Several companies bid for each fuel delivery, but it is often Wacker Oil that supplies the fleet.

Wacker Oil is located in Manchester, a half hour southwest of Ann Arbor, and looks like any BP station on the nation's roads. A close look at the fuel pumps reveals a difference. Among the usual grades of gas and diesel, you can see a biodiesel pump. Wacker Oil had the first retail biodiesel pump in Michigan.

"We have a B20 pump winterized down to 20 below, same as with diesel," said Wacker Oil's Kim Mahrle.

In the spring and fall they have B50 on a pump, and in summer they carry B99. If you prefer any other percent, they can blend it for you any time of the year.

In 2005, Wacker Oil distributed 1.3 million gallons of the 3 million gallons of biodiesel used in Michigan. The United States used 75 million gallons the same year. Compared to the billions of gallons of petroleum diesel, "it doesn't sound like much, but it's a start," said Mahrle.

"We just jumped into it with both feet," said Mahrle.

Wacker Oil has sold biodiesel since 2000, when they received a bid for B20 from the University's Transportation Services Department. It was new to them. Mahrle recalled thinking, "I guess we're going to have to figure out what this is." Six months later, they had tracked down a source.

While biodiesel is "very close to production in Michigan," Marhle said that for the time being, they ship it into the state via semi-trailer or rail from as far away as Florida or Texas.

Last week, petroleum diesel at Wacker Oil cost $2.50/gallon, and the B20 cost $2.56/gallon.

In January 2005, new incentive credits went into effect as part of the American Jobs Creation Act of 2004. This allowed a one-cent rebate per gallon for every 1 percent of biodiesel in the fuel blend. Therefore, B20 fuel gives a rebate of 20 cents per gallon, B50 results in a 50-cent credit, and B99 fuel refunds 99 cents.

In the cold months, when only B20 is available at the pump, biodiesel costs end up near the cost of petroleum diesel, but in warmer weather, when higher blends are sold, biodiesel is often cheaper than petroleum diesel,due to this incentive credit.

"We pass it on in full," Mahrle said.

In order to be sold, biodiesel needs to meet American Society for Testing and Materials specifications for its composition. Producers and marketers of biodiesel have developed a more stringent standard, a BQ9000 certificate, which includes handling, records and tracking of the fuel.

Close to home

Weber thinks the University could take another step in its greening of the campus now that it has started with B20 biodiesel. In 2004, four of his students, Andres Clarens, Lisa Colosi, Ko Nakamura, and Joe

Seidel, investigated the University's ability to make biodiesel out of used cooking oil from the cafeterias on campus and published a report titled, "A Slick Method to Advance Sustainable Mass Transportation at U of M."

The report concluded that the University could produce biodiesel from its cafeteria waste grease, reduce environmental impacts, and save approximately $28,000 each year.

This savings could increase if the source of grease was expanded to include the University Hospital and area restaurants. However, it would entail the University getting into the biodiesel production business, or contracting to have its waste grease converted into biodiesel.
