An Evaluation of Converting Wellesley's Diesel Fleet to B20 Biodiesel

Biodiesel offers Wellesley College a chance to demonstrate a commitment to the environment without a costly change of infrastructure. The conversion of vehicles from the use of conventional petrodiesel to cleaner biodiesel is a painless process, with minimal costs to the college, and is one that yields many benefits. The use of biodiesel provides all the important and beneficial properties of vehicle fuel while yielding environmental benefits. This report will evaluate the costs, feasibility, and environmental benefits of switching Wellesley's diesel-run maintenance vehicles to use a 20% biodiesel fuel blend instead of 100% petrodiesel.

Background on Biodiesel

Biodiesel is one of the most extensively tested alternative fuels currently on the market. This renewable fuel can be produced from a wide variety of materials including vegetable oils, animal fats, and waste or recycled oils. The biodiesel used in fuel undergoes a rigorous inspection process in order to ensure that it meets industry specifications and performance standards. In fact, biodiesel is the only alternative fuel that has completed the health effects testing requirements of the Clean Air Act.[1]

Biodiesel can be made from any combination of 100% biodiesel and diesel. Common blends include B5, a blend of 5% biodiesel and 95% diesel, B20, 20% biodiesel and 80% diesel, and B100, 100% biodiesel. B100 costs more than B20, and B20 costs more than petrodiesel, but several studies have shown that the lower maintenance cost associated with mechanical advantages of biodiesel outweigh extra fuel costs.

[1] http://www.biodiesel.org/pdf_files/fuelfactsheets/HealthEffectsTesting.PDF

Biodiesel can be used in any diesel vehicle. If conventional petrodiesel has formerly been used, however, pure biodiesel will act as a solvent and dissolve accumulated diesel residue, clogging a vehicle's fuel filter, tanks and delivery systems. To avoid this potential clogging, the filters in older vehicles should be changed before converting to biodiesel. For newer vehicles, there is no evidence that lower-blend diesel, such as B20, clogs filters.[2]

Biodiesel emissions also differ greatly from petroleum diesel emissions. A biodiesel blend reduces the deleterious effects of emissions on human health. The amount of particulate matter, linked to asthma, along with other air-pollution, is reduced. It is, however, important to note that biodiesel may emit more nitrogen oxides (NOx) than conventional diesel.[3]

Biodiesel comes from renewable sources and contributes less to climate change than conventional diesel. Unlike fossil fuels, biodiesel can come from plants, which can be harvested in a sustainable manner. In addition, although a car running on biodiesel still releases CO_2 into the atmosphere, a plant being grown to produce biodiesel sequesters CO_2. Biodiesel thus results in lower overall greenhouse gas emissions than petrodiesel.

Not only are biodiesel blends more environmentally sustainable, they also offer advantages over pure diesel fuel. Biodiesel has a higher cetane number and a higher BTU content (a measure of heat energy), both of which help maximize engine performance. Biodiesel also increases fuel quality by raising lubricity. The National Biodiesel Board

[2] http://www.filtercouncil.org/techdata/tsbs/06-1.pdf
[3] http://www.newfuelco.com/faq.php

(NBB) states that even biodiesel blends of 1% can provide up to 65% increase in lubricity, over time requiring fewer oil changes.[4]

Biodiesel in the United States

The current use of biodiesel in the United States is increasing. There are biodiesel pumps across the country, and large fleets like those of the U.S. Postal Services, transit authorities, construction companies, and even farmers are running on some form of biodiesel blend.[5] From 2004 to 2005 alone, biodiesel volumes tripled, growing from 25 million gallons to 75 million gallons.[6] Many states are considering biodiesel legislation requiring a certain percentage of the diesel sold in-state to be biodiesel or exempting biodiesel from state diesel tax. [7]

Implementation of Biodiesel at Other Educational Institutions

Many prominent educational institutions have been able to integrate biodiesel into their operations. At both large universities and small colleges, maintenance and agricultural fleets have converted to run on B20 biodiesel. Pennsylvania State University,[8] Cornell University,[9] University of New Hampshire,[10] Keene State

[4] http://www.biodiesel.org/pdf_files/fuelfactsheets/lowblendFAQ.PDF
[5] Yokaya Biofuels. "Uses of Biodiesel Fuels." ybiofuels.org. 2003. <http://www.ybiofuels.org/bio_fuels/uses.html>
[6] NBB. Biodiesel Backgrounder. Jefferson City: National Biodiesel Board, 2006. <http://biodiesel.org/pdf_files/fuelfactsheets/backgrounder.PDF>
[7] "2007 to be a Bumper Crop Year for Legislation" from April 2007 Issue of the Biodiesel Bulletin put out by the National Biodiesel Board, which can be found at http://biodiesel.org/news/bulletin/2007/040207.htm
[8] <http://www.aginfo.psu.edu/News/06Oct/Biofuels.htm>
[9] <http://www.news.cornell.edu/stories/Jan07/sustainability.biofuel.html >
[10] Pers. comm. Pesci, Stephen, Special Projects Manager at Planning and Transportation services, UNH. 603-862-4297. 02/27/07

University,[11] St. Olaf University,[12] Middlebury College,[13] and Mt. Holyoke[14] are some of these schools. Some schools, like Harvard,[15] Yale,[16] and the University of New Hampshire[17] have also begun to run their transit fleets on biodiesel blends.

In addition to experiencing localized environmental benefits, many of these schools have used biodiesel to affect environmental change in the community. Cornell convinced the local transit authority and school district to commit to buying B5 biodiesel for their vehicles.[18] The rest of these institutions are increasing local demand for biofuel, thus encouraging suppliers to make it more widely available for everyone to use.

These schools are very proud of their demonstration of an environmental commitment, but are also thrilled with the ease of the transition and the biodiesel's performance. Harvard actually chose to switch to biodiesel because they found it to be more cost-effective and less harmful to the environment than conventional diesel, compressed natural gas, and even electric vehicles.[19] These schools tout the ease of converting to biodiesel. Many of the schools were initially concerned about the cold-weather effects on biodiesel (See *Potential Complications* on page 5). Some schools, like Harvard and UNH, have run tests showing these effects to be negligible, and no schools have reported difficulties with B20 arising from cold weather. In fact, none of the schools we contacted reported any complications with a B20 conversion.

---

[11] <http://www.keene.edu/newsevents/default.cfm?Type=NewsDetail&News_ID=1120>
[12] <http://www.stolaf.edu/green/report/status/4.html>
[13] <http://www.nwf.org/campusEcology/files/Yearbook%20Entry-FINAL15.pdf>
[14] <http://www.mtholyoke.edu/offices/es/10722.shtml>
[15] <http://www.greencampus.harvard.edu/>
[16] <http://www.yale.edu/parkingandtransit/shuttle/biodeisel.htm>
[17] Pers. comm. Pesci, Stephen, Special Projects Manager at Planning and Transportation services, UNH. 603-862-4297. 02/27/07
[18] <http://www.news.cornell.edu/stories/Jan07/sustainability.biofuel.html>
[19] <http://www.greencampus.harvard.edu/sip/documents/AlternativeFuelVehiclesInternship2001.pdf>

Wellesley can draw from the experiences of these institutions, especially the smaller schools running their maintenance equipment on biodiesel. We can easily make the transition from our facilities and management fleet running on conventional diesel to B20 biodiesel blend.

Biodiesel at Wellesley

Choosing a Blend

Although biodiesel can be used as a pure fuel, a blend of biodiesel and petroleum will maximize the net benefits for Wellesley College. For Wellesley's conversion to biodiesel we recommend B20 to eliminate any possibility of the warranty being voided. Although any diesel engine can use biodiesel, the current infrastructure is especially well adapted to biodiesel fuel since the switch to low-sulfur diesel fuel.[20]

Potential Complications

Despite the ease of biodiesel conversion, biodiesel raises a few small concerns. One concern, especially with pure biodiesel, is its tendency to crystallize in cold weather, which reduces an engine's ability to run. B100 starts to crystallize at around 32°F, but even traditional diesel will gel at very cold temperatures. B20, like petrodiesel, does not begin to gel until -15°F. Thus, any cold-weather effects on B20 are negligible and there is no need for anti-gelling additives. In addition, the University of New Hampshire just completed its first study on the cold weather effects on biodiesel, and has experienced no such problems thus far.

[20] <http://www.biodiesel.org/resources/faqs/>

We must also consider the possible maintenance cost of filter changes associated with converting to biodiesel. Filters must be changed on a regular basis regardless of fuel type, so this cost is not necessarily additional. It may, however, require that filters are changed prior to when they normally would have been changed, especially in older vehicles.[21]

In the long term, however, there could be a longer time between fuel filter and oil changes because biodiesel leaves less carbon deposits than regular diesel. While this benefit is possible, at the very least biodiesel maintenance will not lead to increased maintenance costs. David Harris Jr., General Manager of Operations and Finance of Harvard University's Transportation Services, recently stated, "We have not completed any "documented" study that B20 reduces maintenance costs. I can tell you that we have not had any "increased costs" related to using B20."[22]

The National Biodiesel Board suggests researching vehicles' Original Equipment Manufacturer (OEM) or engine warranty statements. It is important to consider whether an engine manufacturer will void its parts and workmanship warranty when biodiesel is used and whether the fuel producer or retailer will stand behind its fuels if problems arise.[23] Most engine manufacturers do not void their parts and workmanship warranties when B20 is used in their engines.

Wellesley's Diesel Infrastructure

[21] National Biodiesel Board. "Biodiesel Usage Checklist." http://www.biodiesel.org/pdf_files/fuelfactsheets/bdusage.PDF
[22] Harris Jr., David E. "Re: biodiesel study question." E-mail to Lauren Gritzke. 9 Apr. 2007.
[23]National Biodiesel Board. "Standards and Warranties." 8 Apr. 2007. http://www.nationalbiodieselboard.org/resources/fuelfactsheets/standards_and_warranties.shtm

Wellesley currently owns 23 maintenance and facilities diesel vehicles that could be converted to biodiesel. This includes seven trucks, four tractors, two skidsteers, two holders, one sweeper, one wood chipper, one weed harvester boat, and five large mowers.[24]

Wellesley already has its own filling station, with one gasoline pump and one diesel pump. There are two tanks dispensing to the diesel pump: one has a capacity of 500 gallons, and the other has a capacity of 1000 gallons.[25] Due to this existing infrastructure, start-up costs of conversion would be minimal. Burke Oil, Wellesley's fuel supplier, made nineteen deliveries of fuel to Wellesley in 2006. In that year, Wellesley bought 9,419 gallons of petrodiesel from Burke at a total cost of $21,795.[26]

Pilot Program: Five-Vehicle Switch

We are not recommending an immediate switchover of the entire diesel fleet; rather, we advocate a pilot program in which we run five of our vehicles on biodiesel for a one-year period. These five vehicles would consist of one truck (of the seven we have), one tractor (of four), one skidsteer (of two), one holder (of two), and one large mower (of five). These five vehicles would be representative of our fleet, but would never require all of any type of vehicle to run on biodiesel. For one year, these vehicles would require:

(9419 gallons of fuel) * (5 vehicles/23 vehicles)

= **2048 gallons of fuel** (used by these 5 vehicles over the course of the year)

---

[24] Pers. comm. Willoughby, Patrick, Physical Plant Associate Director, Wellesley College. pwilloug@wellesley.edu. 04/29/07

[25] Pers. comm. Olmsted, John R., Manager of Landscape and MotorPool, Wellesley College. jolmsted@wellesley.edu. 05/11/07

[26] Pers. comm. Willoughby, Patrick, Physical Plant Associate Director, Wellesley College. pwilloug@wellesley.edu. 04/29/07

Burke Oil offers B20 biodiesel that can be delivered in five-gallon pails, 55-gallon drums, or by the tankful straight to our pump[27]. For the pilot program, we offer two choices. The first choice is to fill the smaller 500-gallon tank with B20. It should be noted that biodiesel delivered directly to the pump is cheaper than the smaller quantities. The alternative choice is to have Burke deliver 55-gallon drums to be stored at the motor pool, which would be used to fill the tanks of the vehicles running on biodiesel. These drums will be easy to store because unlike diesel, biodiesel is safe to handle, store and transport and it offers many safety benefits as it is much less combustible.[28]

If we converted the 500-gallon diesel tank, filling it at each delivery to 80% capacity (400 gallons out of the 500-gallon capacity), we would need in a year:

(2048 gallons of fuel) / (400 gallons of fuel / delivery)

= **5.12 deliveries**

If we decided not to convert the tank and opted for the 55-gallon drums, we would need:

(2048 gallons of fuel) / (19 deliveries)

= 108 gallons of fuel / delivery

Burke could deliver **two 55-gallon barrels every two to three weeks**. Burke delivery trucks work on a will-call basis, can deliver any day of the week (although it is

[27] Burke Oil, "Fleetline Product Information: Patriot B20 Biodiesel." http://www.burkeoil.com/pdf/patb201.pdf

[28] National Biodiesel Board. "Environmental and Safety Information." http://www.biodiesel.org/pdf_files/fuelfactsheets/Environment_Safety1.pdf

most convenient on weekdays before 4PM), and would easily accommodate us if our delivery needs were to change.

B20 prices, like other fuel prices, fluctuate. Even though B20 usually costs a few cents more per gallon than petrodiesel, this cost is on a downward trend. Sometimes B20 even costs less, like in March 2007 when the price of B20 was 7 cents lower than the price for conventional diesel.[29] Local distributor Burke Oil estimates an additional cost of 12-24 cents per gallon for B20, compared to conventional diesel.[30]

For Wellesley College, over the course of the pilot program, this will cost:

[Per gallon price of diesel in 2006: ($21,795) / (9419 gallons) = **$2.31/gallon**]

Cost of Diesel Saved (not being bought because we're using biodiesel in some vehicles):

(2048 gallons) * ($2.31/gallon) = **$4730.88**

Savings/Costs of Switching to biodiesel:

Low Estimate: - $0.07 + $2.31 = $2.24/gallon

[$4730.88] - [2048 gallons * $2.24/gallon]

= $143.36

We would save $143.36 over the course of the year.

Medium Estimate: + $0.12 + $2.31 = $2.43/gallon

[$4730.88] - [2048 gallons * $2.43/gallon]

= -$245.76

[29] U.S. Department of Energy: Energy Efficiency and Renewable Energy. *Clean Cities Alternative Fuel Price Report.* Washington, DC: U.S. Deparment of Energy, 2007. 3.

[30] Pers. comm. Pesci, Stephen, Special Projects Manager at Planning and Transportation services, UNH. 603-862-4297. 02/27/07

It would cost us $245.76 extra over the course of the year.

High Estimate: + $0.24 + $2.31 = $2.55/gallon

[$4730.88] - [2048 gallons * $2.55/gallon]

= -$245.76

It would cost us $491.52 extra over the course of the year.

Full Conversion

After a year, the college could consider a complete switch of the fleet to biodiesel. If the pilot program has run smoothly, the college can change the fuel filters on the remaining diesel vehicles, and start receiving deliveries of biodiesel directly to the diesel pump, which would simply dispense Burke's B20 biodiesel blend instead of petrodiesel.

For Wellesley College, once the conversion of all our diesel vehicles to B20 has occurred, this difference in cost would be:

[Per gallon price of diesel in 2006: ($21,795) / (9419 gallons) = $2.31/gallon]

Estimated cost of biodiesel:

Low Estimate: - $0.07 + $2.31 = $2.24/gallon

9,419 gallons * $-0.07= **-$659.33**

($659.33) / ($21,795)

= 3% savings from 2006 prices

Medium Estimate: + $0.12 + $2.31 = $2.43/gallon

9,419 gallons[1] * $0.12= **$1130.28**

($1130.28) / ($21,795)

= 5% increase

High Estimate: + $0.24 + $2.31 = $2.55/gallon

9,419 gallons * $0.24 = **$2260.56**

($2260.56) / ($21,795)

= 10% increase

Environmental Effects

There are many environmental benefits to using biodiesel. Biodiesel reduces harmful emissions significantly. By using B20, we will benefit from a 12% reduction in carbon monoxide, a 12% reduction in particulate matter, a 20% reduction in hydrocarbons and a 20% reduction in sulfates.[31] B20 reduces CO_2 emissions by 20%.[32] Carbon monoxide is a poisonous gas, inhalation of particulate matter can lead to respiratory disease, hydrocarbons lead to smog and ozone, sulfates can lead to acid rain, and carbon dioxide contributes to climate change. In addition, biodiesel exhaust odor is less offensive than diesel exhaust.[33] In general, there will be less localized pollution from biodiesel, leading to health benefits to Wellesley students, staff and other members of the local community.

Some of these benefits or reduced emissions can be quantified; the calculations below are based on the assumption that the combined gas mileage of Wellesley's fleet

[31] National Biodiesel "Board. Biodiesel Emissions." http://www.biodiesel.org/pdf_files/fuelfactsheets/emissions.pdf
[32] http://www.coolitchallenge.org/documents/CoolItcalcInstruct1.3.pdf
[33]National Biodiesel Board. "Interesting Facts about Biodiesel." http://www.biodiesel.org/markets/gen/

averages at 10 mpg. All estimates of emissions reductions per gallon of biodiesel are based on the assumption that the diesel already in use is at federal regulation standards.[34]

Carbon dioxide: 20% reduction

[Gallons of diesel fuel currently used] * [Amount of carbon dioxide emitted per gallon] * [20%] = Amount of carbon dioxide emissions reduced by using biodiesel

Reductions resulting from biodiesel conversion:

$$= (20\% * \frac{22\,pounds}{gallon}) = 4.4\,pounds/gallon$$ [35]

Total annual CO_2 reductions for Wellesley:

$$= 9419\,gallon * \frac{0.2\,g}{gallon} = 1{,}884\,grams/year$$

Carbon monoxide: 12% reduction

Reductions resulting from biodiesel conversion:

$$= \frac{4.2\,grams}{mile} * \frac{1\,pound}{454\,grams} * \frac{10\,miles}{gallon} = .093\,pounds/gallon$$

$$= (20\% * \frac{.093\,pounds}{gallon}) = 0.0186\,pounds/gallon$$

Total annual CO reductions for Wellesley:

$$= \frac{9419\,gallons}{year} * \frac{0.0186\,pounds}{gallon} = 175\,pounds/year$$

Particulate matter: 12% reduction

Reductions resulting from biodiesel conversion:

[34] Code of Federal Regulations. Title 40, Volume 16. < http://a257.g.akamaitech.net/7/257/2422/14mar20010800/edocket.access.gpo.gov/cfr_2002/julqtr/40cfr86.1812-01.htm>

[35] 22 pounds/gallon estimate from http://www.epa.gov/otaq/climate/420f05001.htm

$$= (20\% * \frac{1gram}{gallon}) = .2g / gallon$$

Wellesley's total annual particulate matter:

$$= 9419gallon * \frac{0.2g}{gallon} = 1{,}884grams / year$$

Hydrocarbons: 20% reduction

Reductions resulting from biodiesel conversion:

$$= \frac{.8g}{mile} * \frac{1lb}{454g} * \frac{10miles}{gal} = .0176lb / gallon$$

$$= 20\% * \frac{.0176lb}{gallon} = .0.00352lb / gallon$$

Wellesley's total annual particulate matter:

$$= \frac{9419gallon}{year} * \frac{0.00352lb}{gallon} = 33.2lb / year$$

Sulfates: 20% reduction

No value for sulfate emissions is readily available. However, the college will see an annual reduction of 20% by converting to biodiesel

There are also possible environmental costs associated with biodiesel use. Nitrogen oxide (NO_x) emissions from biodiesel may increase or decrease by 2% depending on the type of engine used and testing practices.[36] Nitrogen oxides lead to localized smog and ozone. If an increase in nitrogen oxides does result from biodiesel use, however, there are means of mitigating these emissions. Many biodiesel companies have developed additives to significantly reduce NO_x emissions from biodiesel.[37]

[36] National Biodiesel Board. "Biodiesel Emissions."
[37] National Biodiesel Board. "Biodiesel Emissions."

Conclusion

A conversion of Wellesley's diesel fleet to run on biodiesel would be nearly painless. Compared to the $24,000 Wellesley spends each month to dispose of its trash, even the highest cost estimates ($491.52 for the pilot program, $2260.56 for the full switchover) for a diesel conversion program are minimal. In addition, Wellesley's existing infrastructure already includes the capabilities to receive and dispense biodiesel.

This cheap, easy conversion to biodiesel would also yield environmental benefits to Wellesley College, with decreases in emissions of pollutants like carbon dioxide, particulate matter, and sulfates. The air quality of Wellesley would be increased, and the college's environmental impact would be decreased.

Wellesley's environmental action, demonstrated by switching to biodiesel, would boost the college's environmental reputation, which recently received negative press attention. Sustainable Endowments Institute issued a sustainability report of colleges and universities that received coverage in USA today and the Boston Globe. Wellesley received a C in this report, while colleges such as Williams, Harvard and Dartmouth received A-'s. In order to better compete with these colleges for applicants and to attract more alumnae donations, Wellesley should display a commitment to the increasingly popular idea of sustainability.

In evaluating the costs, environmental benefits, and feasibility of switching campus-owned diesel vehicles to run on a B20 biodiesel blend, our research and analysis has shown that such a switch would yield favorable results for Wellesley. It is a small

change that Wellesley could easily implement to demonstrate a commitment to the environment at a very low cost.