Use of Biodiesel as a Heating Oil in New England

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Background and Summary

Biodiesel is a fuel manufactured from vegetable oil (soybean oil is most widely used), recycled cooking grease, or animal fats. Used as a heating fuel biodiesel has numerous benefits over standard (#2) heating oil. These include reduced maintenance costs for heating oil systems, health and environmental benefits, increased fuel diversity and energy independence for the region and nation, and keeping more energy dollars in the region and nation.

Except for power production and co-generation, Biodiesel is rarely used in 100% ("neat") form. Because of costs, availability, and the fact that 100% Biodiesel gels at warmer temperatures than equivalent petroleum fuels, a blend of biodiesel and petroleum diesel/No. 2 is generally the norm for most applications. B-20 (a blend that is 20% biodiesel and 80% No. 2 distillate) is currently the most common blend, followed by B-5 (5% biodiesel and 95% No. 2 distillate). The heating oil industry in New England has not arrived at a standard percentage for general use. For the reasons given above, any such standard (if ever implemented) would likely be B-10, B-5 or less.

Benefits of Biodiesel as a Heating Fuel

- Reduced sulfur emissions.
- Reduced C02 emissions.
- Reduced NOx emissions.
- Reduced particulate emissions.
- Biodegradable and non-toxic.
- Renewable energy source with a positive energy balance.
- Helps move nation towards energy independence.
- Increased burner life and less maintenance.
- Reduced odor.
- Higher temperature flash point makes the fuel safer.

The American Society for Testing and Materials (ASTM) approved specifications for biodiesel in December 2001 (D-6751). It is strongly recommended that biodiesel used for heating oil must meet that standard. This standard ensures that the product will not gel at a warmer than expected temperature, and that it will not harm engines and equipment because of poor fuel characteristics.

Currently, the only reliable source of ASTM biodiesel in New England is from a company called World Energy with operations in Chelsea, MA. World Energy's product comes almost entirely from soy beans grown in the Midwest. The development of a biodiesel source using reclaimed grease as a feedstock would further increase the environmental and economic benefits of biodiesel, particularly if the processing plant was located in the region.

Biodiesel makes an excellent heating oil fuel, and its use should be further promoted along with greater use of low-sulfur heating oil.

Energy Balance and CO_2 Emissions

Biodiesel is better than ethanol in terms of having a positive energy balance, according to studies by David Pimental, a Cornell University professor of ecology and agricultural sciences and others. According to U.S Department of Energy "Modern, high-yield corn production is relatively energy intense, but the net greenhouse gas emission reduction from making ethanol from corn grain is still about 20%. Making biodiesel from soybeans reduces net emissions nearly 80%, about a 60% better energy balance for biodiesel.[1]" The National Renewable Energy Laboratory found that B-100 has a net energy gain of 220% of energy inputs over gains. Petroleum diesel (similar to #2 heating oil), has a net energy loss of 17%. Therefore, a B-20 blend has net energy loss of 2%.[2] Another study by the Institute for Local Self-Reliance (funded by the United Soybean Board) found that the ratio for B-100 can be as high as 251%[3] and another study found Biodiesel to have a 3.2 to 1 positive life cycle energy balance, beginning with bare ground and counting all inputs for growing, harvesting, processing and transportation.[4]

Relationships Among Biodiesel, No. 2 Heating Oil, Sulfur, and Nitrogen

In New England, No. 2 distillate has a sulfur content of 1500-2500 ppm (0.15-0.25% by weight). By contrast coal can be 5% sulfur. The oil heat industry is working towards marketing low sulfur product of 500 ppm. That would be a minimum 66% cleaner.

Sulfur and sulfur oxides are precursors for acid rain, therefore, reducing sulfur is critical for reducing the impacts of acid rain. In addition, 77% of the particulate matter produced in oil-fired heating systems is related to the sulfur content. Reducing sulfur helps reduce particulates, and particulates pose very serious health risks by contributing to respiratory illness, asthma and cancer. Reducing sulfur also helps to reduce the nitrogen content in the fuel during the refining process. Nitrogen is a key smog-causing pollutant.

B-20 has 20% less sulfur than regular #2 heating oil (see table). Using low-sulfur heating oil in the B-20 blend can further reduce the sulfur content.

Research generally shows that using biodiesel reduces most traditional diesel pollutants, including CO and NOx. There has been some concern regarding increased NOx emissions in vehicles. However, for home heating applications NOx emissions are reduced by using biodiesel.[5]

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[1] Producing ethanol from cellulosic material also involves generating electricity by combusting the non-fermentable lignin. The combination of reducing both gasoline use and fossil electrical production can mean a greater than 100% net greenhouse gas emission reduction."
http://www.eere.energy.gov/biomass/environmental.html

[2] "An overview of Biodiesel and Petroleum Diesel Life Cycles," NREL, May 1998

[3] "How Much Energy Does It Take to Make a Gallon of Soydiesel", by I. Ahmed, J. Decker, D. Morris. Institute of Local-Self Reliance, Washington DC, January 1994.

[4] "Life Cycle Inventory of Biodiesel and Petroleum Diesel for Use in an Urban Bus", NREL, May 1998

[5] For internal combustion engines, however, NOx emissions may be higher. Recent tests indicate that some additives are effective at reducing NOx emissions from biodiesel. It is important to note that combustion tests did not include exhaust gas recirculation (EGR) or other NOx treatments that are available in many of today's

According to a paper presented by Carlin Combustion Technology Inc. to the 2002 National Oilheat Technology Symposium, there are a number of low cost, near, or no cost ways to reduce NOx emissions in residential oil burners including:

- A well tuned burner can reduce NOx emissions by 5% or more.
- For an ignition control upgrade of $5, a 10% NOx reduction can be made.
- For a nickel a gallon, low sulfur heating oil will produce a 10% NOx reduction.
- Ultra low sulfur heating oil would produce a 20-30% NOx reduction.
- Combinations of the above, perhaps with biodiesel.

As a result of the multiple benefits of reducing sulfur, early results from a Brookhaven National Laboratory study, in process, suggest that the total environmental costs of low sulfur heating oil are lower than those for natural gas.

The Massachusetts Oilheat Council and the Northeast Oilheat Research Alliance have tested a blend of B-20 with low sulfur heating oil. B-20 mixed with existing #2 heating oil (2000 ppm sulfur), would result in the following emission reductions *:

Emission	**Health/Environmental Effect**	**B-20 reduction** (over #2 oil)
CO_2	climate change	~15%*
CO	smog, asthma	12%
Hydrocarbons	smog, asthma, cancer	20%
Particulates (PM)	respiratory illnesses	12%
Nitrogen Oxides	smog	0-2%
Sulfur Oxides	acid rain	20%
Other Air Toxics	cancers, general air pollution	12-20%
Mutagenicity	cancer precursors, endocrine disruptors	20%

* Figure ES-A Environmental Protection Agency Draft Technical Report EPA420-P-02-001 B100 typically results in a 78% reduction in CO_2, B20 is roughly 1/5 that of B100. Respiration by plants used in plant-based biodiesel can completely offset CO_2 emissions.

Other environmental benefits of Biodiesel [6]:

Biodiesel is non-toxic and biodegrades four times faster than conventional diesel. Biodiesel therefore presents a much smaller risk in the case of spills in marine and other sensitive environments.

Production of biodiesel creates approximately 95% less hazardous waste than petroleum diesel production but more than double the amount of non-hazardous waste. Hazardous waste generally comes from chemical products associated with petroleum refining. The majority of non-hazardous waste from biodiesel is attributed to unprocessed plant material

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more advanced engines. There are a number of NOx treatment methods for vehicle applications. See: http://www.epa.gov/otaq/models/analysis/biodsl/p02001.pdf

[6] Taken from the Union of Concerned Scientists website

from the soybean crushing stage. Theoretically this unprocessed plant material could even be used as compost or to produce electricity.

Issues Relating to Supply and Production

Since biodiesel is made from plant-based oils, or animal and plant waste stream sources, it is considered a renewable fuel. However, the potential impacts of greater use of biodiesel are more complicated than other renewable sources, given the direct relationship with land-use and agricultural issues.

Currently the only source of biodiesel in our region is from "virgin" soy oil grown in the Midwest, namely World Energy, of Chelsea (www.worldenergy.com). However, although this is "virgin" oil, it is actually a by-product (or "co-product") of existing soy production that would likely remain unchanged whether or not the oil was used for biodiesel or another end-use. The reason for this is because soybeans are grown primarily for their protein content, and secondarily for their oil. The dollar value of the soy meal is an order of magnitude greater than the dollar value of the oil. It is safe to say that soy is grown for its protein, and any additional uses for the oil represent an added value to the farmer[7].

Even if current biodiesel comes from oil that is a by-product of extant agriculture practices, ideally our supply would not come directly from sources that raise environmental concerns. One way to address this concern would be to use only waste vegetable and animal fat resources. Currently, these resources are estimated to be able to sustain production on the order of 1 billion gallons of biodiesel per year, or less than 3% of current diesel use.[8] So while waste sources will not make significant impact in terms of simple percentage of consumption, use of these resources would be meaningful given the other benefits of using biodiesel at even the 3% level, and more efficient or beneficial use of waste.

Widespread use of biodiesel beyond this 3% level would require more virgin plant oils or other waste stream sources to meet the larger demands. The potential for large volume use of biodiesel therefore raises the same concerns about genetically modified crops (GMOs), pesticide use, and land-use impacts common to all plant-based fuels, or food production generally for that matter. Ideally, crops for biodiesel would be grown in a manner that supports wildlife habitat, minimizes soil erosion, avoids competition for food crops, and does not rely on the use of harsh chemicals, fertilizers, and GMOs. Or, it might simply be that biodiesel is never used beyond the 3% level, and serves only as a "transition" fuel to cleaner, renewable alternatives to #2 heating oil and diesel.

Given that biodiesel today is essentially a by-product of food production, and in any case a very small use of crop production relative to total crop production, issues around the use of virgin oils would not seem to be of immediate concern. However, going forward recycled (reclaimed), organic, and/or non-GMO virgin oil supplies should be sought and actively pursue as described below.

Ideally Biodiesel used in New England would be processed from feed stocks that are both local/regional and environmentally benign. Currently supply from these sources is very limited, of uncertain availability, and not likely to meet ASTM certification. Building

[7] See, for example, www.unitedsoybean.org
[8] NREL, Urban Waste Grease Resource Assessment, November 1998

demand for biodiesel using the sources that are currently available (from Midwest "virgin" soy) would increase the overall biodiesel market size and thus facilitate the development of these better sources. Indeed, given the many benefits of biodiesel, a number of regional biodiesel-from-waste projects are already underway. Some of these are:

- A consortium composed of the largest waste grease collector in New England, a fossil fuel distributor, and a Rhode Island entrepreneur and biodiesel expert (Bob Cerio) are developing a plant that will use waste grease from the region to produce biodiesel. Currently this waste grease is collected and used for animal feedstock and other uses. The plant is expected to be operational by the end of 2005[9].

- Fred Gordon, a Boston-based business person, is actively developing a project that would produce ASTM certified biodiesel using recycled grease.

- In September 2003, the Vermont Alternative Energy Corporation was awarded a grant to take "Steps Towards a Biorefinery Industry in Vermont".

[9] Bob Cerio, personal communication with People's Power & Light.