Biodiesel Use in Madison's Fleet:
Charting a Path to a Sustainable Future

Report prepared on behalf of the City of Madison's Sustainable Energy and Design Committee by Evan Murdock[1], Jessica Athens[2], David Zaks[1], and Rachel Licker[1]

[1] Nelson Institute for Environmental Studies, University of Wisconsin - Madison
[2] Department of Population Health Sciences, University of Wisconsin - Madison

December 10, 2007

With the push by Governor Doyle to make Wisconsin a leader of the emerging bioeconomy, the production of biodiesel is likely to become an increasingly important part of the State. An additional urgency for Wisconsin and its municipalities to explore non-petroleum energy sources such as biodiesel comes from the causal link between fossil fuel combustion and global climate change. While biodiesel combustion has been demonstrated to have carbon dioxide emission reductions relative to its petroleum-based counterparts, its production can have impacts on water and land quality, as well as human health. It is therefore important to have a broad scope – one that includes a look at the production pathways of biodiesel and its effects on land, water, and human health - when evaluating the ability of the feedstocks to improve a region's sustainability.

Sourcing biodiesel feedstocks that are sustainably produced is thus an important challenge in ensuring that Wisconsin develops a bioeconomy that does more good than harm. Luckily, biodiesel feedstocks exist that are locally obtainable, relatively inexpensive, and have benefits for the environment and public health relative to other fuel sources. *The City of Madison, a leader in the incorporation of biodiesel into public fleets, has the opportunity to support production pathways that are beneficial to the State and City's economy, environment, public health, and public policy arenas.* The following document outlines the benefits and risks of producing biodiesel and incorporating it into Madison's diesel fleet.

The Carbon Footprint of Madison's Diesel Fleet

In light of the M-Power campaign, switching a portion of the City's fleets over to a biodiesel blend could have significant reductions in its carbon dioxide emissions and help Madison achieve its 100,000 ton Clean Energy Program goals. For example, a switch to a B20 blend could lead to a reduction in 3,000 tons of carbon dioxide released over the course of the campaign.

Mix	Carbon Dioxide Reduction (Tons)	Percent
B5	800	~ 4
B20	3,000	~ 15
B100	17,000	~78

Soybeans, Agricultural Land Use, and Wisconsin's Economy

It is well known that agriculture is central to both the economy and culture of Wisconsin. Soybean cultivation constitutes a significant percentage of income generated through crop agriculture – nearly 18 percent of the State's 2.5 billion dollar industry. Similarly, soybean-producing cropland represents almost 20 percent of the area dedicated to growing field crops in the State of Wisconsin, and almost 5 percent of the State's total area (USDA, 2007). Therefore, what happens on these agricultural lands is important for the quality of Wisconsin's environment, as well as its economy.

The drive to use biofuels is expected to shape agricultural land-use in the Wisconsin. Changing agricultural economies may render previously marginal lands economically viable for crop production and may encourage more intensive cropping or a change in rotation patterns on lands already in production. For example, farmers situated in close proximity to soybean crush facilities will likely have an economic incentive to produce as many soybeans possible, and may switch to a soy-only rotation (Conley, 2007).

Agricultural Land Use and Water Quality – Potential Benefits

The potential changes in agricultural land use practices outlined above could have potentially dramatic impacts on Wisconsin's waters. Water issues may be divided into two major areas of concern: water quantity and availability, and water quality. Water quantity is affected in multiple ways - through agricultural withdrawals (estimated at 34% of all freshwater withdrawals in the United States in 2000 (Hutson et al 2004), and 80% of consumptive water use), and by altering the way water infiltrates the land after rainfalls. Water quality is affected by fertilizer and pesticide application, as well as by sediment loading.

Potential impacts, however, are just that - the outcomes of expanded biofuels use cannot yet be predicted with great certainty. This is because the effects are strongly dependent on the production pathways chosen. Given the seeming inevitability of biofuels expansion (both in general and in Wisconsin) the question is not whether biofuels will be produced in Wisconsin, but which fuels will be produced, and which feedstocks will be developed.

From the standpoint of water quality, biodiesel produced from soybeans has a significant advantage over corn ethanol. Not only are demands for irrigation water lower for soybeans than for corn, the demands for chemical fertilizers and

pesticides are dramatically lower - soybean production requires 99% less nitrogen, 92% less phosphorus, and 87% less pesticides (Hill, 2006). Phosphorus from agricultural runoff is primarily responsible for the water quality problems in Madison's lakes.

Agricultural Land Use, Soil Quality, and Yields – Potential Risks

If farmers surrounding soybean crush facilities such as that being developed in Evansville were to switch to soybean-only cultivation, they would likely face a decrease in yields as a result of an increase in the population size of soybean-specific pests and diseases like white mold (Vick et al., 2006). In one study site, soybean yields decreased 33 percent after five years of a soybean-only cultivation (Temperly and Borges, 2006).

In addition, soybean-only cultivation has implications for soil erosion. After harvest, soybean fields have minimal residue left to keep soil in place in comparison with cornfields. If fields were only cultivated with soybeans year-after-year, soil erosion is likely to become a problem, especially in the hillier parts of Wisconsin's landscape (Conley, 2007).

Since persistent soybean-only cultivation has been shown to have adverse effects on both soil quality and yields, but benefits for water quality with its lower fertilizer inputs, cultivation of soybeans as part of a larger soybean-non-soybean crop rotation appears to be the most sustainable production of this feedstock. Although it may seem economically attractive in the short-term for farmers to carry out continuous soybean cultivation in places close to soybean crush facilities, it is important for markets to encourage longer-term thinking and a focus on crop rotations.

Innovative Ideas – Sourcing Biodiesel from Non-Virgin Feedstocks

While soybean-based biodiesel is a feedstock that could have benefits for Wisconsin's economy, another important feedstock that has begun to attract the attention of major municipalities is "yellow grease." Waste vegetable oil, also commonly referred to as yellow grease, is disposed of by households, restaurants and institutions. Disposal of large volumes (greater than 5 gallons) have historically been handled by waste haulers. With the gradual integration of biodiesel into municipal fleets, opportunities exist for cities to harness what was formerly a waste stream into a cost-saving, waste-reducing environmentally friendly fuel.

The City of Madison currently has collection bins for waste vegetable oil that is ultimately delivered to the PrairieFire BioFuels Cooperative to convert the oil into biodiesel. Madison is positioned to benefit from the collection of waste vegetable oils and their conversion into biodiesel by expanding the current collection system to restaurants and businesses. The City of San Francisco, CA has recently launched their "Greasecycle" program to collect waste vegetable oil from residents and

businesses and then process it into biodiesel. The city's initiative targets restaurants that currently do not have a collection service. The service is offered for free as the cost of pickup, transport and processing is less than the cost of purchasing virgin biofuels. Other benefits for the city include reduced sewer repair and cleaning.

While the benefit for restaurants recycling their used cooking oil is financially obvious (no disposal fees), individual residents have little incentive to drop off their used cooking oil at selected disposal sites. The Stagecoach group in the UK has recently launched their "bio-bus" initiative in which customers can exchange used cooking oil for reduced bus fares. After the used cooking oil is converted to biodiesel, it is used in a select set of buses with specialized advertising slogans such as, "Do your part, be Bio smart!" The collection of oil in this program is expected to have a carbon reduction of nearly 1,000 tons per year.

Biodiesel and Public Health

The proponents of biofuels argue that transitioning to these fuels will reduce the emissions of carbon monoxide and dioxide (CO and CO-2), volatile organic compounds (VOCs), sulfuric oxides (SO-x), fine particulate matter, ozone, methane, benzene, butadiene, formaldehyde, and acetaldehyde. In doing so, biofuels can help slow the progression of global climate change. The results will include improved ecosystem services and a mitigation of the health effects resulting from global climate change. Furthermore, a reduction in many of these emissions will reduce the prevalence of respiratory and heart conditions, as well as select cancers.

Biodiesel Emissions

As the City of Madison plans to transition its heavy-duty diesel vehicle fleet to using biodiesel blends, city administrators can anticipate benefits and some possible limitations of the shift to biodiesel in terms of public health. Most importantly, a transition to biodiesel and biodiesel blends can reduce the level of criteria emissions and air toxics (Morris et al., 2003).

Carcinogenic emissions include:

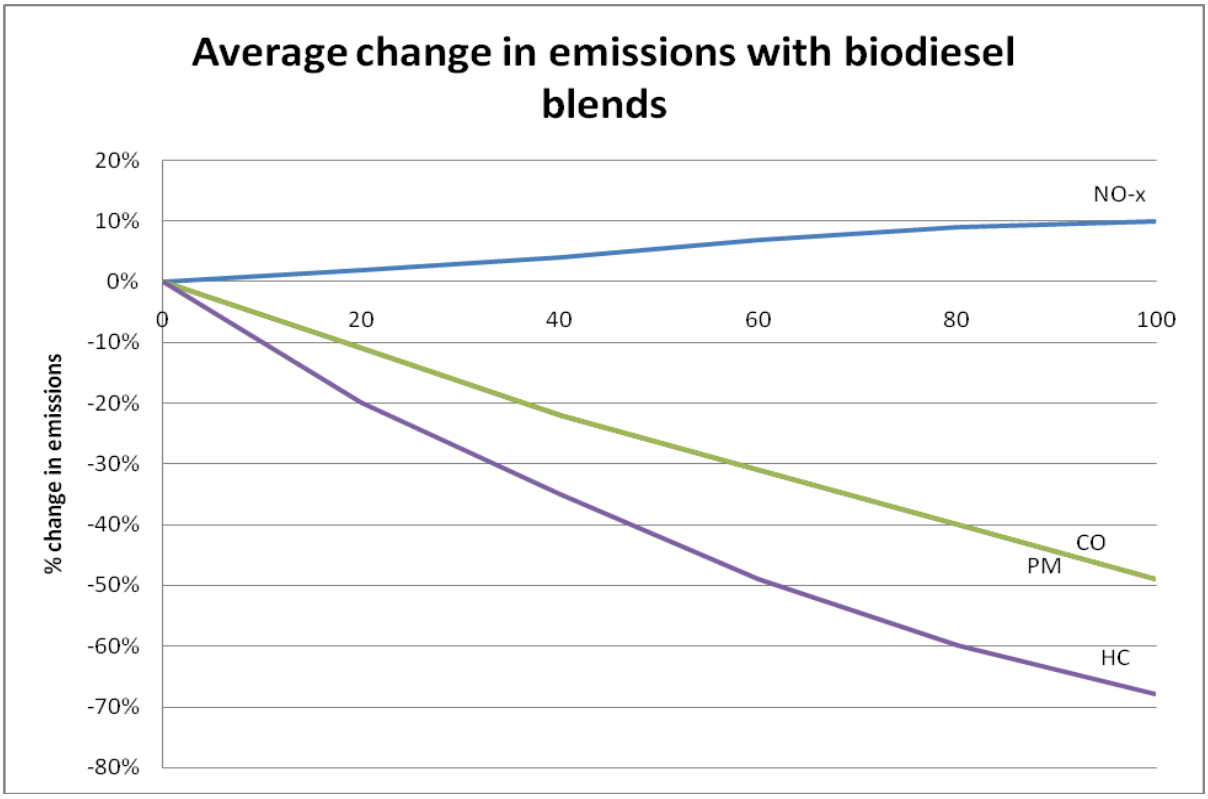
- Volatile Organic Compounds (benzene, 1,3-butadiene, toluene, xylene, etc.)
- PAH and nitro-PAH compounds
- Total hydrocarbons

Emissions that contribute to cardiopulmonary hazards include:

- Fine particulate matter
- Carbon monoxide
- Ozone

However, as the proportion of biodiesel used in fuel blends increases, so do emissions of NO-x, a documented respiratory irritant (Morris et al., 2003). The

graph below depicts average changes in emissions with a shift to biodiesel (California Energy Commission, 2006).



Public Health Implications

The health benefits of reduced emissions from a diesel fleet depend on what proportion of total emissions the diesel fleet contributes. According to National Emissions Trends from the US Environmental Protection Agency, of all emissions in 2006 highway vehicle traffic contributed:

- 54% of the carbon monoxide
- 5% of fine particulate matter
- 36% of nitrogen oxides
- 22% of VOCs (US EPA, 2007)

Much of highway traffic, however, runs on non-diesel fuel, so the total amount by which biodiesel can reduce these emissions is dependent on the proportion of diesel to non-diesel vehicles in a region.

Reduction in the emissions from diesel vehicles as a result of using a biodiesel blend contributes to a lower risk of cancer as a result of air toxics. Three of the national and regional drivers of cancer risk, according to the National Air Toxics Assessment (NATA), would be reduced by a shift to biodiesel (US EPA, 2007).
In addition, there could potentially be reductions in:

- Acute respiratory and cardiopulmonary hospital admissions. A study of hospital admissions in the Los Angeles metro area found that a 50%

decrease in carbon monoxide concentrations led to a 4% reduction in cardiac hospital admissions (Linn et al., 2000).

- School and work absences;
- Medication use among asthmatics and others with compromised respiratory conditions (Kleinmann, 2000);
- Chronic bronchitis, irregular heartbeat, heart attacks (Linn et al., 2000); and
- Health risks as a result of fuel spills are attenuated—but not eliminated—by the use of higher biodiesel blends (B20 and above) (Khan et al., 2007).

Overall, researchers in the Southern California Air Basin (SoCAB) study, a 100% penetration of B20 in the HDDV fleet would result in a 5% reduction in premature mortality due to air toxics exposure (Morris et al., 2003).

Despite these benefits, a shift to biodiesel could also result in negative health consequences. As noted in the figures on page 2, use of biodiesel increases emissions of NO-x, which can increase cardiopulmonary injury, inflammation, and exacerbate allergies.

In summary, it appears that local use of biodiesel is likely to have a negligible effect on human health, because of the proportion of emissions for which the City's diesel fleet is responsible. Furthermore, the change in emissions with biodiesel blends below B20 seems to be negligible. However, expanded use of biodiesel - using it in all diesel vehicles, using higher (>B20) blends of biodiesel, and use over a larger geographic area - could have significant, positive results for the public's health.

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