University of Wisconsin-Madison
Department of Agricultural & Applied Economics

March 2005 **Staff Paper No. 481**

Biodiesel Feasibility Study: An Evaluation of Biodiesel Feasibility in Wisconsin

By

T. Randall Fortenbery

AGRICULTURAL & APPLIED ECONOMICS

STAFF PAPER SERIES

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August 2004

By

T. Randall Fortenbery
Renk Chair in Agribusiness and Director
Renk Agribusiness Institute
University of Wisconsin- Madison

With financial support provided by:

Badger AgVest
Wisconsin Soybean Promotion Board
Renk Agribusiness Institute, UW-Madison

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Introduction

There has been considerable interest focused on the further development and expansion of a domestic bio-fuels industry. While most early attention from the commercial sector focused on ethanol, interest is now growing in the area of biodiesel production. Reasons for growing interest in biodiesel include its potential for reducing noxious emissions, potential contributions to rural economic development, as an additional demand center for agricultural commodities, and as a way to reduce reliance on foreign oil. Despite interest over the past decade or so, however, experience with biodiesel production in the US is limited. According to the Energy Information Administration, participants in the federal Bioenergy program produced only 18.6 million gallons of biodiesel in fiscal 2003. This compares with the production of almost 2.5 billion gallons of ethanol.

The experience with biodiesel is most extensive in Europe. Europeans have been experimenting with biodiesel for several years, and have developed a commercial biodiesel industry. Several things are unique relative to the European experience that do not translate to the US, however. First, a large percentage of private automobile fuel consumption consists of diesel in Europe, where most private consumption in the US is gasoline. In the US and Canada, gasoline consumption accounted for 77 and 72 percent of total fuel consumption in 2002. In Europe, gasoline accounts for 48 percent of total fuel consumption, and in Japan (another high fuel consumption country), 57 percent (Gustafson). Further, the public sector in much of Europe has developed a combination of financial incentives and fuel consumption mandates to encourage both biodiesel production and consumption. For example, in the Black Forest region of Germany, all diesels burned (including private, commercial, and farm consumption) must be a 100 percent biodiesel product. Further, biodiesel is not taxed in Germany, while taxes on petroleum based fuels are quite steep.

What is Biodiesel?

Biodiesel generally refers to the mono-alkyl esters of fatty acids, and can be derived from a variety of vegetable oils and animal fats. Stated simply, it is the product of a chemical reaction between the basic feedstock (vegetable oil or animal fat) and alcohol (in commercial applications usually methanol) in the presence of a catalyst (usually sodium or potassium hydroxide) (Gerpen). The reaction results in a compound called fatty acid alkyl ester (the biodiesel product) and a byproduct called glycerol.

In general, the energy yield of the biodiesel process is significantly greater than that of other bio-fuels (for example, ethanol). Current technology yields about 3.2 units of energy for every unit of energy consumed in the production process. In comparison, the return from ethanol production is less than 1.5 units of energy for each unit consumed in the manufacturing process.

The general conversion of feedstock to biodiesel is:

100 lbs. of feedstock + 10 lbs. of methanol → 100 lbs. of biodiesel + 10 lbs. of glycerol[1]

However, there is some variation depending on the specific feedstock used. The most common feedstock in the US is soybean oil, with other feedstocks being corn oil, canola oil, cottonseed oil, recycled restaurant oils (fry oil, etc), tallow and lard, grease recovered from restaurants, and float grease from waste water treatment plants. Most biodiesel in Europe is made from rapeseed oil.

[1] Copied from Gerpen.

Biodiesel can be marketed in several ways, including as a stand-alone fuel (B100), or as a blend with petroleum-based diesel. The most common blends are a 20 percent biodiesel/80 percent petroleum diesel (B20), a 5/95 blend (B5), and a 2/98 percent blend (B2).

Advantages of Biodiesel

Interest in biodiesel stems from three main areas: 1) reducing US dependence on foreign oil, 2) development of environmentally friendly and renewable energy sources, and 3) promoting industrial uses of agricultural products.

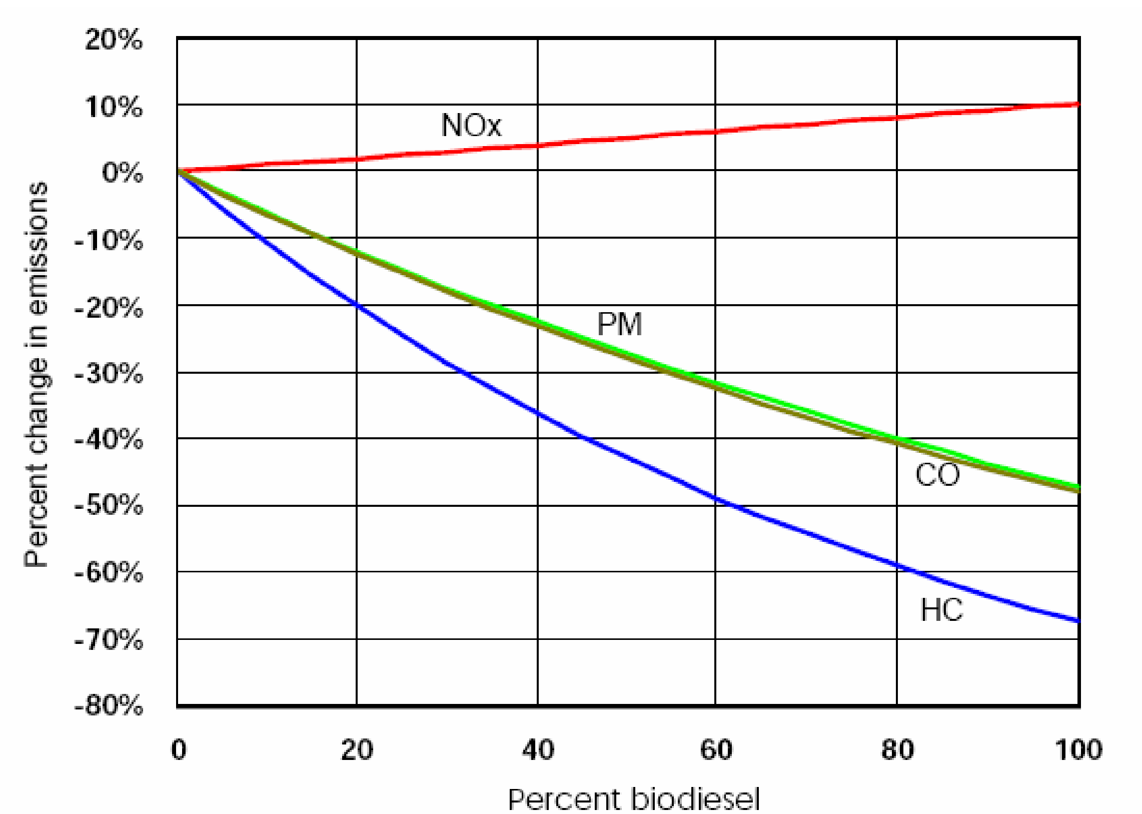
The first potential advantage – reducing dependence on foreign oil – does not appear significant at the current time. According to Pearle, the US produces about 23.7 billion pounds of vegetable oil each year, and 11.6 billion pounds of total animal fat (including recycled grease and oil), for a total potential feedstock of 35.3 billion pounds per year. If the entire feedstock base were committed to biodiesel production, the US could produce 4.64 billion gallons of biodiesel per year using domestic resources.[2] At current consumption, this represents about 15 percent of total US annual diesel demand. However, despite the relatively small percentage, history does suggest that petroleum markets are very sensitive to relatively small changes in supply and/or demand (Gergen). Thus, while there may not be a large substitution away from petroleum based diesel as the result of a more fully developed domestic biodiesel industry, domestic biodiesel production could have a positive influence on both domestic prices and price volatility.

On the environmental side, the argument is stronger. Research has verified that exhaust emissions from biodiesel are substantially less than those from petroleum based

[2] This actually overstates production potential because some recycled grease and oils contain vegetable oil, thus there is some double counting of feedstocks based on the numbers above.

diesel. Further, as the percent of biodiesel in a bio/petroleum diesel blend increases, the benefits of reduced emissions increases (Figure 1). According to the Environmental Protection Agency (EPA), a soybean oil diesel product combined in a 20/80 percent blend with petroleum diesel (20 percent bio/80 percent petroleum) results in a reduction of 10.1 percent in total particulate emissions (PM), 21.1 percent in hydrocarbons (HC), and 11 percent in carbon monoxide emissions (CO). These are offset by a 2 percent increase in emissions of nitrous oxide (NOx) and a reduction in fuel efficiency of 1 to 2 percent, but environmental impacts are positive none-the-less.

Figure 1. Average emissions impacts on heavy-duty diesel engines.



Source: EPA

Because biodiesel is produced from derivatives of a biological system that allows for seasonal reproduction (fats and oils) it is renewable. Further, because much of the carbon contained in biodiesel was originally removed from the atmosphere by plants, there is little net increase in atmospheric carbon dioxide levels as a result of biodiesel use. Research by the National Renewable Energy Laboratory reports a 79 percent reduction in net CO_2 emissions from biodiesel relative to petroleum diesel.

Biodiesel may also provide a source of increased demand not only for agriculturally produced products, but also some wastes from food processing and production. Most times, soybean crush margins are driven by the demand for soybean meal. Current estimates are that demand for meal will grow significantly in coming years. As this happens, uses for soybean oil need to be developed. Further, current concerns over BSE (Mad Cow Disease) suggests that the traditional markets for animal fats and recycled greases may be at risk because of restrictions on their use in animal feeds. If this happens, either alternate uses of the products need to be found or waste management costs in everything from the meat packing to the restaurant industry will increase.

In addition to the advantages described above (those that seem to drive the greatest interest in biodiesel production), there are other advantages to biodiesel as well. First, biodiesel has a significantly lower flash point than petroleum diesel. This reduces risk of fire in transport, storage, and delivery of biodiesel. In addition, use of biodiesel results in increased lubricity, adding to overall engine life. Recent research has shown that even a 2 percent biodiesel blend increases lubricity significantly (Nelson et al.).

Transport and delivery of biodiesel requires no significant changes to existing infrastructure, as it can be handled in a manner similar to petroleum diesel. It can be burned in existing diesel engines without any engine modifications. Finally, it is relatively easy to manufacture biodiesel/petroleum-blended fuels. Biodiesel and petroleum diesels can be splash blended and stored in the same tank. Because the specific gravity of biodiesel is slightly higher than that of petroleum diesel, the preferred blending method is to pour biodiesel on top of petroleum diesel.

Disadvantages of Biodiesel

There are a couple of disadvantages posed by biodiesel. One is that flow properties in biodiesel blends are increased relative to petroleum diesel. This means that the biodiesel will gel at a higher temperature than 100 percent petroleum diesel. However, a study conducted in the winter of 2001/02 in Hennepin County, Minnesota found that snow plows burning a B20 product composed of 10 percent biodiesel manufactured from yellow grease, 10 percent biodiesel manufactured from soybean oil, and 80 percent petroleum diesel performed as well as snow plows powered by 100 percent petroleum diesel (Groschen).

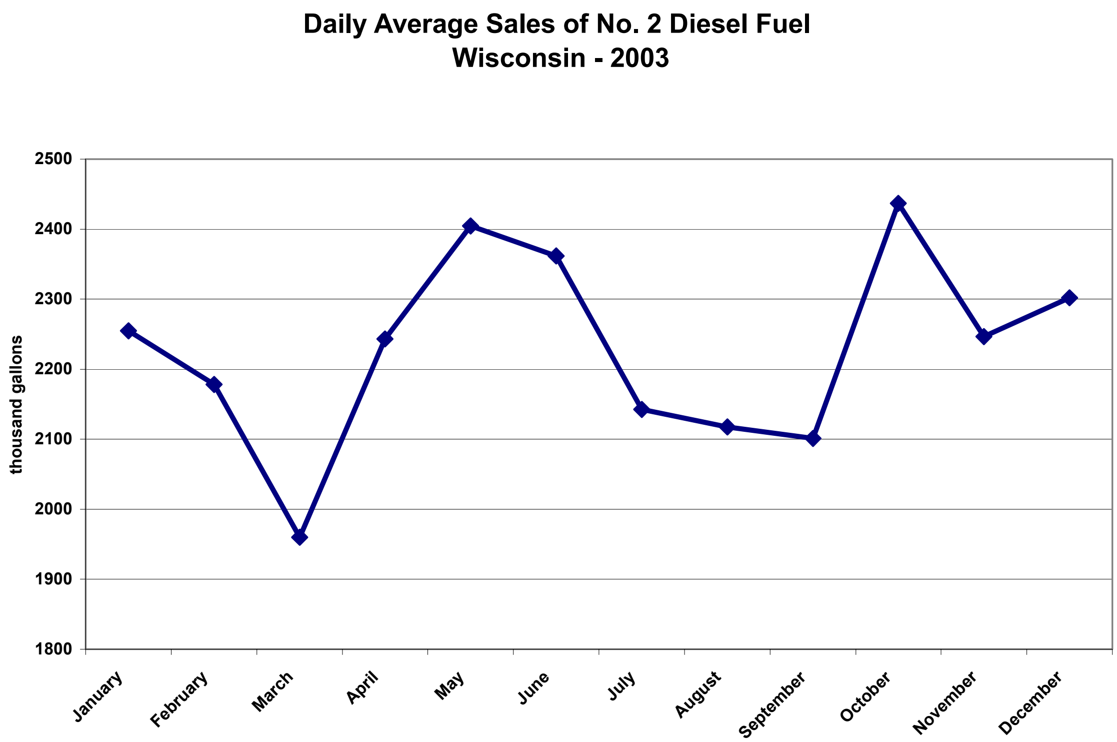
Also, as noted in Figure 3, levels of nitrous oxide emissions are elevated with the use of biodiesel. For low percentage blends, however (B2 to B5), the increase is negligible.

The Wisconsin Market

Based on data from the Energy Information Administration, Wisconsin experienced a daily sales volume of No. 2 diesel just under 2.2 million gallons a day in

2003 (Figure 2), or about 803 million gallons per year.[3] If all No. 2 diesel in Wisconsin was blended with biodiesel as a B20 product (20 percent biodiesel and 80 percent petroleum diesel), current consumption would be 160 million gallons of biodiesel annually. More realistically, if all No. 2 diesel consumption in Wisconsin was a B2 product, total biodiesel consumption in Wisconsin would be 16 million gallons.[4] It should be noted that this likely represents an upper bound, and one that may not be realized without legislative mandates similar to those imposed in Minnesota.

Figure 2. Wisconsin Diesel Fuel Consumption.



Source: Energy Information Administration

[3] Wisconsin consumed another 104.3 thousand gallons of No. 1 distillate per day in 2003. Some percentage of this was also used as a transportation fuel.

[4] While no legislation is currently pending in Wisconsin relative to required use of biodiesel, Minnesota did pass legislation in 2002 requiring all diesel sold in Minnesota be at least a B2 by 2005 (Ag Innovation News).

Potential Feedstocks

Most any vegetable oil or animal fat can be used to produce biodiesel. Vegetable oils currently available in the US include soybean oil, corn oil, peanut oil, sunflower oil, and cottonseed oil. By far the greatest percentage is soybean oil. Vegetable oils are generally liquid at room temperature.

Animal fats are divided into several categories, and there is sometimes overlap. This can lead to confusion when trying to identify animal based products with specific characteristics. Generally, animal fats are products derived from meat processing facilities and are solid at room temperature. They include tallow from beef processing, lard and choice white grease from pork processing, and poultry fat from poultry processing. Animal fats are generally marketed directly by renderers or animal processors (Groschen).

Recycled products (fats and oils) can also be used as feedstock for biodiesel production. The most common types are yellow grease and trap grease. Yellow grease generally refers to grease manufactured from used cooking oil and other fats and oils from large scale cooking operations (restaurants, hospitals, and other types of commercial food service). Renderers who filter out the solids and remove enough moisture to meet industry specifications for yellow grease usually collect these products. Yellow grease is currently used in the manufacture of livestock and pet foods. It is estimated that as much as 70 to 95 percent of available yellow grease in US metropolitan areas is collected (Groschen). Prices of yellow grease are generally well below, sometimes less than half, the prices of soybean and other vegetable oils. Currently, most biodiesel production in the US made with a feedstock other than soybean oil is manufactured from yellow grease.

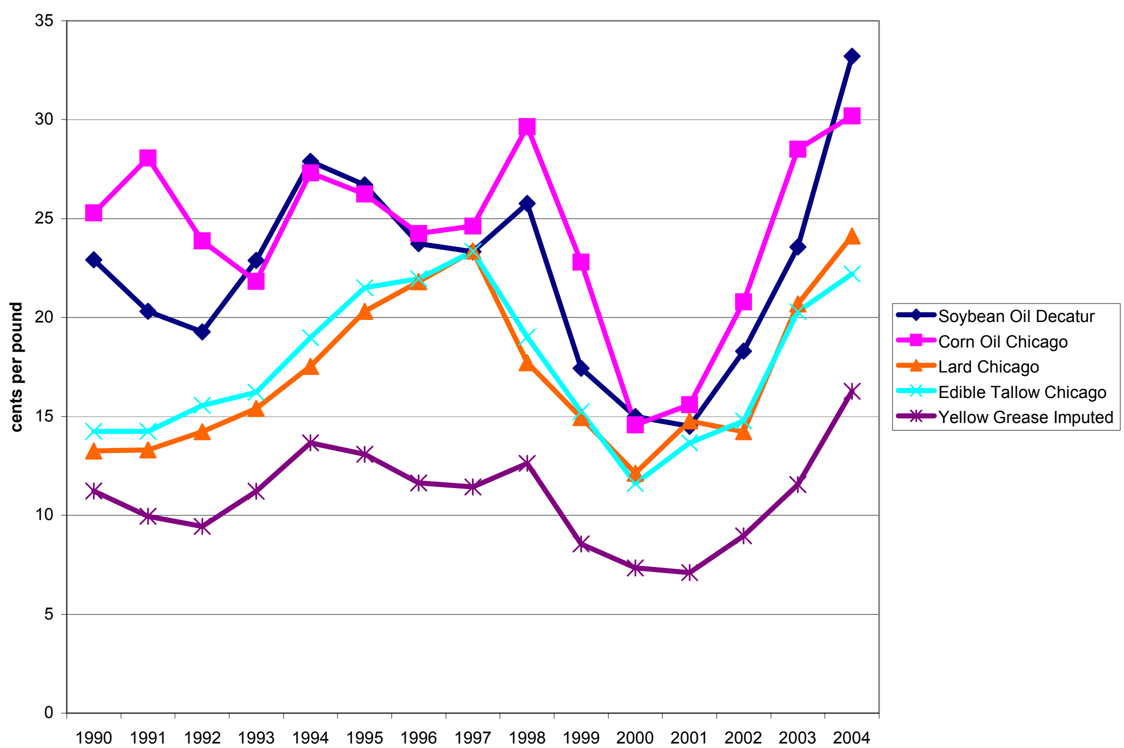
Trap or brown grease is grease that is collected in facilities that separate oil and grease from wastewater (such as waste treatment plants). Generally, grease traps are installed in sewage lines and grease and oil that is flushed with water down a drain floats into the top of the trap. The top of the traps can be opened allowing for the recovery of the oil and grease. Trap grease generally has limited demand because it cannot be used in the animal feeds market. Also, trap grease has a very high water content, meaning it would require significant pre-treatment before it would be useable as a biodiesel feedstock.

Feedstock Availability in Wisconsin

The most likely feedstock options for a biodiesel plant located in Wisconsin include soybean oil, yellow grease and fats recycled from the restaurant industry, and rendered animal fats. In all cases, transportation of the feedstock to the biodiesel facility represents a significant challenge. There are currently no soybean crush facilities in Wisconsin selling crude soybean oil into the market, so soybean oil would have to be imported if used as the feedstock for a plant. Thus, in order to minimize transport costs of the feedstock, a plant would need to be located near the Wisconsin state line and on a major freight railway.

Yellow grease as a feedstock could be sourced in state, but it is difficult to determine exactly what volume is available. Current estimates indicate a total state supply of less than 40 million pounds (Meyer). About 65 percent of this is currently exported out off state. A single 10 million gallon per year plant would require about 80 million pounds of yellow grease. Tallow and rendered fats are also available and likely represent in excess of another 160 million pounds of potential feedstock. They tend to be slightly more expensive than yellow grease, but cheaper than virgin vegetable oils. Figure 3 provides a history of potential feedstock prices. All prices are from the Commodity Research Bureau InfoTech Database, except the yellow grease price. This price is calculated off the soybean oil price using the relationship identified by Radlich.

Figure 3. Annual average costs of potential feedstocks.



Note that all feedstock prices tend to move together. However, the prices of animal fats and yellow grease are consistently the cheapest available feedstocks. The comparative advantage is not quite as dramatic as shown in Figure 3, however. It takes about 8.3 pounds of tallow and lard to get a gallon of biodiesel, about 8 pounds of yellow grease, but only 7.5 pounds of soybean oil to produce one gallon of biodiesel. Thus, less soybean oil is needed for each gallon of biodiesel produced.

Market Access

The most likely market outlet for a biodiesel product is at fuel terminals. The biodiesel would be splash mixed (biodiesel poured on top of petroleum diesel) at the terminal, and then sold through the current fuel distribution channels. This does present some challenges, however. As noted by Gerpen, the petroleum industry in general is vertically integrated, capital intensive, driven by exacting standards, and multinational. For independent biodiesel production to be adopted on a significant scale it must penetrate this structure.

At least in the short run, the most likely scenario for biodiesel to enter the commercial fuel market is to be delivered, likely by semi truck, to local wholesalers or retailers who then blend with petroleum diesel on site. If the diesel blend is in the 2 to 5 percent range, this will require multiple delivery points for a single 5000-gallon capacity semi truck.

A search of diesel storage tanks registered with the Wisconsin Department of Commerce revealed a total of 2752 tanks registered by marketers of diesel. However, when the search was narrowed to tanks in excess of 10,000 gallons, the total fell to 1306. A 10,000-gallon tank would only need 200 gallons of biodiesel for a B2 blend, and 2000 gallons (less than half a truck-tanker load) for a B20 blend.[5] Figure 4 shows all locations in Wisconsin with registered diesel tanks of 20,000 gallons or greater. These are facilities where a B20 diesel blend would require almost a full truckload of fuel.

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[5] It should be noted that several sites have multiple tanks. Thus, a single facility may be able to utilize a full tanker if blending biodiesel into all their registered diesel tanks.

Figure 4. Location of registered diesel storage tanks of at least 20,000 gallons.

Key: Green stars represent tank locations.

Table 1. Biodiesel retailers in Wisconsin as identified by the National Biodiesel Board.

Business Name	Location	Biodiesel Blend Available
Conserv FS	Kansasville	Unavailable
Danco Prarie FS Cooperative	Madison	B20
Edward H. Wolf & Sons	Slinger	All
Larsen Cooperative Co.	Larsen	B3
New Horizons Supply Co-op	Fennimore	B5
Northern FS, Inc.	Elkhorn	B5
Progressive Farmers Cooperative	De Pere	Unavailable
Renewable Alternatives	Green Bay	All

Despite the current lack of biodiesel production in Wisconsin, there are several Wisconsin retailers of biodiesel and biodiesel blends. Table 1 provides at least a partial list based on information from the National Biodiesel Board.

Physical Plant Characteristics

Given an initial upper limit on market size of about 16 million gallons a year, two size plants are considered in this analysis. The first is a 4 million gallon a year plant, and the second a 10 million gallon a year plant. Based on previous studies, these would be considered a small commercial plant, and a plant approaching a large commercial operation.[6] Initial capital costs are similar, and the plants differ primarily based on feedstock needs and output. In general, there are significant economies of scale related to production capacity.

Data from this analysis consists of reviews of studies in several other states, and direct contact with three companies that construct biodiesel facilities. As a general rule of thumb, it costs about $1.25 per gallon of capacity to construct a biodiesel plant at the lower capacity levels, but this is reduced as capacity increases. This does not include the cost of a pre-treatment facility, which can add another 25 percent to the cost of a project (Vermeer).

The physical requirements for the plants consist of 5 to 7 acres of land, a production facility, a tank yard allowing storage of manufactured biodiesel and feedstocks, offices, rail access, highway access, and loading/unloading facilities. For both the 4 and 10 million gallon plants, the footprint of the production facility is about 50

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[6] This is based on several discussions with industry participants. It should be noted, however, that there are a wide range of potential plant sizes. For example, Pacific Biodiesel has developed budgets for plants as small as 400,000 gallons per year. At the other extreme, Todd and Sargent, builders of turnkey biodiesel facilities, will not consider a plant smaller than 10 million gallons per year (Vermeer).

by 50 and stands a minimum of 40 feet tall. Some studies suggest combining the offices and manufacturing facility into one building, and others look at separate buildings. In addition, a pre-treatment facility for treating feedstocks is often required.[7]

Total capital requirements for the 4 and 10 million gallon a year plants are outlined in Tables 2 and 3. The physical site and labor costs are similar across both plants, suggesting significant economies of scale related to plant size. The 4 million gallon plant requires 7 acres of land, a production facility of 2500 square feet, and 2000 square feet of office space and lab space. This is the same physical requirement in the 10 million gallon a year plant. Thus, the 4 million gallon a year plant has the physical space necessary for expansion.

Based on estimates from Imperial Industries in Wausau, Wisconsin, total tank costs for the 4 million gallon per year plant would be $320,000. This includes 8 storage tanks of 75,000 gallons each.[8] One tank would be dedicated to the storage of biodiesel (just under a 7 day supply), and the remaining tanks would be dedicated to storage of feedstocks.

The largest single cost in the plant is the tranesterification equipment. This cost was estimated based on a variety of information, including budgets for various plant sizes provided by Pacific Biodiesel. The cost of this equipment will vary by manufacturer and technology.

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[7] If feedstocks are sourced with the right specifications, pre-treatments may not be necessary. However, a current bio-diesel plant in Ralston, Iowa (12 MGY production capacity) that is linked directly to a soybean processing facility has recently decided that even they need to invest in a pre-treatment facility. They are in complete control of the processing of the soybean oil they use as a feedstock, and still find some pre-processing will increase the efficiency of biodiesel production. The main issue appears to be removal of the phosphorous contained in the crude soybean oil. The phosphorus tends to result in higher maintenance costs and some down time due to plugged equipment.

[8] A 75,000-gallon tank is about as large a tank one can purchase without incurring on site construction costs.

Working capital is assumed equal to one month's operating expenses for a relatively low cost feedstock. Construction and site preparation costs are based on personal communication with Findorf and represent general averages that can vary significantly from location to location. Building construction costs are assumed to be $55 per square foot for the production facility, and $85 per square foot for the office/lab space. Site preparation costs are estimated a $2 per square foot.

Table 2. Capital requirements for a four million gallon per year facility.

Category	Cost
Transesterification Machinery	$4,500,000.00
Land (7 acres)	$70,000.00
Storage Tanks (8 ea. 75k capacity)	$320,000.00
Civil and site work	$609,840.00
Building	$307,500.00
Permits/misc.	$150,000.00
Working Capital	$670,200.00
TOTAL	$6,627,540.00

The costs of the ten million gallon plant increase based on increases in total tank storage, tranesterification equipment, and working capital. However, costs do not increase proportional to increased capacity.

Table 3. Capital requirements for a ten million gallon per year facility.

Category	Cost
Transesterification Machinery	$5,500,000.00
Land (7 acres)	$70,000.00
Storage Tanks (8 100k capacity)	$680,000.00
Civil and site work	$609,840.00
Building	$307,500.00
Permits/misc.	$150,000.00
Working Capital	$1,503,420.00
TOTAL	$8,820,760.00

Operating Costs

The largest single cost in plant operation is the purchase of the feedstock. In general, feedstocks represent up to 85 percent of variable costs, with methanol and the catalyst contributing another 5 percent or so.

Individual plant operating costs for the two different size plants are detailed in Tables 4 and 5. Further, operating costs are broken down based on feedstock. The individual tables for each plant size (tables A and B) represent alternative cost structures based on what would likely be the least expensive and most expensive feedstock choices. In reality, an individual plant would likely rely on a variety of feedstocks, including some not included in either table (tallow and lard, for example), and actual operation costs would lie somewhere between the two extremes presented.

The operating costs are derived from a variety of sources, including previous research and other published studies, direct communication with three different plant design/construction firms, and direct contact with potential biodiesel producers. Transportation costs are based on Union Pacific rates to ship feedstocks about 150 miles (rates were computed for both soybean meal and rendered products).

The largest cost differences between the 4 and 10 million gallon plants are in the amount of feedstock, energy, and water use. In addition, a small marketing budget has been added to the 10 million gallon plant. It is anticipated that such a large volume of biodiesel will require an active marketing program (this is a cost that is lacking in most other feasibility studies). The general staffing levels are the same regardless of plant size, again suggesting some economies to be gained with a larger operation.

As noted earlier, the important cost component is that of the feedstock. For example, if you cut labor costs in the 4 million gallon per year plant in Table 4A by 50 percent, operating costs per gallon of biodiesel production only fall from $1.75 to $1.71, a total cost reduction of only 2.3 percent per gallon. However, just a 2-cent per pound change in the price of yellow grease results in per gallon production costs falling from $1.75 to $1.59, a change in excess of 9 percent.

Table 4A. Operating costs for a four million gallon per year plant using yellow grease.

FOUR MILLION GALLON PER YEAR PLANT

		Price/unit $	Units per Gallon of Diesel	Units/year	Cost/Year $	Cost per Gallon of Diesel
Raw Materials						
	Yellow Grease (lbs).	$0.1700	8	32,000,000	$5,440,000	$1.3600
	Transportation (rail cars)	$1,200.0000		160	$192,000	$0.0480
	Methanol (gal)	$0.8400		560,000	$470,400	$0.1176
	Catalyst (lb.)	$0.4000	0.08	320,000	$128,000	$0.0320
Utilites						
	Electricity (kilowatt hours)	$0.0600	0.003	12,000	$720	$0.0002
	Natural gas/diesel (decatherms	$7.0000	0.0077	30,800	$215,600	$0.0539
	Water	$0.0030	0.3822	1,528,800	$4,586	$0.0011
Labor						
	Manager/Operator	$65,000.0000		1	$65,000	$0.0163
	Operator	$40,000.0000		6	$240,000	$0.0600
	Lab Technician	$35,000.0000		1	$35,000	$0.0088
	Maintenance	$30,000.0000		2	$60,000	$0.0150
	Sales	$35,500.0000		1	$35,500	$0.0089
	Support Staff	$18,000.0000		1	$18,000	$0.0045
	Benefits @ 40 percent				$181,400	$0.0454
Misc.						
	Maintenance				$40,000	$0.01
	Insurance				$100,000	$0.03
	Marketing					
	Permits				$30,000	$0.0075
	Waste Disposal (tons)	$35.0000		600	$21,000	$0.0053
	Waste Water Treatment	$0.0110		2,000,000	$22,000	$0.0055
	Interest Expense (assumes 50% equity)				$117,990	$0.0295
Depreciation						
	Building				$7,872	$0.0020
	Equipment				$571,600	$0.1429
	Storage Tanks				$45,728	$0.0114
Sale of Byproducts						
	Glycerin (lb.)	$0.4000		2,600,000	-$1,040,000	-$0.2600
	Soap Stock (lb.)	$0.0100		1,600,000	-$16,000	-$0.0040
TOTAL					$8,042,396	$1.7466

Table 4B. Operating costs for a four million gallon per year plant using soybean oil.

FOUR MILLION GALLON PER YEAR PLANT

		Price/unit $	Units per Gallon of Diesel	Units/year	Cost/Year $	Cost per Gallon of Diesel
Raw Materials						
	Soybean Oil	$0.3300	7.5	30,000,000	$9,900,000	$2.4750
	Transportation (rail cars)	$1,200.0000		160	$192,000	$0.0480
	Methanol (gal)	$0.8400		560,000	$470,400	$0.1176
	Catalyst (lb.)	$0.4000	0.08	320,000	$128,000	$0.0320
Utilites						
	Electricity (kilowatt hours)	$0.0600	0.003	12,000	$720	$0.0002
	Natural gas/diesel (decatherms	$7.0000	0.0077	30,800	$215,600	$0.0539
	Water	$0.0030	0.3822	1,528,800	$4,586	$0.0011
Labor						
	Manager/Operator	$65,000.0000		1	$65,000	$0.0163
	Operator	$40,000.0000		6	$240,000	$0.0600
	Lab Technician	$35,000.0000		1	$35,000	$0.0088
	Maintenance	$30,000.0000		2	$60,000	$0.0150
	Sales	$35,500.0000		1	$35,500	$0.0089
	Support Staff	$18,000.0000		1	$18,000	$0.0045
	Benefits @ 40 percent				$181,400	$0.0454
Misc.						
	Maintenance				$40,000	$0.01
	Insurance				$100,000	$0.03
	Marketing					
	Permits				$30,000	$0.0075
	Waste Disposal (tons)	$35.0000		600	$21,000	$0.0053
	Waste Water Treatment	$0.0110		2,000,000	$22,000	$0.0055
	Interest Expense (assumes 50% equity)				$117,990	$0.0295
Depreciation						
	Building				$7,872	$0.0020
	Equipment				$571,600	$0.1429
	Storage Tanks				$45,728	$0.0114
Sale of Byproducts						
	Glycerin (lb.)	$0.4000		2,600,000	-$1,040,000	-$0.2600
	Soap Stock (lb.)	$0.0100		1,600,000	-$16,000	-$0.0040
TOTAL					$12,502,396	$2.8616

Table 5A. Operating costs for a ten million gallon per year plant using yellow grease.

TEN MILLION GALLON PER YEAR PLANT

		Price/unit $	Units per Gallon of Diesel	Units/year	Cost/Year $	Cost per Gallon of Diesel
Raw Materials						
	Yellow Grease (lbs).	$0.1700	8	80,000,000	$13,600,000	$1.3600
	Transportation (rail cars)	$1,200.0000		400	$480,000	$0.0480
	Methanol (gal)	$0.8400	0.14	1,400,000	$1,176,000	$0.1176
	Catalyst (lb.)	$0.4000	0.08	800,000	$320,000	$0.0320
Utilites						
	Electricity (kilowatt hours)	$0.0600	0.003	30,000	$1,800	$0.0002
	Natural gas/diesel (decatherms	$7.0000	0.0077	77,000	$539,000	$0.0539
	Water	$0.0030	0.3822	3,822,000	$11,466	$0.0011
Labor						
	Manager/Operator	$65,000.0000		1	$65,000	$0.0065
	Operator	$40,000.0000		6	$240,000	$0.0240
	Lab Technician	$35,000.0000		1	$35,000	$0.0035
	Maintenance	$30,000.0000		2	$60,000	$0.0060
	Sales	$35,500.0000		1	$35,500	$0.0036
	Support Staff	$18,000.0000		1	$18,000	$0.0018
	Benefits @ 32 percent				$145,120	$0.0145
Misc.						
	Maintenance				$100,000	$0.01
	Insurance				$250,000	$0.03
	Marketing				$100,000	$0.0100
	Permits				$30,000	$0.0030
	Waste Disposal (tons)	$35.0000		600	$21,000	$0.0021
	Waste Water Treatment	$0.0110		2,000,000.00	$22,000	$0.0022
	Ineterst Expense (assumes 50% equity)				$157,320	$0.0157
Depreciation						
	Building				$16,500	$0.0017
	Equipment				$571,600	$0.0572
	Storage Tanks				$45,728	$0.0046
Sale of Byproducts						
	Glycerin (lb.)	$0.4000		6,500,000	-$2,600,000	-$0.2600
	Soap Stock (lb.)	$0.0100		4,000,000	-$40,000	-$0.0040
TOTAL					$18,041,034	$1.5401

Table 5B. Operating costs for a ten million gallon per year plant using soybean oil.

TEN MILLION GALLON PER YEAR PLANT

		Price/unit $	Units per Gallon of Diesel	Units/year	Cost/Year $	Cost per Gallon of Diesel
Raw Materials						
	Soybean Oil	$0.3300	7.5	75,000,000	$24,750,000	$2.4750
	Transportation (rail cars)	$1,200.0000		400	$480,000	$0.0480
	Methanol (gal)	$0.8400	0.14	1,400,000	$1,176,000	$0.1176
	Catalyst (lb.)	$0.4000	0.08	800,000	$320,000	$0.0320
Utilites						
	Electricity (kilowatt hours)	$0.0600	0.003	30,000	$1,800	$0.0002
	Natural gas/diesel (decatherms	$7.0000	0.0077	77,000	$539,000	$0.0539
	Water	$0.0030	0.3822	3,822,000	$11,466	$0.0011
Labor						
	Manager/Operator	$65,000.0000		1	$65,000	$0.0065
	Operator	$40,000.0000		6	$240,000	$0.0240
	Lab Technician	$35,000.0000		1	$35,000	$0.0035
	Maintenance	$30,000.0000		2	$60,000	$0.0060
	Sales	$35,500.0000		1	$35,500	$0.0036
	Support Staff	$18,000.0000		1	$18,000	$0.0018
	Benefits @ 32 percent				$145,120	$0.0145
Misc.						
	Maintenance				$100,000	$0.01
	Insurance				$250,000	$0.03
	Marketing				$100,000	$0.0100
	Permits				$30,000	$0.0030
	Waste Disposal (tons)	$35.0000		600	$21,000	$0.0021
	Waste Water Treatment	$0.0110		2,000,000.00	$22,000	$0.0022
	Ineterst Expense (assumes 50% equity)				$157,320	$0.0157
Depreciation						
	Building				$16,500	$0.0017
	Equipment				$571,600	$0.0572
	Storage Tanks				$45,728	$0.0046
Sale of Byproducts						
	Glycerin (lb.)	$0.4000		6,500,000	-$2,600,000	-$0.2600
	Soap Stock (lb.)	$0.0100		4,000,000	-$40,000	-$0.0040
TOTAL					$29,191,034	$2.6551

Table 6 provides a measure of biodiesel price sensitivity to changes in basic feedstock costs. For the purposes of the table, it is assumed that 8 pounds of feedstock are required per gallon of diesel. In reality, and as illustrated in tables 4 and 5, this varies by feedstock. For example, fewer pounds of soybean oil are needed relative to yellow grease, and fewer pounds of yellow grease are needed compared to lard. However, 8 pounds per gallon seems a reasonable average for the example below.

Table 6. Per gallon production costs of biodiesel as a function of feedstock cost.

Feedtock Cost($/lb.)	Biodiesel Cost	
	Plant Size	
	4 MGY	10 MGY
$0.10	$1.19	$0.98
$0.15	$1.59	$1.38
$0.20	$1.99	$1.78
$0.25	$2.39	$2.18

Cost Competitiveness of Biodiesel

This section examines the cost competitiveness of biodiesel using the costs of production above, and historical diesel prices and feedstock costs. The comparison is a direct market comparison. In other words, there are no federal or state subsidies included in the costs of the biodiesel, and all the prices are net of fuel taxes. Figure 5 illustrates the relative prices that would have existed over the last couple of years based on the operating budgets above. In the absence of any subsidies on either the sourcing of feedstocks or the production process itself, biodiesel has a very difficult time competing with petroleum based diesel from a price perspective. However, since most biodiesel blends contain a relatively small percentage of biodiesel, the competitive disadvantage of blended fuels is not as extreme as shown in Figure 5. For a B2 blend, combining biodiesel at its full unsubsidized price with petroleum diesel adds about 2 cents per gallon to the wholesale price. However, this ignores any additional costs associated with transporting the biodiesel to the blending site, and costs associated with the blending process itself. As such, it is a lower bound estimate of the wholesale price of blended fuel. Figure 6 assumes the biodiesel is produced from a yellow grease feedstock in a 4 million gallon per year plant.

Figure 5. Relative prices of petroleum and biodiesel based 4 MGY plant costs.

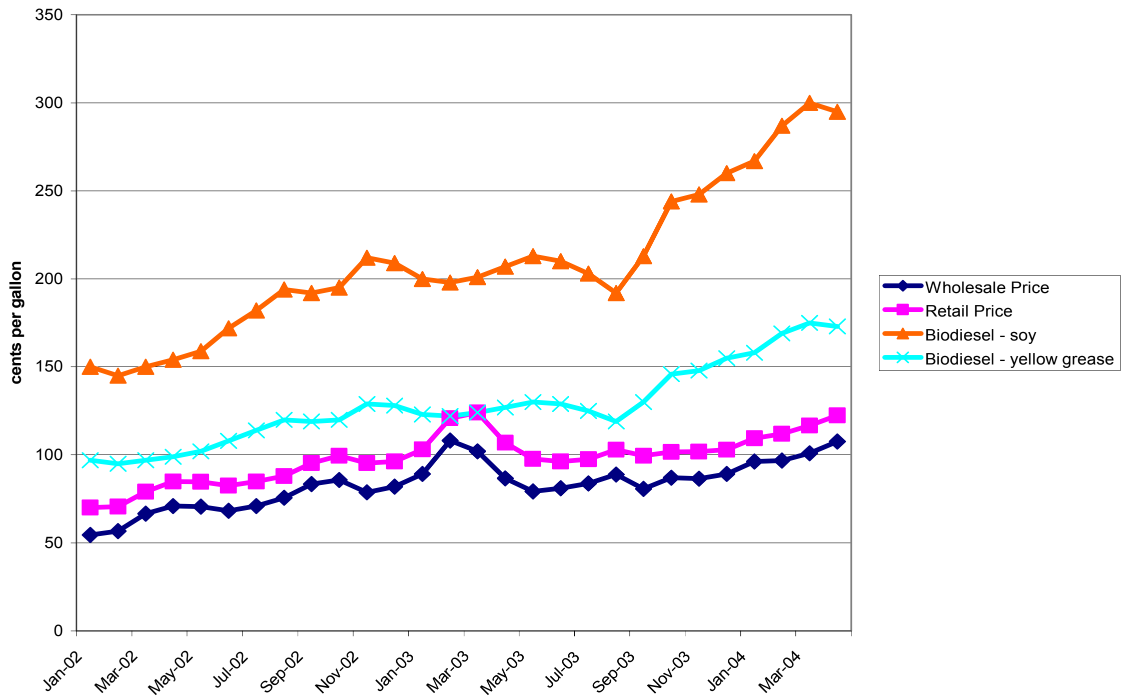
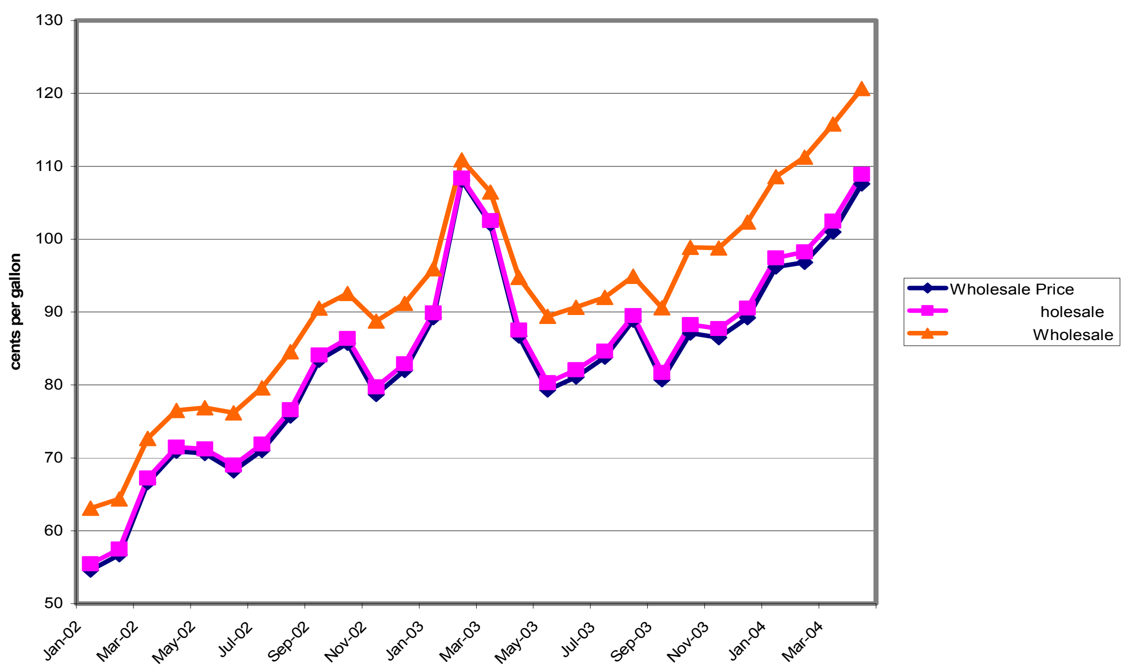


Figure 6. Wholesale prices of petroleum diesel and biodiesel blends.



Regulatory Environment

Given the comparative disadvantage of biodiesel on a pure price basis, the future of biodiesel production and consumption is likely tied to public policy. Regulations that encourage or even force biodiesel consumption coupled with financial incentives tied to both production and blending will be key in determining the future of biodiesel in the near term. There are several policies either in place or under consideration at both the federal and state levels that will impact on the ability of biodiesel to enter the mainstream of fuel consumption. In 1992, Congress passed the Energy Policy Act (EPAct) intended to improve air quality by encouraging the use of cleaner burning fuels. In 1998, Congress approved use of B20 as an EPAct compliance strategy for federal fleet vehicles. This has resulted in increased use of biodiesel in federal fleets. According to the National Biodiesel Board, there were 400 major fleets in the US using biodiesel as of May 2004. The fleets represented all branches of the US military, Yellowstone National Park, NASA, several state departments of transportation, public utility fleets, city fleets, and over 50 school district fleets.

The Renewable Fuel Standard that is part of the pending Energy Bill requires that some percentage of overall fuel consumption come from renewable fuels. Current estimates are that the combination of the EPAct and the Renewable Fuel Standard (if passed) would result in a total biodiesel demand by 2016 of between 400 and 700 million gallons per year (Frazier Barnes and Associates). It is possible that the Energy Bill, if passed, will also include a 2 cent per gallon tax credit for B2 or higher diesel blends.

The most direct support for biodiesel production to date has come from the Commodity Credit Corporation (CCC) of USDA. The CCC subsidizes the purchase of feedstocks used in biodiesel production based on the price of soybean oil (the payment for other feedstocks is a function of the ratio of the feedstock's price to the price of soybean oil). However, under current legislation these payments will expire in 2006, and thus were not included in the operating budgets presented earlier. However, if the payments did apply, the CCC payment to the 4 million gallon per year plant using yellow grease production would be about $2,000,000, or 50 cents per gallon (based on yellow grease and soybean oil prices used in the budgets). For the 4 million gallon per year plant using soybean oil as its only feedstock, the subsidy would be over $4,000,000. There would be payment limitations to all plants if subsidy requests exceeded budgeted funds, and plants with capacity in excess of 65 million gallons per year are not eligible for full subsidy payments.

Several states have either passed or are currently considering legislation to increase demand for biodiesel in their states. The first state to mandate biodiesel consumption was Minnesota (similar to their leadership in forcing the use of ethanol blended gasoline). In 2002, the state legislature passed a law requiring the State's diesel fuel supply to be at least a B2 blend by 2005, assuming a couple of conditions are met. First, there must be 8 million gallons of biodiesel production capacity available in the State, and second, at least 18 months must have passed after the federal or state government passes a tax credit or other type relief providing at least a 2 cent reduction in the cost of B2 or higher blends.

Arkansas is currently considering legislation that would provide a 5 percent income tax credit for the plant and equipment needed for biodiesel wholesale and retail distribution. They are also considering a 10-cent per gallon grant to qualified biodiesel producers.

Plant Location

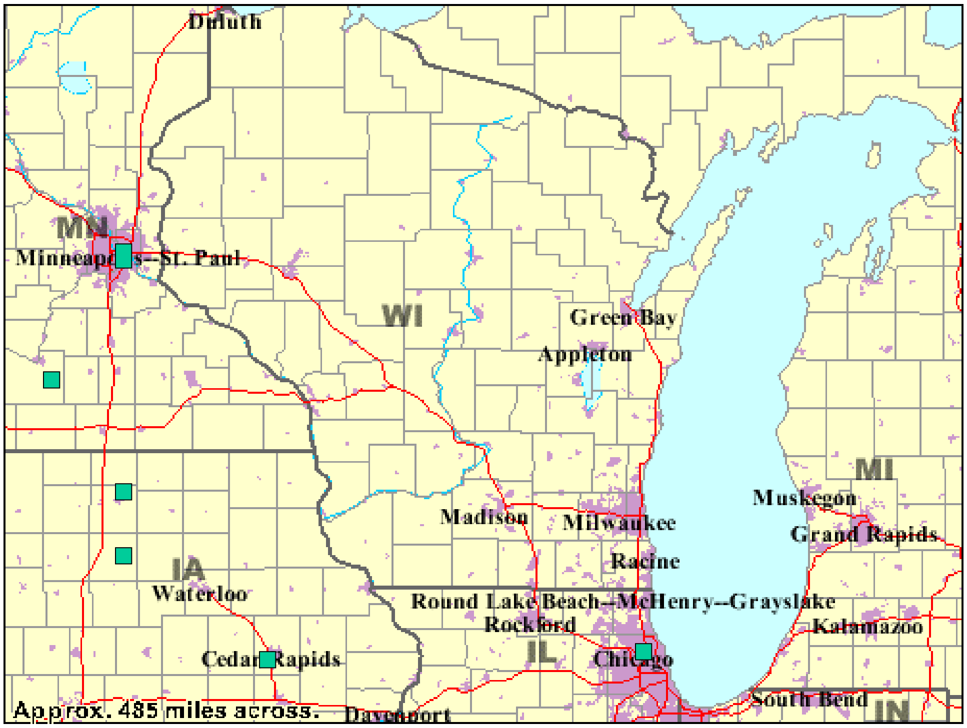
There are several important considerations in selecting a plant site location. Particularly important is access to a rail line, and excellent road service. Costs will be minimized if feedstocks can be delivered by rail, and if manufactured fuel is to be distributed by semi it is important to have good access to major roadways. It is also important to consider the source location of possible feedstocks. However, the largest cost in transporting feedstocks is incurred in the loading processes, and the marginal costs of additional miles traveled are relatively low. For example, shipping soybean oil from Chicago to Milwaukee (a total of 83 miles) on the Union Pacific railroad is $1100 per 25,000-gallon tank car. Shipping from Chicago to Watertown, a total of 143 rail miles only increases the per car charge by $50 (Union Pacific Railroad). The budgets above assume that the biodiesel plant is located on a railroad, and is within 150 miles of its feedstock suppliers.

Figure 7 is a copy of the Wisconsin state rail map for 2004. There are several major freight carriers that serve Wisconsin, as well as some spur lines. However, given the location of feedstock sources, the most likely opportunity for rail service resides with the Union Pacific, the Wisconsin and Southern, or possibly the Burlington Northern - Sante Fe which skirts the western border of the State.

Since it is anticipated that a biodiesel plant would utilize more than one feedstock, selecting a specific location requires looking for a site that minimizes transportation costs

Figure 7. Wisconsin rail map.

Figure 8. Potential sources of soybean oil.



Key: Green squares represent locations of soybean oil supplies.

for a combination of potential feedstocks. The greatest source of yellow grease in state is in Deforest (Meyer). Anamax currently processes about 95 percent of all yellow greases in Wisconsin, and all processing is done in Deforest. Further, they are set up to ship by rail from Deforest. Other animal fats can also be sourced from this location.

Sourcing soybean oil will require out-of-state purchases. This could be done from any number of facilities in Illinois, Iowa, or Minnesota. Locations with facilities processing soybean oil within 150 miles of the Wisconsin border are shown in Figure 8.

Based on feedstock sources, it appears that the most logical site for a biodiesel plant would be in the Southwest quadrant of Wisconsin, or the Southeast if all soybean oil were sourced out of Chicago. In either case, the best site location appears to coincide with higher than average real estate values.

Community Impacts of Plant Development[9]

The economic impact resulting from building a biodiesel plant in Wisconsin was estimated using input-output analysis. A biodiesel plant (or any manufacturing facility) can be expected to impact on the economy two ways: 1) through direct sales of biodiesel and byproducts and the purchase of inputs for production, and 2) through a ripple effect generated in the local and state economy as a result of plant activity. The input-output model used here was estimated through IMPLAN, an input-output analysis software program developed in Minnesota. The results reported are for a four million gallon a year plant utilizing yellow grease as its only feedstock. As such, the results represent the lower bound of expected economic activity for the range of plants considered earlier. Because a specific site for a plant has not been identified, the results reported are for the Wisconsin economy in general. Specific local effects may vary based on differences in sales tax rates, property tax rates, average wage scale, etc.

The total sales increase in the Wisconsin economy resulting from the operation of a four million gallon per year plant would be $11.9 million, of which $7.9 million would come directly from sales of products produced at the biodiesel plant itself. The rest comes from sales made by other businesses as a result of plant activity. In addition, the plant will employ 12 people, but total job creation in Wisconsin would be 49.7 jobs. State income would increase by $3.1 million, with just over $1 million resulting from direct plant employment, and the residual from activity outside the plant. Besides the taxes paid directly by the biodiesel plant, there would be an additional $366 thousand in state and local tax revenue (not including any property or school taxes), $116 thousand

[9] This part of the analysis was conducted with the help of Dr. Steve Deller. Any errors remain the responsibility of the author.

increase in sales tax revenue (again, not including sales from the plant itself), and $115 thousand increase in property taxes (not including property taxes paid by the plant).

Conclusions

There are good reasons to be optimistic about the future development and growth of a domestic biodiesel industry. However, in the current economic environment, investment in a biodiesel plant is essentially a speculative bet on favorable public policy initiatives occurring in the near future. As things stand now, biodiesel does not compete with petroleum diesel on a price per gallon basis, even after accounting for the revenue stream generated by the byproducts of biodiesel production. The current CCC payment program appears capable of bringing a small or mid-sized plant to marginal profitability, but the program is currently slated to end in 2006, delivering no benefits for plants not yet under construction.

States could follow the Minnesota lead and force use of a blended fuel product. While this would increase costs to fuel wholesalers because of increased transportation needs and costs associated with the blending activity, the final price at the retail pump for the consumer would not change dramatically for small percentage blends. The resulting price increase for a B2 product appears to be significantly less than the current seasonal variation in diesel prices. While some wholesalers and retailers are offing a biodiesel product, it is not likely the market will grow appreciable unless biodiesel becomes more price competitive, or there are mandates on use.

In the absence of incentives from the public sector, biodiesel profitability will be driven by feedstock costs. Unless a plant can consistently source quality feedstocks at a cost near 10 cents per pound, it will be difficult to compete with petroleum based diesel prices in any commercial size operation. There will continue to be niche markets for biodiesel without government incentives, but these markets do not appear large enough to support the size plants considered here.

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