Bioresource Technology, 1999, Vol. 70, pp 81-87.

Economic Feasibility Review for Community-Scale Farmer Cooperatives for Biodiesel

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Abstract. *A review of 12 economic feasibility studies shows that the projected costs for biodiesel from oilseed or animal fats have a range of US$0.30-0.69/L, including meal and glycerin credits and the assumption of reduced capital investment costs by having the crushing and/or esterification facility added onto an existing grain or tallow facility. Rough projections of the cost of biodiesel from vegetable oil and waste grease are respectively US$0.54-0.62/L and US$0.34-0.42/L. With pre-tax diesel priced at US$0.18/L in the US and US$0.20-0.24/L in some European countries, biodiesel is thus currently not economically feasible, and more research and technological development will be needed. Economic analysis of a farmers' biodiesel cooperative near Vienna, Austria, shows that government subsidies enable the farmers to produce the canola on set-aside land for biodiesel and by-product meal cake at almost no net cost to the farmers.*

Introduction

Biodiesel, an alcohol ester, is a renewable fuel because its agricultural production and processing have a positive energy balance of roughly 2.5:1 (Ahmed et al. 1994). Also, no appreciable difference between biodiesel and diesel in engine durability or in carbon deposits have been demonstrated in most laboratory studies (Borgelt et al. 1994).

The following European manufacturers offer biodiesel-compatible tractors: Fendt, Fiatagri, Ford, Case, John Deere, Deutz-Fahr, Lamborghini, Lindner, Massey-Ferguson, Mercedes-Benz, Same, and Steyr (Austrian Institute of Agricultural Engineering 1991). Extensive tractor field tests have been done with biodiesel in Europe (Austrian Institute of Agricultural Engineering 1991, Weber 1993) and in the US (Peterson et al. 1991, Schumacher et al. 1992, Wilson 1993, Illinois Soybean Checkoff Board 1994).

Biodiesel production and commercial use in the European Union (EU) has expanded due to the union's Common Agricultural Policy that enables farmers to receive a premium for growing industrial oilseeds on set-aside land (US Department of Agriculture 1995). There are also exemptions for biodiesel from excise taxes in Germany, Austria, Italy, France, Sweden, Denmark and the Czech Republic (Körbitz 1995). The EU plans to develop a 5 percent market share for biofuels by the year 2005 (Connemann and Fischer 1998). However, in response to US concerns about foreign oilseed meals competing with US soybean exports, the EU and US did sign the Blair House Agreement in 1992 (US Department of Agriculture 1995). While this trade agreement did not affect biofuels other than biodiesel, it limited the production of industrial oilseeds on European set-aside land such that recent production is probably near those limits. Moreover, there have been recently proposed changes in the Common Agricultural Policy to reduce or eliminate premiums to farmers for non-food production (Connemann and Fischer 1998).

As of late 1993, there were seven industrial-scale biodiesel refineries (defined as 7.5 million L or more in annual capacity) in Austria, France, Germany and Sweden with 10 more underway in Austria, France, Italy, Czech Republic, Germany and Denmark (Körbitz 1995). There were at least 11 smaller facilities and many under construction in the above countries including Sweden and Hungary. In the US, there are currently five biodiesel refineries of given annual capacity operated by the following companies: Twin Rivers Technologies (Quincy, Massachusetts, 115 million L), NOPEC Corporation (Lakeland, Florida, 83 million L), Pacific Biodiesel (Maui, Hawaii, 570,000 L), Columbus Foods (Chicago, Illinois, 750,000 L), and Ag Environmental Products (Eagle Grove, Iowa, 25 million L) [National Renewable Energy Laboratory 1996a, b, c; 1997].

There are currently three farmer biodiesel cooperatives: Ag Processing Inc. in the US, British Biodiesel Ltd. in northern England, and the Asperhofen Öko-Dieselprojekt near Vienna, Austria. While the latter is a community facility, the former two are industrial scale. Ag Environmental Products cited above is actually a division of Ag Processing, which is the world's largest soybean processing cooperative with a membership of 300,000 Midwest farmers (Anonymous 1994). This cooperative is based in Omaha, Nebraska and operates eight soybean processing plants in Arkansas, Minnesota, Missouri and Iowa, the latter state having the biodiesel refinery added onto one of the soybean-crushing facilities. British Biodiesel Ltd. is an industrial arrangement because of the large sizes of Farmway (agricultural cooperative), Unitrition (oilseed crusher) and Chemoxy International (contract methyl ester company). Farmway offers contracts to farmers to grow canola and markets the biodiesel. In contrast, the farmer cooperative in Austria had an annual capacity of only 435,000 L prior to 1992, which was being doubled thereafter (Weber 1993). The cooperative is still in operation (personal communication, Donald VanDyne, University of Missouri, Columbia). The 290 members contract oilseed acreage but avoid marketing margins by retaining ownership of their seed, biodiesel and meal cake. This is the sort of community arrangement that is explored in this review along with the industrial scale.

Review of economic feasibility studies

The following review of 12 feasibility studies shows that projected production costs for biodiesel are greater than current pre-tax diesel prices in the US and various European countries. Projected costs for biodiesel from oilseeds ranged from US$0.30/L from soybeans to US$0.69/L from rapeseed, with those for canola, sunflowers and animal fats falling in between (Table 1). Costs for biodiesel from vegetable oil or waste grease are discussed at the end of this section.

Results from three studies included three scales for the biodiesel facility: community (2 million L), industrial (7.5-12 million L), and large industrial (much more than 12 million L). The studies demonstrate the expected economy of scale for the total cost of biodiesel, at least for animal fats (Table 1). This result is mainly due to the economy of scale for capital costs. Also, the three studies assumed that the crushing and/or esterification facility was added onto an existing grain or tallow facility with excess capacity, such as a feed mill, grain elevator or rendering plant. This reduced the capital investment costs since much of the necessary equipment such as augers, storage, conveyors, scales and loading areas would already be available.

Cost of operation does not reflect economy of scale because scale-dependent expenses such as labor are only a small part of the operating cost (Table 1). Because canola and sunflowers have an oil content of 40% and soybeans, only 20%, costs for capital and operation for the former oilseeds are lower than those for the latter, mainly due to less capacity needed for the extruder and oilseed press. Animal fats and waste grease have lower capital and operational costs than the oilseeds because the press and extruder are not required.

The cost of chemicals, mainly alcohol and catalyst, depends on the process, as well as the unit prices for the chemicals. The continuous flow process requires only the stoichiometric amount of alcohol, while the batch process requires an excess of at least 75% to drive the reaction to completion. Noordam and Withers (1996) suggest that 60% of the excess alcohol could be recovered, so that an effective net excess of only (0.75)(0.4), or 30%, would be needed for the batch process. With this amount of projected recovery, the increased cost of chemicals in the batch process over the continuous process would be relatively small at the same prices (Table 1, footnote f).

Noordam and Withers (1996) included 75% recovery of technical grade glycerin in their feasibility study, which brought in an extra US$0.04/L of biodiesel over crude glycerin (Table 1). However, the glycerin market is known to be volatile. For example, a 12 million-litre biodiesel refinery was built in Aschach, Austria in 1990, with 27% of the capital investment costs going to construction of the technical glycerin facility (Weber 1993). Although the price of technical glycerin was US$3.52/kg at the time of construction, it fell to US$1.76/kg by December 1991 (compare Table 1, footnote g). By 1993, the refinery had closed because its profit potential was diminished by the low price for technical glycerin (Körbitz 1993). Also, extensive biodiesel production could flood the market with glycerin and drive the price down. Although glycerin is an ingredient in many foods and pharmaceuticals and is used in various manufacturing processes, there has been little study of the potential economic effects of including these glycerin processes as part of a biodiesel production facility.

Although soybeans are the most expensive feedstock, its byproduct meal cake has the highest monetary credit, such that its total cost is lower than the others for the particular assumptions in Table 1. This is due to the relatively high market price for soybean meal and to the large amount of meal resulting from the low oil content of soybeans. Since sunflower, rapeseed and canola meal have lower nutritional quality than soybean meal, they have less value on the agricultural market than soybean meal.

The relative costs of biodiesel from different oilseeds cannot be determined with absolute certainty because the total costs in Table 1 are affected by the assumed prices for inputs and outputs in biodiesel production. Weber (1993) conducted some simple economic simulations and found that the prices of feedstock and meal were the two most important factors in the cost of biodiesel production. Their effects were much larger than the others. The next two important factors were capital costs and electricity (the latter constituting roughly one-third to one-half of the operating costs for oilseeds in Table 1, mainly for expelling the oil). For example, at the community scale, decreases in the price of soybean meal to US$230 and US$220/t would lead to biodiesel production costs of US$0.40 and US$0.49/L, respectively. The former result would make biodiesel cheaper from canola than from soybeans, and the latter would make biodiesel cheaper from animal fats than from soybeans (Table 1). Another example of the effect of meal price in Table 1 is illustrated by a decrease in the seed price of rapeseed to that assumed by Weber for canola in Table 1, namely US$0.17/kg. This would drop the production cost of rapeseed biodiesel in Table 1 from US$0.69 to US$0.39/L, almost the same as that for canola.

From his simulation studies, Weber (1993) made several conclusions on the economic feasibility of cooperative biodiesel facilities. They should be most successful for farmers who are diversified in both crop and livestock, especially in regions where a large spread exists between the price that farmers receive for their oilseed and the price they pay for protein meal. This is clearly evident from a comparison of the oilseed costs and meal credits in Table 1. Also, due to the energy demands of the extruder and press, electricity costs should be carefully examined in the decision to invest in a biodiesel facility.

Studies on biodiesel produced from vegetable oil or waste grease as feedstock were not included in Table 1 because projected costs were not sufficiently disaggregated or some were atypical. Published estimates for biodiesel produced from vegetable oil feedstock generally fall in the range of the higher estimates for biodiesel from oilseed in Table 1. A rough projection of the cost of biodiesel from oil, including a glycerin credit of US$0.07/L of biodiesel, is in the range of US$0.54-0.62/L. This is based on the costs given by the National Biodiesel Board of US$0.53/L of biodiesel for vegetable oil feedstock and US$0.08-0.16/L of biodiesel for conversion (American Biofuels Association and Information Resources Inc. 1994). The conversion costs of US$0.08 and US$0.16 are respectively based on European commercial experience and on Procter and Gamble in Cincinnati, Ohio (American Biofuels Association and Information Resources Inc. 1994). This range of conversion costs agrees with those given by Korus et al. (1993) and Lumbroso et al. (1993) for biodiesel produced from rapeseed oil.

The projected feedstock cost for waste grease is approximately US$0.26/L of biodiesel (Reed 1993), or half that given above for vegetable oil feedstock. Given the unsubstantiated assumption that clean-up of waste grease would incur an additional cost of US$0.07/L, a rough estimate of biodiesel cost from waste grease would then be US$0.34-0.42/L, including the same biodiesel conversion cost and glycerin credit as that for vegetable oil feedstock. This falls in the same range as that for animal fats (Table 1).

The current cost for biodiesel from vegetable oil is somewhat greater than the above projection for vegetable oil feedstock. Biodiesel is currently produced in small US markets for about US$0.79/L (National Renewable Energy Laboratory 1995). For example, the NOPEC Corporation reports that its current cost of US$1.00/L for biodiesel from soybean oil in its 75 million-litre refinery could drop to as low as US$0.66 (National Renewable Energy Laboratory 1996b). Biodiesel from waste grease is reported to cost about US$0.38/L (National Renewable Energy Laboratory 1995), which falls within the above projected range. But, when the NOPEC refinery achieves full operation on waste grease, it estimates that its cost would be US$0.53/L. Some of these current costs are greater than the rough projections perhaps because of the small market and the immature biodiesel industry in the US. Presumably, as the market increases and technology is improved, costs will be driven down.

The average US price for pre-tax diesel in 1994 was close to US$0.18/L (US Bureau of the Census 1996, Federal Highway Administration 1994). During that same year, pre-tax diesel prices were US$0.20-0.24/L among France, Germany, Italy, Spain and UK (International Energy Agency 1997). Thus at this time, biodiesel is not economically competitive with highway diesel. More research and technological development will be needed to bring the production cost of biodiesel down.

While policy impacts do not alter the economic feasibility of biodiesel, they can affect biodiesel prices. An obvious policy would be an extension of the federal tax credit for renewably-derived ethanol, currently US$0.14/L. Unsuccessful legislation introduced by US Senator Tom Daschle (D-SD) in 1993 proposed that the extension be done on an energy basis. Thus, with the energy contents of ethanol and biodiesel being 20.0 and 31.4 MJ/L, respectively, biodiesel would be eligible for a tax credit of US$0.22/L (American Biofuels Association and Information Resources Inc. 1994). Hence, US$0.40/L would be the maximum price for biodiesel competitive with that for US pre-tax diesel. With this federal tax credit, biodiesel could thus be cheaper than diesel in the US if it was obtained from soybeans and canola at a community level or from animal fats at an industrial level (Table 1).

Economic analysis of the Asperhofen Öko-Dieselprojekt

The Asperhofen Öko-Dieselprojekt is a farmer cooperative of 290 members that contracts approximately 430 ha of canola and some sunflowers with an average yield of 3 t/ha, or approximately 1300 t of oilseed (Parrer 1990). The reported yield of 1000 litres of biodiesel from 3 t of oilseed equates to an extraction efficiency of 73% for the presses, which agrees with the reported 15% oil content in the meal cake. Reacting the mixture twice instead of once gave high esterification efficiencies of at least 98.5% and ensured high quality that exceeded the European minimum standards for biodiesel (Weber 1993). Thus, the facility annually produced 435,000 L of biodiesel and 900 t of meal, or 1500 L and 3.2 t for each farmer. This provided only 40% of their fuel and 20% of their cattle feed (Adamsak 1992). Thus, the farmers voted to double the processing capacity of the facility, which was being done in fall 1992 (Weber 1993). The by-product glycerin, which contains potassium hydroxide catalyst, is not cleaned for sale, but is simply spread as fertilizer on fields of members with potassium-deficient soil (Adamsak 1992).

Government subsidies enable the farmers in the cooperative to produce the canola on set-aside land for biodiesel and meal cake at essentially no net cost (Table 2). This is because the production expenses and processing fee for the farmer are just offset by the subsidies for putting set-aside land into canola and for the amount of oilseed produced. If a farmer had chosen to sell the biodiesel, it would have brought US$0.74/L, much higher than in the US because the cost of diesel was more than US$0.80/L in Austria at that time. Also, the canola meal cake would have sold for US$220/t, close to the US$210/t reported by Weber for canola meal in the US (Table 1). In this case, the farmer's income exclusive of ownership costs would have been US$1170/ha (Table 2). For comparison, typical income exclusive of ownership costs in Austria for corn (7.5 t/ha) and winter wheat (5.0 t/ha) were respectively US$795 and US$720/ha in 1990 (Parrer 1991). There have been recently proposed changes in the Common Agricultural Policy to withdraw support to farmers for non-food production (Connemann and Fischer 1998). Without the subsidies, a loss of US$160/ha would have been incurred with the sale of biodiesel and meal cake.

Information was not provided on the cooperative cost for capital and operation, but a break-even capital and operating cost for producing the biodiesel for sale to the public can be calculated with biodiesel and meal cake respectively at US$0.74 and US$0.44/L biodiesel (Table 2). With canola at US$106/t (Hochkönig 1991) and 3,000 kilograms of canola required for 1,000 litres of biodiesel (Table 2), the cost of canola feedstock would have been US$0.32/L biodiesel. This means that the break-even capital and operating cost would have been US$0.86/L biodiesel. It should be relatively easy for the cooperative to do it cheaper than this because the greatest projected capital and operating cost for any of the examples in Table 1 is only US$0.47/L. The reason this break-even cost is much greater than the projected capital and operating costs in Table 1 is the high price for biodiesel and the low cost of canola feedstock in Austria.

Potential macroeconomic effects of farmers' biodiesel cooperative

The production of biodiesel by farmers' cooperatives would be important in the development of rural economies on local renewable resources. Most of the current agricultural R&D expenditures by private and public sectors now goes to developing value-added food products (Morris and Ahmed 1993). To have this added value go to farmers and rural economies instead of to specific national companies, there is a need for farmers' cooperatives and small companies that use local materials (Ikerd 1992). For example, farmers in a biodiesel cooperative can feed the by-product meal cake to obtain increased profits through higher-valued livestock. Breimyer (1997) added an important caveat that the farmer cannot hope to benefit from a value-added product if the key to the differentiated product lies in external seedstock and not the farmer's own soil or resource.

Weber and Van Dyne (1994) modeled the potential macroeconomic effects of a cooperative biodiesel facility on the economy of Audrain County in Missouri. For a biodiesel facility with an annual capacity of 2 million L (as in Table 1), the net total benefit to that county during the year of construction would be US$145,000 in net wages and salaries for the 9 temporary jobs to construct the plant (assumes workers live in Audrain County), plus some personal state income tax. In the years after construction, the annual net total benefit to Audrain County would be about US$300,000, from the following: US$25,000 net salary for the 1 permanent job to operate the plant; US$25,000 for the 1.5% property tax on the US$1.6 million value of the biodiesel facility (Table 1, footnote e), plus some personal state income tax; and US$250,000 for balance of trade based on the reduced annual import of 2 million L of diesel fuel at US$0.125/L. The results included the decrease in jobs for bulk fuel supply firms, local feed dealers and grain elevators, which was nil for the cooperative scale, but considerable for the larger industrial scales that Weber and Van Dyne modeled.

Other benefits listed by Weber and Van Dyne (1994) were the investment in the biodiesel facility, the reduced underemployment of rural resources, and value added to the feedstock. For soybeans in Table 1, with biodiesel priced at US$0.22/L, they computed the value-added to soybeans as US$58/t, which includes the contribution of meal cake and glycerin. It should be noted that some of the community benefits would be a transfer rather than an increase in the gross domestic product. Similar studies on macroeconomic effects of industrial-scale biodiesel facilities have been done by Weber and Van Dyne (1994) and Ma et al. (1996).

Conclusion

Biodiesel is currently not economically feasible. When the technology has been developed to make it so, farmers' biodiesel cooperatives should be most successful for farmers who are diversified in both crop and livestock, especially in regions where a large spread exists between the price that farmers receive for their oilseed and the price they pay for protein meal. The economics of biodiesel is volatile due to the large effects of feedstock cost and meal credit. Also, factors such as capital costs, electricity costs and glycerin credit can appreciably affect production costs for biodiesel. As currently for gasohol in the gasoline market, tax credits would be needed to make biodiesel competitive with diesel fuel at this time.

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