COST IMPLICATIONS OF FEEDSTOCK COMBINATIONS FOR COMMUNITY SIZED BIODIESEL PRODUCTION

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Abstract

Biodiesel can be processed from oilseeds or animal fats and used in unmodified diesel engines. This type of fuel has been produced commercially in Europe for over three years. European research and testing indicate that used as a diesel fuel substitute, biodiesel can replace diesel fuel without causing harmful effects to an unmodified engine and reduce harmful emissions simultaneously. In addition, some European biodiesel plants operate at the community level and effectively supply both fuel and protein needs to area producers.

The objective of this study was to examine multiple feedstocks that could be utilized by a community sized biodiesel plant and indicate which feedstocks are superior economically. The model plant used in this study is a 500,000 gallon processing facility that is operated as a cooperative. The model plant is assumed to be installed in an existing grain handling facility or feed mill. Animal fats would be purchased from outside sources and oilseeds would be provided by area producers. Producers would retain ownership of the oilseeds and pay a processing fee to the cooperative. Oilseeds would be extruded before being separated into meal and crude oil. The crude oil would be esterified into biodiesel using continuous flow esterification technology.

The results of this study conclude that under specific conditions, biodiesel can be processed economically at the community level. The results of different simulations demonstrate that without farm program benefits to minor oilseeds, soybeans are the most economic feedstock to use in a community based operation. Realistic price information suggests that biodiesel (from soybeans) could be produced for $1.26 per gallon. If producers participate in government programs and are capable of growing minor oilseeds, canola may represent a better feedstock than soybeans. This conclusion is dependent on localized factors. In addition, achieving the lowest costs of production depends on the value assigned to co-product credits such as oilseed meal. Community based biodiesel plants will be successful for producers that are diversified in both crop and livestock operations and can utilize oilseed meals. More specifically, the more producers pay for high protein meal for their livestock and poultry, the lower the residual price of biodiesel.
A combination of factors has pushed energy from biomass into the forefront of policy and industry discussions. Large harvests of traditional crops, low farm prices, dependence of foreign energy sources and environmental problems have increased interest in renewable energy sources. Austrian communities have been successful at producing biodiesel economically at the community level for the last three years. The qualities of this fuel, environmentally as well as technically, have pushed this fuel close to the final stages of commercialization in the United States.

**Description of Biodiesel**

The idea of chemically altering vegetable oils was noted even before World War II. Walton wrote in 1938, "...to get the utmost value from vegetable oils as fuels it is academically necessary to split off the glycerides and to run on the residual fatty acid" because "...the glycerides are likely to cause an excess of carbon in comparison (Quick, 1989)." Although not studied extensively until later, animals fats are also able to be chemically converted into esters (biodiesel). The chemical process used to transform vegetable oils, animal fats, and waste grease into a usable energy form is called trans-esterification. During this process, large, branched, triglyceride molecules of bio-oils and fats are transformed into smaller, straight-chain molecules. These straight-chain molecules are very similar to diesel (Quick, 1989). The chemical transformation is documented as follows:

\[
\text{Triglyceride} + \text{Alcohol} \rightarrow \text{Ester} + \text{Glycerol} + \text{Alcohol}
\]

*Source: Quick, 1989*

**Model Plant for This Study**

The baseline model plant for this study will closely parallel the Austrian system in form of ownership of the facility and the utilization of the products. The biodiesel facility will be operated as a cooperative. U.S. producers will bring in their *oilseeds* (soybeans, canola, or sunflower) to the facility. Ownership will be retained by the producer at all times and the cooperative will charge a processing fee that will cover real annual capital costs and operating costs. The resulting products—biodiesel, meal, and glycerol will remain in the ownership of the producer. Both the biodiesel and meal will be taken back by the producer and the producer will be given a processing credit for the glycerol. The glycerol will be sold on the commodity market as saponification (88%) crude or soap lye (80%) crude. Animal fats, if required, will be purchased from local or regional slaughter facilities. Extrusion and expelling equipment used in this study will be manufactured by Triple "F" Feeds (Des Moines, IA) and the continuous flow esterification unit has been designed by Stratco (Leawood, KS).

The biodiesel facility will be computerized as much as possible in order to minimize labor costs. If the facility was to run 24 hours per day, three shifts of people would be required. However, with computerized sensors less labor will be required as proven by the Austrian system.

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1 Biodiesel is a diesel fuel substitute from vegetable oils and/or animal fats.
2 Mention of these private firms does not indicate sole endorsement by the University of Missouri.
In the extreme case that the plant is underutilized, excess pressing capability will be used to crush soybeans into meal and oil. The crude soybean oil can be sold on the open market and soybean meal can be sold to other livestock producers in the area.

The following additional assumptions were made for a 500,000 biodiesel processing facility operating as a cooperative:

- the plant would be situated into an existing feed mill or gram elevator
- extrusion/pressing equipment to crush 493,000 gallons worth of soybeans
- utility hookups are available and on-site
- oil removal is as follows:
  - soybeans - 50% of total oil content (10%)
  - canola or sunflowers - 68% of total oil content (27%)
- plant presses operate 300 days/year, 24 hours per day
- plant esterification equipment operates 330 days/year; 24 hours per day
- estimated yields of oilseeds (soybeans and canola - 35 bu/acre; sunflowers - 1500 lbs/acre)
- producers would retain ownership of the seed
- facility can process animal fats into biodiesel (valued @ 12¢ per pound)
- excess pressing capacity can be used to produce meal and oil for the commodity markets
- supply 70% of the producer’s fuel needs and serve approximately 550 producers
- soybeans valued at $5.60 per bu., canola @ $4.25/bu. and sunflowers @ 11¢/lb.
- soybean meal (44% protein) is valued at $220 per ton
- canola meal (38% protein) is valued at $190 per ton
- sunflower meal (28% protein) is valued at $140 per ton
- crude glycerin valued at 30¢ per pound
- electricity purchased at $0.07 per kilowatt hour

Scenarios Utilizing 100% of a Specific Feedstock

A comparison of the different feedstocks is detailed in Table 1. At first glance soybeans appear to be the logical feedstock choice. Given the same set of operating conditions and the specific amount of pressing/extrusion equipment provided in the baseline simulation, soybeans do result -in the least cost per gallon for biodiesel. However, much of the higher costs for the remaining feedstocks result from the underutilization of oilseed extrusion/pressing equipment. Table 1 displays the percent utilization of the pressing/extrusion equipment for each feedstock. For example, if animal fats are the sole feedstock then none of the pressing equipment is used and capital costs as a percent of total costs increases to 35%. Scenario I, which uses soybeans as the main feedstock, fully utilizes all of the equipment in this simulation and capital costs are only 8% of the total costs. Both canola and sunflowers rate in-between the previous two feedstocks.

Due to the underutilization of the pressing/extrusion equipment when canola, sunflower, or animal fats are used as the only feedstock, examining the feedstocks against each other does not provide for a valid comparison. Therefore, a comparison should be made according to how much of the pressing equipment is actually utilized. If only 38% of the pressing equipment is allocated to the costs of production when canola or sunflowers are used, the cost per gallon of biodiesel decreases. Also, the cost per gallon of biodiesel from animal fats decreases if none of the pressing/extrusion capital costs are allocated to the total costs of production. Listed below are the costs per gallon for each of the feedstocks if the appropriate amount of pressing/extrusion capital costs are allocated.
Soybeans $1.26
Canola  $1.46
Sunflower $2.35
Animal Fats $1.35

Based on this analysis soybeans would be the logical feedstock to use in a community based operation, given no federal support for other feedstocks.

Table 1

<table>
<thead>
<tr>
<th>Changing Cells:</th>
<th>Scenario I</th>
<th>Scenario II</th>
<th>Scenario III</th>
<th>Scenario IV</th>
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<td>Percent Beans</td>
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<td>0%</td>
<td>100%</td>
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<table>
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<tr>
<th>Cells Result:</th>
<th>Biodiesel Cost-per-gallon</th>
<th>Capital Costs-as-%-of-Total Cost</th>
<th>Percent-Press-Capacity-Used</th>
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Comparison of the Effect of Meal Values on Biodiesel Cost per Gallon

On a per pound basis, canola is the least cost feedstock to use in a biodiesel operation in this simulation. However soybeans achieve a lower cost of production per gallon of biodiesel. Therefore another variable is affecting the economics of this operation. The value of meal co-products is very important in determining the economics of a community based biodiesel plant. Soybean meal is a high protein, low fiber meal. On the other hand sunflower meal is valued lower then soybean meal due to its higher fiber content and lower protein levels. Table 2 demonstrates the importance of the value of oilseed meals in determining the economics of community based biodiesel plants.

The shaded areas represent the values used in the previous simulations. Therefore, once again the pressing/equipment for both canola and sunflowers is underutilized. If this problem is overlooked, the importance of the meal in the economics of biodiesel can still be viewed. A $5 per ton increase in the value of soybean meal will decrease the cost of one gallon of biodiesel by 16¢ per gallon. However, a $5 per ton increase in value for sunflower meal will only net a 5¢ per gallon decrease in the cost of biodiesel. An increase in value by $5 per ton for the last feedstock, canola, will also result in a decrease in the costs of production of each gallon of biodiesel by 5¢.
### Table 2: Price Sensitivity of Oilseed Meal Values

<table>
<thead>
<tr>
<th>Soybean Meal ($/ton)</th>
<th>Canola Meal Cost per Gallon ($/ton)</th>
<th>Sunflower Meal Cost per Gallon ($/ton)</th>
<th>Cost per Gallon</th>
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<tr>
<td>$250</td>
<td>$0.30</td>
<td>$220</td>
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**Relationship between Soybean Prices and Soybean Meal Prices**

According to the information presented, soybeans represent the best feedstock to produce biodiesel given no policy scenarios. Soybean meal was valued at $220 per ton in the baseline simulation. In fact, producers paid an average of $256 per ton for 44% soybean meal in 1991 (’92 Soya Bluebook). Therefore, a community sized biodiesel plant may be capable of producing biodiesel for less than $1.26 with soybeans as the major feedstock. In addition, meal normally marketed would not have the additional energy content that would be found in the soybean meal produced by a biodiesel operation. The meal from the biodiesel plant contains approximately a 10% residual oil content for soybeans (13% for sunflowers or canola). Because the average soybean price received by farmers in 1991 was actually $5.70 per bushel and producers paid $256 per ton on average for 44% soybean meal, a logical question to ask concerns the economics of biodiesel production given conditions from the past. Assuming that the price of diesel fuel at the farm level is $0.85 per gallon, a community sized biodiesel plant could have produced fuel for a cost lower than #2 diesel fuel in 8 of the 11 years considered (1981-1991): This conclusion is based on the average prices paid for 44% soybean meal and the average prices received by farmers for soybeans (data taken from the 1992 Soya Bluebook). These data do not include a value for the residual oil in the meal, which may be worth $20 to $35 per ton.

**Opportunities for Other Feedstocks**

**Double-Cropping Opportunities**

Some areas of the United States have climates that allow planting of a second crop during the same year due to the length of the growing season. The southern portion of the U.S. fits into this category. Because the first crop has already been grown, the second crop will not have a land charge associated with its production budget. Therefore, producers will only need to cover variable costs of production in order to break-even. Using this rationale creates a feedstock that is actually less expensive for the production of biodiesel. However, producers would not process a feedstock into biodiesel if it were more valuable to sell in the commodity market. If producers
cover only variable production costs then any of the oilseed feedstocks could be processed into biodiesel for less than $1.26 per gallon.

Policy Opportunities

Farm program incentives also exist that could effectively lower the feedstock cost of a community based biodiesel operation. The Minor Oilseeds Clause was written in the 1990 Farm Bill and provided the opportunity for producers to O-92 program crop acres, plant a minor oilseed on program crop acres and retain 92% of their deficiency payment. If the assumption is made that the minor oilseed and the program crop are economically competitive without the deficiency payment, then the deficiency payment per acre becomes a subsidy per gallon of biodiesel. If an average canola yield was 35 bushels/acre, then a deficiency payment of $21 per acre would be required to break even with soybeans given the same extrusion and expelling equipment as in the baseline simulation. If only 38% of the extrusion/pressing equipment capital costs were allocated to the costs of production, then a deficiency payment of only $13 per acre would be required to break-even with soybeans. Any future legislation that affects feedstock cost will dramatically impact the cost of producing biodiesel in a community sized plant.

Location Opportunities

In addition to the previous observations, location, in combination with changing oilseeds prices and meal prices, could create an opportunity for feedstocks besides soybeans. If only esterification equipment was installed in a 500,000 gallon plant, tallow that could be purchased at 11¢/pound would break even with soybeans given the prices in the baseline simulation. Community based biodiesel operations that were located extremely close to slaughtering facilities may be able to purchase animal fats and process them into biodiesel for the same costs as an oilseed.

Conclusions

The results of this study conclude that under specific conditions, biodiesel can be processed economically at the community level. The results of different simulations demonstrate that without farm program benefits to minor oilseeds, soybeans are the most economic feedstock to use in a community based operation. Realistic price information suggests that biodiesel (from soybeans) could be produced for $1.26 per gallon. If producers participate in government programs and are capable of growing minor oilseeds, canola may represent a better feedstock than soybeans. This conclusion is dependent on localized factors. In addition, achieving the lowest costs of production depend largely on the value assigned to co-product credits such as oilseed meal. Community based biodiesel plants will be successful for producers that are diversified in both crop and livestock operations and can utilize oilseed meals. More specifically, the more producers pay for high protein meal for their livestock and poultry, the lower the residual price of biodiesel.

Selected References:
