Economics of Small-Scale Biodiesel Production

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The feasibility of farm-scale biodiesel production from oilseed crops has been investigated for oilseed-producing regions (for instance, see Kenkel & Holcomb, 2008), and processing oilseeds into biodiesel is an emerging area. According to University of Vermont Extension (UVM), production of oilseed crops is rare and small-scale oilseed and on-farm biodiesel production remain largely unproven concepts. Farmers generally perceive that they have neither the necessary equipment nor experience to raise these crops. However, if farmers could grow and harvest oilseed crops, press the seeds into vegetable oil and oilseed meal, and process the oil into biodiesel, they could independently produce both liquid biofuel and livestock feed. Early experience with pressing oilseeds into vegetable oil and meal has shown that on-farm oil and meal production is technically feasible (Stebbins-Wheelock et al., 2012).

Production cost and returns are key concerns when deciding to invest in on-farm biodiesel production. Understanding the key economic issues relating to biodiesel production can help potential biodiesel producers make more informed decisions (eXtension, 2012). The cost of biodiesel extraction includes capital costs and variable costs. Capital cost includes the initial investment for equipment and variable costs include chemical, labor, fuel, electricity and annual repair costs.

Equipment

For on-farm biodiesel production, farmers need to purchase a new or used oilseed expeller press. The expeller uses a motor-driven screw to push the oil-containing seeds against a small outlet under significant pressure to extract the oil. According to UVM, expelling is a continuous method and can reduce meal fat content to 6%–7% and capture 50%–85% of the available oil. To press well, the seed must be clean and have a moisture content of 6% to 9%. If the seed is wet, it does not flow through the nozzle well, and if it is too dry, the press grinds the seed to dust. A biodiesel processor converts the oil to biodiesel using chemicals and the cost of a biodiesel processor varies depending on its size. The cost of an 80 gallon processor varies between $4,000 – $5,000 and an oil press unit is around $8,000 with an additional $2,100 for installation. The equipment cost for a methanol recovery system at current market price is $3,495. Assuming a 10-year loan period under full financing with initial investment cost of $18,835, the estimated annual interest payment at the interest rate of 4.5% (FBU, 2014) is about $848. The depreciation cost per gallon of biodiesel depends on the annual production of biodiesel. For example, depreciation costs per gallon of biodiesel with annual production of 1000, 1500 and 2000 gallons in the unit described above are $1.88, $1.26 and $0.94, respectively.

Processing Cost

The biodiesel production process requires an alcohol like methanol for the transesterification process (for more information on the transesterification process see de Koff 2013; 2014). About 8 gallons of methanol are needed for a 40 gallon batch of biodiesel. If methanol costs $1.80 per gallon, then each gallon of biodiesel requires $0.36 of methanol.

Potassium hydroxide is one of the common catalysts required to facilitate the reaction between the oil and alcohol to create biodiesel. About 4 pounds of potassium hydroxide is required for a 40 gallon batch of biodiesel. Given that the market price for 45 pounds of potassium hydroxide is around $107, it makes up about $0.24 of the cost for every gallon of biodiesel.

The estimated electricity cost is $0.77 per gallon of biodiesel.

Based on the annual total production of biodiesel in the system, total processing costs could vary from $2.79 to $4.23 per gallon of biodiesel (Fig. 1).

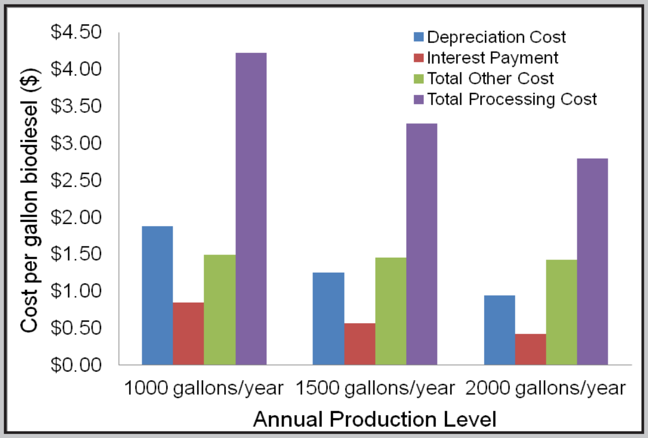

Figure 1. Estimated processing costs per gallon of biodiesel. Note, these costs exclude feedstock and labor costs.

Note, these costs exclude the feedstock cost. Below, we use canola as an example feedstock for determining cost and revenue. In Figure 1, the labor costs were also excluded since economists often treat labor costs differently and some small-scale producers consider their biodiesel production as a hobby and do not place a value on their time involved (eXtension, 2012).

Canola Feedstock Cost

Average variable production cost of canola is about $160 per acre excluding capital costs. The capital cost of the farm equipment involved is excluded since winter canola production is considered as an extra source of income. Since the oilseed expeller can be run at different speeds (low, medium and high), the overall biodiesel yields and costs will differ based on these rates and could vary from $2.15-$2.73 per gallon. With this feedstock cost, total production costs (feedstock + processing) of a gallon of biodiesel could range from $5.53-$6.38.

Revenue

In addition to the biodiesel produced, the seed meal produced by oilseed pressing is also of value. The seed meal can be sold or used as an alternative animal feed. As mentioned previously, the seed press can operate at different speeds so the yield of oil (which is converted to biodiesel) as well as the seed meal could vary according to the selected operating speed. The following estimations of biodiesel (Table 1) and seed meal (Table 2) yield and revenue are based on a per acre basis.

Table 1. Estimated revenue generated from biodiesel production on a per acre basis.

Operating speed	Total oil Yield (lbs/acre)[a]	Biodiesel Yield (gallons/acre)[b]	Biodiesel Revenue ($/acre)[c]
Low	572	74	$283
Medium	464	60	$230
High	451	59	$223

[a]Oil yield is based on two year average (2011 & 2012) winter canola seed yield from national winter canola trials in Tennessee. Accordingly, per acre seed yield was taken as 2,100 lbs.

[b]The efficiency of oil extraction in the small processing unit ranged between 0.54-0.69 so biodiesel yield from an acre of canola is lower than theoretically expected.

[c] Biodiesel price was based on US Department of Energy alternative fuel price for the Mid-West region in October 2013.

Table 2. Estimated revenue generated from seed meal production (per acre or per gallon of biodiesel).

Operating speed	Total Meal Yield (lbs/acre)[a]	Meal Revenue ($/acre)[b]	Seed Meal Value ($/gallon)
Low	1518	$161	$2.17
Medium	1639	$183	$3.03
High	1653	$184	$3.14

[a] Higher operating speed produces comparatively higher meal yield due to the greater amounts of unextracted oil which would affect seed meal quality.

[b] Canola seed meal price was based on historical price data from USDA-NARS and estimated price based on average price from 2009-2012 which was $297 per ton. Since the price of seed meal would depend on its quality, it was assumed to be $223 per ton.

The lower operating speed is more efficient at extracting oil but does take longer. The lower speed, however, will produce a higher quality meal due to its lower fat content, increasing the meal value. [Though this was not taken into account in Table 2, since actual feed values were unavailable, it is important to keep in mind.] When both biodiesel and meal are taken into account, the total revenue is $407-$444 per acre.

As mentioned previously, the cost to produce biodiesel is $5.53-$6.38 per gallon. This is higher than the current price of regular diesel. If one takes into account the value of the seed meal produced ($3.03 per gallon), the cost to generate biodiesel becomes much lower, about $2.50-$3.35 per gallon.

Farmers also have various options regarding ownership of the equipment involved in this process. Production costs and returns were evaluated under several different ownership scenarios namely individual, subsidized and shared ownership (Table 3).

Table 3. Profitability of biodiesel production under various ownership scenarios.

Ownership	Total Processing Costs ($/gallon)	Total Production Costs ($/gallon)[a]	Total Production Costs with Meal Value ($/gallon)[b]
Individual	$3.27	$5.92	$2.89
Subsidized (25%)	$2.82	$5.47	$2.44
5 farmers	$1.79	$4.44	$1.41
10 farmers	$1.64	$4.29	$1.26

Note: The above estimation is based on the biodiesel production under medium processor speed with annual production of 1,500 gallons, feedstock cost of $2.65/gallon biodiesel produced, seed meal value of $3.03/gallon biodiesel produced.

[a] Total production cost includes processing cost plus feedstock cost.

[b] Total production cost per gallon of biodiesel = Total production costs/gallon – value of seed meal in terms of gallon of biodiesel produced.

The type of ownership mainly affects the capital costs of producing biodiesel. Capital costs per gallon of biodiesel can be considerably reduced under shared ownership or through federal assistance programs (i.e. subsidized 25%). Therefore, farmers could receive even higher net profits per gallon of biodiesel. Also, if seed meal is priced between $0.16 - $0.20/lb ($315 - $436/ton) the production costs could be totally recovered from selling the meal.

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