A Feasibility Study of a Mobile Unit for Processing Oilseed Crops and Producing Biodiesel in Vermont

prepared for

The Vermont Sustainable Jobs Fund
as part of the Vermont Biofuels Initiative

by

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and
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About the Vermont Sustainable Jobs Fund and the Vermont Biofuels Initiative

This study has been commissioned by the Vermont Sustainable Jobs Fund as part of the Vermont Biofuels Initiative and its Feed & Fuel Project.

The Vermont Sustainable Jobs Fund (VSJF) was created by the Vermont Legislature in 1995 to identify and fund market driven solutions to our pressing economic, social, and environmental issues. VSJF's grant-making and technical assistance programs support innovative enterprises and business networks. VSJF's current efforts focus on the intersection between the biofuels / renewable energy, sustainable forestry and agricultural sectors. VSJF works to accelerate the rate at which products (and the businesses that make these products) from these sectors become firmly established in the marketplace.

The purpose of the **Vermont Biofuels Initiative** (VBI) is to foster the development of a viable biomass-to-biofuels industry in Vermont that uses local resources to supply a portion of the state's energy needs. Investments in feasibility analyses, research and development, and demonstration projects for various biomass / biofuels feedstocks are intended to lead to their commercialization over a 7 year time horizon.

Overall Project Objectives:

1. To support the expansion of the supply of and demand for locally produced and commodity level biofuels in Vermont in order to reduce the state's dependency on petroleum;
2. To promote entrepreneurial activity in the emerging biofuels sector by providing grant funding and technical assistance to new businesses which can or will eventually create livable wage jobs;
3. To stimulate farm-based biofuels production efforts as a means of enhancing farm viability (reducing costs and/or increasing revenue) and local fuel security; and
4. To help educate the public about the benefits of sustainably and locally produced biofuels.

Starting in 2006, the VSJF began to work closely with **University of Vermont Extension** and a number of farmers who were starting to grow oilseed crops in Vermont. VSJF has funded oilseed field trials over several growing seasons and has used a FY05 US Department of Energy Congressionally Directed Award (through the office of US Senator Patrick Leahy) and private foundation support from the **High Meadows Fund** to develop two small on-farm biodiesel facilities which serve as a learning laboratory for other interested farmers. Over the next 7 years the VSJF intends to work with interested farmers to help develop a sufficient number of on-farm and mobile facilities to grow and process enough oilseed crops to replace at least 12.5% (750,000 gallons) of the 6 million gallons of imported diesel and at least 12,500 tons of the over 100,000 tons of livestock meal consumed each year on Vermont farms with homegrown biodiesel and feed.

Another goal of VSJF's work is to develop an alternative to the industrial-scale model for biofuels production, by creating a parallel marketplace where first generation biofuels can be sustainably grown and produced locally, to serve a particular market radius and reflect true costs. While locally produced biofuels will not be able to completely replace Vermont's liquid fuel consumption, VSJF believes that local production can replace some percentage of the total (e.g., replace on-farm diesel consumption with locally produced biodiesel). VSJF believes that the model of distributive, farm-scale production for local use is one that could be replicated in other small rural communities and states.

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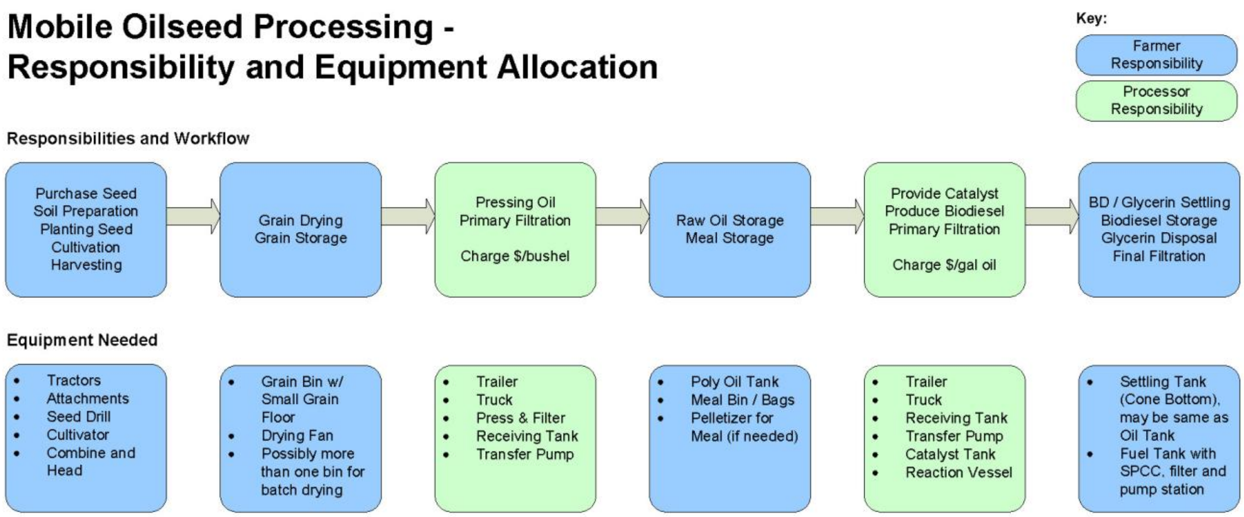
EXECUTIVE SUMMARY

Vermont oilseed production in support of food, feed and fuel markets on Vermont farms shows great promise. One challenge is the distribution of necessary equipment to process oilseeds into more useful forms; meal, oil and biodiesel. Most farmers will not assume the risk of both producing oilseed crops and attempting to convert them to oil and meal. Mobile processors are one way to enable this fledgling agricultural industry.

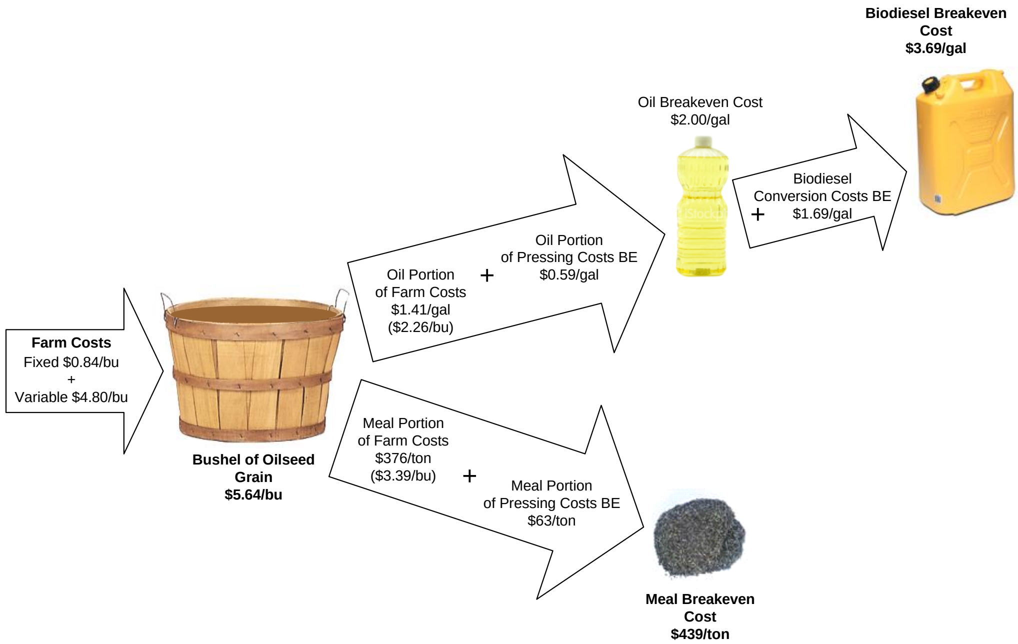
A business model has been developed to estimate the operating characteristics of a mobile oilseed processor that provides services as shown in the figure below. While this model has immediate value in determining feasibility, it also will have future value to entrepreneurs considering and planning for such ventures. The model has been built with flexibility to allow for future changes in costs and prices and to allow for changes in the processor characteristics.



The approach to this study was to compare estimated costs of converting oilseeds to meal, oil and biodiesel with the market value of these products. Estimates of all the costs associated with processing oilseed into meal, oil and biodiesel have been included. Farmers' costs are estimated along with costs associated with the mobile processor. Market values were assumed for diesel fuel ($4.00/gal), organic meal ($599/ton) and conventional meal ($340/ton).

Modeling assessed (1) a stand alone pressing operation, (2) a stand-alone biodiesel conversion operation and (3) a combined operation. Within each of these three operations additional options also have been considered. For example, both manual and automated pressing operations were considered and operations with both single and multiple biodiesel converting trailers were considered. Expenses were estimated for each operational model.

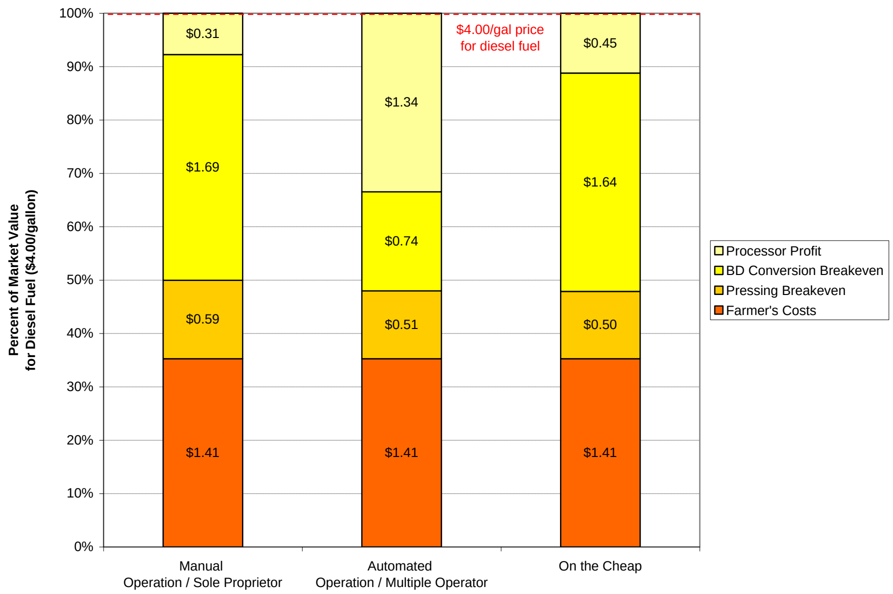
An example of the modeling results is shown below.

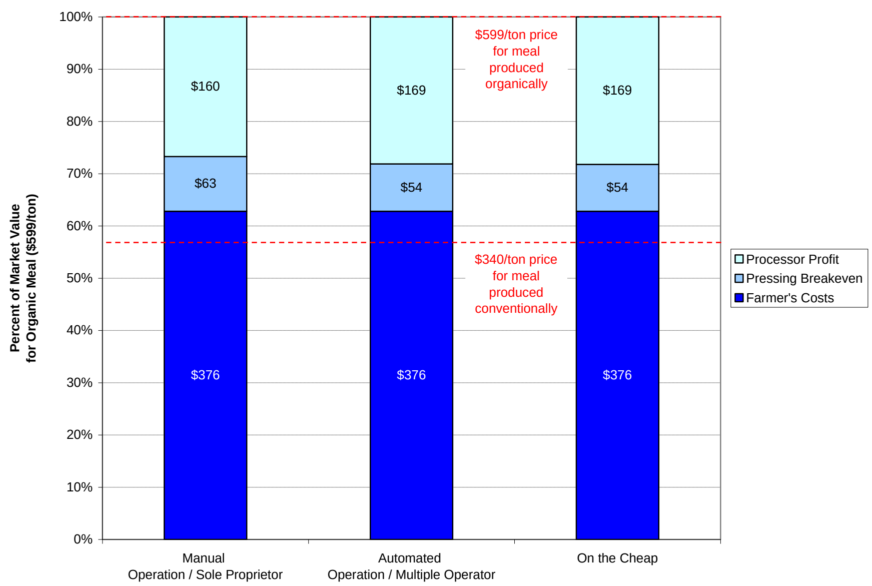


This figure illustrates the breakeven costs of the two main outputs of oilseed processing; biodiesel fuel ($3.69/gal) and meal ($439/ton). This example shows the results for a typical farm using 3,000 gallons of fuel and a mobile processor which provides pressing and biodiesel conversion, pressing 48,000 bushels per year and converting 180,000 gallons of oil per year to biodiesel.

The farmer's costs in this example are relatively high due to conservative assumptions for production costs ($240/acre) and yield (1,500 lbs/acre). The processor's costs are also relatively high due to it being a relatively low volume processor of biodiesel and, thus, paying more for methanol than a higher volume processor would. In short, this model is feasible even with conservative assumptions, and shows room for improvement.

A comparison of three combined service models is provided in the two graphs below. The first graph shows the value of converting oilseeds to either vegetable oil or biodiesel as fuel for the farm when compared with market value. The significantly lower cost of conversion for the automated/two operator model comes from lower methanol costs. The second graph shows the value of converting oilseeds to meal when compared with market value. A result of the conservative farmer cost assumptions above is that the farmer's cost of unprocessed grain exceeds the market value for conventional meal.





Mobile oilseed processing in Vermont is predicted to be a feasible and profitable opportunity based on the results of this study. It is technically feasible to transport appropriately sized equipment with a truck and small trailer to remote locations to provide processing services. It is also estimated that the cost of processing is below the market value of certain outputs (biodiesel and organic meal). A key challenge to such an operation will be establishing a sufficient initial market to breakeven at a reasonable price while also planning on future growth to capitalize on economies of higher volume production. As production volume increases, the breakeven price will decrease and higher profit can be realized at the same market price. ***A processor charging a price between breakeven and market value will realize a profit while providing some savings to the farmers they serve.***

1. INTRODUCTION

This study has been prepared for the Vermont Sustainable Jobs Fund to assess the feasibility of a mobile processor to convert oilseed crops into oil and meal on Vermont farms. Funding for this work has been provided by the High Meadows Fund and the Vermont Sustainable Agriculture Council.

Oilseed production in support of food, feed and fuel markets on Vermont farms shows great promise. One challenge is the distribution of necessary equipment to process the oilseeds into more useful forms; oil and meal. Some pioneering farms and groups have purchased oil presses and have constructed or purchased equipment to convert raw oil into biodiesel. But this is the exception. Most farmers will not assume the risk of both producing oilseed crops and attempting to convert them to oil and meal. Mobile processors are one way to enable this fledgling agricultural industry.

A business model has been developed to estimate the operating characteristics of a mobile processor. While this model has immediate value in determining feasibility, it also will have future value to entrepreneurs considering and planning for such a venture. The model has been built with flexibility to allow for future changes in prices and to allow for changes in the processor characteristics.

The business operation has been reviewed as (1) a stand along pressing operation, (2) a stand-alone biodiesel conversion operation and (3) a combined operation. Within each of these three operations additional options have been considered. For example, both attended and unattended pressing operations were considered.

A list of the equipment required for each operation was generated and prices were estimated to establish initial capital (or fixed) costs. Operational (or variable) costs were estimated along with each operation’s capacity. This portion of the analysis led to the determination of the breakeven price for the operator.

Market value of the pressing and biodiesel conversion services is based on subtracting the market value of the end products from the farmer’s cost to produce dry grain. The farmer’s cost basis has been based on oilseed crop production costs and yields as well as capital investment costs which a farm would bear to enable mobile processing at their location (e.g. grain bins and driers).

2. BACKGROUND – OILSEED CROPS IN VERMONT

Oilseed crops such as sunflower, canola and soybeans contain relatively high amounts of vegetable oil in their seeds. This oil can be converted to a food commodity and can also be used as a fuel for diesel engines either as raw oil or after being converted to biodiesel. Additionally, after the oil is pressed from the seeds, solids remain which can be made into a high protein meal for use as livestock feed. Previous work has demonstrated the feasibility of oilseed crop production[2,4] and the potential benefit of an oilseed industry in Vermont[7].

This previous work has concluded that oilseed crops can be feasibly produced in Vermont and that their production can be done sustainably (e.g. balancing feed, food, and fuel needs).

Certain equipment and services are required to support such an endeavor and they largely do not exist on most Vermont farms. Oil presses and biodiesel conversion systems are key components of oilseed production for food or fuel and represent a relatively large investment for a single farm. It is, therefore, unlikely that each farm will invest in such equipment for their sole use. This is particularly true when considering the very short period of time that such equipment would be used to provide the farm's fuel.

One solution to this problem is a centralized processing facility. Capital costs and logistics tend to be prohibitive challenges for an early stage oilseed industry like Vermont's. This is one case in which moving the equipment may be more feasible than moving the product. This study assumes portable equipment that can be "shared" among many farms. **A mobile processor, sized to handle one farm at a time offers the advantage of lower capital costs and increased flexibility to respond to the processing market as it changes.**

This study considers how such a model of business might operate and what the cost structure might be.

3. MODELS OF MOBILE OILSEED PROCESSING

This section describes the operational models assumed in the analysis. Because oilseed crops may be marketed as feed, food, and/or fuel it is important to assume a modular operation in which the valued outputs might be oil, meal and/or biodiesel. For this reason it is assumed that the mobile processor provides two discrete services: (1) converting grain to oil and meal and (2) converting oil to biodiesel.

A farm may choose to utilize only one of these services or may choose to utilize both. The decision is likely to be influenced by the value that the farm places on raw oil vs. meal vs. fuel.

Another consideration in support of a modular operation is found in the concept of a hybrid market model. In such a model, it is assumed that the primary product is food grade vegetable oil sold to the food market with a contingency that the oil is returned as waste oil. This waste oil could then be converted to biodiesel for use as fuel.

The overall model of operation is summarized in Figure 1 and the details assumed for each module are discussed in the following sections. As shown in Figure 1, this study assumes the farm is responsible for oilseed production, drying and storage as well as raw oil, meal and biodiesel storage and final filtration. The value proposition of this mobile processor, therefore, is converting raw materials to more valuable or useful forms. This structure is also likely to reduce liability on the part of the processor. Crop loss in storage, spills of oil or biodiesel and appropriate filtration of fuel prior to filling equipment are all the responsibility of the farm. This seems reasonable considering that all these risks are longer term daily risks that the farm is better suited to mitigate than the processor.

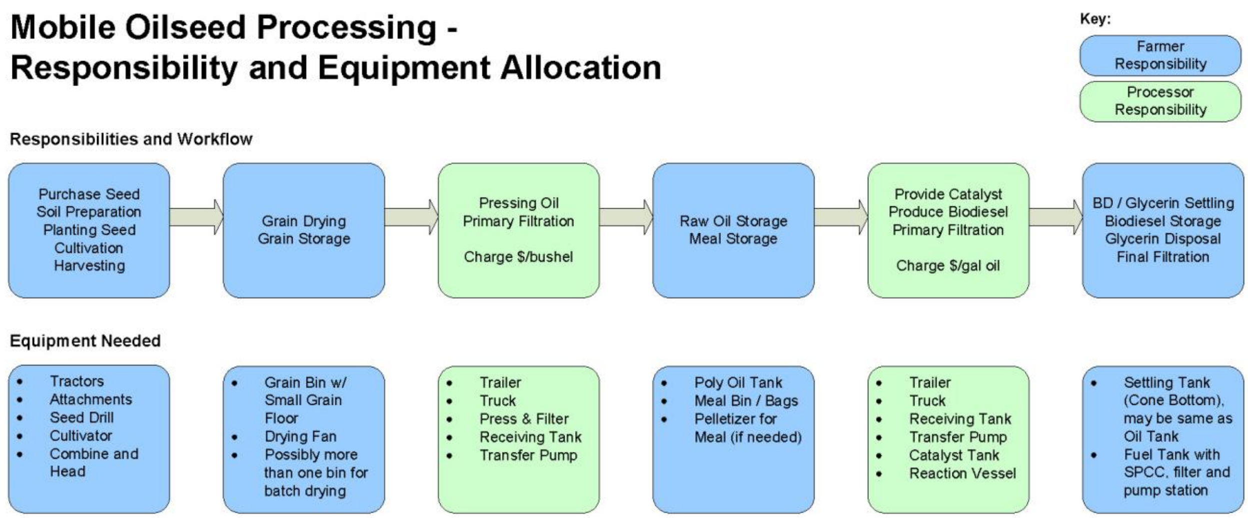


Figure 1 – Flowchart of mobile oilseed processing.

Figure 1 shows the assumed model of operation when the processor works for a farmer who is growing grain and desires meal and biodiesel fuel as outputs. There are other arrangements possible in which, for example:

- A farmer wants only to press the grain to vegetable oil and meal
- A farmer wants to press all the grain to vegetable oil and meal, and convert a portion of the oil to biodiesel
- A farmer or other customer wants to convert waste vegetable oil to biodiesel
- A farmer may want grain processed into oil and meal: using the meal on the farm, selling the oil to a restaurant, and then recovering the oil from the restaurant before producing fuel for farm use.

For this reason the fee structure for the mobile processor will likely be based on (1) pressing grain on a per bushel basis and (2) converting oil to biodiesel on a per gallon of feedstock basis.

Overall modeling assumptions (independent of the business model chosen) include:

Average Gallons of Oil Per Farm:..........................1000 gallons
Operator Wage ....$17 / hour
Fuel Cost (to processor)..................................$4.00 / gallon
Portion of year spent pressing................................. 6 months
Portion of year spent making biodiesel..................... 6 months
Average distance to farm from base ....30 miles

Start up costs:
Planning.. $5,000
Legal Counsel $5,000
Accounting Counsel $2,000
Incorporation.. $500
Operator Recruitment and Training............................. $2,000

Other assumptions related to specific portions of the business models are discussed in the following sections.

3.1 Mobility: Truck and Trailer

In order to provide for efficient distribution of the oil pressing and conversion services a platform of a heavy duty diesel pick-up truck and landscaper's trailer is assumed. Many Vermont farms are hard to reach and such a nimble transportation platform allows access to more farms than a larger platform such as tractor trailer.

A trailer which is easily removed from the towing vehicle is also important when multiple trailer or multiple operator models are considered. There is an economic efficiency advantage to the service provider that can leave an automated press operating at one farm while setting up a second pressing trailer at another farm.

The modular pressing and conversion trailers are also relatively lightweight and, therefore, do not necessitate a significant towing capacity. This is made possible by assuming on-farm storage of dry oilseeds, pressed oil and converted fuel.

For purposes of financial analysis two business startup options are considered; purchasing a new truck and purchasing a used truck. In all cases a new trailer is assumed.

The truck assumed for this study is a GMC Sierra 3500 Crew Cab 4x4 or equivalent. This truck is a diesel and has estimated fuel economy of 18.3 MPG alone and 10.5 MPG when hauling a trailer. It has an MSRP of $50,834. A used pickup with a purchase price of $12,000 is assumed for an "on-the-cheap" startup operation.

The trailer assumed for this study is a Pace Summit landscaper's trailer. These trailers are built for rugged use and are highly customizable (door locations, vents, lights, etc.) The trailer has a retail cost of $6,500 and a payload of 4500 lbs in 761 cu. ft..

Figure 2 - Trailer Platform: Commercially available "landscaper's" trailer. Pace American Summit line, model SL714TA2, $6500 MSRP, 7.5' W x 14.5' L x 7' H, 4500 lbs payload.

The logistics of operating a mobile oilseed processing business require significant travel on Vermont roads. The number of farms one trailer can serve is limited by the reach of the operation. The reach of the operation is limited by driving time. A simple assessment of driving distances for 30 and 60 minute drive times is shown graphically in Figure 3. Two mobile operations were assumed with one based in Rutland and the other in Montpelier. Assuming an average speed is 30 mph, a 60 min drive results in 30 mile radius and a 120 min drive time allowance results in a 60 mile radius assuming an ideal condition of perfect roads in every direction. The map shows the more realistic effect of actual roads. It is important to note spill over potential in Western NH and Eastern NY. There is some overlap in service area in this scenario. Base locations were chosen somewhat arbitrarily, although this model does assume that farmers in close enough proximity to the two stationary oilseed pressing and biodiesel production operations which currently exist in Alburgh and Shaftsbury, would not need to utilize a mobile service provider.

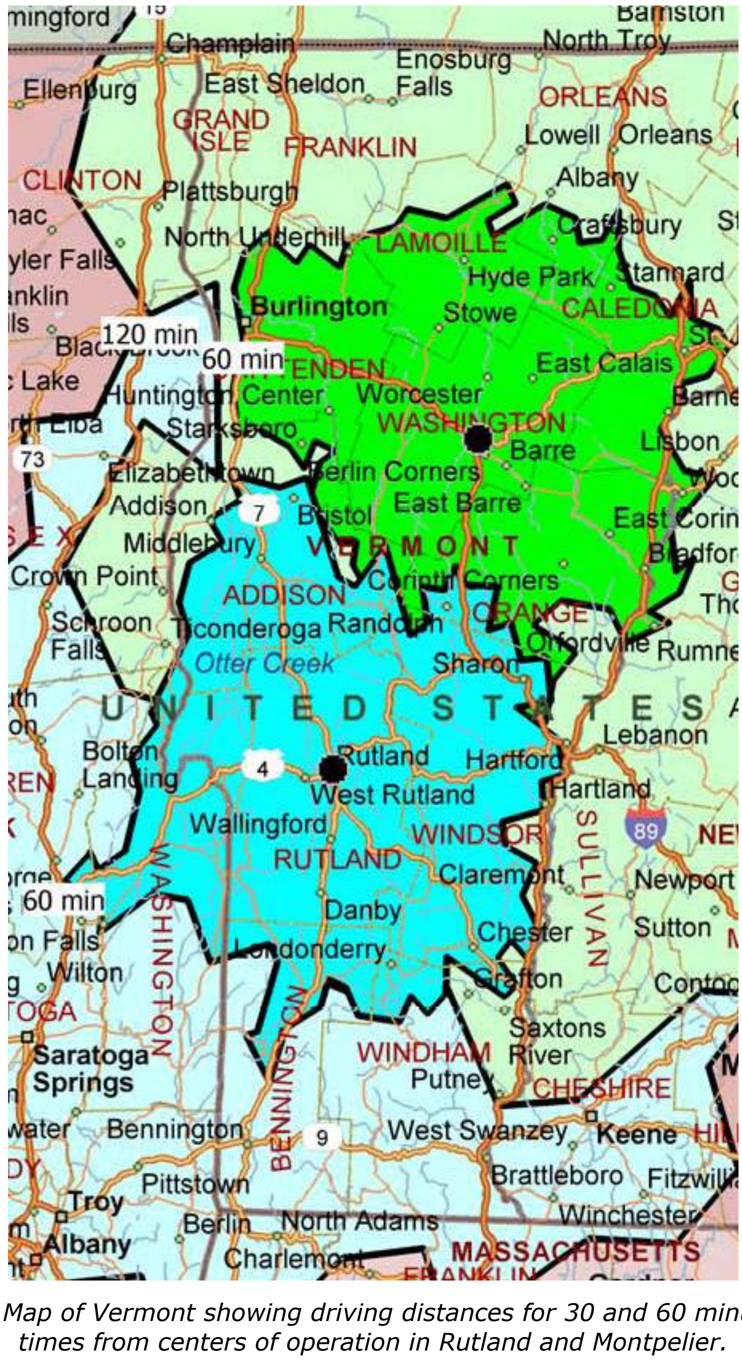


Figure 3 - Map of Vermont showing driving distances for 30 and 60 minute driving times from centers of operation in Rutland and Montpelier.

3.2 Oil Pressing

The equipment required for oil pressing includes grain moving equipment, grain hopper, one or more oil presses, oil collection tank(s), meal collection container(s) and an electric generator or power source.

A farm that is producing oilseed crops will require grain moving equipment (augers or elevators) for the harvest and drying of the grain. For this reason, it is assumed that the processor will not need a second set of this equipment.

A small grain hopper will be required to serve as a buffer between the farm's bulk grain storage bin and the oilseed press. These hoppers are usually situated above the press to allow gravity feed of seed to the press. A small polypropylene tank with conical bottom is assumed.

There are two main categories of oil presses; those produced in Asia and those produced in Europe. The former are generally considered cruder in design and are more operator dependant, though they are considerably less expensive than the, latter, more automated presses. There is a trade off related to investing in press capacity or automation. Both options were considered in the study.

Each press has a rated capacity as summarized in Figure 4. Multiple presses can be fed from the same hopper and result in increased capacity. However, in the case of a mobile press, there are payload and power limits to be concerned with. The relative power input requirements and mass as a function of capacity is shown in Figure 5.

Based on these considerations two basic oil press trailer configurations were included in the study. One is comprised of a Zhengzhou 6YL-130 oil press (manual) with a capacity of 11,200 lb seed / day (8 hour day) at an initial cost of $2,710. The other trailer configuration uses two (2) Täby 90 presses (automated) with a capacity of 20,000 lb seed / day (24 hour day) per trailer at an initial cost of $32,942 (for two presses in one trailer). The first configuration requires the regular attention of an operator, limiting operation to an assumed 8 hours per day. The second configuration is intended to be largely automated, which allows 24 hour operation.

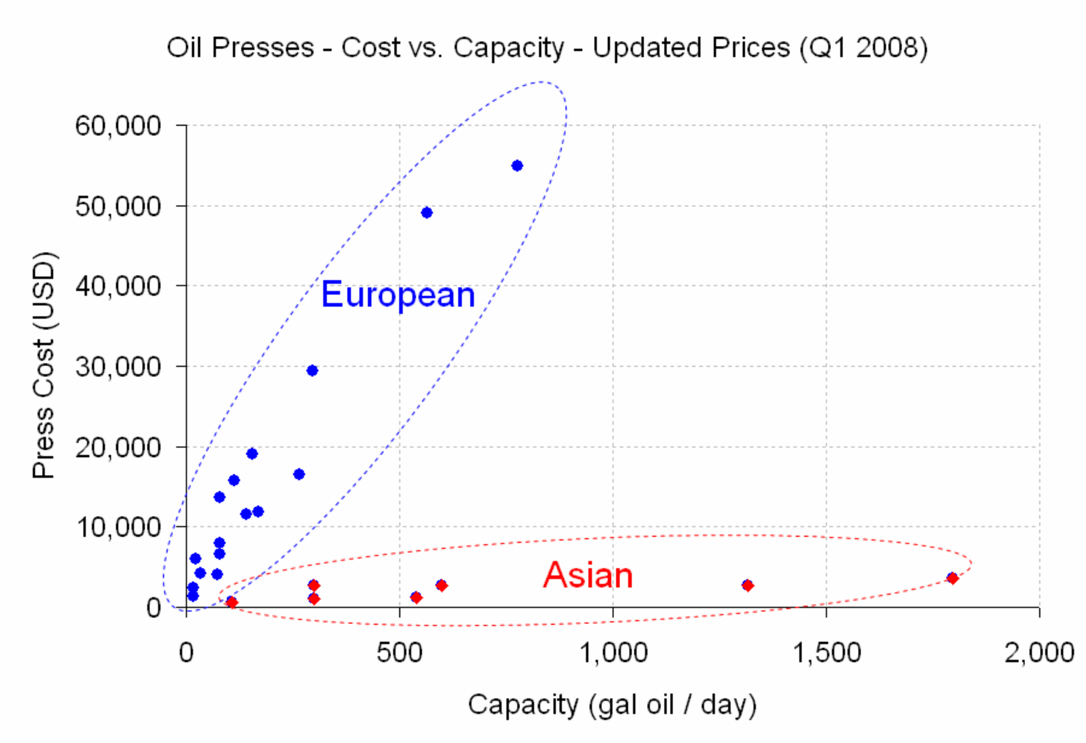


Figure 4 – Cost and capacity of oilseed presses.

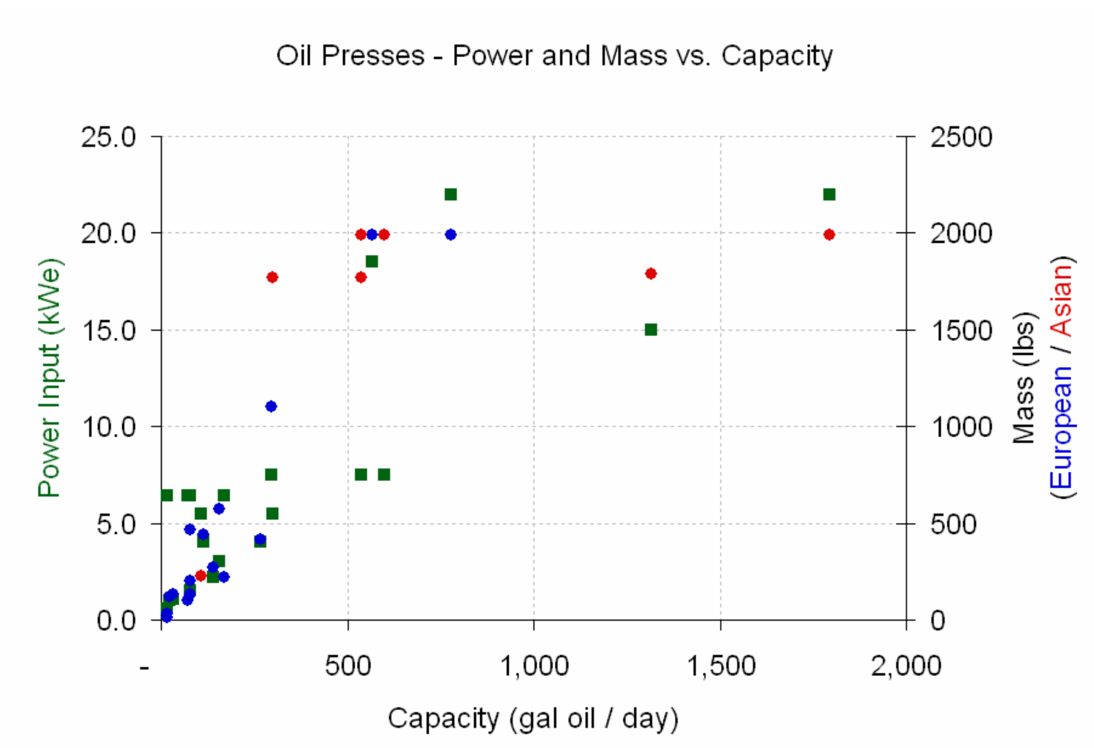


Figure 5 - Power requirements and mass of oilseed presses.

Figure 6 - Examples of oilseed presses:
Zhengzhou 6YL-130 (LEFT) and two Täby 90's (RIGHT).

Some assembly and fabrication is also assumed on the part of the business owner to integrate the parts into the trailer. An amount of $4,000 has been allocated for this purpose.

	Manual Operation		Automated Operation		On the Cheap (Manual)	
Fixed Costs						
Truck	$	52,000	$	52,000	$	12,000
Trailer(s)	$	33,441	$	130,346	$	21,996
Fixed Cost per Trailer						
Trailer	$	6,500	$	6,500	$	6,500
Grain Handling	$	5,000	$	5,000	$	2,500
Seed Hopper	$	340	$	340	$	340
Press with Motor	$	2,710	$	32,942	$	2,710
Generator	$	8,891	$	8,891	$	4,446
Oil Handling	$	1,000	$	2,500	$	1,000
Meal Handling	$	5,000	$	5,000	$	2,500
Assembly and Fabrication	$	4,000	$	4,000	$	2,000
Subtotal per Trailer	**$**	**33,441**	**$**	**65,173**	**$**	**21,996**
Total Fixed Costs	**$**	**85,441**	**$**	**182,346**	**$**	**33,996**

Table 1 - Summary of fixed costs for mobile oil pressing unit.

Variable costs of operation for the pressing trailer include the operator wage, fuel used in travel and hauling, fuel used in the generator to power the press, insurance costs, administrative costs, maintenance, registration fees, depreciation of equipment, amortization of start-up costs, and debt service.

Operator wages and fuel for transport have been discussed above.

The fuel used for pressing is based on the known power input required for the press, the number of hours of operation and the efficiency of the generator. Combined, this amounts to about 2% of oil pressed (i.e. for 100 gallons pressed, the system uses the fuel equivalent of 2 gallons of oil).

Insurance is assumed as $3,000 per year for typical commercial general liability coverage combined with commercial auto coverage.

Administrative costs assume that some bookkeeping and other administrative work will be required to support the enterprise. An annual $10,000 is assumed.

Maintenance costs are assumed as 10% of fixed costs on an annual basis.

Registration fees are for the truck and trailer and are assumed to be $250 for each truck and $250 for each trailer per Vermont Agency of Motor Vehicles.

Depreciation assumes 20 year life with zero salvage value.

Debt service assumes 5.5% APR and 7 year term per the Vermont Economic Development Authority Small Business Loan program.

	Manual Operation	Automated Operation	On the Cheap (Manual)
Operating Costs (including ammortized startup costs and depreciated equipment expenses)			
Operator	$ 17,680	$ 17,680	$ 17,680
Fuel - Travel	$ 1,872	$ 3,086	$ 1,872
Fuel - Pressing	$ 1,560	$ 3,600	$ 1,560
Insurance	$ 3,000	$ 3,000	$ 3,000
Administrative	$ 10,000	$ 10,000	$ 10,000
Maintenance	$ 3,344	$ 6,517	$ 2,200
Registrations / Fees	$ 500	$ 750	$ 500
Depreciation of Equipment	$ 4,272	$ 9,117	$ 1,700
Ammortized Startup Costs	$ 1,450	$ 1,450	$ 950
Debt Service	$ 17,234	$ 33,944	$ 7,500
Total Operating Costs	**$ 60,912**	**$ 89,145**	**$ 46,962**

Table 2 - Summary of operating costs for mobile oil pressing unit.

3.3 Biodiesel Production

The equipment required for converting oil to biodiesel includes a oil holding tank, a catalyst mix tank, a settling tank, a jacketed reaction vessel (probably combined with oil holding tank), balance of plant (pumps and valves), controls, safety equipment, and an electric generator or power source. While some initial settling is assumed to occur on the trailer in a 250 gallon settling tank, the time constraints of a portable operation will require that the farm have some settling capability as well.

An oil holding tank allows for initial loading of a 250 gallon batch of oil to be placed on the trailer. The 250 gallon batch size was selected based on payload limits of the trailer. Consider that 250 gallons of oil being converted in the reaction tank plus 250 gallons of finished fuel in the settling tank would weigh about 3,650 lbs. The balance of the payload will be taken up by other equipment, personnel and other reactants.

This batch size also allows for quality control on relatively small batches. Considering the variety of oils that the processor will be working with, it is assumed that each batch may require specific adjustments to the biodiesel recipe. For the purposes of this analysis, simple field quality control tests are assumed (e.g. FLIP and "Warnqvist 27/3"). These tests are considered to provide sufficient confidence in fuel quality for on-farm use. If the farm desires to sell fuel to customers, additional quality testing would be required. That is considered to be out of the scope of the current study.

A polypropylene tank with a conical base is assumed for a settling tank. The cost for a 250 gallon tank is $750.

A stainless steel jacketed reaction tank is assumed to be purchased used from one of many distributors. A recent survey of such distributors indicates a price of $10,000 for a 250 gallon vessel.

A stainless steel mixing tank is assumed for the catalyst mixing tank (methoxide tank). A price of $4,000 is estimated based on similar assumptions and survey as in the jacketed reaction tank.

The cost of pumps, valves and plumbing was estimated as 20% of the cost of the tanks. This works out to roughly $4,250.

Controls include pump motor drives, heater controls, valve switching, etc. A conservative amount of $5,000 is estimated for this item.

Safety systems include combustibility sensor and emergency stop switches. The budget assumes $2,000 for this.

As in the pressing trailer, some assembly and fabrication is assumed on the part of the owner. An amount of $4,000 is allocated for this purpose.

	Sole Proprietor		Multiple Operator		On the Cheap	
Fixed Costs						
Truck	$	52,000	$	104,000	$	12,000
Trailer(s)	$	36,500	$	73,000	$	26,190
Repair Equipment and Spares	$	7,300	$	7,300	$	5,238
Total Fixed Costs	**$**	**95,800**	**$**	**184,300**	**$**	**43,428**
Fixed Cost per Trailer						
Trailer	$	6,500	$	6,500	$	6,500
Oil Holding / Reaction Tank	$	10,000	$	10,000	$	7,000
Alcohol/Oxide Mix Tank	$	4,000	$	4,000	$	2,800
Settling Tank	$	750	$	750	$	525
Balance of Plant	$	4,250	$	4,250	$	3,365
Controls	$	5,000	$	5,000	$	2,000
Safety Equipment	$	2,000	$	2,000	$	2,000
Assembly and Fabrication	$	4,000	$	4,000	$	2,000
Subtotal per Trailer	**$**	**36,500**	**$**	**36,500**	**$**	**26,190**

Table 3- Summary of fixed costs for a biodiesel conversion unit.

Variable costs of operation for the biodiesel trailer are largely similar to those for the pressing trailer, but also include the fuel used in the generator to heat oil and run pumps as well as chemical costs (e.g. methanol and lye for catalyst).

The fuel used to heat the oil and run the pumps amounts to 1.4% of the fuel produced (i.e., 1.4 gallons for every 100 gallons produced is used to fuel the process).

The costs associated with methanol and lye are significant and have been quite volatile. The prices used for this analysis are based on conversations with a large scale distributor. Costs assume deliveries in either totes (250 gallons @ $5.00 / gal) or tanker trucks (7,000 gallons @ $1.55 / gal).

	Sole Proprietor		Multiple Operator		On the Cheap	
Operating Costs (including ammortized startup costs and depreciated equipment expenses)						
Operator	$	17,680	$	35,360	$	17,680
Fuel - Travel	$	4,320	$	8,640	$	4,320
Fuel - Reacting / Converting	$	10,386	$	20,773	$	10,386
Methanol	$	216,000	$	144,000	$	216,000
Lye	$	28,800	$	28,800	$	28,800
Insurance	$	3,000	$	6,000	$	3,000
Administrative	$	10,000	$	10,000	$	10,000
Maintenance	$	3,650	$	3,650	$	2,619
Registrations / Fees	$	500	$	1,000	$	500
Depreciation of Equipment	$	4,790	$	9,215	$	2,171
Ammortized Startup Costs	$	1,450	$	1,650	$	950
Debt Service	$	19,020	$	34,626	$	9,127
Total Operating Costs	**$**	**319,597**	**$**	**303,714**	**$**	**305,554**

Table 4 – Summary of operating costs for a biodiesel conversion unit.

3.4 Combined Model

One likely business model would combine the pressing and biodiesel conversion operations into a single venture. This model capitalizes on shared common expenses such as the truck, trailers, generator, insurance, administration, and start-up expenses.

It is assumed that a single trailer could be used to perform both pressing and oil conversion processes. This would require temporary fixtures in the trailer for the press and biodiesel equipment.

The operator of this trailer would have to determine the most appropriate split of the calendar year between pressing oil and converting oil to biodiesel. This would likely be very dependent on a changing market demand for each service. For the purposes of this study each service was allocated 6 months of the year.

	Manual Operation / Sole Proprietor	Automated Operation / Multiple Operator	On the Cheap
Fixed Costs			
Truck	$ 52,000	$ 52,000	$ 12,000
Trailer(s)	$ 63,441	$ 190,346	$ 41,686
Repair Equipment and Spares	$ 23,088	$ 48,469	$ 10,737
Total Fixed Costs	**$ 138,529**	**$ 290,815**	**$ 64,423**
Fixed Cost per Trailer			
Common Components			
Trailer	$ 6,500	$ 6,500	$ 6,500
Generator	$ 8,891	$ 8,891	$ 4,446
	$ 15,391	**$ 15,391**	**$ 10,946**
Pressing Components (swapped seasonally for BD Conversion Components)			
Grain Handling	$ 5,000	$ 5,000	$ 2,500
Seed Hopper	$ 340	$ 340	$ 340
Press with Motor	$ 2,710	$ 32,942	$ 2,710
Oil Handling	$ 1,000	$ 2,500	$ 1,000
Meal Handling	$ 5,000	$ 5,000	$ 2,500
Assembly and Fabrication	$ 4,000	$ 4,000	$ 2,000
	$ 18,050	**$ 49,782**	**$ 11,050**
BD Conversion Components (swapped seasonally for Pressing Components)			
Oil Holding / Reaction Tank	$ 10,000	$ 10,000	$ 7,000
Alcohol/Oxide Mix Tank	$ 4,000	$ 4,000	$ 2,800
Settling Tank	$ 750	$ 750	$ 525
Balance of Plant	$ 4,250	$ 4,250	$ 3,365
Controls	$ 5,000	$ 5,000	$ 2,000
Safety Equipment	$ 2,000	$ 2,000	$ 2,000
Assembly and Fabrication	$ 4,000	$ 4,000	$ 2,000
	$ 30,000	**$ 30,000**	**$ 19,690**
Subtotal per Trailer	**$ 63,441**	**$ 95,173**	**$ 41,686**

Table 5- Summary of fixed costs for a combine business model having both pressing and biodiesel conversion operations.

Operating Costs (including ammortized startup costs and depreciated equipment expenses)

Common Costs			
Operator	$ 35,360	$ 53,040	$ 35,360
Insurance	$ 3,000	$ 3,000	$ 3,000
Administrative	$ 10,000	$ 10,000	$ 10,000
Maintenance	$ 6,344	$ 9,517	$ 4,169
Registrations / Fees	$ 500	$ 750	$ 500
Common Depreciation	$ 4,524	$ 5,793	$ 1,684
Ammortized Startup Costs	$ 1,450	$ 1,450	$ 950
Debt Service (Common)	$ 15,602	$ 22,633	$ 5,808
	$ 76,780	**$ 106,183**	**$ 61,471**
Pressing Costs			
Fuel - Travel	$ 1,872	$ 3,086	$ 1,872
Fuel - Pressing	$ 1,560	$ 3,600	$ 1,560
Pressing Equip Depreciation	$ 903	$ 14,541	$ 3,221
Debt Service (Pressing)	$ 3,113	$ 17,169	$ 1,905
	$ 7,447	**$ 38,395**	**$ 8,559**
BD Conversion Costs			
Fuel - Travel	$ 4,320	$ 8,640	$ 4,320
Fuel - Reacting / Converting	$ 10,386	$ 20,773	$ 10,386
Methanol	$ 216,000	$ 144,000	$ 216,000
Lye	$ 28,800	$ 28,800	$ 28,800
Conv. Equip Depreciation	$ 1,500	$ 1,500	$ 985
Debt Service (Conversion)	$ 5,173	$ 10,346	$ 3,395
	$ 266,180	**$ 214,059**	**$ 263,886**
Total Operating Costs	**$ 350,407**	**$ 358,638**	**$ 333,916**

Table 6- Summary of operating costs for a combine business model having both pressing and biodiesel conversion operations.

3.5 Farmer Responsibilities & Costs

As summarized in Figure 1, the farmer who desires the services of such a mobile oilseed processor has certain responsibilities and will need to have some specialized equipment.

The farmer is assumed to be responsible for:

1. Soil preparation and amendment
2. Planting
3. Cultivating
4. Harvesting / Combining
5. Drying Grain
6. Storing Grain
7. Storing Oil
8. Storing Biodiesel
9. Paying the processor for their services.

Fixed Costs to Farmer

Some of the specialized equipment required by the farm includes:

1. Small Grain Combine
2. Grain Drier - Small Grain Floor
3. Grain Storage Bin(s)
4. Grain Elevator / Auger System
5. Raw Oil Storage / Settling Tank
6. Diesel Storage Tank (w/ Spill Prevention Containment and Collection (SPCC) measures)

Capital costs associated with this equipment were estimated in order to assign a value to the farmer's contribution to the production of the final product. These costs are summarized in Table 7 along with the resulting costs per bushel of grain, per gallon of oil, and per ton of meal.

Small grain combine costs are based on used combines sized for the acreage estimated to support the desired oil production. These values are representative, based on a brief survey of several used equipment vendors.

Grain drier costs are based on using ambient temperature air forced into a bin with a small grain floor by a fan.

Grain bin costs are based on $4.00/bushel for new and $1.00/bushel for used. These values are from a supplier of grain bins in Western New York and have been confirmed by a recent journal article[5&9]. In both cases the bins are sized to 125% of the indicated harvest for margin.

Grain elevator / auger costs are based on reasonably sized units as advertised by several agricultural equipment vendors.

Settling tank costs are based on polypropelene tanks sized to contain all the desired oil or fuel production.

Diesel fuel storage costs are based on double wall steel tanks.

Summary of Farm Capital Costs to Support a Mobile Processor

Gallons of Oil / Biodiesel Used (gal/yr)	500	1000	1500	3000	5000	7500
Equivalent Acreage of Oilseed (acres)	5.2	10.4	15.6	31.3	52.1	78.1
Equivalent Bushels of Oilseed (bu)	313	625	938	1875	3125	4688
Equivalent Tons of Oilseed (tons)	4.7	9.4	14.1	28.1	46.9	70.3
Equivalent Tons of Meal (tons)	2.8	5.6	8.4	16.9	28.1	42.2
Equipment						
Small Grain Combine, used	$ 2,000	$ 3,000	$ 4,000	$ 5,000	$ 15,000	$ 25,000
Grain Drier - Small Grain Floor	$ 1,000	$ 2,000	$ 3,000	$ 5,000	$ 10,000	$ 15,000
Grain Storage Bin(s)						
New	$ 1,563	$ 3,125	$ 4,688	$ 9,375	$ 15,625	$ 23,438
Used	$ 391	$ 781	$ 1,172	$ 2,344	$ 3,906	$ 5,859
Grain Elevator / Auger System						
New	$ 1,500	$ 2,000	$ 2,500	$ 3,500	$ 5,833	$ 8,750
Used	$ 750	$ 1,000	$ 1,250	$ 1,750	$ 2,917	$ 4,375
Raw Oil Storage / Settling Tank	$ 600	$ 1,200	$ 1,800	$ 3,600	$ 6,000	$ 9,000
Diesel Storage Tank (new w/ SPCC)	$ 5,405	$ 6,120	$ 9,180	$ 13,950	$ 23,250	$ 34,875
Total equipment investment by farmer						
Mainly used equipment	$ 10,146	$ 14,101	$ 20,402	$ 31,644	$ 61,073	$ 94,109
Mainly new equipment	$ 12,068	$ 17,445	$ 25,168	$ 40,425	$ 75,708	$ 116,063
Capital cost (amortized over 20 years with 0% salvage value)						
per bushel of grain						
Mainly used equipment	$ 1.62	$ 1.13	$ 1.09	$ 0.84	$ 0.98	$ 1.00
Mainly new equipment	$ 1.93	$ 1.40	$ 1.34	$ 1.08	$ 1.21	$ 1.24
per gallon of fuel (only allocated to fuel)						
Mainly used equipment	$ 1.01	$ 0.71	$ 0.68	$ 0.53	$ 0.61	$ 0.63
Mainly new equipment	$ 1.21	$ 0.87	$ 0.84	$ 0.67	$ 0.76	$ 0.77
per ton of meal (only allocated to meal)						
Mainly used equipment	$ 180	$ 125	$ 121	$ 94	$ 109	$ 112
Mainly new equipment	$ 215	$ 155	$ 149	$ 120	$ 135	$ 138
per ton of meal and gallon of fuel (allocated by mass ratio)						
per ton of meal						
Mainly used equipment	$ 108	$ 75	$ 73	$ 56	$ 65	$ 67
Mainly new equipment	$ 129	$ 93	$ 89	$ 72	$ 81	$ 83
per gallons of fuel						
Mainly used equipment	$ 0.41	$ 0.28	$ 0.27	$ 0.21	$ 0.24	$ 0.25
Mainly new equipment	$ 0.48	$ 0.35	$ 0.34	$ 0.27	$ 0.30	$ 0.31

Table 7 - Summary of farmer's capital costs required to participate in a mobile oilseed operation.

Variable Costs to Farmer

Previous work has estimated the cost and yields of harvested oilseeds in Vermont[2,4]. The costs vary depending on crops, varieties, management practices, and yields. But a range of $215-$228 per acre of oilseed production can be assumed based on this reference. The yields for this investment also vary widely and will likely be lower for farms just starting oilseed production. A range of 1,100-2,200 lbs/acre has been assumed for purposes of this study. This study also assumes 30 lbs/bu of oilseed and 7.5 lbs / gallon of oil for conversion to other units of measure. A summary of production costs in is provided in Table 8.

An example is also provided to help the reader follow along. This example assumes a relatively high $240/acre of cost and a relatively low yield of 1,410 lbs/acre. This yield was used because it is the breakeven point for production when a farmer values both oil and meal and is trying to replace purchased diesel fuel and conventional meal.

	Low	Avg	High	Example	
Farmer's Variable Crop Costs					
Cost to Farmer to plant, grow, harvest and store (organically)	$ 215	$ 222	$ 228	$ 240	/acre
Farmer's Yields	1100	1650	2200	1500	lbs grain / acre
	37	55	73	50	bu / acre @
Oil content of grain	30%	35%	40%	40%	% by weight
Yield of Oil	330	578	880	600	lbs / acre
	44	77	117	80	gal / acre @
Yield of Meal	770	1073	1320	900	lbs / acre
	0.39	0.54	0.66	0.45	ton / acre

Table 8 - Summary of farmer's variable crop costs for different scenarios.

Part of this study assessed assumptions about what the farmer values; oil or meal or both. If one or the other end products is valued disproportionately over the other, then the value of the one the farmer doesn't care about may be neglected. In this case the total costs of producing oilseeds are assigned to only the valued product produced (gallons of oil or tons of meal.)

It is likely that as the market matures both end products will be equally valued. This scenario is referred to as a "split" market. In this case, the total costs of producing oilseeds are split among the resulting end products according to the proportional mass of each in the seed. Results of this portion of the study are provided in Table 9. This table considers the impact of having a low yield or low oil content despite high per acre costs (a worst case). In this way it provides a range of variable crop costs from worst case to best case.

Conversion of Farmer's Variable Costs: From $/acre to $/bu of grain, $/gal of oil and $/ton of meal	Worst Case	Avg Case	Best Case	Example	
Bushel cost:	$ 6.22	$ 4.58	$ 2.93	$ 4.80	/bu grain
Oil Focus: If oil is considered the only valuable end product, then all crops costs are allocated to the oil yield. Cost of Oil (in form of stored seed), if oil is the only valuable product	$ 5.18	$ 3.51	$ 1.83	$ 3.00	/gal oil
				$ 4.80	/bu grain equiv
Meal Focus: If meal is considered the only valuable end product, then all crop costs are allocated to the meal yield. Cost of Meal (in form of stored seed), if meal is the only valuable product	$ 592	$ 459	$ 326	$ 533	/ton meal
				$ 4.80	/bu grain equiv
Split Focus: If both meal and oil are both considered valuable end products, then crops costs are allocated to the oil and meal based on their respective mass proportion in the seed.					
Cost of Oil (in form of stored seed), if oil and meal are valuable	$ 1.55	$ 1.14	$ 0.73	$ 1.20	/gal oil
				$ 1.92	/bu grain equiv
Cost of Meal (in form of stored seed), if oil and meal are valuable	$ 415	$ 305	$ 195	$ 320	/ton meal
				$ 2.88	/bu grain equiv
Assumed Farmer Fixed Costs (Ammortized)				**$ 0.84**	**/bu grain**
To support 3000 gallons of fuel, used equip. (oil portion)				$ 0.21	/gal oil
				$ 0.34	/bu equiv
To support 3000 gallons of fuel, used equip. (meal portion)				$ 56	/ton meal
				$ 0.51	/bu equiv
Total Farm Costs					
bushel of grain				$ 5.64	/bushel grain
gallon of oil				$ 1.41	/gal oil
				$ 2.26	/bu equiv
ton of meal				$ 376	/ton meal
				$ 3.39	/bu equiv

Table 9 - Farmer's cost of production converted to various units of measure and amortized fixed costs for a 3,000 gallon example case (from Table 7.)

3.6 Valuation of the Service

In order to establish a range of market prices for the service of pressing oilseeds and converting the oil to biodiesel the farmer’s capital and variable costs need to be considered relative to the retail cost of the products being substituted for (i.e. commodity meal and diesel fuel). Retail costs assumed for the purposes of this analysis are $4.00/gallon for diesel fuel, $599/ton for organic meal and $340/ton for conventional meal. Results are provided in Table 10 and the example calculation is explained below.

If a farm that uses 3,000 gallons of fuel per year starts oilseed production by purchasing mainly used equipment, that farmer’s capital cost of fuel is $0.21 / gal and the capital cost of meal is $56 / ton (Table 7).

Assuming this farmer can yield 1,500 lbs/acre sunflower seed at a cost of $240/acre (plant and grow organically, harvest and then store), the cost per pound of seed produced is $240/acre / 1500 lbs/acre = $0.16/lb grain. Assuming there is 40% oil in the seed (600 lbs/acre) and assuming this oil weighs 7.5 lbs/gal, the resulting yield of oil is 80 gal/acre. The cost for the portion of the grain which is oil is 40% of $240/acre, or $96/acre, therefore the variable cost to the farmer of the oil (in the seed) is $0.16/lb oil or $1.20/gal oil. Meal is the balance of the weight (60%), or 900 lbs/acre. The cost for the portion of the grain which is meal is 60% of $240/acre, or $144/acre. The variable cost to farmer for the meal (in the seed) is $0.16/lb meal or $320/ton meal (see Table 9).

When fixed farm costs and variable crop costs are added the resulting total farmer costs are $1.41/gal of oil and $376/ton meal.

Assuming a farmer normally pays $4.00/gal for fuel and $599/ton for organic meal (i.e. values both end products) the difference between their cost of production and the market value of the products is what they could pay a processor to result in an even substitution (see Figure 7). The difference is $4.00 – 1.41/gal or $2.59/gal oil [or $4.14/bu], and $599 – 376/ton of meal or $223/ton of meal [or $2.00/bu]. So the value of the service to the farmer in this case is $4.14 + 2.00/bu or $6.14/bu. This allocates all costs of processing to a per bushel fee. In reality the processing charges would likely be per bushel for converting grain to meal and oil and then per gallon to convert the oil to biodiesel. The fee structure based on cost breakdown is discussed in Section 4.4

These charges are the amount a farmer can pay (beyond their cost of grain production) to convert the grain into meal and oil for use on the farm without exceeding the cost they would have paid to import it onto the farm. The foregoing assumes organic meal which commands a premium.

A farmer interested in conventional meal would loose money even before processing that product in this example. If meal is considered the only valuable output it would cost the farmer $376/ton to produce unprocessed grain while processed meal can be bought for $340/ton. *This demonstrates the importance of an early market that values organic meal.*

In this same case, the "split" value of processing to provide oil and meal is $4.34/bu, despite a breakeven benefit on the meal alone when considered along with oil as a valuable output. *This demonstrates the importance of a market that values both outputs.*

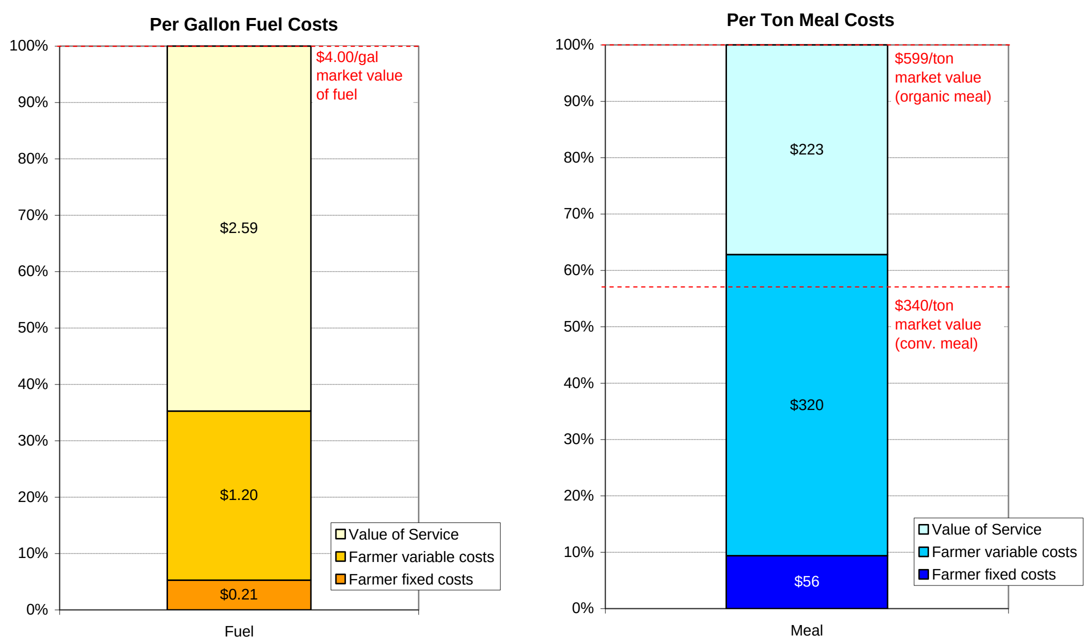


Figure 7 – Valuation of pressing and biodiesel conversion service based on market value of products and farmer's fixed and variable costs.

Whether a processor fully capitalizes on the value a farmer places on their service depends on the fee they charge for their services. It also depends on how their costs change as they increase the volume of processing. A typical breakeven curve is shown in Figure 8, demonstrating the reduction in the necessary price for a service as volume increases (i.e. fixed costs are spread across more production). Knowing the value of the service enables the processor to establish a price that will not be seen as too high (maximum price). Knowing the breakeven pricing for their operation enables the processor to establish a price that will not be too low (minimum price). A price below the maximum provides the processor a market advantage over fuel and feed purchased on the market. A price above breakeven provides for profit. The processor should set a price somewhere between the two values which enables profit for themselves and savings for the farmer when compared to the market value of the end products.

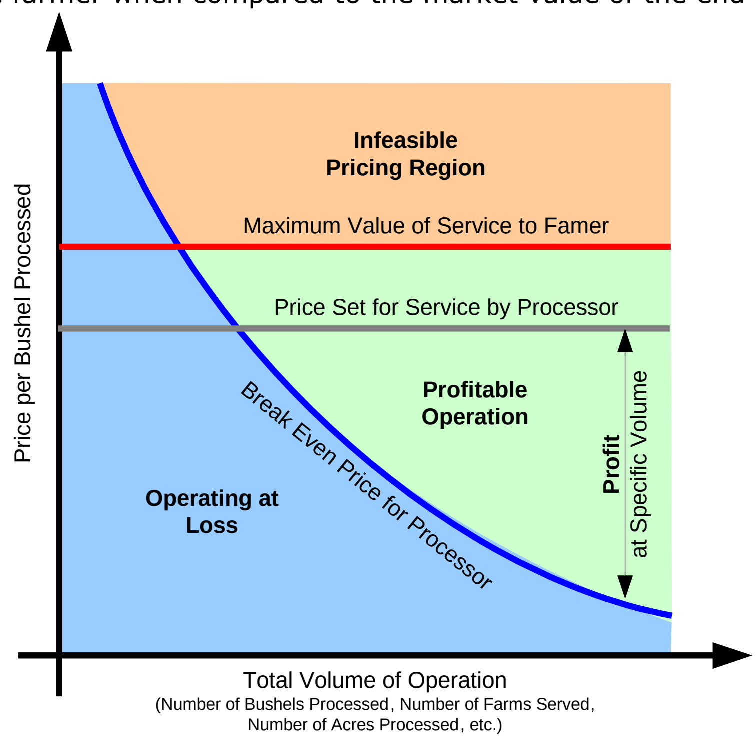


Figure 8 - Generic pricing graph demonstrating breakeven and profit determination.

Breakeven curves are provided for pressing and biodiesel conversion services in Figure 9 and Figure 10. Breakeven curves for the combined model of operation are provided in Figure 11, Figure 12, and Figure 13. Profit for each case can be determined by comparing the price charged for the service to the breakeven pricing for that service, as shown in Figure 8. Care should be taken when applying this technique to the graphs for the combined service model. Two prices will be required; one price for pressing and one price for biodiesel conversion. Also, these graphs are constructed with opposing axes since a single operator will likely need to split the calendar between pressing and biodiesel production. Thus, if more pressing is done in one year, less biodiesel production will be done. Purchasing additional trailers is an option once capacity becomes severely limited by increased market share.

What the Pressing Service Should Cost (difference between market value and farmer's cost)

	Worst Case	Avg Case	Best Case	Example	
Oil / Biodiesel Focus	$ (1.39)	$ 0.07	$ 1.96	$ 0.79	/gal oil
	$ (1.67)	**$ 0.10**	**$ 3.13**	**$ 1.26**	**/bu grain equiv**
Meal Focus - Organic	$ (49)	$ 84	$ 217	$ 9	/ton meal
	$ (0.52)	**$ 0.82**	**$ 1.95**	**$ 0.08**	**/bu grain equiv**
Meal Focus - Conventional	$ (308)	$ (175)	$ (42)	$ (193)	/ton meal
	$ (3.24)	**$ (1.71)**	**$ (0.38)**	**$ (1.74)**	**/bu grain equiv**
Split Focus					
Oil	$ 2.23	$ 2.65	$ 3.06	$ 2.59	/gal oil
	$ 2.68	**$ 3.70**	**$ 4.89**	**$ 4.14**	**/bu grain equiv**
Organic Meal	$ 128	$ 238	$ 347	$ 223	/ton meal
	$ 1.35	**$ 2.32**	**$ 3.13**	**$ 2.00**	**/bu grain equiv**
Conventional Meal	$ (131)	$ (21)	$ 88	$ (36)	/ton meal
	$ (1.37)	**$ (0.21)**	**$ 0.79**	**$ (0.33)**	**/bu grain equiv**
Total for Split Focus - Organic	**$ 4.03**	**$ 6.02**	**$ 8.02**	**$ 6.15**	**/bu grain**
Total for Split Focus - Conventional	**$ 1.31**	**$ 3.50**	**$ 5.68**	**$ 3.82**	**/bu grain**

Table 10 - Range of variable "should costs" for the pressing of oilseeds to oil and meal. Negative values (red in parentheses) indicate infeasible scenarios where production is more costly than purchasing from the market.

4. RESULTS

This section summarizes the resulting financial performance and energy return on energy investment for the various models.

4.1 Oil Pressing

This section summarizes the estimated revenue and earnings before income tax for a mobile oilseed pressing trailer. Breakeven pricing is also calculated. Table 11 shows the sensitivity of revenue and earnings before income tax to the price charged to press each bushel of grain. Breakeven pricing is also calculated and reported in several units of measure.

Pricing Sensitivity and Break Even Analysis and Earnings Before Income Tax (EBIT)

			Manual Operation		**Automated Operation**		**On the Cheap (Manual)**	
Charge $/Bushel	Equivalent $/gal Oil	Equivalent $/ton meal	**Revenue**	**EBIT**	**Revenue**	**EBIT**	**Revenue**	**EBIT**
$ 12.80	$ 8.00	$ 512.00	$ 624,000	$ 563,088	$ 1,440,000	$ 1,350,855	$ 624,000	$ 577,038
$ 9.60	$ 6.00	$ 384.00	$ 468,000	$ 407,088	$ 1,080,000	$ 990,855	$ 468,000	$ 421,038
$ 8.00	$ 5.00	$ 320.00	$ 390,000	$ 329,088	$ 900,000	$ 810,855	$ 390,000	$ 343,038
$ 6.40	$ 4.00	$ 256.00	$ 312,000	$ 251,088	$ 720,000	$ 630,855	$ 312,000	$ 265,038
$ 4.80	$ 3.00	$ 192.00	$ 234,000	$ 173,088	$ 540,000	$ 450,855	$ 234,000	$ 187,038
$ 3.20	$ 2.00	$ 128.00	$ 156,000	$ 95,088	$ 360,000	$ 270,855	$ 156,000	$ 109,038
$ 1.60	$ 1.00	$ 64.00	$ 78,000	$ 17,088	$ 180,000	$ 90,855	$ 78,000	$ 31,038
$ 0.80	$ 0.50	$ 32.00	$ 39,000	$ (21,912)	$ 90,000	$ 855	$ 39,000	$ (7,962)
$ 0.40	$ 0.25	$ 16.00	$ 19,500	$ (41,412)	$ 45,000	$ (44,145)	$ 19,500	$ (27,462)
Revenue for Break Even			$ 60,912	$ -	$ 89,145	$ -	$ 46,962	$ -
Breakeven Price Per Bushel			**$ 1.25**		**$ 0.79**		**$ 0.96**	
Breakeven Price Per Gallon Equivalent			**$ 0.78**		**$ 0.50**		**$ 0.60**	
Breakeven Price Per Ton Meal Equivalent			**$ 50**		**$ 32**		**$ 39**	

Table 11 - Price sensitivity of revenue, earnings before income tax (EBIT) and breakeven price for pressing operation (6 months of operation per year).

Figure 9 illustrates the sensitivity of breakeven pricing relative to scale of operation. In this case, the scale of the operation is measured in bushels processed per year. A rough estimate of the number of equivalent farms is provided by the top axis. The right end of each curve represents the maximum pressing capacity for each operation over a twelve month period.

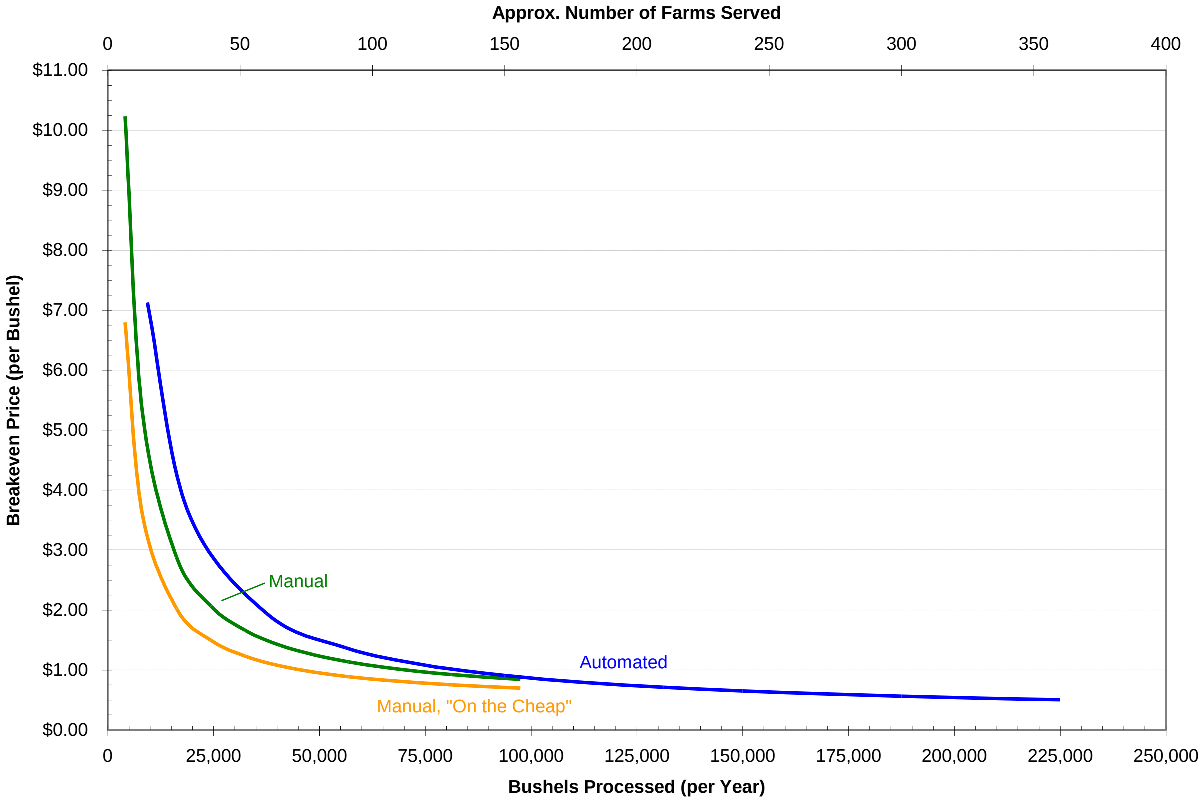


Figure 9 - Breakeven pricing for pressing.

Table 12 summarizes the energy return on energy invested (EROEI) for the pressing operation.

	Manual Operation	Automated Operation	On the Cheap (Manual)
Energy Return on Energy Invested			
Grain Processed per Year (Tons)	**731**	**1,688**	**731**
Grain Processed per Year (Bushels)	**48,750**	**112,500**	**48,750**
Oil Pressed per Year (Tons)	**293**	**675**	**293**
Meal Expelled per Year (Tons)	**439**	**1,013**	**439**
Est. Areage Equivalent Processed per Year	**1,040**	**2,400**	**1,040**
Oil Pressed per Year (Gallons)	**78,000**	**180,000**	**78,000**
Fuel Consumed per Year (Gallons)			
Travel (Round)	468	771	468
Pressing	390	900	390
Total Fuel Consumed (Gallons)	**858**	**1,671**	**858**
Fuel Consumed per Year (Gal / Gal of Oil)			
Travel (Round)	0.006	0.004	0.006
Pressing	0.005	0.005	0.005
Total Fuel Consumed (Gal / Gal Oil)	**0.011**	**0.009**	**0.011**
EROEI (Ratio)	**91**	**108**	**91**

Table 12 - Energy return on energy invested (EROEI) for pressing operation.

4.2 Biodiesel Conversion

This section summarizes the estimated revenue and earnings before income tax for a mobile biodiesel conversion trailer. Breakeven pricing is also calculated. Table 13 shows the sensitivity of revenue and earnings before income tax relative to the price charged to convert each gallon of oil. Breakeven pricing is also calculated and reported.

Pricing Sensitivity and Break Even Analysis	Sole Proprietor		Multiple Operator		On the Cheap	
Charge $/gallon	**Revenue**	**EBIT**	**Revenue**	**EBIT**	**Revenue**	**EBIT**
$ 8.00	$ 1,440,000	$ 1,120,403	$ 2,880,000	$ 2,576,286	$ 1,440,000	$ 1,134,446
$ 6.00	$ 1,080,000	$ 760,403	$ 2,160,000	$ 1,856,286	$ 1,080,000	$ 774,446
$ 5.00	$ 900,000	$ 580,403	$ 1,800,000	$ 1,496,286	$ 900,000	$ 594,446
$ 4.00	$ 720,000	$ 400,403	$ 1,440,000	$ 1,136,286	$ 720,000	$ 414,446
$ 3.00	$ 540,000	$ 220,403	$ 1,080,000	$ 776,286	$ 540,000	$ 234,446
$ 2.00	$ 360,000	$ 40,403	$ 720,000	$ 416,286	$ 360,000	$ 54,446
$ 1.00	$ 180,000	$ (139,597)	$ 360,000	$ 56,286	$ 180,000	$ (125,554)
Revenue for Break Even	$ 319,597	$ -	$ 303,714	$ -	$ 305,554	$ -
Breakeven Price Per Gallon	**$ 1.78**		**$ 0.84**		**$ 1.70**	
Fixed Cost Per Gallon, at breakeven	$ 0.22		$ 0.17		$ 0.14	
Variable Cost Per Gallon, at breakeven	$ 1.56		$ 0.67		$ 1.55	

Table 13 - Price sensitivity of revenue, earnings before income tax (EBIT) and breakeven price for biodiesel conversion operation (6 months of operation per year).

Figure 9 illustrates the sensitivity of breakeven pricing relative to scale of operation. In this case, the scale of the operation is measured in gallons processed per year. As in the previous section the equivalent number of farms served is on top and the capacity of the operation is illustrated by the right end of each curve.

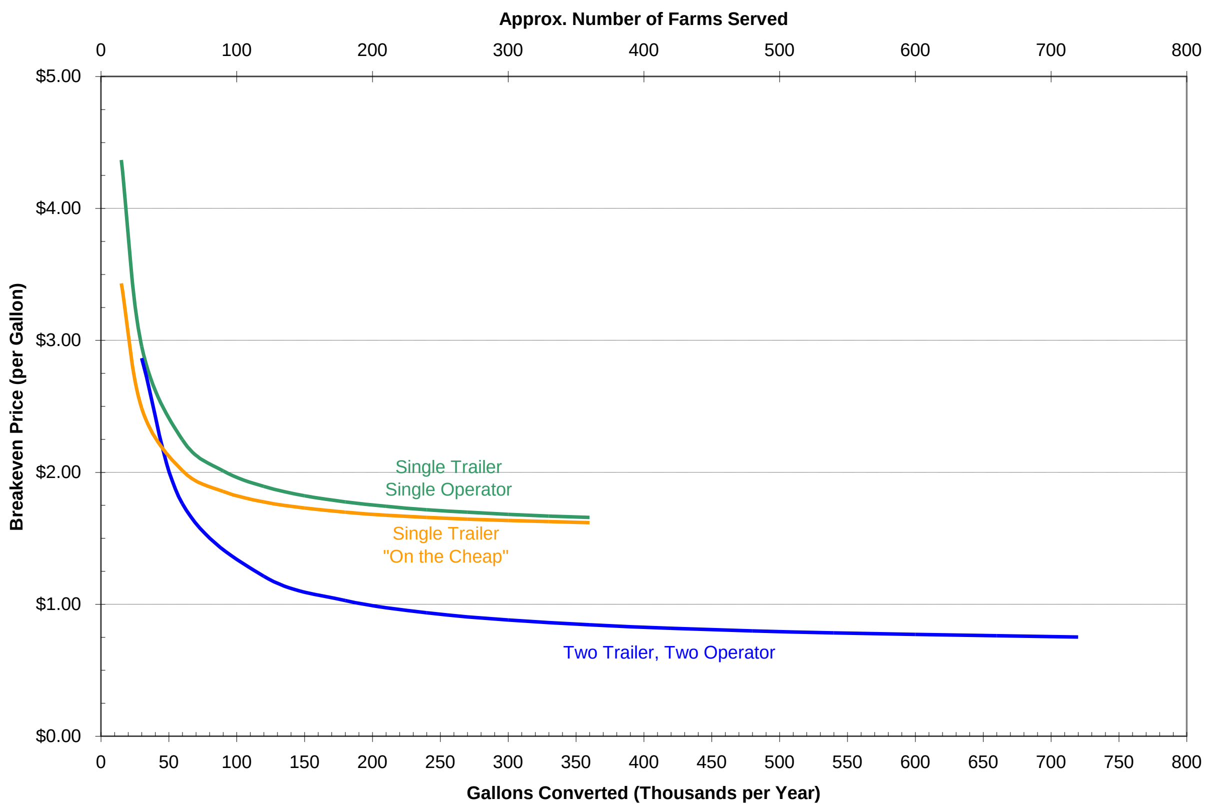


Figure 10 - Breakeven pricing for biodiesel conversion.

Table 14 Summarizes the energy return on energy invested (EROEI) for the biodiesel operation. Note the significant amount of energy embodied in the methanol and lye used in the biodiesel conversion process.

	Sole Proprietor	Multiple Operator	On the Cheap
Energy Return on Energy Invested			
Biodiesel Produced per Year (Gallons)	**180,000**	**360,000**	**180,000**
Methanol Used per Year (Gallons)	36,000	72,000	36,000
Lye Used per Year (Pounds)	14,400	28,800	14,400
Fuel Consumed per Year (Gallons)			
Travel (Round)	1,080	2,160	1,080
Converting	2,597	5,193	2,597
Methanol	8,795	17,589	8,795
Lye	1,993	3,987	1,993
Total Fuel Consumed (Gallons)	**14,465**	**28,929**	**14,465**
Fuel Consumed per Year (Gal / Gal of BD)			
Travel (Round)	0.006	0.006	0.006
Converting	0.014	0.014	0.014
Methanol	0.049	0.049	0.049
Lye	0.011	0.011	0.011
Total Fuel Consumed (Gal / Gal BD)	**0.080**	**0.080**	**0.080**
EROEI (Ratio)	**12.4**	**12.4**	**12.4**

Table 14 - Energy return on energy invested (EROEI) for biodiesel conversion operation.

4.3 Combined Model

This section summarizes the estimated revenue and earnings before income tax for a combined mobile press and biodiesel conversion operation. Breakeven pricing is also calculated. Table 15 shows the sensitivity of revenue and earnings before income tax relative to the price charged to both press each bushel of grain and to convert each gallon of oil. Combined revenue and EBIT are also provided and breakeven pricing is also calculated and reported.

Pricing Sensitivity and Break Even Analysis

Pricing for Pressing

Charge $/Bushel	Equivalent $/gal Oil	Equivalent $/ton meal	Manual Operation / Sole Proprietor Revenue	Manual Operation / Sole Proprietor EBIT	Automated Operation / Multiple Operator Revenue	Automated Operation / Multiple Operator EBIT	On the Cheap Revenue	On the Cheap EBIT
$ 8.00	$ 5.00	$ 320	$ 390,000	$ 344,163	$ 900,000	$ 808,513	$ 390,000	$ 350,706
$ 6.40	$ 4.00	$ 256	$ 312,000	$ 266,163	$ 720,000	$ 628,513	$ 312,000	$ 272,706
$ 5.60	$ 3.50	$ 224	$ 273,000	$ 227,163	$ 630,000	$ 538,513	$ 273,000	$ 233,706
$ 4.80	$ 3.00	$ 192	$ 234,000	$ 188,163	$ 540,000	$ 448,513	$ 234,000	$ 194,706
$ 3.20	$ 2.00	$ 128	$ 156,000	$ 110,163	$ 360,000	$ 268,513	$ 156,000	$ 116,706
$ 1.60	$ 1.00	$ 64	$ 78,000	$ 32,163	$ 180,000	$ 88,513	$ 78,000	$ 38,706
$ 0.80	$ 0.50	$ 32	$ 39,000	$ (6,837)	$ 90,000	$ (1,487)	$ 39,000	$ (294)

Pricing for BD Conversion

Charge $/gallon	Manual Revenue	Manual EBIT	Automated Revenue	Automated EBIT	On the Cheap Revenue	On the Cheap EBIT
$ 4.00	$ 720,000	$ 415,430	$ 1,440,000	$ 1,172,849	$ 720,000	$ 425,378
$ 3.50	$ 630,000	$ 325,430	$ 1,260,000	$ 992,849	$ 630,000	$ 335,378
$ 3.00	$ 540,000	$ 235,430	$ 1,080,000	$ 812,849	$ 540,000	$ 245,378
$ 2.50	$ 450,000	$ 145,430	$ 900,000	$ 632,849	$ 450,000	$ 155,378
$ 2.00	$ 360,000	$ 55,430	$ 720,000	$ 452,849	$ 360,000	$ 65,378
$ 1.00	$ 180,000	$ (124,570)	$ 360,000	$ 92,849	$ 180,000	$ (114,622)
$ 0.50	$ 90,000	$ (214,570)	$ 180,000	$ (87,151)	$ 90,000	$ (204,622)

Combined Revenue and EBIT

$/bu Press	$/gal BD Conversion	Manual Revenue	Manual EBIT	Automated Revenue	Automated EBIT	On the Cheap Revenue	On the Cheap EBIT
$ 8.00	$ 4.00	$ 1,110,000	$ 759,593	$ 2,340,000	$ 1,981,362	$ 1,110,000	$ 776,084
$ 6.40	$ 3.50	$ 942,000	$ 591,593	$ 1,980,000	$ 1,621,362	$ 942,000	$ 608,084
$ 5.60	$ 3.00	$ 813,000	$ 462,593	$ 1,710,000	$ 1,351,362	$ 813,000	$ 479,084
$ 4.80	$ 2.50	$ 684,000	$ 333,593	$ 1,440,000	$ 1,081,362	$ 684,000	$ 350,084
$ 3.20	$ 2.00	$ 516,000	$ 165,593	$ 1,080,000	$ 721,362	$ 516,000	$ 182,084
$ 1.60	$ 1.00	$ 258,000	$ (92,407)	$ 540,000	$ 181,362	$ 258,000	$ (75,916)
$ 0.80	$ 0.50	$ 129,000	$ (221,407)	$ 270,000	$ (88,638)	$ 129,000	$ (204,916)

	Manual	Automated	On the Cheap
Breakeven Price Per Bushel for Pressing	**$ 0.94**	**$ 0.81**	**$ 0.81**
equivalent price per gallon of pressed oil	$ 0.59	$ 0.51	$ 0.50
equivalent price per bushel	$ 0.38	$ 0.33	$ 0.32
equivalent price per ton of meal	$ 63	$ 54	$ 54
equivalent price per bushel	$ 0.56	$ 0.49	$ 0.48
Breakeven Price Per Gallon for BD Conv	**$ 1.69**	**$ 0.74**	**$ 1.64**

Table 15 - Price sensitivity of revenue, earnings before income tax (EBIT) and breakeven price for a combined services model operation (6 months of operation per year per service).

Figure 11 through Figure 13 illustrate the sensitivity of breakeven pricing to volume of operation in the combined service model. This model of operation is more complex than the previous two since the processor will have to balance pressing of grain with processing of oil. For this reason, the breakeven curves for each process are shown on opposing curves.

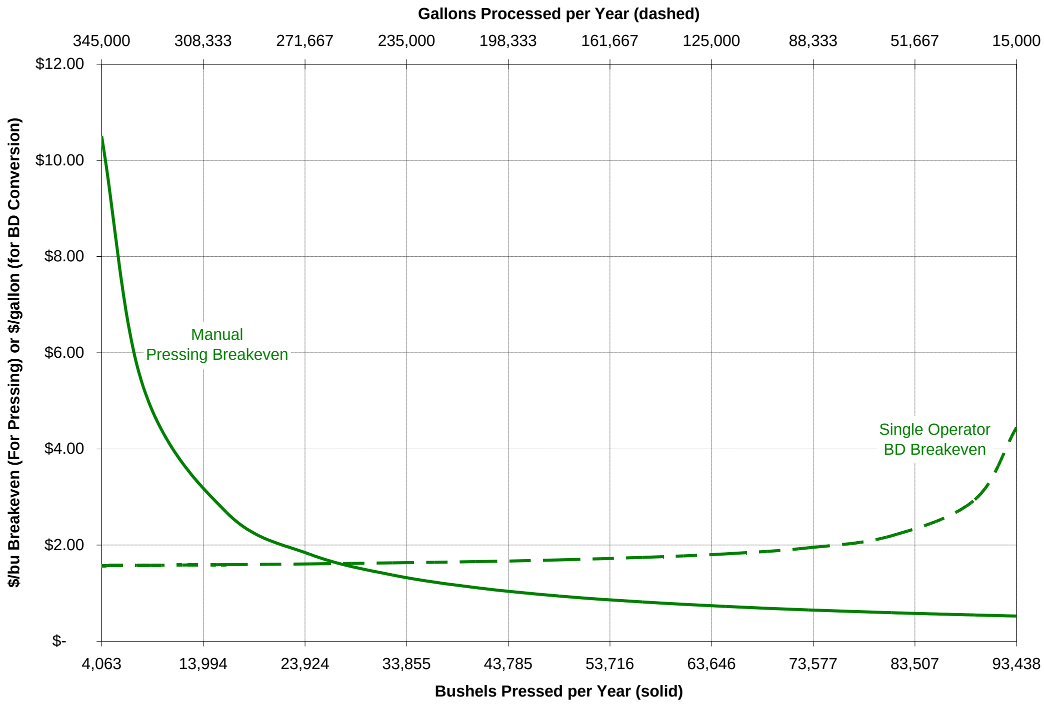


Figure 11 - Breakeven curves for pressing (solid) and biodiesel conversion (dashed) assuming the Manual / Single Operator Model.

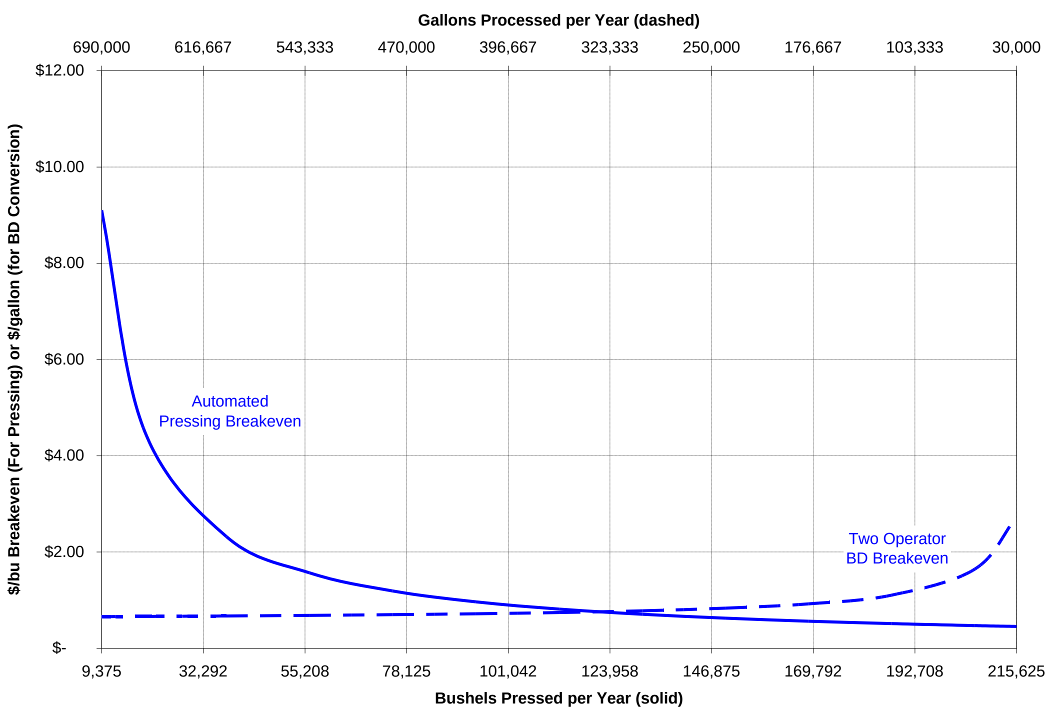


Figure 12 - Breakeven curves for pressing (solid) and biodiesel conversion (dashed) assuming the Automated / Two Operator Model.

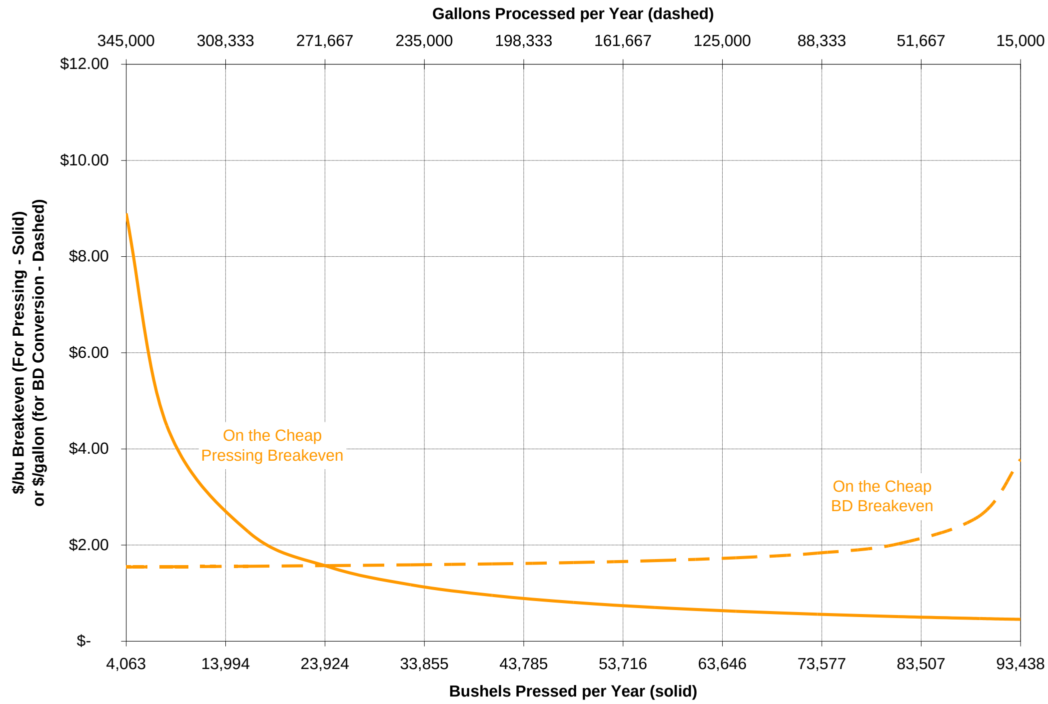


Figure 13 - Breakeven curves for pressing (solid) and biodiesel conversion (dashed) assuming the Manual / On the Cheap Model.

Table 16 summarizes the EROEI for the combined services model. The EROEI is dominated by the biodiesel conversion process, and specifically by the catalytic chemicals consumed in that process (methanol and lye).

	Manual Operation / Sole Proprietor	Automated Operation / Multiple Operator	On the Cheap
Summary Information			
Grain Processed per Year (Tons)	731	1,688	731
Grain Processed per Year (Bushel)	48,750	112,500	48,750
Oil Pressed per Year (Tons)	293	675	293
Meal Expelled per Year (Tons)	439	1,013	439
Est. Acreage Equivalent per Year	1,040	2,400	1,040
Oil Pressed per Year (Gallons)	78,000	180,000	78,000
Biodiesel Produced per Year (gal)	180,000	360,000	180,000
Methanol Consumed per Year (gal)	36,000	72,000	36,000
Lye Consumed per Year (lbs)	14,400	28,800	14,400
Energy Return on Energy Invested			
Fuel Consumed per Year (Gallons)			
Travel (Round)	1,548	2,931	1,548
Pressing	390	900	390
Converting	2,597	5,193	2,597
Methanol	8,795	17,589	8,795
Lye	1,993	3,987	1,993
Total Eq. Fuel Consumed (Gallons)	**15,323**	**30,601**	**15,323**
Fuel Consumed per Year (Gal / Gal of Oil)			
Travel (Round)	0.009	0.008	0.009
Pressing	0.002	0.003	0.002
Converting	0.014	0.014	0.014
Methanol	0.049	0.049	0.049
Lye	0.011	0.011	0.011
Total Eq. Fuel Consumed (Gal / Gal Oil)	**0.085**	**0.085**	**0.085**
EROEI (Ratio)	**11.7**	**11.8**	**11.7**

Table 16 - Energy return on energy invested (EROEI) for a combined services model.

4.4 Overall Cost Breakdown

The cost breakdown of a gallon of fuel or a ton of meal will include the farmer's cost of production and amortized capital costs plus any processing costs. The specific cost breakdown will depend on many factors including a farmer's approach to crop variety, soil preparation, planting, cultivation, harvesting, yield, processor's choice of business model, etc. One possible cost breakdown is illustrated in Figure 14. This breakdown assumes a farmer using 3,000 gallons with a $240/acre variable cost of production, $31,675 in total fixed capital costs amortized over 20 years, 1,500 lbs/acre yield with 40% oil content in the seed. The breakdown also assumes a mobile processor operating a manual press and a single operator biodiesel trailer.

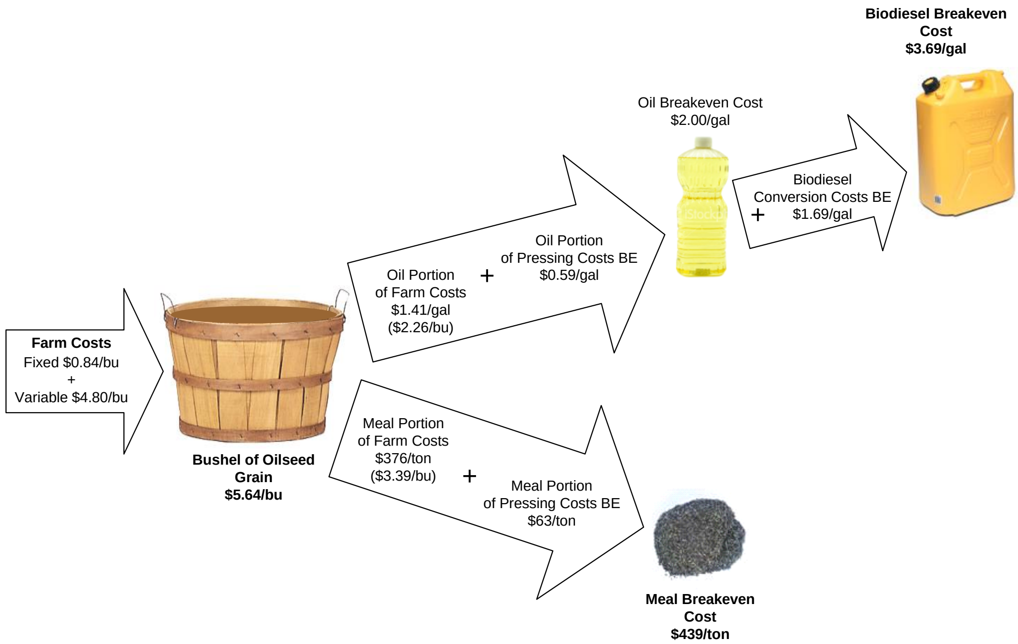


Figure 14 – Cost breakdown of oilseed processing.

Cost breakdowns for each of the combined models have been determined as shown in Figure 15 and Figure 16. In each case the same assumptions about farmer costs apply. Additionally, profit is noted in these figures based on the market values of diesel fuel ($4.00/gal) and organic meal ($599/ton).

A large profit differential exists among the models for biodiesel processing due to the variation of methanol costs. The single trailer operation has higher methanol cost since they are assumed to be buying at lower volumes.

There are also differences among the models in the cost per ton of meal. These differences are small in comparison to the overall cost of the meal which is dominated by the farmer's costs. A market price of $340/ton for conventional meal has also been shown on this chart to demonstrate the importance of the organic meal market during the early stages of oilseed production and processing. Note that even the farmer's cost of producing the grain alone ($376/ton) exceeds the market price for conventional meal. As farmers develop experience with oilseed crops they are likely to have higher yields with lower variable costs. This will result in the farmer's cost per ton being reduced.

Likewise, as the processor begins serving more farms, their variable costs will also be reduced.

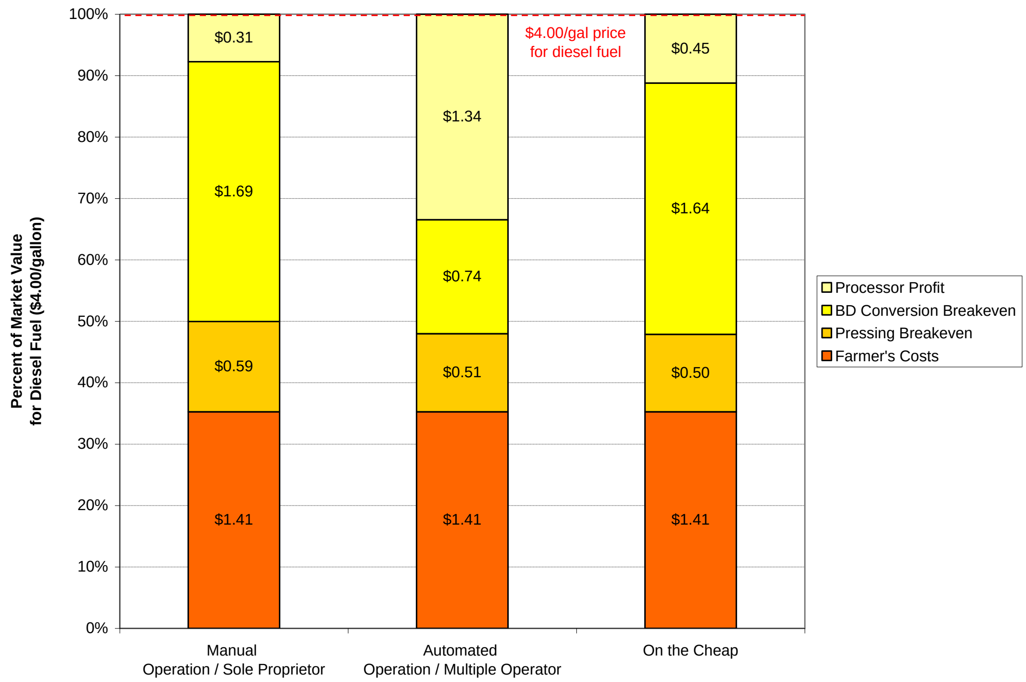


Figure 15 - Cost breakdown for a gallon of oil produced from oilseed crops using a mobile press and mobile biodiesel conversion unit.

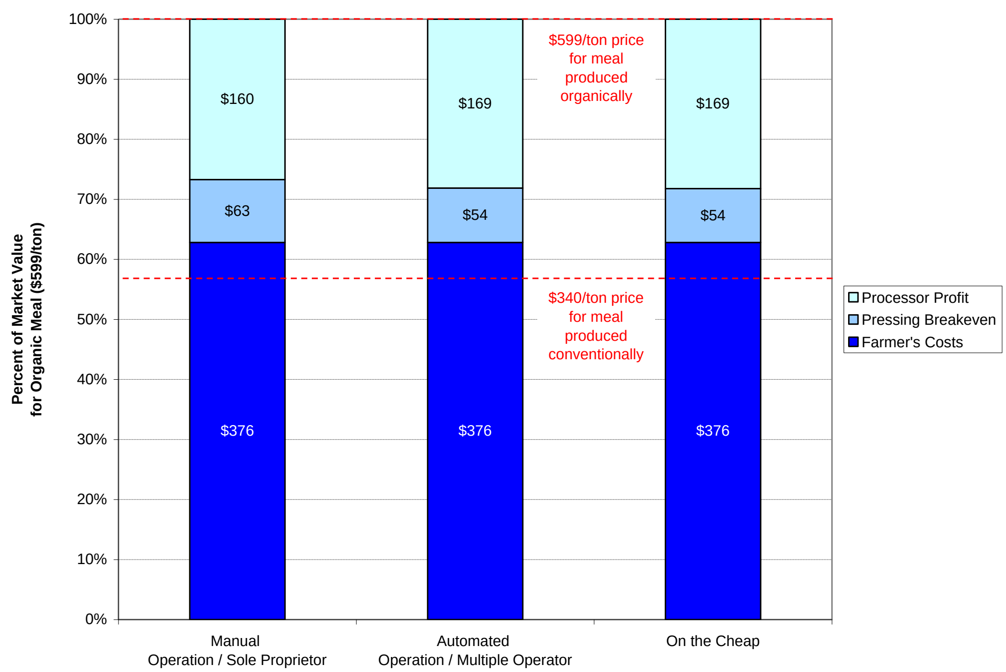


Figure 16 - Cost breakdown for a ton of meal produced from oilseed crops using a mobile press.

The foregoing assumes the mobile processing service is directly substituted for existing products at market cost. This establishes the maximum pricing possible for the service and results in zero savings for the farmer. However, if the processor sets their price somewhere below this.

5. LIMITS OF MODELING – IMPACT OF EXTERNALITIES

There are several externalities that influence the validity of the model and its results. While care has been taken to include all significant factors in the model of this hypothetical mobile oilseed processing enterprises, cost and pricing assumptions represent today's knowledge. The following is a list of some factors that could affect the findings of this study.

Cost of off-road diesel fuel – A value of $4 / gallon has been assumed for the purposes of this model. During the study period, the cost of off-road diesel fuel has varied widely and will likely continue to do so. While the cost of fuel is an expense for the operator of the service, its primary influence is in driving the operator's market toward self-production of fuel and resulting in a higher allowable price for the processor's services. In summary, a higher market fuel cost will support the venture.

Cost of Methanol and Lye – Methanol is both a significant expense in the production of biodiesel (47-66% in this study) and is also a significant source of embodied energy consumption (61%). Methanol is produced from natural gas at an estimated energy cost of 29 kBTU/gal (equivalent to 0.11 gallon per gallon of biodiesel produced). Its cost is likely, therefore, to be volatile along with all other energy costs. Developing a regional, stable and sustainable alcohol production industry would help to support a mobile oilseed processing business.

Regulatory influences – At this time regulations regarding transport of small quantities of methanol and lye (as would be required for a mobile processor) are minimal. The same is true for current regulations pertaining to on-farm oil and fuel storage. However, it is expected that as the market for these products grow, more regulation will pertain to their use. This may include HAZMAT permitting for transport of even small quantities of production materials and/or taxation on fuel produced for farm use.

Hybrid Market Model – As noted above, a farmer may have interest in pressing oilseeds to obtain feed and oil. The oil may be sold to a restaurant or other food market and reclaimed after use as waste oil. This waste oil could then be converted to biodiesel. In such a model, it is possible that the mobile processor could serve as either a broker or a distributor, and thus charge an additional fee beyond pressing and biodiesel conversion. This study has not examined the impact of this type of operation on the mobile processing business.

6. CONCLUSIONS

The results of this study suggest that a mobile oilseed processing enterprise is feasible on technical and financial terms. The early market for such an enterprise remains to be completely defined, but will likely be farmers with an interest in both fuel and organic feed from oilseed crops which they have grown themselves. This market will assign the greatest value to the service. Several other specific conclusions follow.

General

1. Farmer's capital costs (combine, grain bins, driers, etc.) are estimated to be $0.27-0.48 / gallon of fuel or $72-129 / ton of meal assuming new equipment and $0.21 - 0.41 / gallon or $56-108 / ton assuming mainly used equipment. For a typical farm oilseed operation supporting 3,000 gallons of fuel use using mainly used equipment, the costs are estimated as $0.21/gallon of fuel and $56/ton of meal.
2. Based on $340 / ton market value of conventionally produced meal, a mobile processor serving a market with only interest in conventional meal is not feasible based on conservative crop production costs ($240/acre) and yields (1,500 lbs/acre).
3. A mobile oilseed processor with modular pressing and biodiesel equipment in a single trailer is technically and financially feasible.
4. Considering a typical farmer's capital and production costs (for 3,000 gallons fuel use, 1,500 lbs / acre yield, $240 / acre production) and market value of substituted products ($4 / gallon fuel and $599 / ton organic meal), a charge of $3.33 / bu for pressing (oil and meal) and $1.75 / gal for conversion to biodiesel is supported.
5. This would result in profit for the processor of $2.39 / bu (72%) for pressing and $0.06 / gal (3%) for biodiesel conversion (manual, single trailer operation.)
6. The same pricing applied to the automated, two operator model would result in profit of $2.49 / bu (75%) for pressing and $1.01 / gallon (58%) for conversion to biodiesel.
7. Minimum pricing (breakeven) and maximum pricing (direct market substitution) have been analyzed. Actual pricing somewhere between these two extremes should allow for both savings to farmer and profit to the processor.

Pressing

8. A "manual" press, single trailer operation with a 6 month business calendar has a breakeven price of $1.25 / bushel and a capacity of 78,000 gallons serving 78 farms. This price is equivalent to $0.78 / gallon or $50 / ton of meal.
9. An "automated" press, two trailer operation with a 6 month business calendar has a breakeven price of $0.79 / bushel and a capacity of 180,000 gallons serving 180 farms. This price is equivalent to $0.50 / gallon or $32 / ton of meal.
10. A "manual" press, single trailer operation started "on the cheap" with a 6 month business calendar has a breakeven price of $0.96 / bushel. This price is equivalent to $0.60 / gallon or $39 / ton of meal.
11. The ratios of energy return to energy invested in these three models are 91, 108 and 91 respectively (without accounting for farmer's energy investment).

Biodiesel Conversion

12. A single trailer, single operator mobile biodiesel processor with a 6 month business calendar has a breakeven price of $1.78 / gallon and a capacity of 180,000 gallons serving 180 farms.
13. A two trailer, two operator mobile biodiesel processor with a 6 month business calendar has a breakeven price of $0.84 / gallon and a capacity of 360,000 gallons serving 360 farms.

14. A single trailer, single operator mobile biodiesel processor done "on the cheap" with a 6 month business calendar has a breakeven price of $1.70 / gallon and a capacity of 180,000 gallons serving 180 farms.
15. The ratios of energy return to energy invested in these three models are all 12.4 (without accounting for farmer's energy investment).
16. Methanol costs represent 67% of the variable costs for biodiesel production for a lower volume processor and 47% for a higher volume processor. A stable and sustainable source of alcohol will become a limiting factor in cost reduction and protection from price volatility in this type of venture.
17. Methanol represents 61% of the energy consumed to produce biodiesel in these models.

Combined Pressing and Conversion Operation

18. Combining the common costs of pressing and biodiesel conversion operations results in reducing the burden of those costs on either operation alone.
19. A combined operation is also predicted to be feasible and profitable when considering farmer's costs and market value of meal and fuel.
20. A common operator providing both services will be faced with balancing the calendar time dedicated to each service. Pressing for more months in one year, will likely mean less biodiesel conversion (when assuming a common trailer with modular contents.) Another possibility is to consider dedicated trailers for each purpose; a consideration not fully explored in this study.

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