VERMONT BIOENERGY INITIATIVE

Vermont On-Farm Oilseed Enterprises: Production Capacity and Breakeven Economics

Netaka White and Chris Callahan

Version Date: July 2013

Vermont Sustainable Jobs Fund

LOCAL PRODUCTION FOR LOCAL USE

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How can Vermont farmers reduce fuel and feed costs? How can Vermont increase its capacity for generating bioenergy? What are the essential infrastructure needs for on-farm biofuel production?

The Vermont Sustainable Jobs Fund's *Vermont Bioenergy Initiative* (VBI) has successfully demonstrated a farm-focused, community-scale biofuel production model that is relevant to many other rural communities across the nation.

One of the biggest jobs of a farm is to feed people. But farming takes an incredible amount of energy and we thought we'd really like to try to grow some of that energy, to run our tractors and heat our homes — ***Peggy Hewes, VBI Grantee***

According to the last *Census of Agriculture*, Vermont farmers spent $151.6 million on animal feed in 2007, equal to 26.2% of total farm production expenses. They also spent $34.3 million (5.9% of total expenses) on fuel and $20.8 million (3.6% of total expenses) on fertilizers and soil conditioners—and the amount of money Vermont farmers spent on fuel and fertilizers increased 83% and 50%, respectively, from 1997 to 2007. **Vermont farmers can expect to pay more for animal feed, fuel, and fertilizer as the climate changes and the cost of petroleum continues to rise.**

The VBI is an attempt to increase the long-term sustainability and economic feasibility of our farms and help keep Vermont's working landscape open and productive. The VBI model is based on sustainable oilseed production on Vermont farms that:

- Integrates with existing food production systems through crop rotations and local distribution channels
- Encourages equipment sharing among farmers
- Saves money on operating costs while minimizing the need for imported fuel, feed, and fertilizer—and the price volatility associated with these products.

The VBI model does not depend on advanced technology or capital intense systems but rather on sound land use, smart integration of existing equipment and technologies, and careful process control by the farmers and businesses involved in production.

The VBI has been supplemented by technical assistance and grant funding as needed during design, construction, and operation phases. **The production of crops, seed processing, oil extraction, and fuel production can be economically viable at farm-scale facilities.**

VBI GOALS

The purpose of the 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. It is a component of sustainable, diversified agriculture with demonstrated progress towards the following objectives:

1. Expand the local production of feedstocks for bioenergy
2. Reduce dependency on petroleum
3. Promote entrepreneurial activity in the bioenergy sector
4. Educate the public about sustainably and locally produced bioenergy fuels

SUMMARY

Since 2004, the Vermont Sustainable Jobs Fund's Vermont Bioenergy Initiative, along with the University of Vermont Extension (UVM), and others has funded and supported the strategic development of on-farm biodiesel and meal production from oilseeds such as sunflower, soybean, and canola. The growth of these enterprises is shown in Table 1.

As of early 2012, installed biodiesel processing equipment in Vermont can accommodate approximately **10,242 acres of oilseed production** annually (2 percent of 517,000 total cropland acres in the state). This is **equivalent to annual biodiesel production of 604,857 gallons, and meal production of 3,108 tons.** This capacity is based on an operation schedule for the producers covered on pages 5-8. The annual 24 hours per day x 7 days per week biodiesel processor capacity is 2.6 million gallons of biodiesel equating to approximately 42,220 acres of oilseed

Table 1: History of Acres Planted and Average Yields

Year	# of Farms	Planted acres	Yield (pounds per acre)	Total tons of seed	Total gallon of oil (equivalent)
2004	1	n/a	n/a	0.9	72
2005	2	5	560	1.4	112
2006	3	29	76	1.1	88
2007	3	29	190	3	220
2008	10	62	323	10	800
2009	12	318	230	37	20,670
2010	11	288	1,461	210	18,700
2011	7	99	598	30	6,435
2012	16	160	700	56	10,400

Note: The oilseed production component of the VBI started in 2005 with two farms growing oilseeds. Table 1 illustrates the growth of oilseed production in Vermont. In addition to an increase in the number of farms contributing production data, the key variables affecting average yields are pest, weather, and disease pressures. Readers should refer to the UVM Crops and Soils website for in-depth information and reports concerning the agronomics of oilseeds.

Canola Field in Alburgh, Vermont.

Table 2: Case Study Analysis; 100,000 gallons per year

	Breakeven Pricing	Market Pricing*	Potential Profit, Savings, or Loss
Seed	$338 per ton seed at volume of 987 tons	$579 per ton seed	$241per ton seed
Meal conventionally grown	$340 per ton meal (shared burden) at volume of 611 tons	$247 per ton meal	-$93 per ton meal
Oil	$340 per ton oil $1.26 per gallon (shared burden) at volume of 100,000 gallon	$1,420 per ton oil $5.30 per gallon oil	$1,080 per ton oil $4.02 per gallon oil
Meal and Oil			**$353 per ton seed**
Biodiesel	$2.13 per gallon fuel (shared burden) at volume of 100,000 gallon	$3.59 per gallon fuel	$1.46 per gallon fuel
Meal and Biodiesel			**$101 per ton seed**

* "Market pricing" is indexed to USDA and US DOE reports[1]

production. In both cases, however, more oilseed processing capacity (seed storage and pressing capacities) would be required to support these levels of biodiesel production.

A hypothetical case study based on data collected from Vermont sunflower operations was developed for a 100,000 gallon per year facility with $570,000 initial investment, $153 per acre production costs, and 1,200 pounds per acre yield (Table 2). Greater detail on how we arrived at these results can be found on pages 9 -13. A second hypothetical case based on 13,000 gallon per year facility is also discussed starting on page 14.

Based on costs of production and current market pricing indices, all end products other than conventional meal are profitable. It should be noted, however, that actual selling prices will vary (i.e., although the "market price" is $247 per ton, the meal is selling above market prices locally for a profit). Organic meal and oil also command higher prices, often about 40% over conventional market prices for the oil and two times as much for the meal.

Given these current market prices and production costs—and depending on annual revenue and the combination of co-products being sold—payback periods of 5-year and 10-year are achievable in this 100,000 gallon per year hypothetical case study.

This study also considered the impact of variable yields (pounds per acre) and production costs (dollars per acre) on the breakeven costs of products (seed, meal, oil, and biodiesel). In this study, it was shown that over a range of crop production costs between $100 and $200 per acre, and yields between 1,000 and 2,000 pounds per acre, the profitable sale of all products (other than meal alone) is feasible. At current market prices, meal is generally a loss except at low production costs and high yields. That loss turns to a net profit however, when calculating the combined value of the meal and the oil or the meal and the biodiesel (see Table 2).

FUNDING and SCOPE OF THIS REPORT

As a result of U.S. Department of Energy funding made possible by U.S. Senator Patrick Leahy, between 2005 and 2012 VSJF has been able to invest $423,450 in grants and technical assistance to on-farm biodiesel production facilities.

These Vermont farms now have the capacity and experience to extract oil and/or produce biodiesel from soy, canola, and sunflower. In what has become known as the "Vermont Model," these enterprises have demonstrated the feasibility of farm-scale, diversified oilseed production and processing in the Northeast. Using the *Vermont Oilseed Cost and Profit Calculator*,[2] this report endeavors to address the following questions:

- How many acres of land are needed annually, and under what conditions, to make efficient use of the capacity on each farm-scale facility?
- If a farmer wishes to achieve a certain payback period or net annual income target, how many acres, how much oil, biodiesel, and/or meal do they need to produce to reach their goal?
- How are these results impacted by crop production costs and crop yield (i.e., the two most significant variables)?

INSTALLED CAPACITY and LAND USE

For an oilseed facility of a given size (e.g., press capacity, biodiesel production capacity, etc.), there are a finite number of acres that can be reasonably served. We were interested in determining "breakeven acreage" to evaluate land use needs for each VBI grantee.

We have estimated the breakeven point in terms of acres of oilseed in production showing average yields (coming into the facility) and average volumes of meal and biodiesel (leaving the facility) in order for each facility to be running at 80 percent capacity ("80% uptime," see Table 3). A brief description of each enterprise is provided below, along with a summary of their production capacity and "breakeven acreage."

Table 3: Summary of Current Oilseed Processing Capacities

	Storage Bins		Pressing Capacity		Biodiesel Capacity
Site	**bushel**	**tons**	**gallons per year**	**tons per year**	**gallons per year**
Rainbow Valley Farm (soybean)	30,000	900	155,733	2,920	417,133
State Line Farm Biofuels (sunflower)	1,363	22	26,280	183	312,857
Borderview Farm (sunflower)	2,130	34	179,093	1,679	13,036
Ekolott Farm (sunflower)	9,500	152	26,280	183	N/A
N. Hardwick Dairy (sunflower)	1,643	26	23,360	219	13,036
Totals	**44,636**	**1,134**	**371,813**	**5,183**	**756,071**
Totals with 80% uptime	*N/A*	*N/A*	*297,451*	*4,146*	*604,857*

__Note:__ The calculations assume 15% oil content for soybeans and 38% for sunflower as well as an oil density of 7.5 pounds per gallon. In most cases the farms would need to purchase additional oil extraction and storage equipment to match their biodiesel production capabilities. These components are modular and can be added in the future as dedicated acreage is secured.

Rows of soybeans.

RAINBOW VALLEY FARM – Orwell, VT

Mark Mordasky planting soybeans

Bill and Janice Mordasky and their son, Mark, run Rainbow Valley Farm as a custom field operations enterprise out of their former dairy farm. This is a relatively large operation by Vermont standards—custom planting and harvesting roughly 1,500 acres each year in addition to their own 290 acres. The equipment used for field work consumes 10,000 gallons of diesel each year.

The prospect of oilseed processing became attractive to the Mordaskys when local fuel prices nearly hit $5.00 a gallon in 2008, and they biodiesel production as a means to diversify their operation and to potentially increase profits by adding value to their own soybeans and oilseeds from other local farms.

With that interest, they renovated a milking parlor into an oil pressing and biodiesel processing room, with two 4-ton per 24-hour day Anyang (Chinese) oilseed presses. They later custom-built a 600-gallon per batch biodiesel processor using a bulk milk tank and other scrap steel tanks they salvaged along with stainless steel piping previously used for milking.

The selection of non-automated Anyang presses means this is a relatively labor intensive pressing operation that requires constant attention. As a result, the maximum operating hours assumed is 8 hours per day x 5 days per week.

Table 4: Production Capacity and Land Use at Rainbow Valley Farm

Production Capacity			
Operating 8 hours per day x 5 days per week with 80% uptime, the production capacity at Rainbow Valley Farm is:			
8,337 ton soybean per year	**= 7,087 ton soymeal per year**		
	= 333,500 gallons oil and biodiesel per year		
Land Use			
Yield assumption (pounds soybean per acre)	2,000	2,500	3,000
Acreage needed at capacity:	**8,338**	**6,948**	**5,558**

SUMMARY: Rainbow Valley could process 8,337 tons of soybeans from 6,948 acres with their facility, resulting in an estimated 333,500 gallons of oil or biodiesel and 7,087 tons of soy meal.

Soybean harvest at Rainbow Valley Farm.

STATE LINE FARM BIOFUELS – Shaftsbury, VT

John Williamson and his son Tanner were among the first farmers in Vermont to try growing oilseed crops for meal and fuel production in 2004. State Line is a 4th generation former dairy farm, with a 1,000 tap maple sugar operation and 230 acres in hay.

John Wiilamson of State Line Farm Biofuels.

The primary motivation for oilseed work at State Line is energy independence. A passive solar "Bio-Barn" has been constructed to house the oilseed press and biodiesel processor.

State Line opted for a more expensive, lower capacity (Swedish) Täby oilseed press that is, however, more automated and can be run 24 hours per day. The pressing capacity is 0.5-ton per 24-hours. The 400 gallon per batch biodiesel processor was custom built on the farm from salvaged stainless steel tanks and pipe previously used for milking. A batch requires about 3 hours to complete and the operation would likely be staffed 8 hours per day x 5 days per week at capacity.

Table 5: Production Capacity and Land Use at State Line Farm Biofuels

Production Capacity			
Operating 8 hours per day x 5 days per week with 80% uptime, the production capacity at State Line Farm Biofuels is:			
2,463 ton sunflower seed per year	**= 15,27 ton sunflower meal per year**		
	= 250,000 gallons oil and biodiesel per year		
Land Use			
Yield assumption (pounds sunflower per acre)	1,000	1,500	2,000
Acreage needed at capacity:	**4,926**	**3,284**	**2,463**

SUMMARY: State Line could process 2,463 tons of sunflower seed from 3,284 acres with their facility, resulting in an estimated 250,000 gallons of oil or biodiesel and 1,527 tons of sunflower meal.

Filling a jug with homegrown biodiesel.

BORDERVIEW FARM – Alburgh, VT

Roger Rainville of Borderview Farm.

Roger and Claire Rainville are the owners of Borderview Farm in Alburgh. The farm was formerly a dairy and still raises heifers in addition to hosting a wide array of crop trials for UVM Extension. Borderview was one of the earliest VBI grantees and has successfully grown sunflowers, canola, and soy, and now produces all of the biodiesel they need to power their equipment.

Borderview's goal to develop as a research farm (rather than as a commercial operation) has impacted their selection of biodiesel processing equipment and led to the investment in a variety of presses to use in their operation.

Two presses are in place, a 4 ton per day Anyang (Chinese) and a double head, 0.6-ton per 24-hour day Kern Kraft (German). The Anyang requires an operator when running, but the Kern Kraft is partially automated and only requires periodic attention. In addition to the presses, Borderview owns a BioPro190 automated biodiesel processor which can produce 50 gallons per 24-hour day. Because of the automated nature of the equipment, Borderview can operate at this relatively low volume of 24 hours per day x 260 days per year.

Table 6: Production Capacity and Land Use at Borderview Farm

Production Capacity			
Operating 24 hour per day x 5 days per week with 80% uptime, the production capacity at Borderview Farm is:			
103 ton sunflower seed per year	**= 64 ton sunflower meal per year**		
	= 10,500 gallons oil and biodiesel per year		
Land Use			
Yield assumption (pounds sunflower per acre)	1,000	1,500	2,000
Acreage needed at capacity:	**207**	**138**	**103**

SUMMARY: Borderview could process 103 tons of sunflower seed from 138 acres with their facility, resulting in an estimated 10,500 gallons of oil or biodiesel and 64 tons of sunflower meal.

Borderview Farm.

EKOLOTT FARM – Newbury, VT

Larry Scott and Peggy Hewes of Ekolott Farm.

Larry Scott and Peggy Hewes operate Ekolott Farm—a diversified farm raising emus, Herefords, and hogs, and growing crops such as shell corn, sunflowers, and soybeans on 200 acres of river valley land. Ekolott is interested in producing a portion of their own fuel, but also has a strong interest in the feed value of the oilseed meal for their animals.

The farm has a double-press Täby Model 70 similar to the one at State Line Farm (0.5-ton per 24-hour day). At the moment, they do not have a biodiesel processor at the farm, but contract with a neighbor who owns a BioPro190.

Table 7: Production Capacity and Land Use at Ekolott Farm

Production Capacity			
Press only (no biodiesel capacity):			
207 ton sunflower seed per year	**= 334 ton sunflower meal per year**		
	= 21,000 gallons oil		
Land Use			
Yield assumption (pounds sunflower per acre)	1,000	1,500	2,000
Acreage needed at capacity:	**414**	**276**	**207**

SUMMARY: Ekolott could process 207 tons of sunflower seed from 276 acres, resulting in 21,000 gallon of oil and 334 tons of sunflower meal.

NORTH HARDWICK DAIRY – North Hardwick, VT

Taylor and Nick Meyer of North Hardwick Dairy.

The Meyer family owns and operates an organic dairy on a 327-acre farm in North Hardwick. Nick Meyer became interested in oilseed crops because he wanted to displace some of the diesel fuel and expensive organic feed that they had been importing to their dairy. Additionally, selling organic food-grade oil is an attractive opportunity due to price premiums available in that market.

North Hardwick has a double-head Kern Kraft (0.6-ton per 24-hour day) and also has a BioPro190, similar to Borderview Farm. Both of these pieces of equipment are partially automated.

Table 8: Production Capacity and Land Use at North Hardwick

Production Capacity			
Operating 24 hours per day x 5 days per week with 80% uptime, the production capacity at North Hardwick Dairy is:			
103 ton sunflower seed per year	**= 64 ton sunflower meal per year**		
	= 10,500 gallons oil and biodiesel per year		
Land Use			
Yield assumption (pounds sunflower per acre)	1,000	1,500	2,000
Acreage needed at capacity:	**207**	**138**	**103**

SUMMARY: North Hardwick Dairy could process 103 tons of sunflower seed from 138 acres, resulting in 10,500 gallon of oil or fuel and 64 tons of sunflower meal.

ENTERPRISE EXAMPLE #1: ECONOMIC FEASIBILITY OF 100,000 GALLONS PER YEAR, FARM-SCALE FACILITY

One of the goals of the VBI is to demonstrate the economic feasibility of on-farm oilseed and biodiesel operations. Running a hypothetical enterprise through the *Oilseed Cost and Profit Calculator* developed with support from the U.S. Department of Energy via VSJF, UVM Extension and *USDA Northeast SARE*, the following example, *processing only conventionally grown (non-organic) sunflower seed*, shows the economic characteristics of interest.

Using an example of a farm-scale biodiesel facility with 100,000 gallon per year capacity of oilseed pressing and biodiesel production, we ran several simulations to calculate the required pricing to provide 5-year and 10-year paybacks, and to explore the sensitivity of the results to yield and crop production costs.

What follows is a step-by-step approach to arrive at oilseed production and processing costs, *assuming 38% oil in seed and 7.5 pounds per gallon of oil.* (See Table 9 for a summary of equipment costs).

Step 1: ACREAGE REQUIRED

To estimate crop production costs, we first estimated the acreage required. For 100,000 gallon per year of oil or biodiesel, we assumed a yield of 1,200 pounds per acre, so we would need **1,645 acres of cropland** in production. Accounting for a 5-year rotation of oilseed crops with other crops to avoid disease pressure, a total of 8,225 acres of cropland would be required.

Seed processed: 987 tons (~61,700 bushels) seed per year

Meal produced: 611 tons sunflower meal per year

Acreage needed:

- 1,645 acres @ 1,200 pounds per acre yield (a low average among VT growers)
- 1,316 acres @ 1,500 pounds per acre yield (average)
- 987 acres @ 2,000 pounds per acre yield (very good for VT and attainable)

Step 2: LAND COST

Average Vermont land cost (tax burden) is **$37 per acre**, so annual land cost is $60,865 per year.

Step 3: COST OF CROP PRODUCTION

The average cost of field operations in Vermont (i.e., "cost of production") for oilseeds is **$153 per acre** based on recent data. This is the recurring cost per acre to till or prep, plant, fertilize, cultivate/spray, harvest, and haul seed to a cleaner and storage bin.

Step 4: CROP EQUIPMENT COST

Selection and purchase of equipment is very dependent on individual management practices and is difficult to assume in a theoretical case. In reality, for an operation on this number of acres, equipment investment would probably be distributed among participating farmers, along with some field operations being hired-in as custom work. However, a reasonable crop equipment cost for this theoretical 1,645 acre per year operation would be $350,000, based on a yield of 1,200 pounds per acre and new equipment purchases. Amortized over an average equipment life of 20 years, this results in about $17,500 annual equipment costs or **$10.64 per acre per year** ($17.73 per ton).

John Williamson at Seed Cleaner, State Line Farm.

Step 5: SEED CLEANER COST

Cleaning is typically done prior to drying and storage in order to avoid the cost of drying and storing foreign material (waste). Therefore, a seed cleaner with capacity of 2-ton per hour will be needed at an estimated cost of $7,000 and life span of 20 years, giving us an annual cost of **$350 per year or $0.36 per ton**.

Step 6: BIN COST

Seed and meal storage bins will be needed at an estimated installed cost of $1.20 per bushel of storage or $75,000 in this case (with a life span of 40 years). The annual fixed cost per ton of seed is therefore $1.90 per ton. Drying adds recurring cost due to electricity use of $1.28 per ton. Thus the annual cost of drying and storing is **$3.18 per ton of seed**.

Table 9: Estimated Equipment Costs For 100,000 Gallons Per Year Facility

Equipment Type (assumed new)	Estimated Cost
Crop Equipment	$350,000
Seed Cleaner	$7,000
Storage Bins	$75,000
Oil Expeller (Press)	$45,000
Biodiesel Processor	$93,000
TOTAL	**$570,000**

Step 7: COST OF SEED IN THE BIN

At a recurring crop production cost (not including machinery) of $153 per acre with land cost of $37 per acre and a yield of 1,200 pounds per acre, the **cost of seed standing in the field is $190 per acre or $317 per ton ($0.16 per pound)**. Adding in the amortized costs of field operations equipment ($17.73 per ton), cleaner ($0.36 per ton), and dryer and bins ($3.18 per ton) adds a total of $21.47 per ton resulting in an **overall cost of clean, dry seed in the bin of $338 per ton.**

Step 8: PRESS COST

To press 987 tons of sunflower seeds over the course of the year requires a constant rate of at least **2.7 tons per day.** Two Täby Model 70's cost $45,000, and would provide 3-ton per day capacity when running 24 hours per day, seven days per week. A life span of 20 years is assumed. Pressing labor is assumed to be 2 hours of cleaning and maintenance attention for every 24 hours of operation ($0.05 per ton). **Therefore, the unit cost of pressing seed is $2.36 per ton seed.**

Step 9: COST OF PRESSED OIL AND MEAL

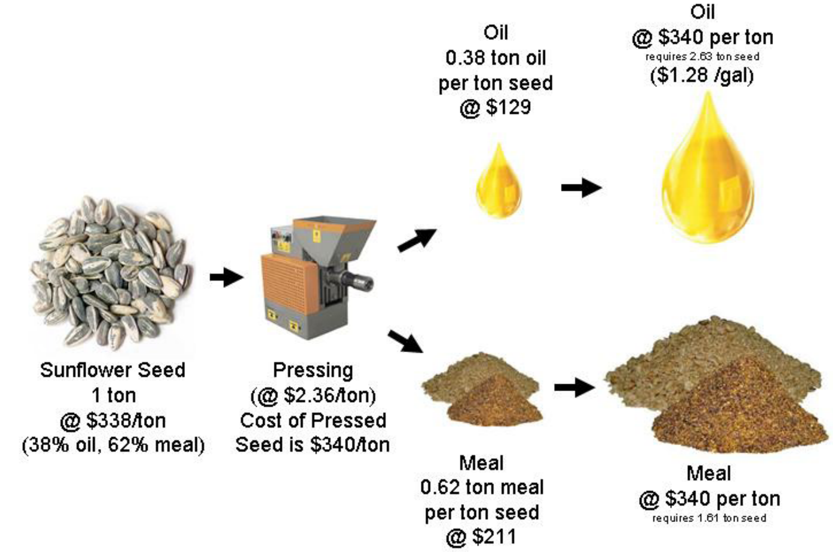
The cost of pressed seed is now **$340 per ton** ($338/ton cost of seed in the bin + $2.36/ton press cost). When a ton of sunflower seed is pressed, the result is 0.38 ton of oil and 0.62 ton of meal, so allocating the "shared burden" of this cost to the oil and meal on a mass basis results in the 0.38 ton of oil costing $129, and the 0.62 ton of meal costing $211. **Adjusting these costs to whole ton costs results in oil at $340 per ton** (i.e., $129 divided by 0.38 ton) **or $1.28 per gallon, and meal at $340 per ton** (i.e., $211divided by 0.62 ton) (Figure 1).

Step 10: BIODIESEL PROCESSOR COST

For a biodiesel capacity of 100,000 gallons per year, we assumed an investment of $0.93 per gallon for the entire facility's capital cost (e.g., biodiesel conversion, tanks, storage, safety, etc.). So the capital investment is $93,000 for all biodiesel related assets. This figure is based on the average capital cost of the five VBI on-farm facilities. If we further assume a 40 year life of these assets, the annual cost is $2,325 per year and the **fixed cost per unit converted is $0.02 per gallon of fuel**.

To produce 100,000 gallon per year of biodiesel in an 8 hours x 5 day operation (working 260 days per year) requires at least a 383 gallons per day production to make a reasonable batch size. A batch of this size can generally be done in 2-4 hours, meaning the same operator could attend to other operational duties (e.g., pressing, meal processing, sales, etc.). Minimally attended operation of the biodiesel processor is assumed (1 hour per batch at a wage of $20 per hour, or $0.04 per gallon). Heating the oil costs approximately $0.02 per gallon assuming $0.14 per kWh electricity cost. Alcohol cost is assumed to be $3.00 per gallon alcohol used at a ratio of 0.22 gallons alcohol per gallon oil (i.e. $0.66 per gallon fuel). Lye cost is assumed to be $1.50 per pound used at a rate of 0.08 pounds per gallon oil (i.e., $0.12 per

Figure 1: Breakdown of the pressing costs and their allocation based on mass



gallon fuel). **The variable cost of converting oil to biodiesel is, therefore, $0.84 per gallon fuel**.

Therefore, it **costs $0.87 per gallon to convert vegetable oil to biodiesel** (the rounded sum of fixed and variable costs). When added to the cost of oil coming off the press ($1.28 per gallon), the **cost of finished fuel is $2.14 per gallon fuel**.

BREAKEVEN, PROFITABILITY, AND PAYBACK PERIOD

The values of the different co-products affect overall profitablity of the operation *(The information in the boxes on page 12 assume 611 tons of meal and 100,000 gallons of oil are derived from 987 tons of seed):*

- Selling seed at market price of $579 per ton with a cost (or breakeven price) of $338 per ton, means unit profit of $241 per ton. For 987 tons at $241 per ton, this equals a profit of $237,867 for seed.

BREAKEVEN PRICING at 100,000 GALLONS PER YEAR

[A breakeven price is the sale price at which all production costs are covered, but no profit is made.] Breakeven prices for this enterprise are:

- Seed — $338 per ton at volume of 987 tons
- Meal — $340 per ton (shared burden) at volume of 611 tons
- Oil — $1.28 per gallon (shared burden) at volume of 100,000 gallon
- Biodiesel — $2.14 per gallon (shared burden) at volume of 100,000 gallon

- Selling meal at market price of $247 per ton, and oil at a market price of $5.30 per gallon, with costs of $340 per ton and $1.28 per gallon respectively, means a unit loss of -$93 per ton for meal and a unit profit of $4.02 per gallon for oil. For 611 tons meal at -$93 per ton, this equals a -$56,823 loss on the meal, with 100,000 gallons of oil at $4.02 per gallon, equal to $402,000. Adding them together translates to a profit of $345,177.

MARKET PRICING

[The market price is the retail cost or value at a given point in time.]

Current market prices for the end products are:

- Seed — $579 per ton (USDA OCS 09/13/2012 - pg. 16, Table 8)
- Meal — $247 per ton (USDA OCS 09/13/2012 - pg. 18, Table 10)
- Oil — $5.30* per gallon (USDA OCS 09/13/2012 - pg. 17, Table 9)(*Take $6.30/gallon for published *deodorized, bleached & refined oil* price, LESS refining costs of approxiately $1.00 per gallon)
- Off-Road Diesel — $3.59 per gallon (USDOE EIA Retail #2 NE, avg. Jan-Jul 2012 less taxes)

- Selling meal at market price of $247 per ton with costs of $340 per ton, and off-road biodiesel priced at $3.59 per gallon, and costing $2.14 per gallon, similarly yields -$56,823 from meal and $1.45 per gallon or $145,000 from biodiesel for a total profit of $88,177.

PROFITABILITY at 100,000 GALLONS PER YEAR

[Based on costs of production and market pricing, all end products other than selling meal alone, are profitable at market prices.]

At the market prices noted above, the enterprise sourcing from the 1,645 acres would net (before income tax and debt service):

- Selling Seed — $ 237,867 per year
- Selling Meal & Oil — $ 345,177 per year
- Selling Meal and Off Road Biodiesel — $ 88,177 per year

Note: All projections other than seed alone, assume either both meal and oil, or both meal and fuel are sold when determining costs and profits. This is necessary because the cumulative costs of production up to and through the pressing operation have been split between the oil and meal, thereby reducing the unit cost of each. In other words, meal is a co-product with oil and/or fuel, and each of these products are sharing their "burden of cost" of production.

Targeting a payback period of 10 years (i.e., paying off one's $570,000 investment in 10 years of operation) would require an annual net income of $57,000 per year (before taxes and debt service). A 5-year payback would require $114,000 per year.

In the above simple payback calculations, assume the market price of the meal is its minimum sale price since the actual cost of meal production is above the market price. In the cases of oil and biodiesel, the costs of production are below market price and there is room between cost and market price for adjustment in order to calculate a specific payback period price.

SENSITIVITY ANALYSIS

A broader consideration of the hypothetical enterprise's sensitivity to operational variables is provided in Table 10, which explores how breakeven pricing depends on several independent factors.

Dependent variables of interest—the results—are breakeven price of seed, oil, meal and biodiesel. Independent variables of interest—the items we adjust—are yield and crop production costs. These calculations assume a 100,000 gallon per year facility with $350,000 in crop production equipment costs, $82,000 in cleaning/drying equipment, $45,000 in pressing equipment, and $93,000 in biodiesel production equipment (the same as discussed thus far).

Cover crop at Wood's Market Garden, Brandon.

Table 10: Breakeven Pricing for Sunflower Products at Various Costs of Crop Production and Yield

Recurring costs (of crop production)	1,000 pounds per acre	1,500 pounds per acre	2,000 pounds per acre	Units
$100/acre	295	204	158	Seed, $/ton
	298	206	161	Meal, $/ton
	1.12	0.77	0.60	Oil, $/gallon
	1.98	1.64	1.47	Biodiesel, $/gallon
	1,974	1,316	987	Acres required
$150/acre	395	271	208	Seed, $/ton
	398	273	211	Meal, $/ton
	1.49	1.02	0.79	Oil, $/gallon
	2.36	1.89	1.66	Biodiesel, $/gallon
	1,974	1,316	987	Acres required
$200/acre	495	337	258	Seed, $/ton
	498	340	261	Meal, $/ton
	1.87	1.27	0.98	Oil, $/gallon
	2.73	2.14	1.84	Biodiesel, $/gallon
	1,974	1,316	987	Acres required

= not profitable at assumed market prices

Note: Unless otherwise noted, all acreage above are net acres. These figures do not account for necessary rotation acres (4-5 x annual net oilseed acres), which will be necessary for sustained production as well as minimized pest and disease pressure. If the oilseed production is integrated with a diversified crop enterprise, this may not be a large factor in the operation.

ENTERPRISE EXAMPLE #2: SMALL-SCALE; 13,000 GALLONS PER YEAR

In addition to assessing a 100,000 gallon per year oilseed enterprise (large by current Vermont standards), we also wanted to explore the feasibility and economics of a smaller scale, 13,000 gallon per year system. The initial motivation for this case comes from interest among several farms to fuel their operations with minimal capital investment. The *Vermont Oil Seed Cost and Profit Calculator* was used to determine the economic characteristics of interest for this case.

We have assumed the use of an off-the-shelf biodiesel processor (e.g., BioPro190) with a batch capability of 50 gallons in 24 hours. Additionally we have assumed the purchase of a single, automated oil press. The crop assumed for this case is sunflower.

What follows is a step-by-step approach to arrive at oilseed production and processing costs for this operation.

Step 1: ACREAGE REQUIRED

To estimate crop production costs, we need to first estimate acreage required. For 13,000 gallon per year of oil or biodiesel (assuming 38% oil in seed and 7.5 pounds per gallon oil):

Initially, for a baseline result, we have assumed a yield of 1,200 pounds per acre, therefore **214 acres of cropland would be required** to run the biodiesel processor at full capacity (5 batches per week). *Accounting for a 5-year rotation of this oilseed crop with other crops to avoid disease pressure, a total of 1,070 acres of cropland would be required.*

Step 2: LAND COST

Average Vermont land cost (tax burden) is **$37 per acre**, so annual land cost is $7,918 per year.

Seed processed: 128 tons (~8,018 bushels) seed per year

Meal produced: 79 tons sunflower meal per year

Acreage needed:

- 214 acres @ 1,200 pounds per acre yield (a low average among VT growers)
- 170 acres @ 1,500 pounds per acre yield (average)
- 128 acres @ 2,000 pounds per acre yield (very good for VT and attainable)

Step 3: COST OF CROP PRODUCTION

The average cost of field operations in Vermont (i.e. "cost of production") for oilseeds is **$153 per acre** based on recent data. This is the recurring cost per acre to till or prep, plant, fertilize, cultivate or spray, harvest and haul seed to a cleaner and storage bin.

Step 4: CROP EQUIPMENT COST

Selection and purchase of equipment is very dependent on individual management practices and is difficult to assume in a theoretical case. For a small operation like this, equipment investment would be as minimal as possible. Existing field operations equipment would be used (i.e., for plowing, planting, no-till planting, etc.). The main new capital investment would likely be a used combine. A reasonable crop equipment cost for this theoretical 213 acre per year operation would be $25,000, based on a yield of 1,200 pounds per acre and used equipment purchases (see Table 11, pg 15). Amortized over an average **equipment life of 20 years,** this results in about $1,250 annual equipment costs or **$5.84 per acre per year** ($9.76 per ton).

Step 5: SEED CLEANER COST

Cleaning is typically done prior to drying and storage in order to avoid the cost of drying and storing foreign material (waste). Therefore a seed cleaner with capacity of 0.5 ton per hour will suffice at an estimated cost of $3,000 and life span of 20 years, giving us an **annual cleaning cost of $150 per year** or **$1.17 per ton.**

Step 6: BIN COST

Seed and meal storage bins will be needed at an estimated installed cost of $2.00 per bushel of storage or $20,000 in this case (life of 40 years). The annual fixed cost per ton of seed is therefore, **$3.89 per ton.** Drying adds recurring cost due to electricity use of $1.19 per ton. Thus the annual cost of drying and storing is **$5.08 per ton of seed.**

Step 7: COST OF SEED IN THE BIN

At a recurring crop production cost (not including machinery) of $153 per acre with land cost of $37 per acre and a yield of 1,200 pounds per acre, **the cost of seed standing in the field is $190 per acre or $317 per ton** ($0.16 per pound). Adding in the amortized costs of field operations equipment ($9.76 per ton), cleaner ($1.17 per ton), and dryer and bins ($5.08 per ton) adds a total of $16.11 per ton resulting in an **overall cost of clean, dry seed in the bin of $333 per ton.**

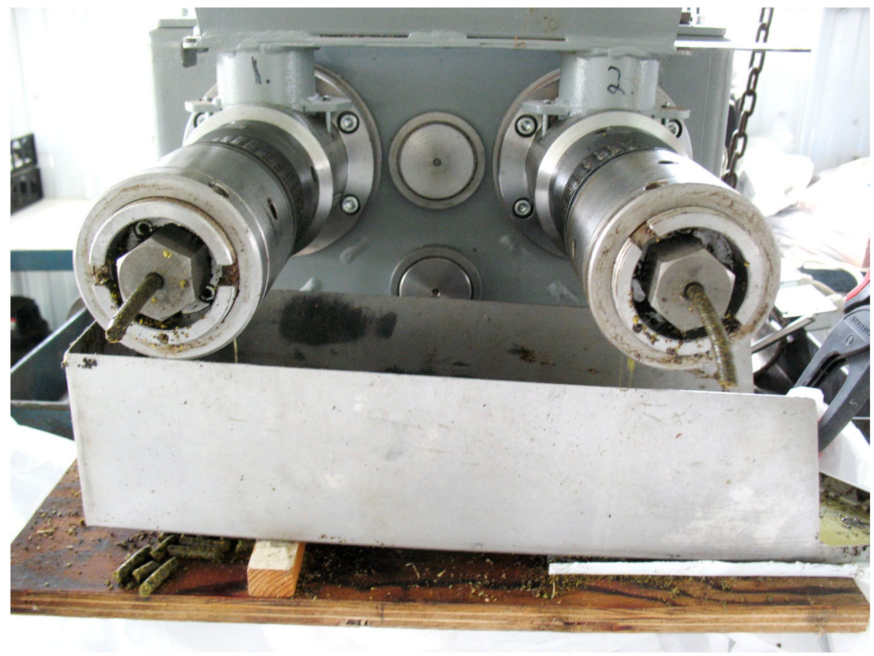
Step 8: PRESS COST

To press 128 tons of sunflower seeds over the course of the year requires a constant rate of at least **0.35 tons per day.** A single *Kern Kraft Oil Press* is available with sunflower capacity of 0.5 ton per 24-hour day at a cost of $12,000. A life span of 20 years is assumed. Pressing labor is assumed to be 2 hours of cleaning and maintenance for every 24 hours of operation ($0.05 per ton).

Therefore, **the unit cost of pressing seed is $4.75 per ton seed.** This equates to **$4.75 per ton of oil** and **$4.75 per ton of meal**.

Table 11: Estimated Equipment Costs For 13,000 Gallons Per Year Facility

Equipment Type	Estimated Cost
Crop Equipment (used)	$25,000
Seed Cleaner (used)	$3,000
Storage Bin (used)	$20,000
Oil Expeller Press (new)	$12,000
Biodiesel Processor (new)	$20,000
TOTAL	**$80,000**



Pressing canola seed to oil and meal with Kern Kraft (KK40) expeller.

Step 9: COST OF PRESSED OIL AND MEAL

All cumulative production costs (land, equipment, cropping costs, cleaning, storing, etc.) should be similarly allocated. Therefore, the total cumulative costs of meal are **$353 per ton and for oil, $1.32 per gallon of fuel** (or $353 per ton oil).

Step 10: BIODIESEL PROCESSOR COST

For a biodiesel capacity of 13,000 gallon per year we've assumed the purchase of an off-the-shelf biodiesel processor such as the *BioPro190 from Springboard*. The capital investment for this type of machine is $20,000 and includes fuel finishing (cleaning) equipment. If we assume a 40 year life of this processor, the annual cost is $500 per year and the fixed cost per unit converted is **$0.04 per gallon of fuel**.

BioPro 190 at Borderview Farm.

Minimally attended operation of the biodiesel processor is assumed (20 minutes per 50 gallon batch at a wage of $20 per hour, or $0.13 per gallon). Heating the oil costs approximately $0.02 per gallon assuming $0.14 per kW hour electricity cost. Alcohol cost is assumed to be $3.00 per gallon alcohol used at a ratio of 0.22 gallon alcohol per gallon oil (i.e., $0.66 per gallon fuel). Lye cost is assumed to be $1.50 per pound used at a rate of 0.08 pounds per gallon of oil (i.e., $0.12 per gallon fuel). Therefore, **it costs $0.97 per gallon to convert vegetable oil to biodiesel** (the rounded sum of fixed and variable costs).

When added to the cost of oil coming off the press ($1.20 per gallon), the cost of finished fuel is **$2.29 per gallon of fuel**.

ANALYZING THE START-UP PHASE OF A 13,000 GALLON PER YEAR ENTERPRISE

The above calculation assumes production at a capacity of 13,000 gallons per year on 214 acres. This is based on maximizing the output of the biodiesel processor. However, at the startup stage, an oilseed farmer might first operate at lower production to produce perhaps 4,000 gallons to meet their own farm's needs, while bringing on additional acres to increase production and lower unit costs. At 4,000 gallons per year capacity the following changes are reasonable to expect:

- **Change in acreage required:** 66 acres net (330 accounting for rotation)
- **Change in the amortized costs of field operations** equipment from $9.76 to **$31.67 per ton**
- **Change in amortized cost to clean seeds** from $1.17 to **$3.99 per ton**
- **Change in bin investment:** $9,000 to store 39 tons of seed at $3 per per bushel capacity. This changes the cost of drying and storage from $5.08 to **$6.88 per ton.**

At the same recurring crop production cost (not including machinery) of $153 per acre with land cost of $37 per acre and a yield of 1,200 pounds per acre, **the cost of seed standing in the field is still $190 per acre or $317 per ton.** But with lower production volume, the amortized costs are higher.

Factoring in the revised costs of field operations equipment, the smaller storage bin and operation of the seed cleaner and dryer, and higher fixed cost of pressing fewer tons, adds a total of $41.00 per ton. The end result for **39 tons of clean, dry seed in the bin is an overall cost of $374 per ton** (compared to $333 per ton when 128 tons are processed).

MARKET PRICING

[The market price is the retail cost or value at a given point in time.]

Current market prices for the end products are:

- Seed — $579 per ton (USDA OCS 09/13/2012 - pg. 16, Table 8)
- Meal — $247 per ton (USDA OCS 09/13/2012 - pg. 18, Table 10)
- Oil — $5.30* per gallon (USDA OCS 09/13/2012 - pg. 17, Table 9)(*Take $6.30/gallon for published *deodorized, bleached & refined oil* price, LESS refining costs of approxiately $1.00 per gallon)
- Off-Road Diesel — $3.59 per gallon (USDOE EIA Retail #2 NE, avg. Jan-Jul 2012 less taxes)

BREAK EVEN PRICING at 13,000 GALLONS PER YEAR

[A breakeven price is the sale price at which all production costs are covered, but no profit is made.] Breakeven prices for this enterprise are:

- Seed — $348 per ton at volume of 128 tons
- Meal — $353 per ton (shared burden) at volume of 80 tons
- Oil — $1.32 per gallon (shared burden) at volume of 13,000 gallons
- Biodiesel — $2.29 per gallon (shared burden) at volume of 13,000 gallons

BREAK EVEN PRICING at 4,000 GALLONS PER YEAR

[A breakeven price is the sale price at which all production costs are covered, but no profit is made.] Breakeven prices for this enterprise are:

- Seed — $374 per ton at volume of 39 tons
- Meal — $389 per ton (shared burden) at volume of 24 tons
- Oil — $1.46 per gallon (shared burden) at volume of 4,000 gallons
- Biodiesel — $2.52 per gallon (shared burden) at volume of 4,000 gallons

Table 12: Profitability and Simple Payback at 4,000/13,000 Gallons Per Year

	Start-Up Phase (4,000 gallon/year)	Full Capacity (13,000 gallon/year)
Startup Costs	$69,000	$80,000
Acres (net / rotation)	66 / 330	214 / 1,070
Tons Seed	39	128
Gallon Oil / biodiesel	4,000	13,000
Tons Meal	24	80
Product Costs		
Seed ($ per ton)	374	348
Meal ($ per ton)	389	353
Oil ($ per gallon)	1.46	1.32
Biodiesel ($ per gallon)	2.52	2.29
Potential Profit or Cost Savings (or Loss)		
Seed ($ per ton)	205	231
Meal ($ per ton)	-142	-106
Oil ($ per gallon)	3.84	3.98
Biodiesel ($ per gallon)	1.07	1.30
Simple Payback (years)		
Sell Seed	n/a	2.7
Sell Oil and Sell or Use Meal*	n/a	1.8
Sell or Use Biodiesel and Sell or Use Meal	n/a	9.4**

** The value of meal assumed above is for sunflower meal for livestock, not for organic fertilizer. The higher value of the meal in this case may be as organic fertilizer rather than the market value for sunflower meal.*

*** An increase in the market price of fuel to $5 per gallon (from the $3.59 per gallon assumed above) would drive the **payback from 9.4 years to less than 3 years,** if using or selling biodiesel and meal.*

CONCLUSION

As evidenced by the case studies in this report, there are a number of approaches and a variety of new and used equipment available to be successful and save money with farm-scale production of oil, oilseed meal, and biodiesel.

In the two examples above, one a 100,000 gallon per year commercial enterprise, and the other a 13,000 gallon per year operation, both used **representative sunflower production data from five Vermont farms.** Over a range of crop production costs between $100 and $200 per acre, and yields between 1,000 and 2,000 pounds per acre, **at current market prices the combined worth of the meal and the oil, *or* the meal plus the biodiesel are shown to be profitable.** Both scales of operation can also see a payback on their investment within a reasonably short time frame. Should diesel prices reach $5 a gallon, simple payback could occur in less than 12 months, to less than 3 years, depending on the scale of the operation.

The two enterprise examples illustrate the potential for an "average case". But like any test case, the assumptions do not account for all of the variables that farmers could encounter in an actual enterprise, and, where noted, some of the data is only an estimate of real world costs.

Furthermore, in terms of revenue potential, an individual farm or business may find access to new or better paying markets not fully addressed in this report (e.g., using or selling the meal product as an organic fertilizer). It is also true that without access to distribution channels, lower than projected revenue may result, especially for the edible oils.

Comparing potential profit or cost savings whether the enterprise is selling whole seed, oil, meal, biodiesel or a combination should also reflect the values and aims of the operation. Fuel and feed security is a key motivation for the Vermont farms participating in the VBI. Others may approach the opportunity primarily to sell the oilseed co-products themselves and should factor in the added costs for distribution, wages, marketing, and so on.

The Vermont Sustainable Jobs Fund, University of Vermont, and Northeast SARE are very encouraged by the results of these oilseed operations so far and are optimistic that wider use of their *Oilseed Cost and Profit Calculator* will lead to increased deployment of this model of on-farm energy, oil, and feed production. Prior to investing in new equipment, this easy-to-use tool and the step-by-step approach used in this report provides a means to evaluate assumptions, actual costs, and current market prices for the new or expanding oilseed enterprise.

END NOTES

1 Pricing: Oil Seed, Meal and Oil prices are per 09/13/2012 forecast from *USDA ERS Oil Crops Outlook Report*. Biodiesel market price reflects 2012 annual average On Road for New England (US DOE EIA PADD 1A) less $0.50 per gallon in assumed taxes.

2 The Vermont Oilseed Cost and Profit Calculator was developed jointly by VSJF, UVM, and Northeast SARE and is available online at: *www.vsjf.org/resources/reports-tools/oilseed-calculator*.

CONTACTS

Netaka White, Bioenergy Program Director
Vermont Sustainable Jobs Fund
(802) 828-1260 • biofuels@vsjf.org

Chris Callahan, Engineer
Callahan Engineering, PLLC
(518) 677-5275 • chris@callahan.eng.pro

The Vermont Bioenergy Initiative is made possible through a U.S. Department of Energy grant and the Office of U.S. Senator Patrick Leahy (DOE grant# DE-FG36-08GO88182).

To see many of the farms and practices explained in this report, visit the VBI YouTube Channel at *http://www.youtube.com/user/VermontBioenergy*