PROMOTING RENEWABLE ENERGY IN VERMONT

Vermont Biofuels Association

Alternatives for On-Farm Energy Enhancement in Vermont: Oilseeds for Feed and Fuel

Photo by Dorn Cox, Tuckaway Farm, 2006

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Table of Contents

Oilseeds for Feed and Fuel in Vermont

The year 2006 brought major breakthroughs in public awareness of the problems posed by climate change and depleting oil reserves. Liquid biofuels—ethanol and biodiesel—are seen widely as part of the solution for reducing greenhouse gas emissions and buffering future oil shortages. While controversy is emerging around industrial scale practices associated with biofuels; from the destruction of rainforests to biofuels' impact on food production, sustainable biofuel production methods hold the promise of yielding environmentally friendly, renewable fuel, feed and food, leading to reductions in greenhouse gas and other emissions and new economic opportunities in rural areas.

Production of oilseed crops (such as soy, canola and sunflower) to produce biodiesel, livestock feed and food-grade oil is technically feasible in Vermont. Recent crop trials from Vermont, Maine, and New Hampshire indicate that yields for oilseed crops at or exceeding the national average are achievable in Vermont's climate and agricultural soils, but additional experience with appropriate harvesting equipment and perfecting oilseed harvesting techniques, as well as adequate drying and storage facilities are required. In response to farmer's interest and global forces affecting energy and agriculture, University of Vermont Extension, the Vermont Biofuels Association (VBA), Vermont Sustainable Jobs Fund (VSJF), UVM Center for Sustainable Agriculture and others have independently and collectively been researching oilseed crop production and value-adding scenarios to further establish the agricultural and economic feasibility of small-scale oilseed enterprises. This On-Farm Energy Enhancement initiative of the Vermont Sustainable Agriculture Council (VSAC) is one such project aimed at improving the viability of Vermont's family farms.

Project Goals

This report to the Vermont Sustainable Agriculture Council comes as the result of decisions by VSAC to study on-farm energy enhancement opportunities and partner with other Vermont organizations working to develop new sustainable agricultural enterprise. The Scope Of Work for this project includes these four goals:

1. Update information from the 2004 Biomass Research and Development Initiative's "Evaluation of the Economic Benefits to Farmers" of producing biodiesel from oil seed in Vermont with data to reflect current markets.

2. Determine the potential on-farm market for biodiesel by identifying the current level of diesel and heating oil use in Vermont in: tractors, other farm field equipment, and on-farm vehicles; greenhouse heaters; farm building oil furnaces; maple syrup production; and any other activities.

3. Determine the potential on-farm market for livestock feed derived from oilseed crops grown in Vermont by identifying the current level of demand for these feed components among the state's dairies, beef, bison, poultry and other livestock operations.

4. List and describe the current tax and environmental rules (both state and federal) pertaining to the production, sale and use of biodiesel made on Vermont's farms.

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Executive Summary

In the summer of 2006 the Vermont Biofuels Association and Vermont Sustainable Jobs Fund organized a research team under the Vermont Feed, Food & Fuel Project (VFFF) that would take the next two years to help evaluate and demonstrate the feasibility of small-scale production of livestock feed, food grade oil and biodiesel from oilseed crops in Vermont. The project partners have been accompanied by University of Vermont Extension and the UVM Center for Sustainable Agriculture, which launched the On-Farm Oilseed Production and Processing and Farm Energy Enhancement initiatives, respectively, in 2005. This collaborative and the farms they work with are exploring whether Vermont communities could sustainably produce some portion of their liquid fuel, food grade oil and livestock feed supply, the requirements for and characteristics of Vermont-scale biofuel production, and whether Vermont entrepreneurs could create a replicable, economically viable model of local production of feed, food and fuel for local use, as an alternative to industrial biofuels and feed production.

Although farmers and biodiesel enthusiasts have been excited about the potential for these products, the full extent of the equipment, capital, and acreage needed has been unknown. Determining the economic feasibility for farmers of such activities is also vitally important at this early stage. Discussions with over a dozen farmers who are at various stages of growing and processing oilseed crops have indicated that market and economic viability data and decision-making tools will be of great value.

Vermont produces far fewer oilseed co-products than it consumes

Vermonters import over 100,000 tons of livestock meal, 78.6 million gallons of diesel fuel, and 147 million gallons of No. 2 heating oil per year, and an as-yet-to-determined amount of food-grade vegetable oil. Demand for fuel is expected to remain strong, and to continue to increase in the short term. Furthermore, volatility and increases in the price of crude oil are expected to continue to raise the prices that farmers and consumers pay for liquid fuels, fertilizers, and livestock feed.

Fewer than 2,000 acres are planted in oilseeds in Vermont today, mostly in soybeans that are roasted whole and fed to dairy cows, with several farms growing less than 200 acres of canola and sunflowers for crop trials and feed and fuel production.

Demand for oilseed meal in Vermont is driven by the dairy industry, with dairy cows estimated to account for approximately 97% of the market potential. Demand is particularly strong for organic livestock meals and vegetable oils, which are in short supply and command substantial price premiums. In general, the more value added to the end product, the higher the return per bushel or acre. The absence of genetically modified organisms (GMOs) is also an important criterion for organic feed mills and farmers, and could present additional opportunities for Vermont farmers interested in meeting this demand. Area purchasers of vegetable oil and meal expressed a willingness to buy and sometimes pay more for these if locally produced, provided they met quality and consistency standards and could be supplied reliably.

Farm-scale production of oilseed products is technically feasible
Production of oilseed crops and co-products is technically feasible in Vermont. Oilseed crops can grow well, and good yields are achievable given improved harvesting equipment and techniques. Crop trials from Vermont, Maine, and New Hampshire indicate that yields for oilseed crops at or exceeding the national average are achievable in Vermont's climate and agricultural soils. The primary factors necessary to increase yields to average levels are appropriate harvesting equipment, additional experience to perfect oilseed harvesting techniques, and adequate drying and storage facilities. Custom combining could represent a new business opportunity if more farms add oilseeds to their crop rotations.

Farm-scale processing techniques can produce high-value, good-quality oilseed co-products, but further refinement and testing are needed. Thus far, the quality of the oil and oilseed meal produced at the farm scale appears promising. As much as 3 lbs per day of this meal, depending on the type of oilseed, could be included in a ration for a high-producing dairy cow. To be able to sell this meal to other farmers or a feed dealer at a competitive price, however, the meal producer must be able to ensure that the meal is of a consistent quality. Further refinement and standardization of batch-processing techniques are needed, and additional, regular testing of the farm-pressed meal is recommended to establish quality and consistency.

A farm-scale seed pressing operation, including seed cleaner, press, and storage facilities is estimated to cost approximately $30,000. Fixed costs to establish a farm-scale biodiesel production facility, with a 40,000 gallon per year output, are estimated at $35,000, with an additional $35,000 in annual operating costs. From a technical perspective, these operations are relatively easy to establish, but require careful site planning to ensure adequate safety measures and maximum efficiency. Some farmers and entrepreneurs are exploring the use of mobile biodiesel processing facilities that could travel from site to site, and this practice bares further study.

35,000 to 90,000 acres in Vermont could be shifted to oilseed crops per year provided farmers were paid prices just slightly higher than national averages for their oilseed crops. If there were no change in the size of Vermont's dairy herd and given the amount of land needed to support the state's dairy-centered agricultural system, it is estimated that approximately 50,000 acres could be rotated to oilseed crops in any given year. However, over the next 10 years, assuming an 18% decline in Vermont's dairy herd, which is consistent with trends over the past 40 years, an estimated 180,000 acres per year (or 90,000 acres on a rotational and sustainable basis) could be shifted to oilseed and other energy crops. This would produce sufficient quantities to meet the total on-farm demand for distillate fuels (6.4 million gallons per year) and as much as 50 percent (78,000 tons) of the anticipated meal demand in 2017.

Economic feasibility of a commercial-scale biodiesel production facility depends heavily on plant capacity. The ecological-economic simulation model, used in this study to simulate plant feasibility, consistently predicts a 500,000-gallon plant has only a small chance of being profitable, whereas a 2.5-million gallon plant will be profitable under every scenario.

In the commercial-scale model, plant revenues, and especially profitability, increase as the price of crude oil rises. Although a rise in the price of crude oil also causes the price of the oilseed feedstock to rise, the fractional increases in input prices are more than offset by the higher value of the biodiesel product.

The greatest potential employment gains can be achieved when Vermont farmers make a strong transition to oilseed crop production, and the commercial-scale biodiesel plant is able to obtain part of its oilseed feedstock from Vermont sources. Biodiesel production alone is predicted to produce 25 to 100 jobs, whereas high levels of oilseed production have the potential of tripling the employment impact.

Biodiesel production under every scenario produces a positive energy return on energy investment (EROEI). The EROEI of soybeans is consistently higher that the EROEI of canola, largely due to the leguminous nature of soybeans and the obviated need for nitrogen fertilizers. Canola, however, produces more net energy per acre, due to canola's higher oil yield.

Biodiesel production has a strong potential to reduce Vermont's carbon footprint, provided that land is shifted into oilseed production from other crops. The model predicts that a 2.5-million gallon plant can reduce carbon loading by over 15,000 tons a year of CO2 equivalent.

The model indicates the highest level of Vermont oilseed production would yield enough net energy to fuel about 10% of total agricultural energy demand, which includes all fuel, electricity and heating. When combined with other on-farm energy enhancements such as increased energy efficiency and the use of other renewables, oilseed crops become an important component in reducing Vermont's dependence on fossil fuels and non-renewable energy to power the state's agricultural sector.

The recent release of two energy industry assessments, point to global petroleum demand outpacing supply from conventional sources as early as 2010-2011. Though vast amounts of oil (and gas) remain underground, "complex challenges" and "global uncertainties" could destabilize the "the sufficient, reliable and economic energy supplies upon which people depend", with oil production becoming a "significant challenge as early as 2015". This assessment, contained within the 420-page report from the National Petroleum Council corresponds with the latest International Energy Agency's prediction that oil supplies could become "extremely tight" in five years. This information highlights the importance of considering Vermont's on-farm fuel demand in context with global projections for crude oil and refined petroleum products.

Small-scale producers have important safety and environmental issues to consider. The farmer/producer needs to be aware of the air-quality, taxation and environmental issues pertaining to on-farm fuel production. In addition, since the production of biodiesel involves the storage and use of hazardous and flammable materials, it should only be undertaken with adequate property and liability insurance.

Recommendations

The following are recommendations for further action and research related to the development and study of farm and small-scale oilseed crop production in Vermont.

1. **Continue to build a network of farmers, processors, and other business owners involved in oilseed crop production, processing, distribution, and sales**. Developing and sharing local experience and expertise in oilseed production, processing, and marketing will be key factors in the success of new growers and processors.

2. **Establish systematic processes for testing, refining, and recording results of on-farm meal production to establish consistent quality standards.** The key determinants of a livestock meal's value to feed dealers and farmers are quality and consistency. Un less quality control can be established, the price of farm-processed meal will be discounted significantly. Farm-scale processors seeking to sell their meal must es tablish a standard process that consistently creates a product of a certain quality. Regular testing of meal batch samples is recommended until a process is established, as well as an in situ amino acid test to establish the protein characteristics of the meal.

3. **Investigate small cooperative enterprise models for oilseed processing and biodiesel production.** Several farmers have expressed interest in sharing investment in larger-scale oilseed-processing or biodiesel-making facilities. Dividing capital and operating costs among five to ten neighboring farms could lower barriers to entry of these markets, but the economic feasibility of such a model has not been studied in-depth. In addition, the costs and benefits of establishing mobile processing of oil seeds should be evaluated as another means to reduce start-up costs and increase economies of scale for small producers.

4. **Conduct further research on additional potential markets for oilseed co-products.** The following potential markets for oilseed co-products were beyond the scope of this study, but should be investigated further:

   - Food-grade oil sales, including analysis of Vermont's vegetable oil consumption, future price projections, and estimation of the extent to which Vermont farmers or entrepreneurs could penetrate local markets.
   - "Lease" of filtered, unrefined vegetable oil to restaurants, with subsequent collection by fuel processors for biodiesel production. This opportunity to use the oil for both food and fuel production is being explored in Canadian and New Eng land markets, but has not been studied in Vermont.
   - Use of oilseed meal as a crop fertilizer, and comparison of the value of this end-use to the value of the meal for livestock feed, require further investigation.
   - Use of Glycerin (a biodiesel production by-product) as an anaerobic digester feedstock and/or livestock feed supplement.

The VFFF and Farm Energy Enhancement partners believe that Vermont is well suited to explore the creation of a distributed liquid biofuels, livestock feed, and organic food-grade oil co-production system in strategic locations around the state.

These farm initiatives are designed to improve Vermont's feed and fuel security over the next 10 years. Their purpose is to foster locally owned, community- and/or farm-based biofuels and feed/food projects that will increase Vermont's renewable energy capacity and generate revenue and alternative sources of livestock feed for farmers. These efforts, combined with other complimentary activities, now underway or in the planning stage, are helping to create new job opportunities, localize energy production, and protect and improve Vermont's natural and social environments.

I. Evaluating the Feasibility of Producing Biodiesel in Vermont

The next section identifies key assumptions and findings from a simulation model for producing biodiesel and its co-products. The Vermont Sustainable Agriculture Council commissioned the work in August 2006, with the full report to be completed in September 2007.

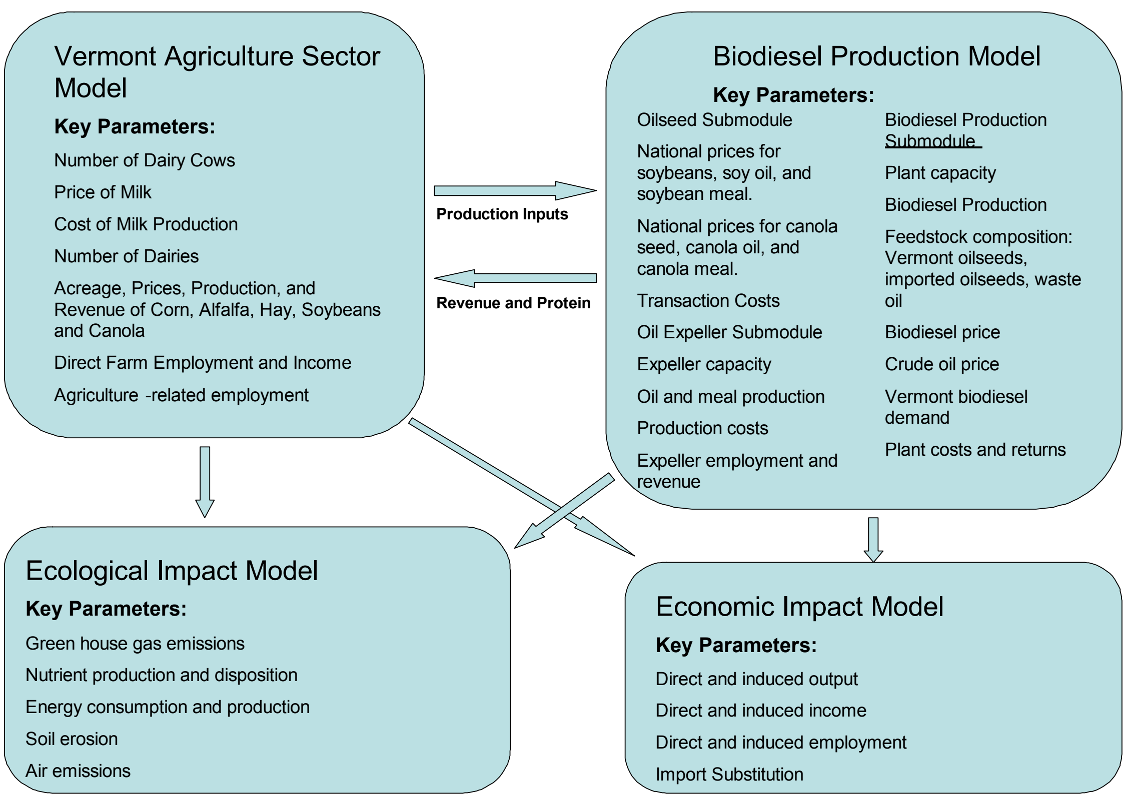
Methodology

The ecological-economic simulation model

This assessment of the feasibility and impact of a small-scale biodiesel facility used a dynamic simulation model first developed by Dr. Kenneth Mulder at the University of Vermont in 2003 and updated for this report in 2007. This model was designed expressly to consider the ecological and economic impacts of small-scale production within the state, and to predict the microeconomic feasibility of such a facility.

The model has four major components: (1) an econometric simulation model of the Vermont agricultural economy; (2) a biodiesel production module that includes an econometric model of national oilseed markets; (3) an environmental impact model that calculates changes in energy consumption and production and greenhouse gas emissions; and (4) a macroeconomic impact model to estimate changes in direct and indirect employment, production, income, and tax revenues [See Figure 1].

Figure 1. Four primary modules of the ecological-economic simulation model



2007 Model Modifications

Mulder's original model[1] was modified for this project in several important ways. First, this version of the model uses a private ownership structure, and does not consider a cooperative, farmer-owned business structure, which was included as an option in the original model. This decision was made in order to more accurately reflect all the transaction costs that will be incurred regardless of the ownership structure. Since it is conceivable that a "New Generation" cooperative could trim operating costs through the creative management of member/owner contributions, and pass the savings on to its members through discounts, patronage dividends or other mechanisms, further study of the Co-op option is recommended. Second, the original work was done in 2003, with the model runs starting in 2002. This version of the model was updated to start in 2006. Third, it was verified that the predictions of the original model were consistent with actual, observed data for the last four years.

Finally, the parameters of several key input variables were modified from the original analysis to reflect current trends. For example, based on trends and industry consensus at the time, Mulder did not consider crude oil prices above $45 a barrel in Y2000 dollars,[2] nor did he consider the possibility that demand for biofuels would result in the current high prices for oilseeds.

Therefore, the following five input variables were modified for the 2007 model update:

Crude oil price – There is much debate about the future price of crude oil. On the one hand, oil depletion scenarios ("Peak Oil"), based on an accounting of known oil reserves, indicate a point of declining global production within 3 to 10 years which, when combined with growing world demand, will result in a new era of sustained high energy prices. Conversely, the Energy Information Agency (EIA) and a number of economists believe that the current high prices for oil will spur increased exploration and recovery efficiency, bringing prices back down to the trend levels of the last two decades. Therefore, the model considers three different levels of crude oil prices to reflect this degree of uncertainty in predicting future energy supplies: (1) a "low-price" case based on EIA forecasts, or $45 per barrel in 2017, (2) a "medium-price" case in which prices rise to $75 per barrel in 2017, and (3) a "high-price" case in which prices rise to $125 per barrel in 2017.

Oilseed prices – There is also some indication that increased crude oil and natural gas prices will continue to raise the cost of fertilizers and fuel. Higher sustained energy costs as well as greater demand for biofuels and meat products could result in significantly higher global prices for oilseeds, such as soybeans and canola. This model therefore includes two levels for oilseed prices: (1) a "baseline" trend extrapolated from past data, and (2) prices 25% higher than the baseline trend.

1 Full details of the model's development and calibration can be found at Dr. Mulder's 2004 report, "An Ecological Economic Assessment of a Proposed Biodiesel Industry for the State of Vermont." Final report for USDA grant NRCS 68-3A75-3-143, Aim 3. Report available at: www.vermontbiofuels.org

2 All model calculations and outputs are done using Y2000 dollars to account for inflation. All model output should be interpreted accordingly.

Plant capacity – This model considers two different sizes of biodiesel production facility: 500,000 and 2.5 million gallons of annual capacity. The smaller plant size is more feasible given the potential for oilseed production in the state, whereas the larger plant size provides greater economies of scale, and was first deemed feasible in the 2003 Mulder study.

Farmer willingness – Perhaps the most difficult component of the model to estimate is the degree to which Vermont farmers are willing to plant oilseed crops. As part of his earlier work, Mulder conducted a survey of Vermont dairy farmers in 2003 in an attempt to estimate an acreage response curve for soybean and canola production in the state.[3] The model uses this response curve to consider three levels of farmer response—best, average, and worst case—with the best and worst cases based on the upper and lower bounds of a 90% confidence interval for the response curve.

State subsidies – Although there is no imminent legislation to enact state-level subsidies for biodiesel production in Vermont, the model includes the presence of a $0.25/gallon new capacity credit in some scenarios.

Developing the scenarios

Six scenarios were developed for simulation modeling by combining different levels of the input variables discussed above. The scenarios fall into three categories based on resource (energy, food and feed) availability, and then consider two levels of Vermont response or involvement for each category. They are described below and summarized in Table 1.

#1-Resource Predictability:
Scenario #1 contemplates a world of relative price stability and little change from past trends in energy and food prices. Concerns about peak oil and global warming turn out to be largely unfounded. Productivity increases in agriculture and fossil fuel extraction ensure that supply keeps up with demand. Prices follow historical trends with few spikes or crashes. Oil prices hold steady around $45 a barrel in 2017. Oilseed prices continue to slowly decline in real terms.

Minimum VT involvement:

- A private firm constructs a 500,000-gallon biodiesel facility in Vermont.
- In general, VT farmers do not respond to supply the facility with oilseeds, transferring minimal acreage from hay and forage crops to oilseed crops.
- The state does not subsidize biodiesel production.

Maximum VT involvement:

- A private firm constructs a 2,500,000-gallon biodiesel facility in Vermont.
- VT farmers transfer modest acreage from hay and forage crops to oilseed crops.
- The state gives the firm a new-capacity credit of $0.25 per gallon of annual

3 Mulder, K.M. 2004. An Ecological Economic Assessment of a Proposed Biodiesel Industry for the State of Vermont. Final report for USDA grant NRCS 68-3A75-3-143, Aim 3.

production capacity.

#2-Resource Constraints:
Scenario #2 considers meaningful but gradual shifts in the global fuel and food economy as energy resources are constrained. Oil prices reach $75 a barrel by 2017. Increasing petroleum prices and rising demand for protein, food, and biofuels raises the price of oilseeds by 25%.

Minimum VT involvement:

- A private firm constructs a 500,000-gallon biodiesel facility in Vermont.
- VT farmers transfer modest acreage from hay and forage crops to oilseed crops.
- The state does not subsidize biodiesel production.

Maximum VT involvement:

- A private firm constructs a 2,500,000-gallon biodiesel facility in Vermont.
- VT farmers transfer substantial acreage from hay and forage crops to oilseed crops.
- The state gives the firm a new-capacity credit of $0.25 per gallon of annual production capacity.

#3-Resource Emergency:
Scenario #3 considers significant changes in global energy and food markets due to resource scarcity. Oil prices reach $125 a barrel by 2017. Petroleum scarcity and rising demand for protein, food, and biofuels raises the price of oilseeds by 25%.

Minimum VT involvement:

- A private firm constructs a 500,000-gallon biodiesel facility in Vermont.
- Vt. farmers transfer modest acreage from hay and forage crops to oilseed crops.
- The state does not subsidize biodiesel production.

Maximum VT involvement:

- A private firm constructs a 2,500,000-gallon biodiesel facility in Vermont.
- Vt. farmers transfer substantial acreage from hay and forage crops to oilseed crops.
- The state gives the firm a new-capacity credit of $0.25 per gallon of annual production capacity.

Table 1. Scenario descriptions

	1 – "Resource Predictability"		2 – "Resource Constraints"		3 – "Resource Emergency"	
Variables	Minimal VT action	Maximum VT action	Minimal VT action	Maximum VT action	Minimal VT action	Maximum VT action
Crude oil price	Low – EIA forecast	Low – EIA forecast	Medium- $75/barrel	Medium - $75/barrel	High - $125/barrel	High - $125/barrel
Oilseed prices	Baseline	Baseline	High	High	High	High
Plant capacity (gallons)	500,000	2.5 million	500,000	2.5 million	500,000	2.5 million
Farmer Willingness (to grow oilseeds in VT)	Worst case	Average case	Average case	Best case	Average case	Best case
State Subsidies	None	Capacity credit of $0.25/gal	None	Capacity credit of $0.25/gal	None	Capacity credit of $0.25/gal

Scenario simulations

The model is a stochastic simulation model, meaning that many of the primary variables in the model, such as U.S. commodity prices and crop yields are allowed to vary randomly within a defined range to better simulate real-world market fluctuations and price volatility. Thus, in order to understand the dynamics of each scenario, the model was run 100 times per scenario, with each run of the model yielding predictions from 2006 to 2020. For each year, the average value and standard deviation over all 100 runs was calculated for all variables of interest. This yielded a large amount of data; only the averages and standard deviations for year 5 (2011) are reported here, for selected variables.

Results summary

Following below are a summary of the results for key variables of interest. The results under each scenario are covered in full detail in the 2007 research report on small-scale biodiesel production in Vermont.[4] All dollar amounts are in year-2000 dollars.

4 Economic Feasibility of Commercial-Scale Biodiesel Production in Vermont: A Dynamic Ecological-Economic Assessment, by K. Mulder, E. Stebbins & G. Wilkerson, July 31, 2007.

Microeconomic feasibility

Profitability

Both plant revenues and plant profits are heavily dependent upon the scale of the biodiesel plant, with the 2.5-million gallon plant consistently profitable and the 500,000-gallon plant consistently losing money, although the error deviations show that there is some chance a smaller plant will be profitable. The impact of the price of crude oil and oilseeds on plant revenues is also apparent, as revenues increase steadily with the price of oil in scenario #2 and #3; profits also increase with crude oil price, but not to the same degree, because of the increased cost to the facility for the oilseed feedstock.

The model includes links from the cost of crude oil to the cost of other production inputs, such as fertilizers and transportation. While agricultural inputs and energy costs affect the cost of biodiesel feedstock production, given that biodiesel is a near-substitute for diesel fuel, the price of biodiesel increases proportionally to the price of crude oil (averaging a $.60 - $.90 per gallon premium over diesel fuel at any given time), whereas the costs of production increase only fractionally. *Thus, the model predicts a strong increase in profits with a rise in the price of crude oil.*

Macroeconomic impact

Oilseed acres

A significant factor showing up in the model is how important the price of oilseeds and the willingness of Vermont farmers to plant oilseed crops are to the impact of biodiesel production on the state's agricultural economy. Under scenario #1, even with an increased willingness on the part of Vermont farmers to grow oilseeds, there is practically no oilseed production in the state. This is because, per the survey results from Mulder's 2003 work, the baseline-projected oilseed prices are not high enough to induce Vermont farmers to plant oilseeds. There is little history of oilseed production in the state, and therefore much of the needed technical knowledge and infrastructure is lacking. Thus, a higher-than-average price level (paid for oilseeds) is needed to induce farmers to produce these crops. Under scenarios #2 and #3, and based on the 2003 Mulder survey, the model projects that with the higher prices paid for oilseeds and biodiesel in 2011, Vermont farmers could be induced to plant up to 35,000 acres of soy and canola.

Job creation

The consequences of low farmer involvement shows up in total employment impacts in the state from oilseed and biodiesel production. Biodiesel production alone is predicted to produce 25 to 100 jobs, whereas high levels of oilseed production in the state, in conjunction with value-added processing, have the potential of tripling the employment impact in 2011.

Import substitution

The level of Vermont involvement strongly affects the degree of self-sufficiency the state derives from biodiesel production. Import substitution measures the total value of out-of-state goods that would be replaced by Vermont products under a given scenario. Assuming a maximum level of involvement, the state could replace between $10 and $15 million worth of imports. Such an increase in local production and purchasing would have additional economic and social benefits through a multiplier effect.

Environmental impacts

Energy return on energy invested (EROEI)
The model was programmed to generate data in order to evaluate the predicted energy return on energy investment (EROEI) for biodiesel production in Vermont. Of note is that the EROEI of soybeans is consistently higher that the EROEI of canola, largely due to the leguminous nature of soybeans and the obviated need for nitrogen fertilizers. The EROEI of Vermont soybeans shows the best energy return across the board, although all measures are well above one-to-one, implying that biodiesel production could yield a significant amount of net energy. Under certain conditions (scenarios #2 and #3), the returns on energy yields are as high as 3:1 and 4:1 respectively.

Carbon emissions
Biodiesel production also has a strong potential to reduce Vermont's carbon footprint. This is especially true for the larger plant; the model predicts that a 2.5-million gallon plant can reduce carbon loading by over 15,000 tons a year of CO2 equivalent. This assumes, however, that land put into oilseed production would have been used for crop production regardless.[5]

Energy return per acre
Interestingly, although canola has a lower EROEI than soybeans, because of its higher oil yield, canola has a higher net energy yield per unit (acre) of land.

Oilseed crop value-adding as a portion of total farm energy
The model indicates the highest level of Vermont oilseed production would yield enough net energy to fuel about 10% of total agricultural energy demand, which includes all fuel, electricity and heating. This proportion of net energy return to total energy consumed is at its highest in scenario #1, in which there is a higher level of biodiesel production in the state, relative to oilseed crop production. This ratio decreases under scenarios in which more oilseeds are grown in Vermont, due to the added energy costs of in-state oilseed production.

Conclusions of the ecological-economic simulation model

The following conclusions and considerations can be drawn based on the results of the simulation modeling of the six scenarios.

5 In an alternative scenario included in the model, agricultural land was allowed to revert to forest, thereby increasing its carbon sequestration potential. Such a scenario could, for instance, be the result of Climate Change policy, and in this case the model predicts an increase in greenhouse gas emissions.

Economic feasibility of a commercial-scale biodiesel production facility depends heavily on plant capacity. A 500,000-gallon plant has only a small chance of being profitable, whereas the model consistently predicts that a 2.5-million gallon plant will be profitable under every scenario (i.e., $3 million to $6 million per year, net). In addition, the project researchers suggest that governance models for 'new generation" cooperatives be explored to identify alternative means of distributing capital and operating costs and revenues.

Plant revenues, and especially profitability, increase as the price of crude oil rises. Although a rise in the price of crude oil also causes the price of other inputs—particularly the oilseed feedstock—to rise, the fractional increases in input prices are more than offset by the higher value of the biodiesel product.

Vermont farmers will produce oilseed crops only if induced to do so by higher-than-average oilseed prices. Higher prices are needed in order for farmers to shift to new crops for which technical knowledge and infrastructure is relatively lacking.

The greatest potential employment gains can be achieved when Vermont farmers make a strong transition to oilseed crop production, and the biodiesel plant is able to obtain part of its oilseed feedstock from Vermont sources. Biodiesel production alone is predicted to produce 25 to 100 jobs, whereas high levels of oilseed production in the state have the potential of tripling the employment impact.

State involvement in the form of a new-capacity credits or other production incentive is needed to boost the level of import substitution Vermont can achieve from biodiesel production. Assuming a maximum level of involvement (large plant and capacity credit), the state could replace between $10 and $15 million worth of imports.

Biodiesel production under every scenario produces a positive energy return on investment (EROEI). The EROEI of soybeans is consistently higher that the EROEI of canola, largely due to the leguminous nature of soybeans and the obviated need for nitrogen fertilizers. Canola, however, produces more net energy per unit of land, due to canola's higher oil yield.

Biodiesel production has a strong potential to reduce Vermont's carbon footprint, provided that land is shifted into oilseed production from other crops. The greatest potential greenhouse gas reductions can be achieved with a larger plant; the model predicts that a 2.5-million gallon plant can reduce carbon loading by over 15,000 tons a year of CO2 equivalent.

The model indicates the highest level of Vermont oilseed production would yield enough net energy to fuel about 10% of total agricultural energy demand, which includes all fuel, electricity and heating. When combined with other strategies such as increased energy efficiency and the use of renewables (biomass, wind and solar) in agricultural production, oilseed crops become an important component in reducing Vermont's dependence on fossil fuels and non-renewable energy to power the state's agricultural sector.

II. Vermont's Potential Demand for Using Biodiesel on the Farm

Current fuel demand

Most liquid fuels consumed in agricultural production and space heating are the "middle distillates," including No. 2 heating oil, diesel, and kerosene. These are the grades of refined petroleum that can be easily reduced or replaced with biodiesel. In some cases, straight vegetable oil or reclaimed vegetable oil, which differ from biodiesel, can also be used as a fuel with good results by modifying the equipment.

According to the Energy Information Administration (EIA) of the U.S. Department of Energy (DOE), Vermont's farm sector received ***6,410,000 gallons of distillate fuel oil in 2005***. Historical data of the last ten years shows a high consumption figure of 6.9 million gallons in 1999 and a low figure of 4.4 million gallons consumed in 1995. The EIA relies on mandatory data submitted by every fuel supplier as part of the Annual Petroleum Report.

Although the EIA identifies the sector to which the fuel was delivered (i.e., farm, residential, industrial, etc.), *it does not distinguish between distillates used for farm equipment and trucking and No. 2 heating oil used to heat structures on the farm, although biodiesel can be blended with or substituted for either one.*[6]

Projected fuel demand and supply

The EIA does not forecast sector demand by state. DOE's EIA 2007 Annual Energy Outlook (AEO), however, includes statistical projections that show total U.S. distillate use increasing by 1.4% per year to 2030. Using the formula of 1.4% growth per year in distillate use, fuel consumption on Vermont farms will increase to ***just over 7 million gallons in 2012***.

It is important when considering future on-farm fuel demand to see it in context with global demand and supply projections for crude oil and refined petroleum products. The on-going debate over oil depletion may have recently turned a corner with the release of two energy industry assessments, pointing to global petroleum demand outpacing supply from conventional sources as early as 2010-2011.[7] Though vast amounts of oil (and gas) remain underground, "complex challenges" and "global uncertainties" could destabilize the "the sufficient, reliable and economic energy supplies upon which people depend", with oil production becoming a "significant challenge as early as 2015".[8] This assessment, contained within the 420-page report from the National Petroleum Council corresponds with the latest International Energy Agency's prediction that oil supplies could become "extremely tight" in five years.

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6 U.S. Dept. of Energy, Energy Information Administration. Petroleum Navigator, Definitions, Sources and Explanatory Notes for Petroleum Consumption/Sales, Adjusted Sales of Distillate Fuel by End Use. Accessed at http://tonto.eia.doe.gov/dnav/pet/TblDefs/pet_cons_821dsta_tbldef2.asp on May 27, 2007.

7 Oil Market Report of the International Energy Association, 2007. http://omrpublic.iea.org/

8 http://downloads.connectlive.com/events/npc071807/pdf-downloads/Facing_Hard_Truths-Executive_Summary.pdf

On-farm use of biodiesel

The majority of fuel used in farm equipment takes place between planting and harvesting, i.e., when cold weather performance issues of biodiesel are not an issue. Therefore, biodiesel produced on-farm and used for crop and food production can usually be consumed in its "neat' form (pure biodiesel or B100). Biodiesel used for space heating or to run equipment when outside temperatures drop and remain below 30 degrees Fahrenheit, should be blended with petrodiesel or No. 2 heating oil (and cold weather additives), to avoid fuel clouding or gelling and reduced performance.

III. Vermont's Potential Demand for Livestock Feed Produced In-State

Feed for livestock drives demand for soybean meal in the United States, with soybean oil as a byproduct. For sunflowers and canola, oil is the primary product, but meal is a valuable byproduct since it also can be fed to livestock. This section looks at the potential demand for organic and conventional protein meals in Vermont. The economic impacts of localizing production of these meals are examined in the upcoming report of the *Vermont Feed, Food and Fuel Project*.[9]

Estimated feed demand

Vermont's agriculture sector is dominated by milk production, and dairy cows are the major livestock type by number of head. Although Vermont farmers also raise sheep, emus, ostriches, alpacas, llamas, and other animals - only cows, hogs, chickens, and turkeys are raised in sufficient numbers to create meaningful demand for protein meal.

Different types of oilseed meal have different characteristics. Overall, soybean meal is the most desirable for livestock feeding in terms of protein content and amino acid profile. Soybean meal contains several factors that reduce its digestibility to poultry and swine, however. The most important such anti-nutritional factors are trypsin inhibitors, which interfere with the trypsin enzyme that breaks down proteins in the animal's intestinal tract. If the trypsin enzyme is inactivated, the animal will not be able to absorb all of the protein nutrients in the meal, and the animal's pancreas may enlarge in order to produce more enzymes.[10] The presence of urease in soybeans is also a concern for ruminants. Urease can react with urea in the cow's diet to produce ammonia. Heating the meal (or the beans prior to crushing) to at least 140–150ºF or roasting whole beans at approximately 220–245ºF both deactivates the trypsin inhibitors and urease.[11] Heating also decreases the amount of rumen-degradable protein in the meal, thereby making it more attractive as a feed for dairy cows.[12]

9 Emily J. Stebbins, "Feasibility of Farm-Scale Biodiesel Production in Vermont", to be published in September 2007

10 Animal Feed Resources Information System, Food & Agriculture Organization of the United Nations. Soybean meal, soyabean meal, soya bean meal, sojabean meal, Manchurian meal. Accessed at http://www.fao.org/AG/aGa/agap/FRG/AFRIS/Data/736.htm on May 27, 2007.

11 Said, N.W. Soybean Processing. InstaPro International. Accessed at http://www.insta-pro.com/pdf/resources/ref_1014.pdf on May 27, 2007; Hollis, G. Swine Management & Nutrition Q&A. University of Illinois. Accessed at http://faq.aces.uiuc.edu/faq.pdl?project_id=12&faq_id=882 on May 27, 2007.

12 Randy D. Shaver, "By-Product Feedstuffs in Dairy Cattle Diets in the Upper Midwest," University of

Relative to soybean meal, canola and sunflower meal have higher amounts of rumen-degradable protein, which can limit the amount fed per day to dairy cows. Canola also cannot be fed in large amounts (maximum 3% of diet by weight) to brown egg–laying chickens.

The estimated protein meal demand by Vermont livestock is based on the assumption that cows on a conventional dairy farm are fed 5 to 8 pounds of protein meal per day,[13] and that organic dairy cows are fed one-third less, or 1.5 to 3 pounds of protein meal per day.[14] Compared to dairy cows, other livestock are fed relatively small amounts of grain per day. Further assumptions are that grain-finished beef cattle are fed 5 pounds per day for 90 days, and that beef calves and heifer replacements are fed 2 pounds per day for 180 days.[15] Hogs, turkeys, and broiler and laying chickens are fed less than a pound per day on average.[16] The lower consumption and smaller numbers of beef cattle, swine, and poultry in Vermont means that approximately 97% of the state demand for protein meal is estimated to come from dairy cows.

Conventional meal demand

Table 2 gives a rounded estimate of the annual demand for conventional oilseed meals. The estimated annual demand for conventional soybean, canola, and sunflower meal in Vermont, respectively, are based on typical livestock diets and rations as referenced above. These estimates showing the maximum potential in-state demand for each oilseed meal were derived by taking each meal singly, determining the mid-point in the range of meal allotment, and assuming it as the only protein source. They do not, therefore, account for the blending of meals that could and does occur.

Table 2. Estimated annual conventional oilseed meal demand (rounded)

Conventional Oilseed Meal	Estimated Annual Vermont Demand
Soybean meal	156,000 tons
or Canola meal	85,000 tons
or Sunflower meal	132,000 tons

Wisconsin – Madison, (Accessed from http://www.wisc.edu/dysci/uwex/nutritn/pubs/ByProducts/Byproduct-Feedstuffs.html).

13 Personal communications with Dr. Matthew Waldron, Department of Animal Science, University of Vermont, and Jacob Bourdeau, Bourdeau Bros., Inc. Harouna A. Maiga, et al. 1997. "Alternative Feeds For Dairy Cattle In Northwest Minnesota: An Update." University of Minnesota Dairy Update, Issue 126, (http://www.ansci.umn.edu/dairy/dairyupdates/du126.htm). Randy D. Shaver, "By-Product Feedstuffs in Dairy Cattle Diets in the Upper Midwest," University of Wisconsin – Madison, (Accessed from http://www.wisc.edu/dysci/uwex/nutritn/pubs/ByProducts/ByproductFeedstuffs.html).

14 Personal communications with Willie Gibson, NOFA-VT Farm Technical Advisor; Jack Lazor, Butterworks Farm; and Brent Beidler, Beidler Family Farm; May 21, 2007.

15 Vern Grubinger personal communication with Dr. Carlton (Sam) Comstock, Beef Livestock Specialist, University of Vermont Extension, April 17, 2007.

16 Subcommittee on Poultry Nutrition, Committee on Animal Nutrition, Board on Agriculture, Nutrient Requirements of Poultry, 9th revised ed., Washington, D.C.: National Academy Press, 1994. Randy Walker, Swine: Feeding, Document RFAA084, Animal Science Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, 2003.

Organic meal demand

Of Vermont's approximately 1,180 dairy farms, about 200 are expected to be certified organic by end of 2007, with the remaining 980 using conventional methods.[17] Organic dairies typically work to increase the quality of their forage and many emphasize grazing/forage feeding practices over grain feeding practices in order to improve animal health and control (or decrease) grain purchases, which can run twice the cost per cow compared to conventional meal. As a result, organic dairies contacted for this study report protein feedings of one-third less, on average. Furthermore, organic dairy herds tend to be smaller then conventional herds. In the long run, a continued shift to organic production could decrease the overall need for protein meal in the state as a result of smaller herd size and feeding practices that focus on forage, not grain. In the short term, however, the shift toward organic milk production is increasing demand for organic protein meal in Vermont. Table 3 illustrates the state's potential demand based on a 2002 herd population of 3,500 (from 2002 Census of Agriculture; herd population in 2007 is likely higher).

Table 3. Estimated annual organic oilseed meal demand

Organic Oilseed Meal	Estimated Annual Vermont Demand
Soybean, canola or sunflower meal	4,800 tons

Land use implications of in-state oilseed meal and biodiesel production

Vermont's current agricultural land uses

According to the 2002 Census of Agriculture, Vermont has approximately 567,500 acres of cropland, 454,700 of which are harvested. This leaves an estimated 112,800 acres of "dormant" cropland.

Of the harvested cropland, approximately 77%, or 350,260 acres, is dedicated to forage crops, such as hay, haylage, and grass silage. Approximately 20%, or 91,300 acres, is used to grow corn for silage. This corn silage acreage can be assumed to represent the best "tillable" land in Vermont that could support growing oilseed or other row crops.

Land needed to meet potential demand for livestock feed or biodiesel

The crop acreages that would be necessary to meet the estimated Vermont demand for oilseed meals with in-state sources can be estimated by using average yields of 1500 lbs meal per acre for soybeans,[18] 840 lbs meal per acre for canola,[19] and 1200 lbs meal per acre for sunflowers. In order to significantly increase the share of Vermont's oilseed meal demand that is met by in-state crop production, some amount of the approximately 112,000 acres of dormant cropland (not currently being cultivated) would need to be used, or substantial acreage shifts from either corn or hay would have to occur. Table 4 illustrates this.

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17 Rathke, Lisa. "More Vermont dairy farmers choose the organic route." *Burlington Free Press*, July 30, 2006.
18 Maier, D.E. et al. (1998). High Value Soybean Composition. Grain Quality Task Force Fact Sheet #39, Purdue University. Accessed at http://www.ces.purdue.edu/extmedia/GQ/GQ-39.html on June 8, 2007.
19 Based on University of Maine canola crop trial data.

Table 4. Estimates of crop acres to meet in-state oilseed meal demand (rounded)

	Midpoint annual VT meal demand	Crop acres needed		
	Conventional Meal	To meet mid-point VT demand	To meet 10% of midpoint VT demand	To meet 50% of mid-point VT demand
Soybeans	157,000 tons/year	208,300	20,800	104,000
or Canola	85,000 tons/year	202,300	20,200	101,000
or Sunflower	132,200 tons/year	220,300	22,000	110,000
	Organic Meal			
Soybeans	4,800 tons/year	6,400	650	3,200
or Canola	4,800 tons/year	11,400	1,100	5,700
or Sunflower	4,800 tons/year	8,000	800	4,000

Assuming that a sustainable crop rotation plan to produce oilseed crops requires at least half the land to be in legumes for nitrogen for fertility, as well as silage corn and/or sweet sorghum to break pest cycles, then Table 5 shows the amount of land that would be needed to produce various quantities of on-farm biodiesel per year. These same calculations could be used to estimate larger biodiesel production volumes on a sustainable basis.[20]

Table 5. Table 5. Estimate of land needed for small-scale biodiesel production

	Annual production of biodiesel		
Oil yields	25,000 gal	50,000 gal	100,000 gal
At 50 gal oil/acre	1,000 acres	2,000 acres	4,000 acres
At 75 gal oil/acre	667 acres	1,333 acres	2,666 acres
At 100 gal oil/acre	500 acres	1,000 acres	2,000 acres

Potential acreage capable of supporting oilseed production

As stated previously, substantially increasing acreage available for oilseed crop production would require a shift away from the current emphasis on planting corn and forage crops to meet the state's dairy feed needs. Under current conditions, with Vermont's agricultural economy dominated by dairy and high corn prices, farmers are unlikely to take land out of corn to plant oilseeds. Under these conditions, at most approximately 50,000 acres (one-quarter of the 91,300 acres in corn production plus one-third of the 112, 800 dormant cropland acres) would be rotated to oilseed crops in any given year. A look at the historical data, however, shows that Vermont's dairy economy is gradually but steadily changing.

Vermont's dairy herd size has been decreasing steadily for at least the past 40 years, dropping from 213,000 cows in 1966 to 141,000 cows in 2006, a 34% decline. Furthermore, the rate of decline was accelerated in the last 20-year period compared to the first. Between 1967 and 1987, Vermont lost 24,000 cows, just over 1,000 cows a year. Between

20 Grubinger, Vern. "On-Farm Oil Seed Production And Processing" http://www.vsjf.org/biofuels/vermont_biofuels_initiative.Seeds.shtml

1987 and 2007, however, the herd has dropped at twice that rate, by 39,000 cows, or just under 2,000 cows per year. Based on this history, one could predict that the herd size will drop by 20,000 to 25,000 cows in the next 10 years, to approximately 115,000 to 120,000 cows by 2017. A drop of 25,000 cows equates to an approximately 18% decline from today's herd total.

Under the assumption that the corn and grass forage acreages planted in the state are consumed by Vermont's dairy herd (by and large, Vermont does not export these crops), then a decline in the dairy herd would also mean a decrease in the number of corn and grass forage acres needed to support that herd. Therefore, if the size of the dairy herd were to decrease by 18% over the next 10 years, in 2017 an estimated 79,500 acres (16,500 acres of corn cropland and 63,000 acres of grass forage cropland) could be freed up for other uses, including oilseed and other "energy crop" production.

In the nearer term, dormant cropland could also be used for oilseed production, but it is not likely that all 112, 800 would be well suited for growing oilseeds. Some dormant cropland is hayland, and the fact that this land is dormant means that it is not likely to be prime tillable ground. These acres may be more likely to have moisture problems that would affect planting and harvest.

For purposes of estimation, however, assuming a sustainable oilseed crop rotation plan, the 79,500 acres, plus the over 112,000 acres of dormant cropland, could produce approximately 45,000 to 67,500 tons of meal and approximately 5 to 6.3 million gallons of biodiesel per year, depending on the crop. This calculation assumes 1500 lbs of meal and 56 gallons of biodiesel per acre of soybeans and 1000 lbs of meal and 70 gallons of biodiesel per acre average of canola and sunflowers and establishes a rotation plan that uses only half of the projected 180,000 acres each year for these crops.

In an effort to create new agricultural revenue, support fuel and feed cost stability, and reduce Vermont's 'carbon footprint" and its dependence on fossil fuels, farmers, entrepreneurs, and policy planners are looking to biomass to generate a greater percentage of the state's future energy output, in the form of biodiesel, biofuel pellets, biogas crops, and cellulosic ethanol. It is therefore worth considering the multiple benefits that could be derived by using half of this projected "surplus" of suitable cropland in the production of oilseeds. These 90,000 acres could meet the total on-farm demand for distillate fuels and nearly 50 percent of the anticipated meal demand in 2017, while the remaining 90,000 acres could be used to produce additional biomass crops and still not impinge on the anticipated future crop needs of Vermont's dairies.

While Vermont oilseeds could provide local, clean biofuel, increasing Vermont's oilseed acreage may have other adverse environmental impacts. If acreage is merely shifted from corn to oilseeds, impacts will be minimal. If oilseed acreage comes from hayland or dormant land that has not been tilled, however, planting oilseeds on land that was formerly sod will mean increased erosion, phosphorus loading into streams and lakes, and carbon release, especially on land with significant slope. For these reasons, plowing current grass-land to plant oilseed may require farms to revise their nutrient management plans.

Market forces, geography, climate, crop rotation strategies, environmental considerations, and process technologies will each play a role in influencing a farmer's decision to focus on one energy crop (or product) over another. How these same factors might affect the conversion of even more (or less) cropland from traditional uses to energy crop production remains to be seen, and is outside the scope of this study. But for the purposes of establishing the potential, 180,000 acres, representing 31% of today's cropland, is a reasonable estimate of the land base from which a variety of dedicated energy and feed crops could be grown sustainably in the next ten years, given the historical rate of decline in Vermont's dairy herd.

IV. Tax and Regulatory Issues Pertaining to On-Farm Biodiesel Production

The start up and operating costs to establish an on-farm biodiesel are beyond the scope of this report, however, for a detailed economic analysis of this enterprise, drawn from local and regional data, refer to two recent companion reports: On-Farm Oil Seed Production And Processing, compiled by Vern Grubinger, University of Vermont Extension and the Vermont Feed and Fuel Project report, compiled by Emily J. Stebbins, UVM Department of Community Development & Applied Economics and available (after October 1, 2007) by contacting info@vermontbiofuels.org.

From a technical perspective, small-scale on-farm biodiesel operations are relatively easy to establish, but they do require careful space and site planning to ensure adequate safety measures and maximum efficiency. Since methanol and the catalysts (sodium hydroxide or potassium hydroxide) required to make biodiesel are hazardous and flammable when combined, developing and following a best practices protocol is essential. In addition local health, safety, environmental and zoning ordinances may be applicable. Establishing a good working relationship with one's local zoning authority prior to beginning or modifying any projects is advised. Therefore rules, regulations, and taxes at the local, state and federal levels are an important consideration.

When directing research in 2006 for "On-farm Oilseed Production and Processing", Vern Grubinger enlisted two students at Vermont Law School, Laura Furrey and Mark Seltzer, to provide an opinion on some of these issues. Their findings, along with research conducted by the Vermont Biofuels Association, are outlined below.

Commercial production vs. production for farm use:
Generally speaking, farm-produced biodiesel can be used or sold directly to end-users in the "off-road" market—for use in farm, construction, or marine equipment; heating; or running diesel generators, with a minimum of tax and environmental regulation. But as soon as farm-produced biodiesel is used or sold for use in licensed vehicles traveling public roads, then federal air quality and taxation issues, administered by the Environmental Protection Agency (EPA) and Internal Revenue Service respectively, come into play and in the case of EPA regulation, they are prohibitively expensive.

The following information has been arranged in three steps; "Before on-farm production", "during on-farm production", and "what to do with on-farm produced biodiesel".

When considering building biodiesel production capacity on-farm, the following factors should be taken into account:

- According to Chapter 117—Subchapter IX §4495 of the Vermont Statutes, farmers do not need to obtain a municipal permit in order to build a farm structure. However, farmers do need to "notify a municipality of the intent to build a farm structure," and "abide by setbacks approved by the Secretary of Agriculture, Food and Markets." Therefore, prior to construction a farmer would need to notify the local zoning administrator or town clerk with their plan, including a sketch of the proposed structure. Contact the Agency of Agriculture, Food, and Markets at (800) 675-9873 or (802) 828-3829.

- Producers should apply to their town's Zoning Administrator or Planning Commission to make sure they are complying with the town's local zoning by-laws.

- For State permits that may be applicable, the state permit coordinator is Nancy Manley at (802) 241-3838 and Judy Mirro, Compliance Assistance Specialist at (800) 974-9559, ext. 2 or (802) 241-3745 and judy.mirro@state.vt.us

- The Environmental Assistance Office of the Vermont Department of Environmental Conservation also provides permitting assistance: http://www.anr.state.vt.us/dec/ead/pa/index.htm

Once producing biodiesel on-farm, the following items should be taken into consideration:

- A Spill Prevention, Control and Countermeasure (SPCC) plan written with "what if?" steps and spill control tools on site for all liquids and chemicals are required If storing more than 1,300 gallons of oil or biodiesel on site. A secondary contain ment surrounding the storage (usually a concrete berm or wall) is also required by EPA SPCC rules. Review the U.S. Environmental Protection Agency's website for guidance: http://www.epa.gov/oilspill/spcc.htm. Or contact the Vermont Biofuels Association, info@vermontbiofuels.org, for a list of local engineers.

- Have an Emergency Response Guidebook on hand. Visit the Federal Department of Transportation website to download a copy: http://hazmat.dot.gov/pubs/erg/erg2004.pdf

- Certified Hazmat handling courses are available to learn the proper handling and use of some components used in the production of biodiesel.

- The Vermont Department of Public Safety has a Hazardous Materials Response

Team that is available 24 hours a day: http://www.dps.state.vt.us/vem/haz_mat.html or 1-800-641-5005.

- The Waste Management Division of the Vermont Department of Environmental Conservation also has a Spills Response Team, (800) 641-5005: http://www.anr.state.vt.us/dec/wastediv/spills/spills_program.htm

- Review Vermont's Stormwater Pollution Prevention Plan policy here: http://www.eaovt.org/sbcap/resources.htm. For assistance in writing a Stormwater Pollution Prevention Plan, call (800) 974-9559.

- The local fire department should be notified as to what is stored on the farm (and where). To identify all on-site chemicals, oil and biodiesel use large easy-to-read signage.

Once biodiesel has been produced and a farmer is contemplating what to do with it, the following factors should be considered:

The farmer/producer needs to be aware of two areas of regulation pertaining to the use of biodiesel (B100, with no petroleum added) and these are air-quality and taxation. In addition, since the production of biodiesel involves the storage and use of hazardous and flammable materials, it should only be undertaken with adequate property and liability insurance.

Air quality issues

- Biodiesel producers are exempt from registering as a "fuel producer" with the EPA only if the pure biodiesel (B100) made or sold is for "off-road" purposes- in farm, construction, or marine equipment; heating; or running diesel generators, etc., If at any time, however, biodiesel is sold for use in licensed vehicles, the producer must be registered with EPA. If an unregistered fuel ends up in use in a licensed motor vehicle, it is the producer and/or seller who may be subject to penalty.

- Furrey reports that producers of biodiesel, selling for on-road use in licensed vehicles are subject to EPA rules regarding registration of fuel and fuel additives under the Clean Air Act (published in 40 CFR part 79). This ruling states that any com mercial manufacturer of a fuel or fuel additive must submit a set of Tier I and Tier II health effects test results to the EPA (with a small business exemption from Tier II). This testing costs close to $3 million and the National Biodiesel Board (NBB) is the only organization to go through with the testing. The NBB results can be used, with their approval, only if the biodiesel being made meets ASTM D6751 specification and the producer pays the minimum $2,500 annual NBB membership, plus a few cents on every gallon sold.

- Furrey also identifies several unresolved issues, including whether an on-farm producer would have to register with the EPA as a fuel manufacturer if "the biodiesel is not ASTM certified, does not meet EPA requirements, and is not being sold, traded, or otherwise 'introduced into commerce in the United States.'" These and other questions have been submitted for review to a staff member of the National Biodiesel Board. Contact the Vermont Biofuels Association, info@vermontbiofuels.org, for additional information.

Taxation issues

- Biodiesel is subject to a federal excise tax of $0.244 per gallon when used in licensed motor vehicles. Typically this tax is paid voluntarily on the producer's or user's annual federal income tax return to avoid a penalty.

- Pure biodiesel and straight vegetable oil (SVO) are exempt from the $.25 per gallon state diesel tax, according to Doug Bissette, from the Vermont Department of Motor Vehicles fuel tax division. Any use of the word "fuel" in the Vermont statute, by definition, exempts pure biodiesel and SVO since they are neither a "clear diesel fuel" nor are they a "blend of undyed diesel and other fuel".

- A Vermont fuel dealer's license is required only if a farmer were to sell biodiesel for use in licensed vehicles that travel on public highways, according to Furrey. How ever, as noted above, since EPA requires that any fuel sold for use in licensed vehicles meet Tier I and Tier II health effects testing and is registered with the EPA, unless the farmer/producer meets these requirements they cannot legally sell to the on-road market and would not therefore be required to obtain a Vermont fuel dealer's license.

- Federal regulations require that diesel used in off-road applications, and is not subject to excise tax, be dyed red for identification purposes (to distinguish it from on-road taxable diesel). Regarding the question of whether biofuels must be dyed for agricultural use, Seltzer found that, "unlike kerosene and diesel fuel, however, 100% biofuel 'liquid' does not need to be dyed for off-road use according to state and federal legislation. If the fuel is blended with off-road diesel or kerosene, dye ing requirement should be followed. For example: 20% biodiesel mixed with 80% off-road diesel should be appropriately dyed."

Insurance

The production of biodiesel involves the storage and use of methanol (or ethanol) and a catalyst, potassium or sodium hydroxide (i.e. lye). Methanol is flammable, and potentially lethal and the catalyst is toxic. When the biodiesel operation follows well-established production and safety protocol, the risks are greatly reduced and everything proceeds smoothly. However, most farm operations have inadequate insurance coverage in case there's an accident.

In addition to liability coverage and property loss protection, the operation also needs to be bonded if the plans include the sale of biodiesel. Insurance premiums can run $300 to $400 per month and if bonding is needed, monthly premiums can cost an additional $150 per month and sometimes considerably higher. For many small-scale farm or "home-brewer" operations, these costs may seem unjustified or are simply out of reach, and the producer may decide to work "under the radar". But it is important to remember that during a few critical steps in the process, making biodiesel carries a high degree of risk to persons and property. Unfortunately as a result, a number of buildings, barns, and garages have been destroyed by fire, leaving the biodiesel producer responsible for the damages. If undertaking the production of biodiesel it is very important to understand the risks, follow established "best practices", safeguard against accidents, and carry adequate insurance. To assure adequate coverage even small-scale biodiesel operations should obtain a policy from a "Commercial Risk Carrier". Since Vermont insurance providers, as a rule, have little to no experience with biodiesel production, they are unable to offer competitive rates. Therefore, it was important to research out-of-state companies with the necessary background and industry knowledge. The information provided below was gathered from a survey conducted in 2007, where prominent small-scale producers from the eastern U.S. were asked to submit contact information and comments on their insurance providers or industry contacts. The three most experienced and prominent national carriers were selected for this report.

- Nationwide Agribusiness appears to be one of the largest underwriters of biodiesel business and the least expensive, mostly due to their experience in the market. Contact Glenn Baker (agent) at (712) 737-3800. The Nationwide web site is www.nationwideagribusiness.com

- Kramer-Warner Associates, Inc. of Pennsylvania is also recommended. Contact Ron Ratigan (agent) at (610) 359-1422

- IMA of Kansas, Inc., is another underwriter with considerable experience in the biodiesel business. They can be reached by contacting David Weaver (agent) at (316) 266-6203

It is important when researching insurance not to underestimate the time it will take to get a policy (sometimes up to 2 months to finalize a quote). And finally, taking the time to educate the agent or broker about the operation–accurately and thoroughly- about its safety procedures and practices, will help insure that obtaining coverage doesn't become a stumbling block for small producers, now or in the future.