Farm Energy IQ

On-Farm Biodiesel and Straight Vegetable Oil (SVO)—Fact Sheet

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INTRODUCTION

Energy costs are often one of the most significant farm expenses. On farms in which tractors and other engine-powered equipment are common, diesel fuel costs predominate. Motivated by volatile and generally high diesel costs, some farmers have experimented with using vegetable oil and biodiesel made from vegetable oil as a replacement or blended supplement for diesel fuel.

Figure 1. John Williamson at State Line Farm Biofuels in Shaftsbury, VT, checking the settling tank holding a 300 gal batch of biodiesel made on the farm.

Replacement fuels can be produced at lower cost than diesel fuel, depending on crop yield and market price of diesel fuel. Since replacement fuels can be sourced from crops grown on the farm in rotation with other existing crops, biofuels produced on the farm can result in greater energy security and more predictable costs. Vegetable oil and biodiesel can also be produced with a positive net energy return (meaning more fuel is produced than is used in its manufacture).

Even at relatively moderate yields and at small scales of production, farm-based biodiesel enterprises are producing fuel:

- At a cost of **$2.30-2.50 per gallon**,
- With a net energy return ratio of between **3.6 and 5.9 to 1**, and
- With net carbon avoidance of **1,984 to 3,227 pounds per acre** per year.

Interestingly, scale of production is not a significant factor in terms of carbon avoidance.

BIODIESEL VS. VEGETABLE OIL

There is sometimes confusion about what “biodiesel” is, especially when compared to vegetable oil. Biodiesel and vegetable oil are chemically different fuels and there are some differences in how they can be used.

STRAIGHT VEGETABLE OIL (SVO)

Vegetable oil, when used as a fuel, is also referred to as straight vegetable oil (SVO), used vegetable oil (UVO) and waste vegetable oil (WVO).

Vegetable oil is a lipid; a chemical combination of free fatty acids attached by a glycerin backbone.

Most vegetable oils are liquid at room temperature but are thicker than diesel fuel. They also tend to gel or even become solid at lower temperatures such as those experienced during winter in the Northeast. As a result, when using SVO in engines, some additional fuel system components are needed. Specifically, SVO fueled engines generally start on diesel fuel and then switch over to a parallel SVO supply system once the SVO system is heated to operating temperature using a special heater or heat exchanger.

SVO is generally less expensive than biodiesel since it requires less processing. However, it requires some additional fuel system complexity and cost. Also, research trials and reports from early adopters have shown increased injector soot deposits.

For more information on using SVO as a fuel see "Straight Vegetable Oil as a Diesel Fuel?" (US DOE EERE Vehicle Technologies Office, 2014)

BIODIESEL

Biodiesel is made by breaking the vegetable oil's free fatty acids off of the glycerin backbone and "esterifying" them. This esterification is typically achieved by mixing the oil with caustic lye and alcohol at about 130 to135°F.

The glycerin is allowed to separate from the now-raw biodiesel. Residual contaminates, such as glycerin, soaps, lye and alcohol, are removed in cleaning and usable fuel results. The term biodiesel is reserved for fuels that conform to a quality standard, ASTM-D6751 which requires lab testing.

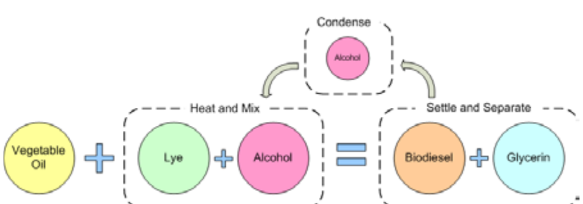

Figure 2 – A simplified diagram showing the conversion of vegetable oil to biodiesel.

By separating the free fatty acids from the glycerin, the liquid fuel becomes less viscous than vegetable oil and can remain that way at lower temperatures. Biodiesel has better cold weather performance than SVO, but it generally clouds and gels at higher temperatures than does petroleum diesel.

The process of making biodiesel involves some hazardous materials and can pose risk to personnel, property, and the environment.

For more information on how to make biodiesel see The Collaborative Biodiesel Tutorial (Utah Biodiesel Supply. 2014). For a video review of on-farm fuel processing, see Making On-Farm Biodiesel on the Vermont Bioenergy Now! YouTube Channel (Vermont Sustainable Jobs Fund. 2013). For more information on safety precautions, see Biodiesel Safety and Best Management Practices for Small-Scale Noncommercial Use and Production (Penn State, 2008)

BLENDS

Biodiesel is commonly used as a blend of biodiesel ("B100" or 100% biodiesel) and petroleum diesel. Blends allow for the use of biodiesel while reducing some of the undesirable properties such as cold weather viscosity.

For more information on biodiesel use and handling see Biodiesel Handling and Use Guide 4th Edition, (NREL. 2009).

OILSEED CROPS

WHAT ARE OILSEEDS?

Oilseed crops are grains that have been identified as having oil content above 20% of total seed weight, which is high compared to other crops such as small grains that have only 1 to 2% oil content. Although there are many oilseed crops, the primary three include soybeans, sunflower, and canola. Sunflower and canola have oil content over 40% of total seed weight. Soybeans have relatively low oil content, often below 25% of total seed weight.

The selection of a specific crop will depend on which other crops are being grown and processed on the farm as well as potential markets for co-products of meal and straw/stover.

OILSEED CROP YIELDS

In research and on-farm trials in the Northeast, yields of 1500-4500 lb/acre for sunflower, 1000-3000 lb/acre for canola and 2000-4000 lb/acre for soybeans grown for oil have resulted. Considering the oil content of each crop and the amount of oil that can be extracted, this translates to 66-200 gal/acre of sunflower oil, 44-132 gal/acre of canola oil and 88-176 gal/acre of soybean oil.

Figure 3 – Sunflowers grown for oil. Shaftsbury, VT.

CROP PRODUCTION EQUIPMENT

Oilseeds are typically grown as row crops. They are planted with a modified corn planter or seed drill depending on the specific crop. Cultivation or spraying with herbicide is required for weed control. Deer can cause damage early in the growing season as they eat early buds. Birds are a pest just prior to harvest when the oilseeds are targeted as a high energy food source.

Harvest requires a combine with a head specific to the crop and the timing of the harvest is determined by the moisture content of the standing crop. Once harvested, seed should be dried prior to storage. If dried well, seed can be stored stably for months and pressed to oil and meal when needed.

Figure 4 - Harvesting canola with a Massey-Harris SP35. In areas with few combines and where oilseeds are being trialed in small acreage, older combines like this are often the first used.

Once harvested, seed needs to be dried and cleaned. The order of these two steps varies by operation. Some have found dry seed cleans better, while others feel cleaning the seed before drying allows increased drying efficiency. The burden of cleaning, in general, will depend on how clear the field was of weeds and how well adjusted the combine was. Some have been able to accomplish adequate cleaning with the combine alone.

Seed cleaners, driers and storage bins are important parts of the process and are sometimes overlooked in the planning stages. The references below offer more information on these pieces of equipment.

For more information on oilseed crops and crop production see Oilseed Production in the Northeast: A Guide for Growers of Sunflower and Canola (Darby, Halteman, Harwood, 2013).. For a video overview of oilseed production for fuel, see Growing Sunflowers for Biodiesel, Growing Canola for Biodiesel and Growing Soybeans for Biodiesel on the Vermont Bioenergy Now! YouTube Channel (Vermont Sustainable Jobs Fund. 2013).

PROCESSING

With seed harvested, dried, and stored in a bin, it is important to check the moisture regularly and also to check for hot spots which might indicate a storage problem.

OTHER EQUIPMENT NEEDED FOR OILSEED CROPS

The importance of oilseeds depends on the oil contained in their seed. In order to remove that oil, seed is pressed in a mill. Once sent through the mill, the seed is split into oil and meal. With filtration, this oil can be used directly as SVO, sold as culinary oil (if processed according to applicable regulations) or converted to biodiesel. The meal can be used as livestock feed (with consideration of its impact on the overall nutrition of the animal), as pelletized fuel (if compliant with local fuel laws), or as a fertilizer for other crops.

Figure 5 - An oil press, a KernKraft KK40 at Borderview Research Farm in Alburgh, VT.

Storage for both meal and oil should be provided. Cool, dry locations for both are preferred. There should also be means for containment, prevention of contamination, and rodent control.

For more information on oilseed presses see Small-Scale Oilseed Presses: An Evaluation of Six Commercially-Available Designs (Callahan et al, 2014)

BIODIESEL PRODUCTION EQUIPMENT

The balance of the equipment needed for making biodiesel generally consists of heated mixing tanks, settling tanks and fuel cleaning equipment. Pumps and valves are usually needed to move process materials and sustain mixing during the conversion process. There are a variety of approaches for designing biodiesel conversion systems; some can be bought as turn-key systems (e.g., BioPro 190 like that used at Borderview Research Farm in Alburgh, VT) while others are custom built (e.g., from salvaged dairy and brewing materials at State Line Farm in Shaftsbury, VT).

Figure 6 – Roger Rainville stands next to a BioPro 190 automated biodiesel processor at Borderview Research Farm in Alburgh, VT.

ECONOMICS, ENERGY BALANCE, AND CARBON AVOIDANCE

BIODIESEL PRODUCTION COST

The costs of making biodiesel can be grouped into two main categories; fixed and recurring costs. Fixed costs include things like equipment while recurring costs includes items that are consumable, such as oilseed crop production costs, labor, and chemicals to convert the fuel. When accounting for all the various costs leading to a gallon of farm-based biodiesel, producers have demonstrated costs of between $2.30 and $2.50 per gallon.

ENERGY RETURN

A review of energy production versus energy invested by on-farm biodiesel enterprises in Vermont (Campbell, YEAR) showed, that although there is variation, all resulted in a net positive energy return. The farms studied showed an energy return of 3.6 to 5.9 times the amount invested.

GREENHOUSE GAS EMISSIONS

The Vermont study also modeled greenhouse gas emissions for biodiesel enterprises and found a net carbon avoidance of 1,984 to 3,227 pounds per acre per year.

For more information about the economics of on-farm biodiesel production see Vermont On-Farm Oilseed Enterprises: Production Capacity and Breakeven Economics (Callahan and White, 2013). For more information on the energy return of on-farm biodiesel see The Energy Return on Invested of Biodiesel in Vermont (Garza, 2011) The study of greenhouse gas emissions was done as part of a Master's Thesis by Elizabeth Campbell at The University of Vermont and is not available online .

RESOURCES

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Darby, H. P. Halteman, & H. Harwood, 2013. Oilseed Production in the Northeast: A Guide for Growers of Sunflower and Canola. University of Vermont. 2013. USDA SARE Project #LNE09-282.

Biodiesel Handling and Use Guide." 4th Edition. NREL/TP-540-43672. NREL, Golden CO, January 2009.

For more information on oilseed presses see "Small-Scale Oilseed Presses: An Evaluation of Six Commercially-Available Designs" C. Callahan and H. Harwood, H. Darby, D. Schaufler and R. Elias. University of Vermont. 2014.

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