CASE STUDY

John Williamson, State Line Farm, Shaftsbury, Vermont

'Closed-Loop' Biodiesel Production on the Farm

John Williamson is the owner-operator of State Line Farm, located in southwestern Vermont, on the New York state line. The family farm consists of 130 acres, and it was a dairy farm until recently. They now produce maple syrup, honey, sorghum syrup, timber, replacement heifers and hay. The farm typically uses about 1500 gallons of diesel fuel annually.

A couple of years ago, Steve Plummer, a local biofuels enthusiast with small-scale production experience, approached John about the possibility of starting a larger-scale, self-sufficient biodiesel project that used only on-farm resources as much as possible. John agreed.

Biodiesel is made by chemically altering a vegetable oil through the use of a catalyst (lye) and an alcohol (typically methanol). A chemical reaction when the mixture is heated causes oil molecules to break down and the glycerin portion of the oil to be replaced by alcohol. The glycerine falls to the bottom of the processing container and is drained off, and the remaining liquid is biodiesel.

John and Steve have the goal of developing a 'decentralized' biodiesel production model that other farmers could adapt to their farms to produce and process the three ingredients of biodiesel (vegetable oil, alcohol and lye) "on the farm." This model supports energy independence, reduces consumption of fossil fuels, and contributes to a sustainable fuel-food cycle.

On-farm production and use of biodiesel could be considered 'low hanging fruit' compared to large-scale production of biofuels for use in the mainstream fuel distribution system. With direct use on the farm (and possibly by neighbors in the local farm community) issues around federal fuel standards (ASTM certification) and fuel taxes are minimized or avoided, since the energy is not sold commercially, and is generally used in older equipment that no longer have engine warranties.

With this approach, relatively small-scale farms could also get extra income by growing oil seed crops for a neighbor that makes biodiesel, as opposed to the larger scale of production that is likely needed to profitably grow oil seed crops for sale at 'commodity' prices to commercial biodiesel plants. In addition, if the seed that local farmers grow and save is from non-transgenic crops, they may have yet another income stream, as on-farm biodiesel production gains in popularity among organic farmers that are prohibited from using genetically modified organisms.

In 2004 a test plot of 2.5 acres of canola, a high-energy oilseed crop, was successfully grown and harvested at State Line Farm. Yield was about 3,000 pounds. In 2005 they planted 5 acres of mustard (two varieties) an acre of flax and 1 variety of canola on 3 acres. Any of these crops can be used to produce vegetable oil for biofuel. After pressing the oil, which is generally 30-40 percent of the bulk, the remaining 60-70 percent is high quality and protein-rich livestock feed, or in the example of flax, a very nutritional human food.

A 1949 McCormick combine was used for harvesting. It was modified to move all the seed through the towers and dump it into the hopper without cleaning it. The seed was later cleaned with a home-made drum cleaner. The old combine is not very efficient at separating the seed from the chaff like modern machines, and all green weedy material must be removed to prevent heating and mold in order to ensure safe, dry storage of seed. Seed must be very clean and dry before processing for oil. Recently, a more efficient Massey-Harris combine was acquired from a neighboring farmer.

To separate or 'clean' the seed, a drum-type screen sieve was constructed. The basic design was taken from a water-powered grist mill seed cleaner, and was built mostly with on farm recycled materials. Seed/chaff mix is fed from the combine bin into a small grain elevator, which deposits the mix into the rotating screen drum. The drum is slightly pitched. Seed and small particles fall thru and a large fan positioned nearby blows the lighter particles to the side, while relatively clean seed falls into a pile on a canvas tarp and is bagged. This is a very low-tech operation because of a lack of funding; there are newer combines and seed cleaners that can make the process much more efficient and less labor intensive.

Pressing the seed to get the vegetable oil is a challenge because traditional small-scale presses are not efficient or effective. Larger presses can be hired out but that involves transporting the seed a long distance. The nearest such presses are in Quebec, and Ontario.

Small, high-quality presses are manufactured in Western Europe. A very efficient product line, Täbby, is made in Sweden. Prices are $4,200 - $14,000. There is a distributor in New York City. Products can be viewed at www.oilpress.com. A screw press well suited to this operation will cost $7,000 - $12,000 and fundraising efforts for purchasing the press are almost complete. Until the seed press is acquired, local waste vegetable oil from restaurants is being used to make biodiesel. Over 500 gallons have been produced so far.

The farm applied to the Bureau of Alcohol, Tobacco and Firearms for a small ethanol producer permit in November, 2005, and this was granted in February, 2005. After research and networking, an ethanol still was built. The still can be viewed and plans ordered at http://running_on_alcohol.tripod.com/id3.html Currently, molasses is fermented to run through the ethanol still. Trials are underway with different industrial yeasts that can be purchased in bulk.

Eventually the plan is to ferment sweet sorghum juice. (Sweet sorghum is already grown on the farm for production of sorghum syrup.) The goal is to produce the 95% ethanol that is needed for biodiesel. In the future, experimentation is planned for sugar beets and Jerusalem artichokes as sources of fermentable sugars. The farm currently uses a 100-year old mechanical sorghum press to extract the juice; it was purchased in Tennessee, where sorghum syrup is widely made.

To more efficiently press sorghum or Jerusalem artichoke canes would require a dewatering press. They are made in Florida by Vincent Corporation and can be viewed at www.vincentcorp.com. These presses are available for rent.

Construction of a biodiesel processor, capable of 125-gallon batches of fuel, has been completed. The alcohol/lye is mixed in a steel 55 gallon drum with a mixer mounted on the top. This mixture is pumped from the bottom of the drum into the top of a 150 gallon poly tank where the vegetable oil is warmed by a hot water element to about 150 degrees F. The larger tank also has a mixer mounted on the top that turns while the fuel is circulated out the bottom and back to the top to ensure complete mixing.

The farm is experimenting with wood ash lye (potassium hydroxide), although potassium or sodium hydroxide can also be purchased inexpensively. The hope is to refine the lye to a strength capable of driving the biodiesel reaction. Interestingly, potash (or lye) was the first cash crop of Shaftsbury in the 1700s. We saved a drum full of hardwood ashes from maple production, drilled a few holes in the bottom, and poured well water on the top, and placed a container to catch the lye water.

To concentrate the lye, it must be boiled down. At this strength it is called potash, and can be used to make soap with any fat or oil. Potash is baked in a kiln to drive off impurities and residues. In colonial times this was called pearlash. Pearlash may need to be further purified in order to use it for making biodiesel. This process is sort of on the 'back burner', but we feel it is important to gain the knowledge and experience to be able to make all three ingredients on the farm.

Discussions are underway with nearby farmers that are interested in sharing some of this equipment if local transportation can be developed to allow for cost-saving on individual farms through cooperative use of the system. Another nearby farm is willing to help with the cost of equipment in exchange for a supply of reasonably priced, locally-produced biodiesel.

Prepared by:
Vern Grubinger
University of Vermont