Case Study: On-Farm Biodiesel Production from Waste Vegetable Oil

Cate Farm, East Montpelier, Vermont

Richard Wiswall and Sally Colman own Cate Farm in central Vermont. They produce vegetables, herbs and flowers on 22 acres, and bedding plants and greenhouse tomatoes in seven 21 by 96 foot greenhouses. Biodiesel made from waste vegetable oil is used to heat the greenhouses as well as power two diesel tractors and one car.

When he decided to switch to an alternative fuel, Richard had the choice of converting vegetable oil to biodiesel that could run in his existing equipment or modifying the existing equipment to use straight vegetable oil. The number of locations where he required the fuel made it simpler and more cost-effective to transform the waste oil so it could be burned in existing equipment rather than changing and maintaining multiple pieces of equipment.

Making biodiesel is not as complex as rocket science, but some knowledge of chemistry is helpful. There are several different options for the ingredients and procedure (see the references at the end of this section). Richard uses a base of oil (triglyceride) combined with methanol in a reaction catalyzed by lye (sodium hydroxide) and heat. This process yields glycerin (a byproduct) and methyl esters (the biodiesel).

A 55-gallon metal drum is used for mixing his biodiesel batches. In the drum, Richard drilled two holes to draw off its contents: one opening at the bottom (for glycerin) and one midway up the barrel with a small pump (for methyl esters). An electric hot water element and thermostat are used to heat the ingredients inside the barrel; a paint mixer attached to a small motor mixes them.

Making biodiesel begins with collecting fryolator oil from area restaurants. Non-hydrogenated oil is best, with canola and soy most sought after. Oils changed weekly at the restaurant are preferred to often-reused oils. Richard has established reliable weekly pick up schedules with restaurants throughout the year. It's important to arrive reliably on a regular schedule throughout the entire year to satisfy the restaurant's needs- otherwise they may return to their more familiar waste haulers.

Once the restaurant oil arrives at Cate Farm, it sits in the sun or on heated concrete slab in plastic jugs while the particulate matter settles out. Once particulates have settled, Richard pours 40 gallons of the oil over a screen into the 55-gallon drum.

He mixes the oil slightly and draws off a sample to take a titration for determining how much lye to add (see resource list for titration instructions). The more free fatty acids in the waste oil, the more lye is required as a catalyst. The oil is then heated to 130 degrees.

Meanwhile, Richard mixes lye with 8 gallons of methanol in a container separate from the oil drum. He is extremely cautious with the methanol, wears protective clothing and eye protection and measures it in the open or in a well-ventilated shed. The lye dissolves in the methanol to produce sodium methoxide.

Finally, Richard adds the lye/methanol mixture to the heated oil and mixes it for one hour, then allows the mixture to sit overnight. The next day he can draw biodiesel from the top 4/5 and glycerin from the bottom 1/5. The biodiesel might sit for awhile before pumping to settle out any residual glycerine. If Richard wants to use it in his diesel vehicles instead of the furnaces, he will wash it with water mist to further remove any impurities. The glycerin goes to the compost pile for now, but with more processing, could be burned or made into soap as other options.

Oil furnace with a Beckett burner inside a tomato greenhouse

Cate farm has 7 greenhouses with oil fired furnaces, as well as oil furnaces in the house and shop. There are several different brands such as Sundair and Sebring, but all have Beckett oil burners. In order to successfully use biodiesel in these units, Richard takes the following steps. To prevent any residues from entering the burner and clogging the nozzle he adds a 5-micron spin-on cartridge filter in the fuel line, right before the burner. Then he removes the air tube and spray paints the inside with high-temperature silver paint. This compensates for the lower luminosity of the biodiesel flame compared to heating oil, thus 'tricking' the cad cell into thinking there's a brighter heating oil flame and not shutting the burner down. To make a fine mist of biodiesel that burns well, Richard increases the burner oil pump pressure from 100 psi to 150 psi, and then compensates for that added pressure by installing a small nozzle and adjusting the air bands to get the proper air intake. These steps may require the assistance of an oil burner technician.

In the greenhouse, 275-gallon fuel tanks hold the biodiesel and are kept inside to make sure the fuel flows well when it's cold outside. At the end of the heating season, Richard makes sure to leave the tanks full so as to minimize the potential for fuel breakdown due to exposure to oxygen. Next year, before starting a furnace for the first time, he drains off the bottom gallon or so of fuel from the tank in case any residues have settled out.

In his tractors, Richard runs straight biodiesel (B100) all season long. Over the winter, he needs only one tractor for limited use and he switches to regular diesel to avoid any low temperature operating problems. Come April, when tractor use increases, he switches back to B100. However, he runs B100 in his home and shop furnace all winter long without problem since the fuel tanks are inside.

A rough estimate for Cate Farm's biodiesel material costs (not including labor) is about $0.85 per gallon. The methanol is the most expensive ingredient and it costs $3.80 per gallon. Richard makes about 20 gallons of biodiesel per hour, and he produces a total of 2000 gallons per year. Including labor for pick-up, handling and processing at $20/hour, the actual cost of his on-farm biodiesel is $ 1.85/gallon. Compared to purchasing 2000 gallons of No. 2 heating oil at $3.85/gallon, his annual savings is $ 4000.

The fuel is kept in a minimally heated storage shed until needed. Drums are moved to the greenhouses by tractor or hand truck, and transferred into the fuel tanks with a rotary hand pump. About 75% of the bio-diesel is burned in the greenhouses in winter and spring, the rest in the two tractors and car.

Some Biodiesel Resources:

Biodiesel: Basics and Beyond, by William H. Kemp (at various bookstores)
Biodiesel Homebrew Guide by Maria Alovert (order online: www.localb100.com/)
http://www.biodieselnow.com
http://biodiesel.info.pop.cc

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