Making 3000gal/year of biodiesel from waste vegetable oil

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My wife and I own and operate Cate Farm, producing certified organic vegetables, herbs, and bedding plants. We sell locally to area stores, restaurants, the Montpelier Farmers Market, and to stores in Boston and NY through Deep Root Organic Growers Co-op. We have 22 acres under cultivation and seven 96' long greenhouses.

In January 2004, I attended a talk by Carl Benson who received a SARE grant to make biodiesel on his farm. Previous to that talk, I had heard of biodiesel, and had a vague notion of what it was, but during the talk, a light bulb went on in my head and I saw the important and immediate application for biodiesel on my farm. Up until five years ago, fuel oil was a cheap 73 cents a gallon. My wife and I had expanded our greenhouse operation during that period to our current seven greenhouses. My ethical concerns about fossil fuel energy went into temporary remission as we were expanding our business. We were trying to juggle too many balls to keep them all in the air.

The moral concerns of turning fossil fuels into food hit me squarely now that an environmentally friendly and socially responsible alternative presented itself. Here was a fuel that could easily replace home heating oil (HHO) and diesel fuel that was renewable, much less polluting, non toxic, and much less expensive. I dived in headfirst to the world of biodiesel (BD) and straight vegetable oil (SVO) and cut off cold turkey our fossil fuel heating oil and off road diesel purchases in all our greenhouses, house, shop, barn, and three season tractor use.

Rudolf Diesel demonstrated his diesel engine in Paris in 1900, running on peanut oil. He foresaw back then the possible need to replace fossil oil with plant based oils. Vegetable oils (canola, soybean, sunflower, etc.) can be used as a HHO or diesel fuel substitute in two ways. One way is to heat the oil to 170 degrees F so that the viscosity of the vegetable oil resembles fossil fuel HHO or diesel. (Both HHO and diesel are termed #2 fuel oil; kerosene is #1 fuel oil similar to jet fuel.) Heating the oil for use in diesel engines require a second tank that is heated. The engine is started on diesel (or biodiesel), warmed up and then the fuel source is switched to hot vegetable oil. For use in a furnace, vegetable oil is heated and atomized with pressurized air. Each diesel engine or furnace needs some type of retrofitting to burn SVO.

The second way vegetable oil is used as a fossil fuel substitute is to *chemically change* the vegetable oil (a triglyceride) to biodiesel (methyl esters in my case.) The resulting biodiesel performs very similarly to fossil diesel or HHO and in its application in diesel engines and heating equipment, thus avoiding retrofitting existing equipment.

I chose to make biodiesel over using SVO because I have ten oil burners for heating, and two diesel tractors. Retrofitting all those burners and two engines would require a lot of tinkering. If you have only one furnace or diesel engine, using SVO may be a better choice.

The benefits of biodiesel over fossil fuel are huge: it uses a waste stream (or under utilized byproduct) into a liquid fuel which is much less polluting, and less toxic to the environment and equipment operators. It has better lubricity and has solvent qualities that will clean your fuel system of fossil fuel impurities. The only downside is that biodiesel is not as cold tolerant for outdoor winter time use, and that it too has a limited availability.

I make 3000 gallons/year of biodiesel, all from used fryer oil collected from three restaurants. That is 60 gallons each week, 52 weeks/year. I tend to make a lot of biodiesel in shorter time periods, usually in the winter and early spring. Three quarters of my 3000 gallon production is used for heating, the remaining quarter is used in diesel engines.

The process of making biodiesel is not rocket science, but some knowledge of chemistry is needed, and there are some steps where one will be around some toxic compounds. As an organic farmer, the last thing I want is to suffer the health effects from chemical contamination, so the process I use for making biodiesel is the safest way I know how to.

I collect the vegetable oil in "cubes", 4.5 gallon plastic containers that restaurants buy virgin oil in. Used fryer oil is drained back into these cubes, and the chefs set them by the back door for me to pick up weekly. I have written agreements with the restaurants I get oil from and I'm committed to picking the oil up regularly.

My annual use is 3000 gallons, so I need to pick up 60 gallons/week. Do the same math for your annual consumption and be careful not to over collect oil, a common occurrence when first starting and enthusiasm is running sky high.

I store cubes inside and outside my shop where the biodiesel is made. I make biodiesel in 40 gallon batches using a retrofitted 55 gallon metal drum as the main processor. 40 gallons of fryer oil and 8 gallons of methanol and about 2 pounds of lye yields 40 gallons of biodiesel and 8 gallons of glycerine. The chemistry looks like this:

Reactants		Catalysts	Products	
Veg oil	and methanol	lye, heat	biodiesel	and glycerine
(triglyceride)	(wood alcohol)	(NaOH)	(methyl esters)	(glycerol alcohol)

A quick overview of the biodiesel making process is: (see photos as well)

- Pour cubes of used oil through house screen into 55 gallon biodiesel processor.
- Heat oil (with electric water heater element on a thermostat) to 130F. (If there may be water in oil, a preheating of oil to 155F and settling may be necessary.)
- While the oil is heating (takes about 3 hours) take a sample of your batch of oil and perform a titration to determine how much lye will be added to the 8 gallons of methanol. Resources listed at the end of the article best describe this, and other, steps.
- Add the determined amount of lye to a carboy outdoors containing the 8 gallons of methanol and swirl to mix it until the lye is dissolved. Extreme caution should be used when handling methanol, lye, and the resulting mixture, sodium methoxide. I use a face shield, long gloves, and full coverage clothing when performing this operation. Again, this is not an instruction manual, but rather an overview of the process. Refer to the listed resources for more info.
- Once the lye is dissolved, the carboy of sodium methoxide (handle with extreme caution; toxic and flammable) is added to heated vegetable oil in the processor. Many safety precautions are taken, see photos.
- The hot veg oil and sodium methoxide are mixed for one hour with a paint stirrer attached to a motor. The processor is plumbed to a methanol recovery heat exchanger to recapture excess methanol now, and after, the reaction. After an hour of mixing, the processor sits for 24 hours, allowing the biodiesel and glycerine layers to separate.
- Once separated, the bottom glycerine layer is drawn off the bottom into 5 gallon pails and poured into a glycerine drum, where it will later be heated to recover more methanol through the heat exchanger. Once methanol is recovered, the glycerine is either neutralized to pH7 with vinegar, or not, and composted in a large pile (30 yards) of bedding material.
- The biodiesel remaining in the processor is then reheated to volatize any methanol to reclaim, and then the biodiesel is pumped to a wash tank for further cleaning, or directly to drums for storage. There is a lot of talk around washed vs. unwashed biodiesel for various uses. In the past I used to wash biodiesel for use in diesel engines and use unwashed in heating applications. It is too big a discussion for this talk.

I store biodiesel in the furnace fuel tanks and 55 gallon closed top drums. I move the 55 gallon drums by hand truck or bucket loader and use a rotary hand pump to transfer the biodiesel.

Using biodiesel works for our farm, though I've had my share of trials and tribulations. In heating applications, I've learned a few things. Some notes for burning biodiesel in furnaces:

I add a 10 micron cartridge filer next to the burner fuel pump and change the bottom tank filter before each heating season. I also drain off a half gallon to remove any settled glycerine or water. Time is your ally when using unwashed biodiesel. I replace the burner pump seals with viton ones, or install a Webster biofuel pump. I increase the pump pressure from 100 psi to 150psi and change the nozzle for the next smaller size for better atomization of the biodiesel. All my fuel tanks are inside to keep the biodisel above 50F. On some furnaces with cooler fuel tanks, I'll add a nozzle heater to provide some extra heat on start up.

Biodiesel is not as luminous as HHO, and sometimes the cad cell safety locks out even though a flame is indeed burning normally. In this case, one can move the cad cell closer to the flame, and/or spray silver paint inside the air tube to increase reflectivity.

The air bands will need to be adjusted slightly so there is little to no smoke; a smoke tester is a handy tool to have. For older furnaces, I sometimes replace the older style transformer with a new 14KV igniter, for producing a better spark, and also I keep the electrodes sharp. All our furnaces use Beckett burners, and I upgrade to the new Honeywell 7184 primaries and clean cut pumps as needed.

As for use in diesel engines, I use B100 seasonally April-November in a 50 hp JD 2240 tractor, a 50 hp Ford 4000 tractor, and a 1982 Mercedes 300D. Because biodiesel is a solvent and cleans out gunk from past fossil fuel use, a fuel filter should be on hand in case of clogging. I've only had to replace my fuel filters once since I started four years ago. On older (pre 90s) diesels, rubber fuel lines may start to weep (and eventually start to leak) so I replace them with fuel line from the auto parts store. Other than that, the only changes you are likely to notice are a smoother running engine, and the smell of French fries.

Resources

Books: Biodiesel: Basics and Beyond by William H. Kemp
Biodiesel Homebrew Guide by Maria Alovert
From the Fryer to the Fuel Tank by Joshua Tickell, the original, great overview, but older.

Web Sources

Collaborative Biodiesel Tutorial www.biodieselcommunity.org
http://biodieselinfopop.cc
altfuelfurnace http://groups.yahoo.com/group/altfuelfurnace
plus many others