Farm Energy IQ

Farms Today Securing Our Energy Future

Biodiesel and Straight Vegetable Oil (SVO)

Chris Callahan, UVM Extension

Outline

• Overview of biodiesel and SVO – Why this matters
• Biodiesel vs. SVO
• Using SVO
• What is B5, B20, and B100? And what should I use in my tractor?
• Equipment (engine) considerations when using biodiesel
• Making biodiesel
• Safety considerations for making and using biodiesel
• Crops for SVO or biodiesel
• Basic agronomics and economics biodiesel crops
• Related equipment needed to process the crops to oil and meal

Benefits of SVO and Biodiesel

Financial – cost of fuel
Planning – stable of cost of fuel
Efficiency – “energy return on investment”
Environmental – net carbon reduction

“A hundred years ago we all grew our own fuel.”
John Williamson
State Line Farm Biofuels, Shaftsbury, VT

The Biodiesel Process

Lots of places to “hop on” or “hop off”
Straight Vegetable Oil (SVO) vs. Biodiesel

- **SVO**
  - Mono, di, or triglycerides
  - a.k.a. vegetable oil, fry oil, “grease”
  - Filtered and de-watered
  - Usually requires secondary tank and heaters for use in diesel vehicle

- **Biodiesel**
  - Mono alkyl esters, methyl esters
  - Refined oil, converted to “methylesters”
  - Lower viscosity, flows and sprays easier leading to better combustion
  - Lower gel and cloud point, better for winter use

Making Biodiesel
Transesterification
Single Stage Base Method

What Should I Use in My Tractor?
Straight Vegetable Oil Overview

- May require engine modifications
- Oil heated to change the viscosity
- Start engine on petro-diesel fuel
- Shut down on petro-diesel fuel

Equipment Considerations - SVO

- Higher viscosity fuel
  - Requires heating
  - Switching between SVO and diesel

- Good spray and combustion can be challenging
  - Injector fouling
  - Impingement

- Requires supplemental fuel system

Viscosity and Fuel Performance

Vegetable oils have high viscosity which may lead to injector coking and eventual engine failure

Equipment Considerations - Biodiesel

- Material compatibility
  - Seal rubber can degrade in older materials
  - Current guidance: Teflon, Viton, and Nylon
- Quality assurance
  - Poor conversion of oil to biodiesel
  - Residual glycerin – clogging, poor combustion
  - Residual methanol – health hazard
  - Residual lye – caustic, corrosion
  - Field quality test kits are available
  - Lab tests are best for specific confirmation
- Some operators add an inline feed filter, and most carry a spare main filter for the unexpected clog

Biodiesel Blends

- “B5,” “B20,” and “B100”
  - Simple ways of referring to the concentration of biodiesel in a fuel blend
  - When 5% biodiesel is mixed into petroleum diesel it is called B5
- Why is it blended?
  - Cold weather properties
  - Cost balance
  - Emissions balance
  - Material compatibility
  - Solvent properties
- B20 is most common blend

What Should I Use in My Tractor?

- Generally B20 is recommended
  - Some OEM’s have fully embraced B100 and their design process focuses on this
- B100 has been successfully used in tractors in the Northeast through winter
  - Farm-based production; i.e., from sunflower and canola oil
- If purchasing, seek BQ-9000 certification: http://www.bq-9000.org/

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Things to watch for...
- Engine may run more quietly
- Biodiesel has lubrication properties
- May have reduced power
  - Biodiesel has lower Btu content per gallon
  - Generally 2% reduction in power, 3% reduction in fuel economy (B20)
- Filters may clog more frequently
  - Generally because biodiesel is “kicking up” sediment in tanks
  - Can also be due to off-spec biodiesel
- Cold weather gelling and poor flow can occur
  - Depends on feedstock

What Should I Use in My Tractor?

Penn State Guide
- Small scale
- Somewhat PA specific, but extremely helpful
- Best single source for this sort of info

Safety Guidelines

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Hazard Analysis for Biodiesel

<table>
<thead>
<tr>
<th>Process Component</th>
<th>Hazard Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetable Oil</td>
<td>People</td>
</tr>
<tr>
<td>Alcohol</td>
<td>Property</td>
</tr>
<tr>
<td>Lye</td>
<td>Environment</td>
</tr>
<tr>
<td>Alcohol/Lye Mixture</td>
<td>People</td>
</tr>
<tr>
<td>Glycerin</td>
<td>Property</td>
</tr>
<tr>
<td>Wash Water</td>
<td>Environment</td>
</tr>
<tr>
<td>Recovered Alcohol</td>
<td>People</td>
</tr>
<tr>
<td>Electrical Componets</td>
<td>People</td>
</tr>
</tbody>
</table>

The main hazards are associated with the reactant and catalyst used in transesterification. Refer to material safety data sheets (MSDS’s) and always use proper personal protective equipment (PPE).

PPE: Personal Protective Equipment

- Eyes
- Ears
- Mouth and nose
- Skin

Material safety data sheets (MSDS’s) for each material or chemical will provide guidance on proper PPE. Copies of MSDS’s for each chemical in use should be on-hand and easily accessible by all personnel.

Safety Review of Process

- Codes and standards
- Material Safety Data Sheets
- Schematic Drawing
- Failure Modes and Effects Analysis (FMEA)
- Standard Operating Procedures (SOPs)
- Dry run
- Wet run
- First batch

PPE: Personal Protective Equipment

- Combustibility sensors
- Often makes sense to have two
  - One high above process
  - One low, within process
- Safety measure
- Quality measure
- Product shown
  - Industrial Test Equipment
  - HC-922 Multigas sensor
  - www.gasdetectorsinc.com
  - $220
SPCC: Spill Prevention, Containment, and Countermeasures

- In that order
  - Prevention
    - FMEA
    - Maintenance
    - SOPs
    - Attention
  - Containment
    - Structural
    - Early consideration
  - Countermeasures
    - Specific to incident and site

http://www.epa.gov/oilspill/spcc.htm

Crop Production

- Recently published handbook for Northeast oilseed production


Crops for SVO or Biodiesel

What are Oilseeds?

Grains and Oilseeds:
"Grains are identified as cereals suitable as food for human beings. Oilseeds are those grains that are also valuable for the oil content they produce."

Soybeans
Canola
Sunflower
Camelina
Crambe
Flax
Mustard
Pennycress
Rapeseed
Safflower

Oilseed Pressing Costs

- Sunflower Seed
  - 1 ton @ $338/ton (38% oil, 62% meal)
- Pressing
  - Cost of Pressed Seed is $340/ton
- Meal
  - 0.62 ton meal per ton seed @ $211

KernKraft 40 at Borderview Research Farm in Alburgh, VT.

"Screw" or "Worm" advances seed, pressing it against the backside of the die. Crushing it along the way. Oil and meal are separated by pressure.
Press Evaluation

- Evaluated six farm-scale presses using a common protocol on three oilseed crops
- Captured owner/operator feedback on press
- Measured
  - Press capacity at various speeds
  - Net oil yield at various speeds
  - Phosphorus at various speeds

General findings

- Operating a newly purchased press depends on a great deal of trial and error. Operators tips and tricks documented for each press.
- Press capacity depends on oilseed and is often different from published specifications.
- Max oil yield is generally below maximum press capacity, and there is a peak in the mid-range of pressing rate (speed).
- Phosphorus in oil declines with pressing rate (speed).


Vermont On-Farm Biodiesel—Cost of Production and Breakeven


2013 report explored 2 scales of farm-based production
- As with most farm operations, highly dependent on cost of crop production and yield
- Analysis is provided in step-by-step form
- Calculator is available to aid in assessing potential cost

Economics and Breakeven of On-Farm Biodiesel Enterprises

Break-even Pricing for Sunflower Products at Various Costs of Crop Production and Yield

<table>
<thead>
<tr>
<th>Scale</th>
<th>Pressing Rate</th>
<th>Yield</th>
<th>Sugar</th>
<th>Net Gain</th>
<th>Net Gain</th>
<th>Net Gain</th>
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</thead>
<tbody>
<tr>
<td>Small</td>
<td>1.20</td>
<td>1.80</td>
<td>0.95</td>
<td>0.25</td>
<td>0.95</td>
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<tr>
<td>Medium</td>
<td>0.80</td>
<td>1.80</td>
<td>0.85</td>
<td>0.95</td>
<td>0.95</td>
<td>0.95</td>
</tr>
<tr>
<td>Large</td>
<td>0.60</td>
<td>1.80</td>
<td>0.55</td>
<td>0.95</td>
<td>0.95</td>
<td>0.95</td>
</tr>
</tbody>
</table>

Note: Break-even Pricing is not an exact measure of cost savings. These prices were developed by surveying Vermonters on their production costs and yield. The numbers are intended to be a rough estimate and are not intended to be used as a direct measure of sales or expenses. The prices do not factor in external factors such as market prices or government subsidies.

State Line Farm

John Williamson - Shaftsbury, VT

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Moisture Tester

65 Massey-Harris SP-35 at work

The “Bio Barn” — Making use of gravity, the sun and shade.

Biodiesel Samples, “Just like at the sugar house.”
Borderview Farm
Roger Rainville - Alburgh, VT

Crop Research Farm
formerly a Dairy Farm
Oil seeds since 2005
Establishing ~150k gal/yr capacity

New grain dryer and oil press
Meal pellet press
Roger and his sunflowers

Presscake

Research combine

Borderview Farm
Roger Rainville - Alburgh, VT

Farm Energy IQ
Biodiesel and SVO
Questions?

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