On-Farm Pressing of Oilseeds for Fuel and Food

A NEWbio Webinar

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Ag ENGINEERING

UNIVERSITY OF VERMONT EXTENSION

PENNSTATE College of Agricultural Sciences

Outline

- Production & Processing

  From seed to oil

- Straight Vegetable Oil

  Using vegetable oil as a fuel

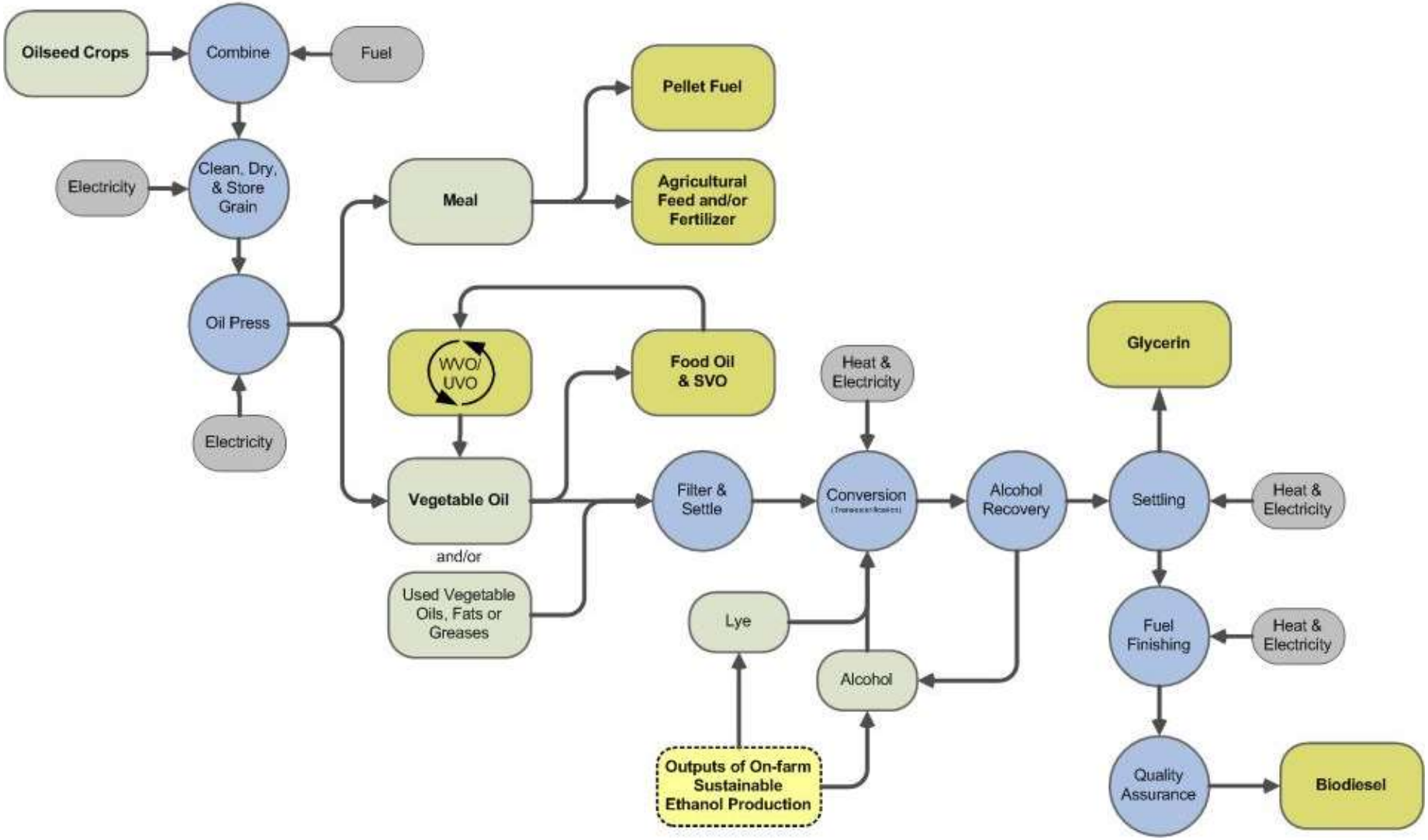
- Biodiesel

  Converting vegetable oil to biodiesel

- Culinary Oil

  Considerations for production of food oils

Conversion of Oilseed Crops to Biodiesel and Other Products



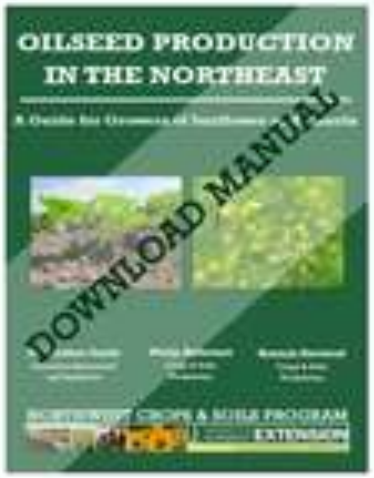
What are Oilseeds?

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

Crop Production

- Not the focus of today's webinar
- Recently published handbook for Northeast Production



Darby, H., P. Halteman, and H. Harwood. 2013. **Oilseed Production in the Northeast: A Guide for Growers of Sunflower and Canola.** University of Vermont Extension Northwest Crops and Soils Program, St. Albans, VT

Available: http://www.uvm.edu/extension/cropsoil/wp-content/uploads/OilseedManualFINAL.pdf

NORTHEAST SARE
Sustainable Agriculture Research & Education

Vermont Oilseed Crop Production Cost and Profit Calculator

USER INPUTS

1. Title: Generic Case for Checking Math
2. Crop: Sunflower

Total Cropland	10 acres
Acres in Oilseeds	10 acres
Acres in this Crop	10 acres

	Typical	My Farm	
Land Cost	$ 37	NA	/acre/yr

GENERAL INSTRUCTIONS: Enter any specific information you have regarding your farm's operation into the white boxes below. If you do not enter a value in the white box, the "typical" value to the left of it will be used. If you enter "0" instead of "NA" a value of zero will be used. "Typical" values are based on research and collection of data from participating farmers and other published resources and are provided for guidance only. Summary results are displayed on the right of the screen, and you can print a more detailed report by clicking "Print Detailed Report".

3 Yield

	Typical	My Farm	
Yield (Seed)	1100	1200	lbs/acre
Oil Content	44%	40%	
Test Weight	32	NA	lbs/bu (dry)

4 Cost of Production

(Labor, fuel and materials should be included in each item. Equipment cost is carried below)

	Typical	My Farm	
Field Prep (plow & disk)	$ 34.00	$ 30.00	acre
Fertilizer (applied)	$ 47.00	$ 20.00	acre
Seed	$ 25.00	$ 30.00	acre
Planting	$ 6.00	$ 10.00	acre
Cultivating	$ 8.00	$ 15.00	acre
Spraying	$ 20.00	NA	acre
Harvesting	$ 12.00	$ 15.00	acre
Hauling	$ 1.00	$ 5.00	acre
OR **Total Cost of Production**	$ 153.00	NA	acre
Total Being used in Calculator		$ 145.00	acre
Prod. Equip. Cost	$ 20,000	$ 50	
Prod. Equip. Life	20	1	years
OR **Cost of Raw Seed**	$ 527.27	NA	ton

5 Costs of Cleaning and Drying

	Typical	My Farm	
Harvest Moisture	14%	8%	% weight
Storage Moisture	8%	8%	% weight
Cleaning Cost Factor	1.5	NA	kWhr/ton
Electricity Cost	$ 0.13	$ 0.14	kWhr
Labor Cost (Dry/Clean per ton)	$ 15.00	$ 0.00	ton
Cleaner Cost	$ 4,000	$ 2,000	
Cleaner Life	30	40	years
Drier Cost	$ 12,000	$ 2,000	
Drier Life	20	30	years
OR **Cost of Clean / Dry Seed**	$ 684.92	NA	ton

6 Cost of Pressing

	Typical	My Farm	
Press Cost	$ 4,000	$ 13,000	
Press Life	20	20	years
Press Capacity	1.0	1.0	ton/day
Press Oil Efficiency	90%	100%	
Press Power Rating	7	6.7	hp
Labor Cost (per ton)	$ 0.75	$ 20.00	ton
OR **Overall Cost of Hired Pressing**	$ 37.14	$ 60.00	ton seed
OR **Cost of Purchased Oil**	$ 1.17	NA	gal
Amount of Purchased Oil		NA	gal/yr

7 Cost of Biodiesel Production

	Typical	My Farm	
Plant & Equip Cost	$ 10,000	$ 20,000	
Plant & Equip Life	30	30	years
Heating Cost	$ 20.00	NA	(mill BTU)
Alcohol Cost	$ 1.07	$ 3.00	gal alc
Alcohol Used	20%	20%	gal / gal oil
Lye Cost	$ 0.80	$ 1.50	lb lye
Lye Used	0.083	NA	lb / gal oil
Labor Cost (per gal)	$ 0.10	$ 0.20	gal
OR **Cost of Hired Production**	$ -	NA	gal B100

8 Market Value of Products

	Typical	My Farm	
Market Price for Seed	$ 362	NA	ton
Market Price for Meal	$ 139	NA	ton
Market Price for Oil	$ 5.59	NA	gal
Market Price for Off-Road Diesel	$ 2.24	NA	gal
Net Market Value of Other Potential Bi	$ -	NA	acre

	Typical	My Farm	
Value of Seed	$ 199	$ 217	acre
Value of Meal	$ 43	$ 50	acre
Value of Oil	$ 361	$ 358	acre
Value of Biodiesel	$ 145	$ 143	acre

Marketing split (oil vs. biodiesel)	Typical	My Farm	
Sell	0%	NA	raw oil
Convert remaining	100%	NA	to biodiesel

RESULTS

Projected Costs	Typical	My Farm	
Incremental (cost for each step)			
Cost of Production	$ 290	$ 187	acre
	$ 527	$ 312	ton seed
Cost of Cleaning/Drying	$ 87	$ 12	acre
	$ 158	$ 20	ton seed
Cost of Pressing	$ 20	$ 36	acre
	$ 21	$ 36	ton meal
	$ 61	$ 90	'000 gal oil
Cost of Biodiesel Production	$ 59	$ 126	acre
	$ 0.91	$ 1.98	gal
Cumulative (total cost for each product)			
Cost to Produce Seed	$ 377	$ 199	acre
	$ 685	$ 331	ton
Cost to Produce Meal	$ 397	$ 235	acre
	$ 706	$ 367	ton
Cost to Produce Oil	$ 397	$ 235	acre
	$ 1.19	$ 0.59	gal
Cost to Produce Biodiesel	$ 456	$ 361	acre
	$ 2.10	$ 2.56	gal

Projected Profit / (Loss)	Typical	My Farm	
Seed Only (Clean and Dry)	($178)	$18	acre
Meal Only	($354)	($185)	acre
Oil Only	($36)	$123	acre
Meal & 100% Oil	$7	$173	acre
Meal and 100% Biodiesel	($268)	($168)	acre
Biodiesel Only	($311)	($218)	acre
Meal and Oil/Biodiesel split	($268)	($168)	acre
Seed Only (Clean and Dry)	($1,776)	$184	total
Meal Only	($3,544)	($1,848)	total
Oil Only	($361)	$1,232	total
Meal & 100% Oil	$66	$1,732	total
Meal and 100% Biodiesel	($2,683)	($1,679)	total
Biodiesel Only	($3,111)	($2,179)	total
Meal and Oil/Biodiesel split	($2,683)	($1,679)	total

Print Detailed Report | Clear My Inputs

See Instructions | Print Instructions

Release 1.1 - 2010 September 13 (Working Draft)

Download at: http://www.vsjf.org/resources/reports-tools/oilseed-calculator

Outline

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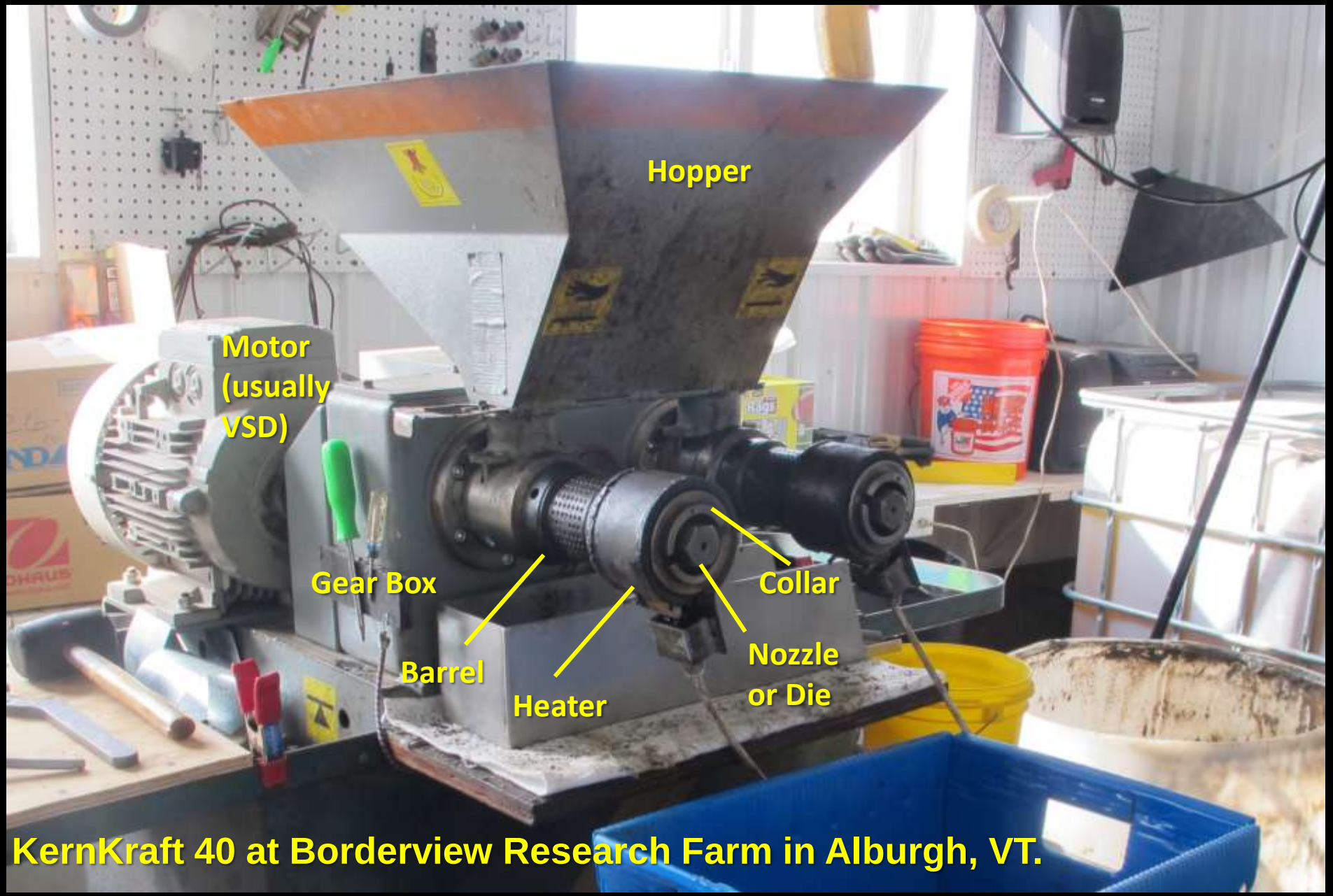
- Biodiesel
  Converting vegetable oil to biodiesel
- Culinary Oil
  Considerations for production of food oils



KernKraft 40 at Borderview Research Farm in Alburgh, VT.

Oil

Oil

Meal

“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.

The Cost Basis of Oil and Meal

Sunflower Seed
1 ton
@ $338/ton
(38% oil, 62% meal)

Pressing
(@ $2.36/ton)
Cost of Pressed Seed is $340/ton

Oil
0.38 ton oil
per ton seed
@ $129

Oil
@ $340 per ton
requires 2.63 ton seed
($1.28 /gal)

Meal
0.62 ton meal
per ton seed
@ $211

Meal
@ $340 per ton
requires 1.61 ton seed

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

C. Callahan & H. Harwood with H. Darby, R. Elias, D. Schaufler. Small-Scale Oilseed Presses: An Evaluation of Six Commercially-Available Designs. March 3, 2014. Associated YouTube Video, with L. Madden.

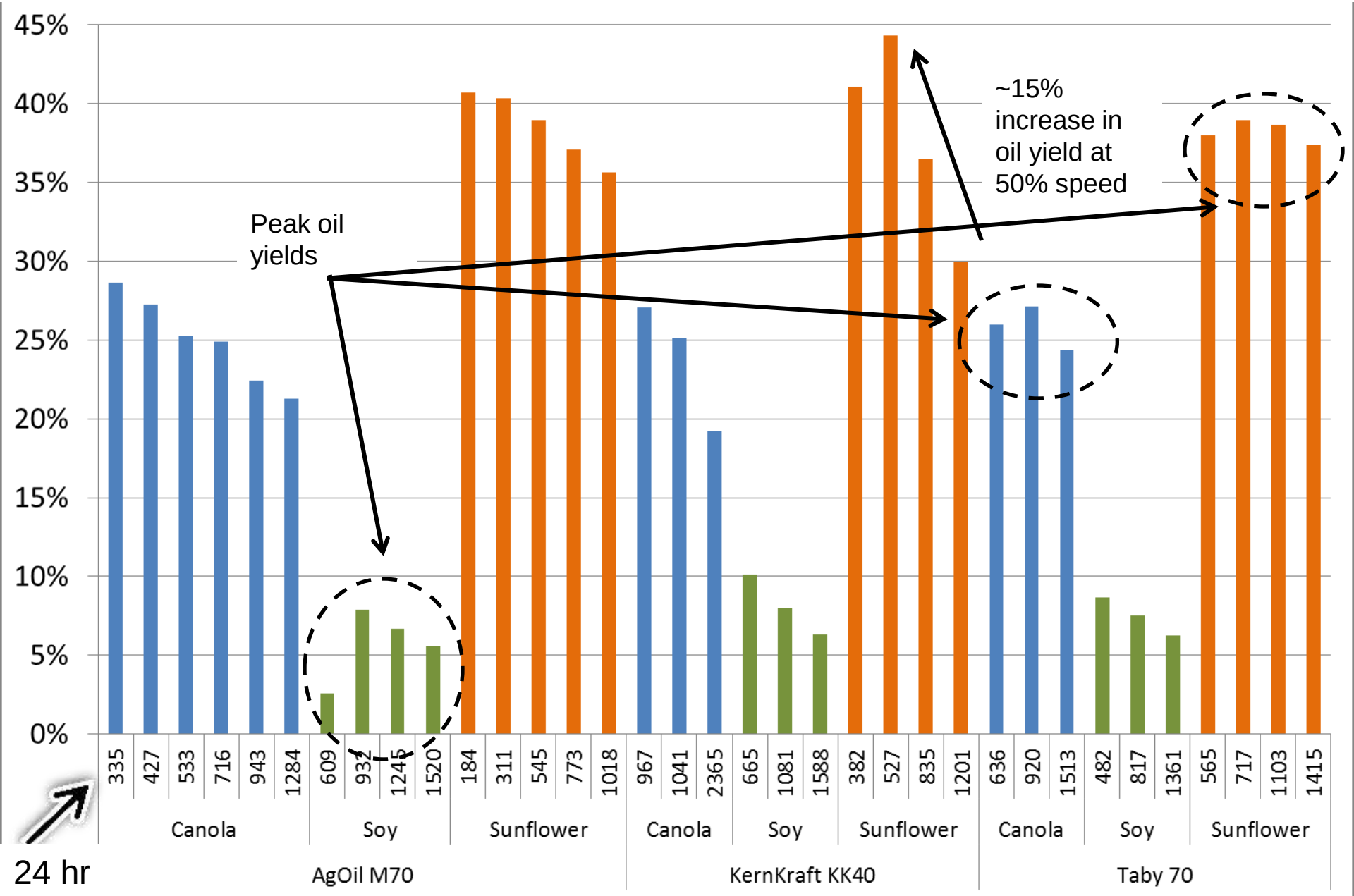
Press Evaluation

General Findings:

- Operation of 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).

C. Callahan & H. Harwood with H. Darby, R. Elias, D. Schaufler. Small-Scale Oilseed Presses: An Evaluation of Six Commercially-Available Designs. March 3, 2014. Associated YouTube Video, with L. Madden.

“Net” Oil Yield (prior to settling)



Other Processing

- Depends on end use
  - Settling of bulk sediment
  - Filtration
  - RBD
    - Refined
    - Bleached
    - Deodorized
  - Convert to Biodiesel

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Mind the Difference - Biodiesel & SVO

Straight Vegetable Oil (SVO)

Animal Fat or Vegetable Oil

↓

Transesterification using alcohol & catalyst

↓

Biodiesel

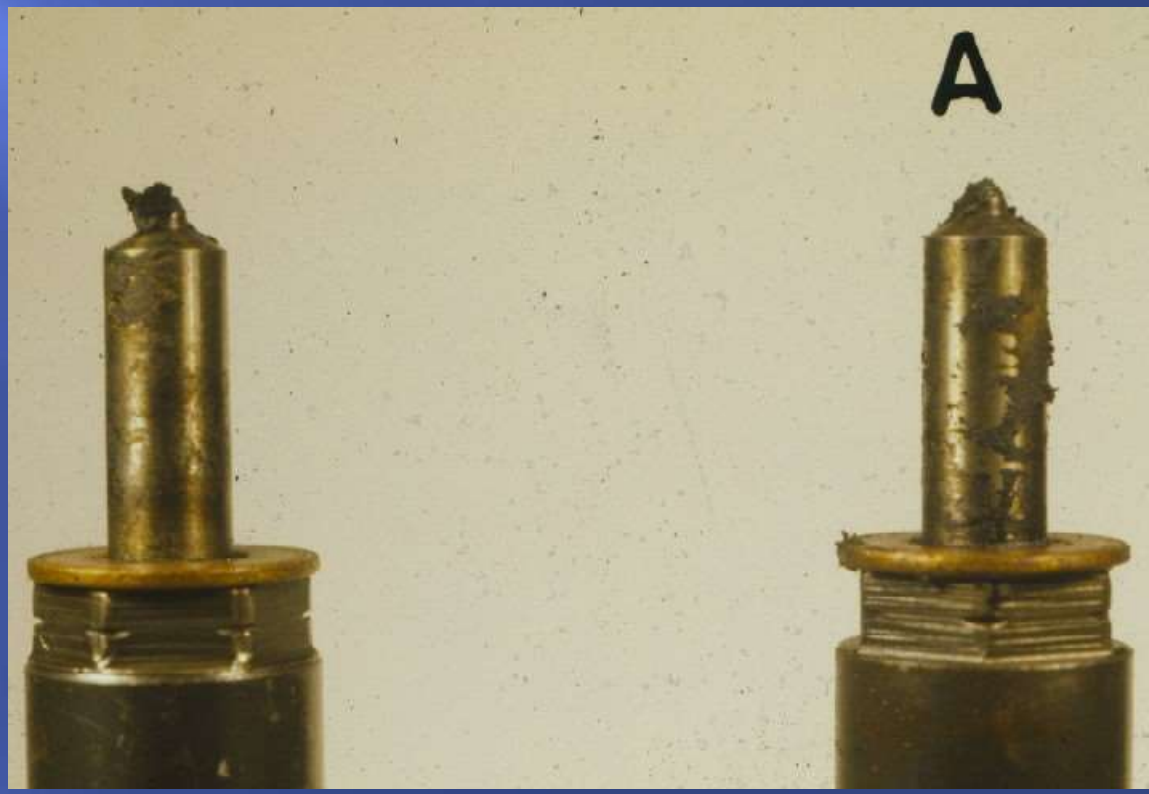
America's First Advanced Biofuel
BIODIESEL

Straight Vegetable Oil as Engine Fuel

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

Viscosity and fuel performance

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

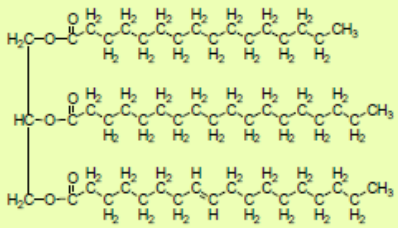


Engine deposit buildups after running on straight soybean oil

Kinematic Viscosity of Rapeseed Oil and Diesel Fuel

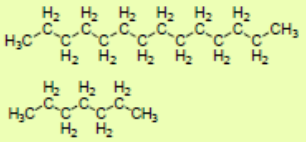
Rapeseed Oil

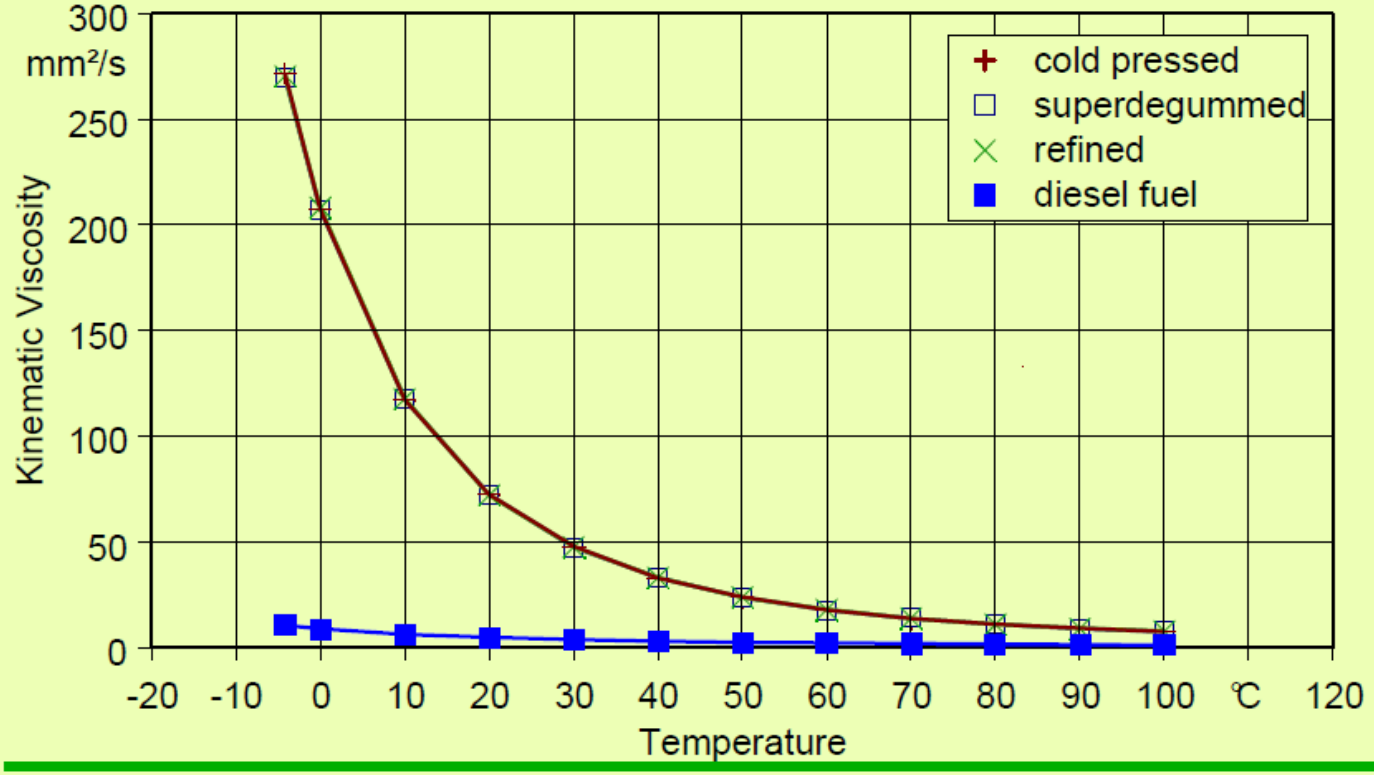
„Triglyceride“



Diesel Fuel

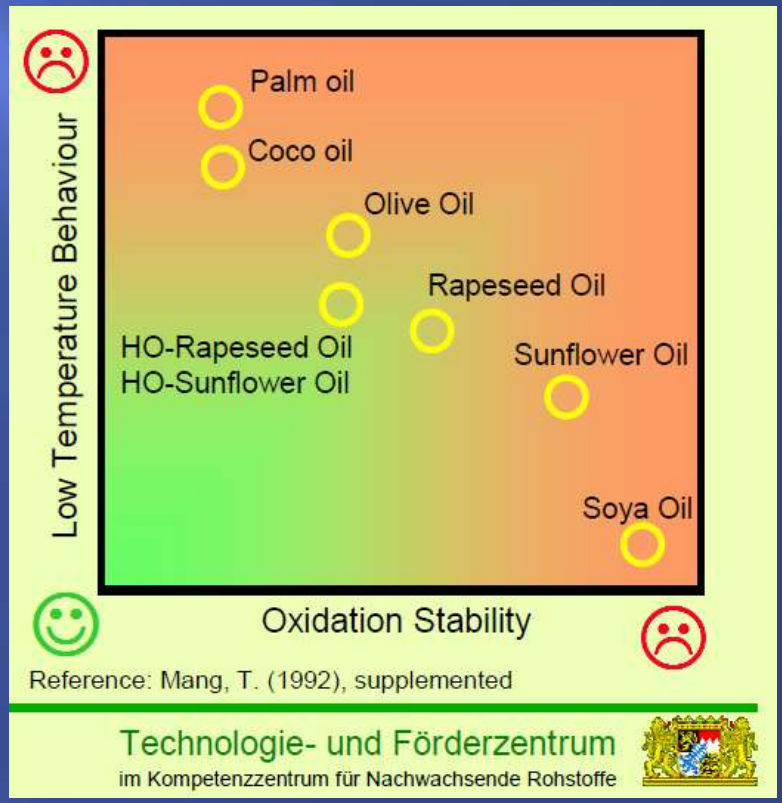
„Hydrocarbon Chains“





Types of vegetable oils (per Elsbett)

Canola or rapeseed….. Ok
Sunflower….. Ok if degummed
Soybean….. Not ok



Straight Vegetable Oil Tractors

- 2 new pieces of equipment running SVO
- Explored long term effects (up to 2000 hours) of SVO fuel

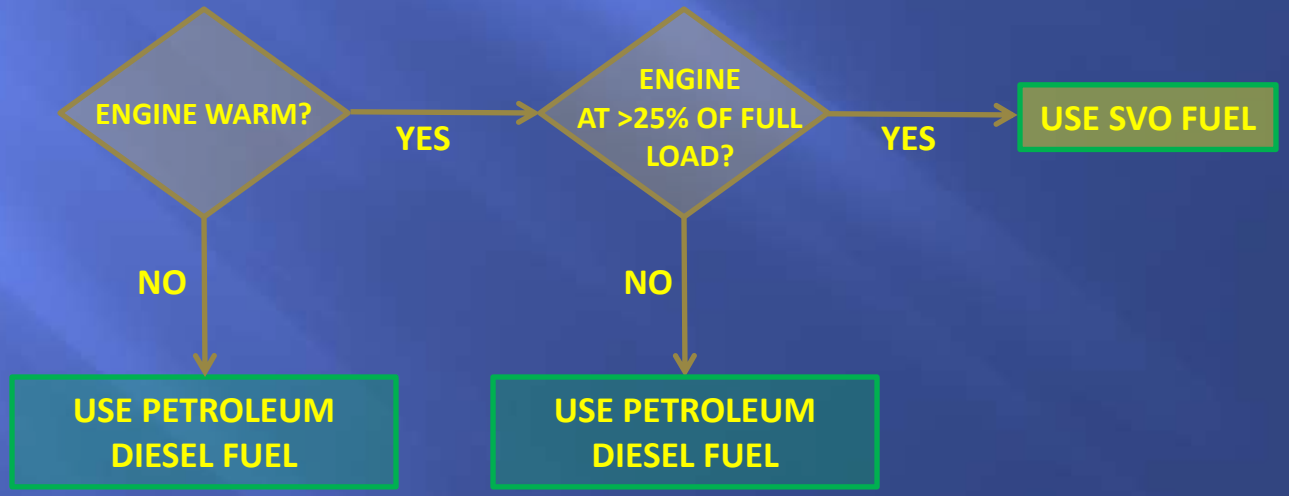
Fuel type (diesel or SVO) criteria

Sensors

Engine coolant temperature sensor

Exhaust temperature sensor

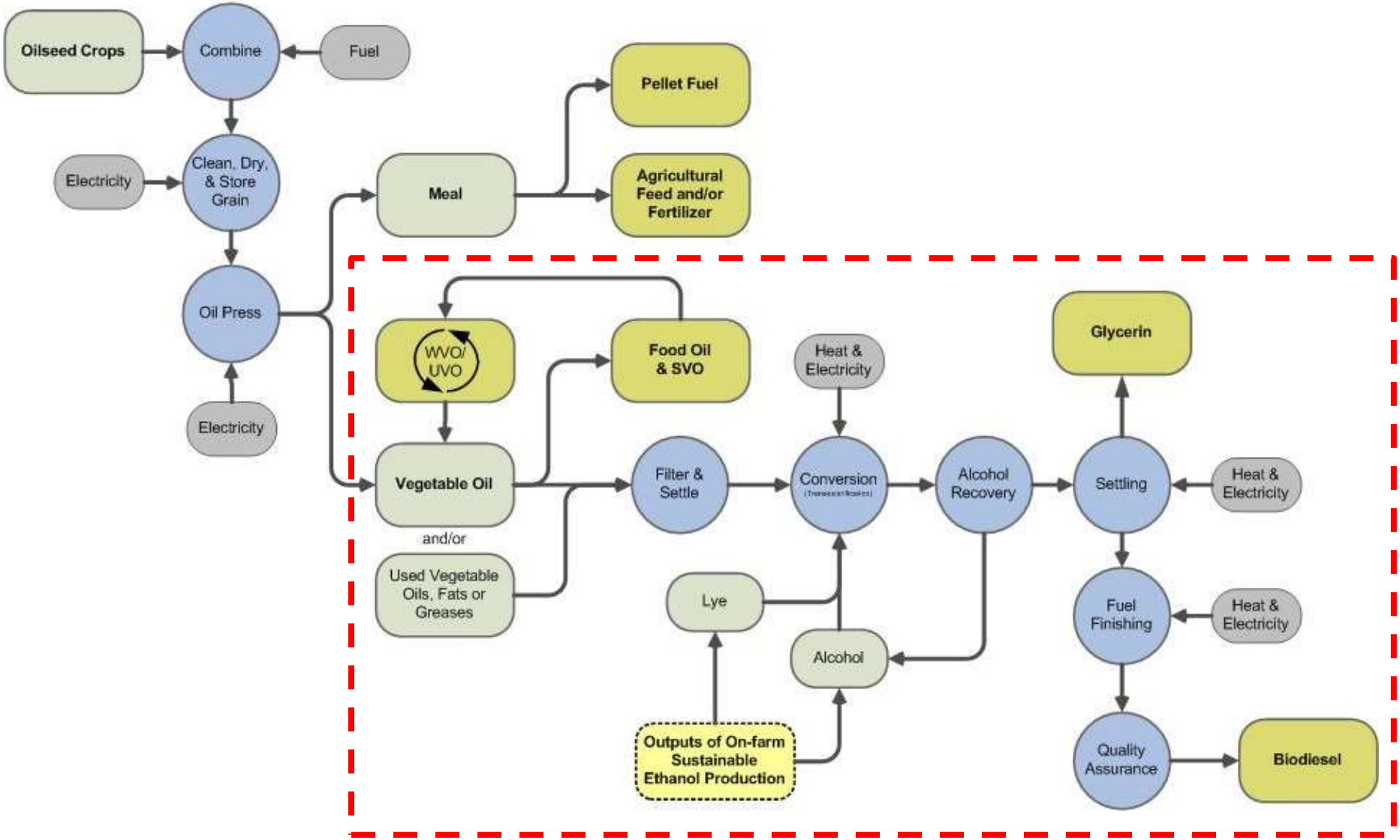
Fuel switching logic



Overall SVO vs. Petro-diesel usage at Penn State

	NH T7060 (1370 hours)	Case 621E (1118 hours)
% SVO used of total fuel use	85%	53%
Total SVO used	3428 gallons	796 gallons
Total diesel used	628 gallons	701 gallons

On-Farm Biodiesel Production



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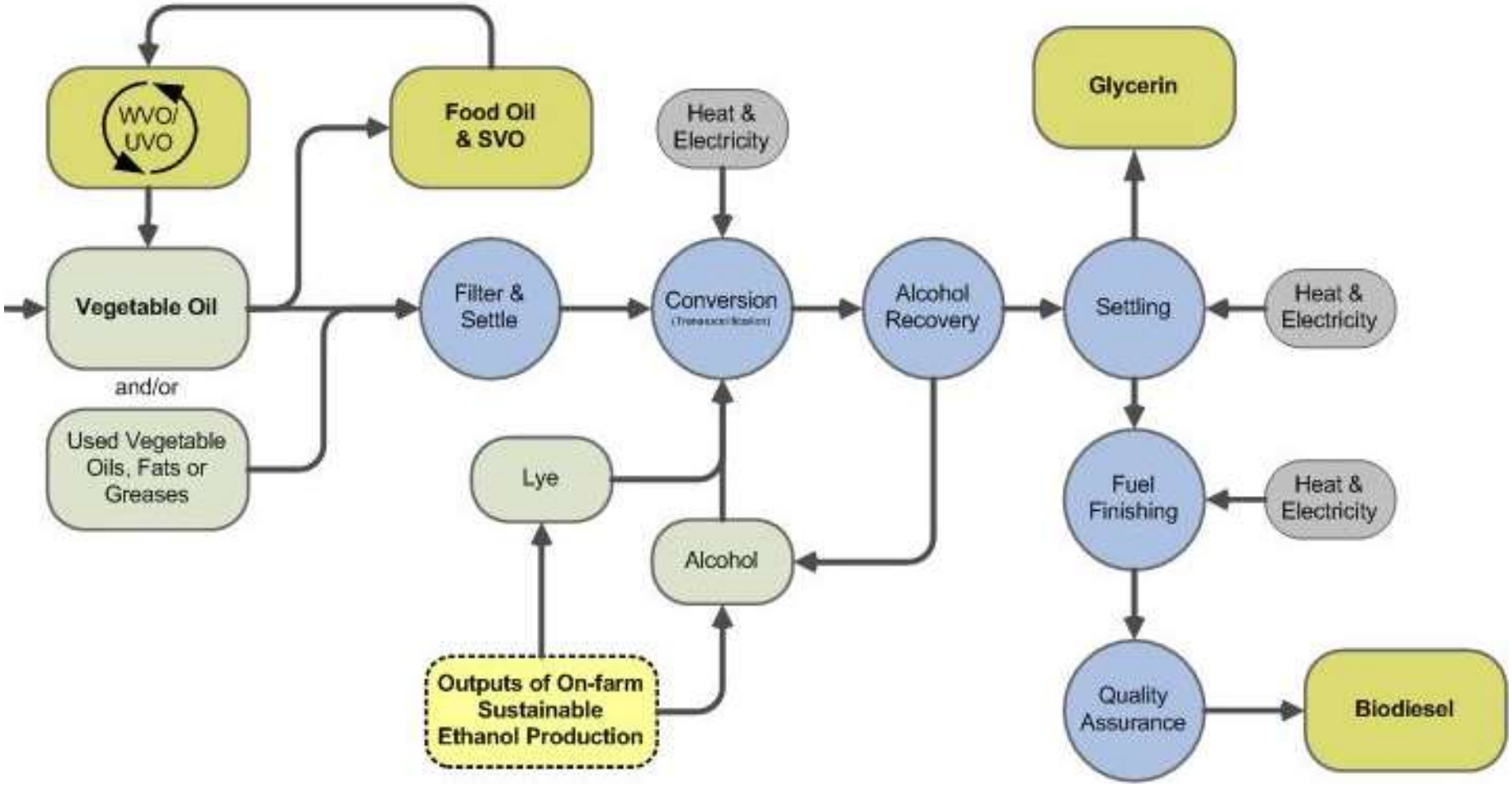
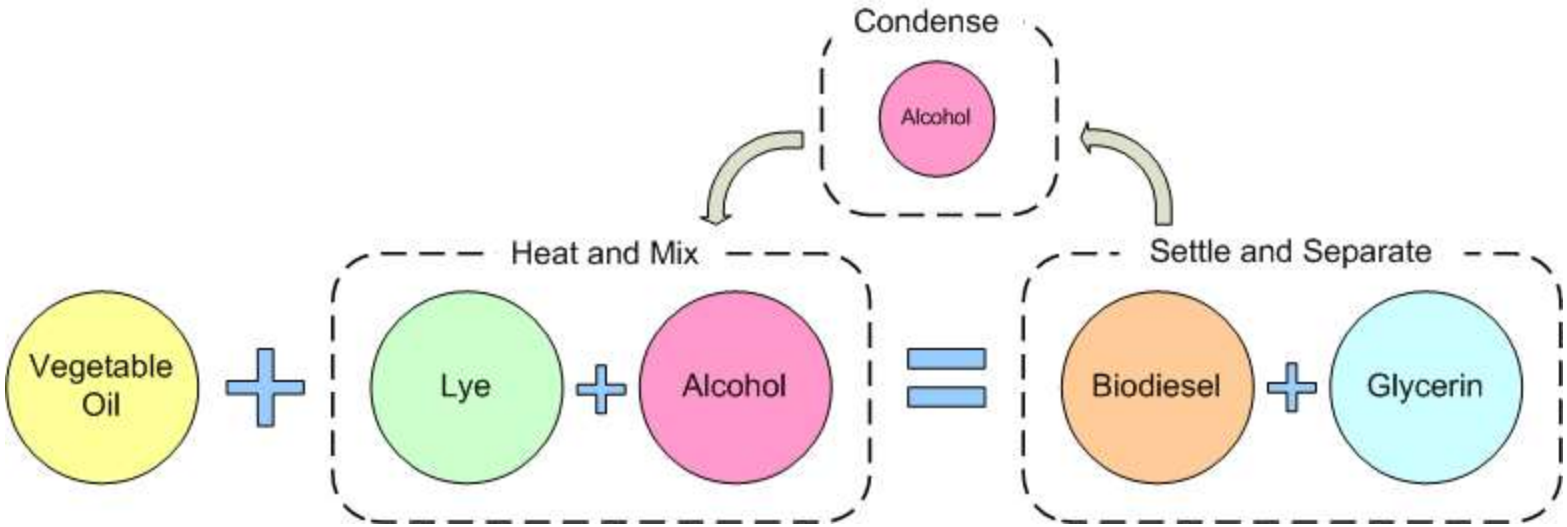


Making Biodiesel
Transesterification
Single Stage Base Method



State Line Farm

John Williamson - Shaftsbury, VT

Maple Sugar & Honey
formerly a Dairy Farm

Oil Seeds since 2005

Operate at 2k gal/yr with ~300k gal/yr capacity

’65 Massey-Harris SP35 at work

Biodiesel Samples, “Just like at the sugar house.”

Moisture tester

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

State Line Farm

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Maple Sugar & Honey
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Oil Seeds since 2005

Operate at 2k gal/yr with ~300k gal/yr capacity


Biodiesel processor


Taby Press


XP Pump

Borderview Farm

Roger Rainville - Alburgh, VT

Crop Research Farm
formerly a Dairy Farm

Oil Seeds since 2005

Establishing ~150k gal/yr capacity


Presscake


Research combine


Roger and his sunflowers


New grain dryer and storage bin.
Biodiesel barn behind


Meal pellet press


Oil press

Borderview Farm

Roger Rainville - Alburgh, VT

Crop Research Farm
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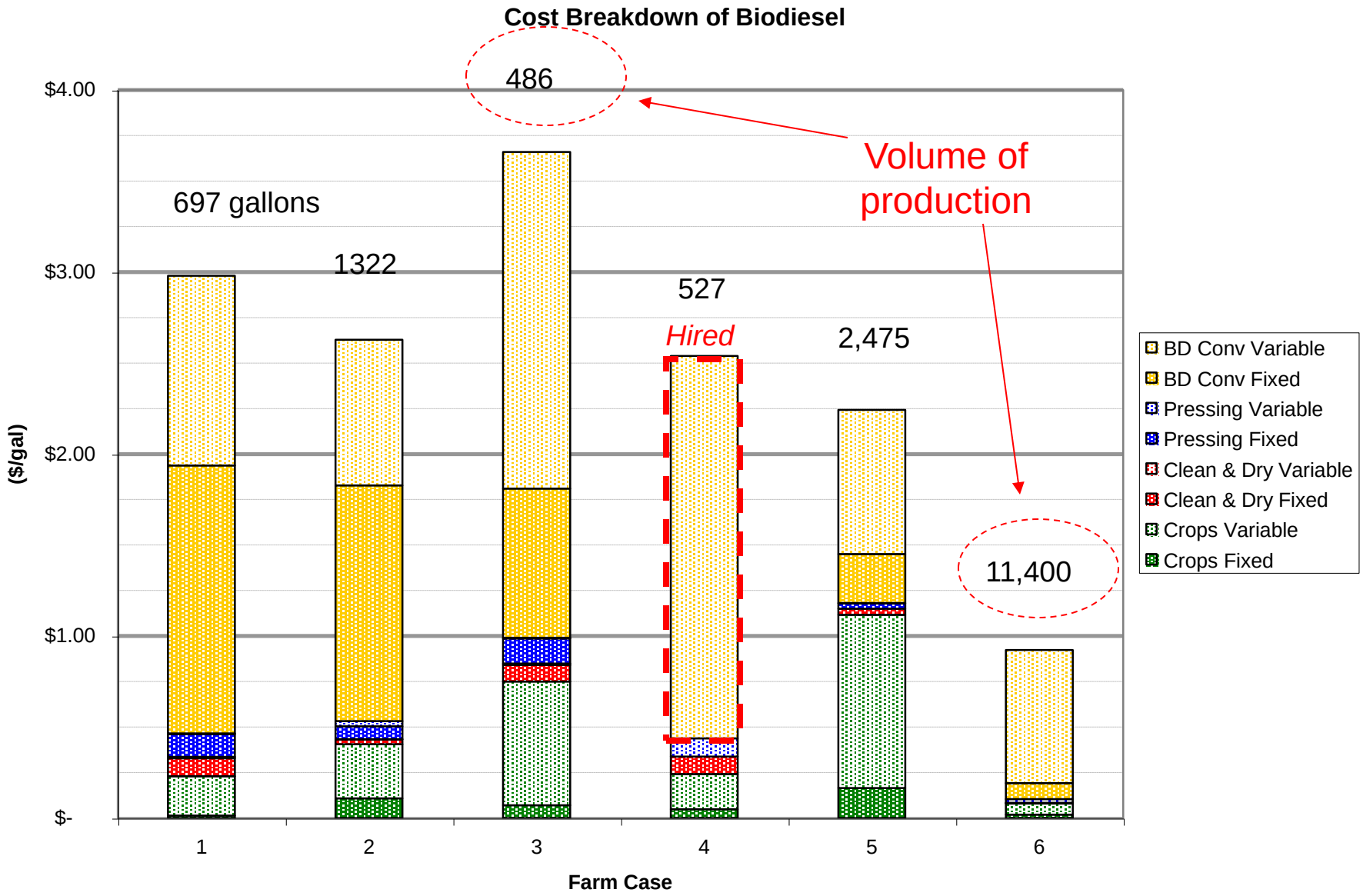
Oil Seeds since 2005

Establishing ~150k gal/yr capacity



Assumes conversion of all oil to biodiesel (projected in some cases)

Biodiesel Variable Costs = Chemical costs

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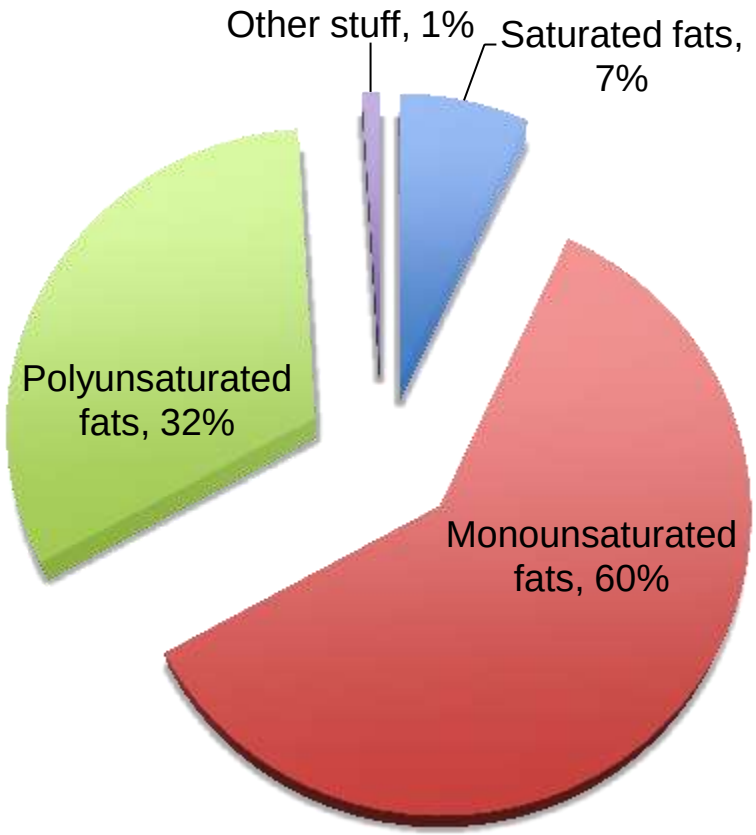
Another use for pressed oil:

Culinary or edible oils!

Source: Brett Jordan, Flickr Creative Commons, Jan 9, 2012

What's in canola oil?

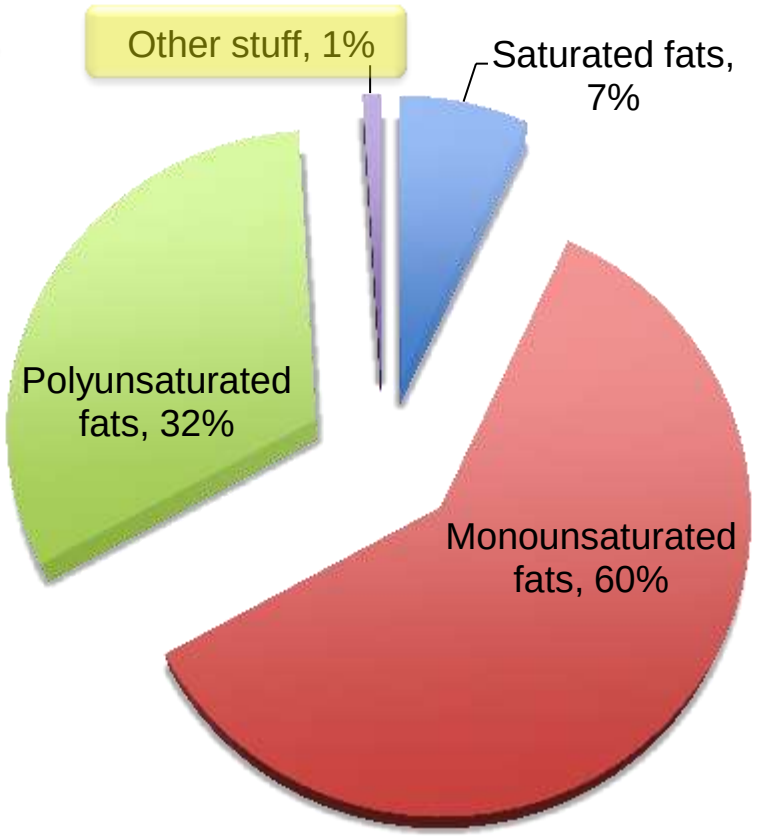


in other words, 99% triglycerides and 1% "other stuff"

F.D. Gunstone. Rapeseed and Canola Oil. CRC Press. 2004

Why refine?

to get rid of this
“other stuff”



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Minor components (<1%) in canola

Antioxidants

- Tocopherols (vitamin E)
- Carotenoids (xanthophylls, lutein)

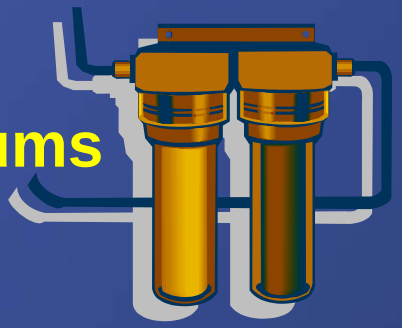
Pro-Oxidants

- Water
- Transition metals (Fe, Cu)
- Polar lipids
- Chlorophyll (chlorophyll a, chlorophyll b)

Ways to Slow the Road to Rancidity

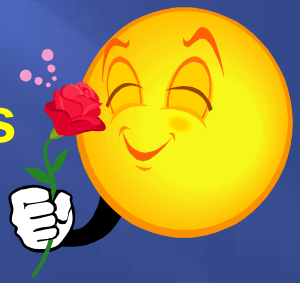
1. Get rid of unsaturated fat portion
   - Hydrogenated oils (e.g., soybean oil to margarine) - make liquid oils into hard fats; therefore more stable
2. Prevent or scavenge free radicals
   - Use antioxidants to bind
   - Prevent exposure to light (UV)
   - Avoid high temperatures
3. Limit exposure to oxygen
   - Minimize air (oxygen) exposure
   - Replace air (oxygen) with inert gases (N_2, CO_2, Ar)

Commercial oils are RBD:

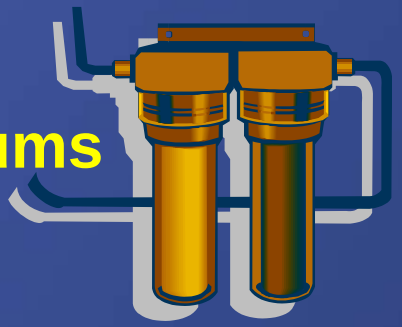


- Refined – removes particulates and gums

- Bleached – removes colorants 

- Deodorized – removes odors 

Commercial oils are RBD:



- Refined – removes particulates and gums

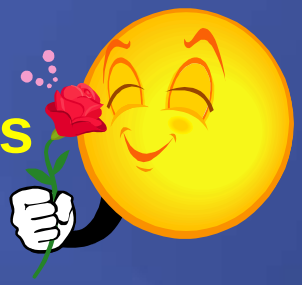
Covered in filtration earlier

Commercial oils are RBD:

- Bleached – removes colorants

Commercial oils are RBD:

- Deodorized – removes odors



Not commonly or easily done on a small scale

Steam bubbled through oil under vacuum

Source of information for small-scale oilseed processing

http://www.uvm.edu/extension/cropsoil/oilseeds

Fact sheets on oilseed pressing, filtering, storage, processing regulations

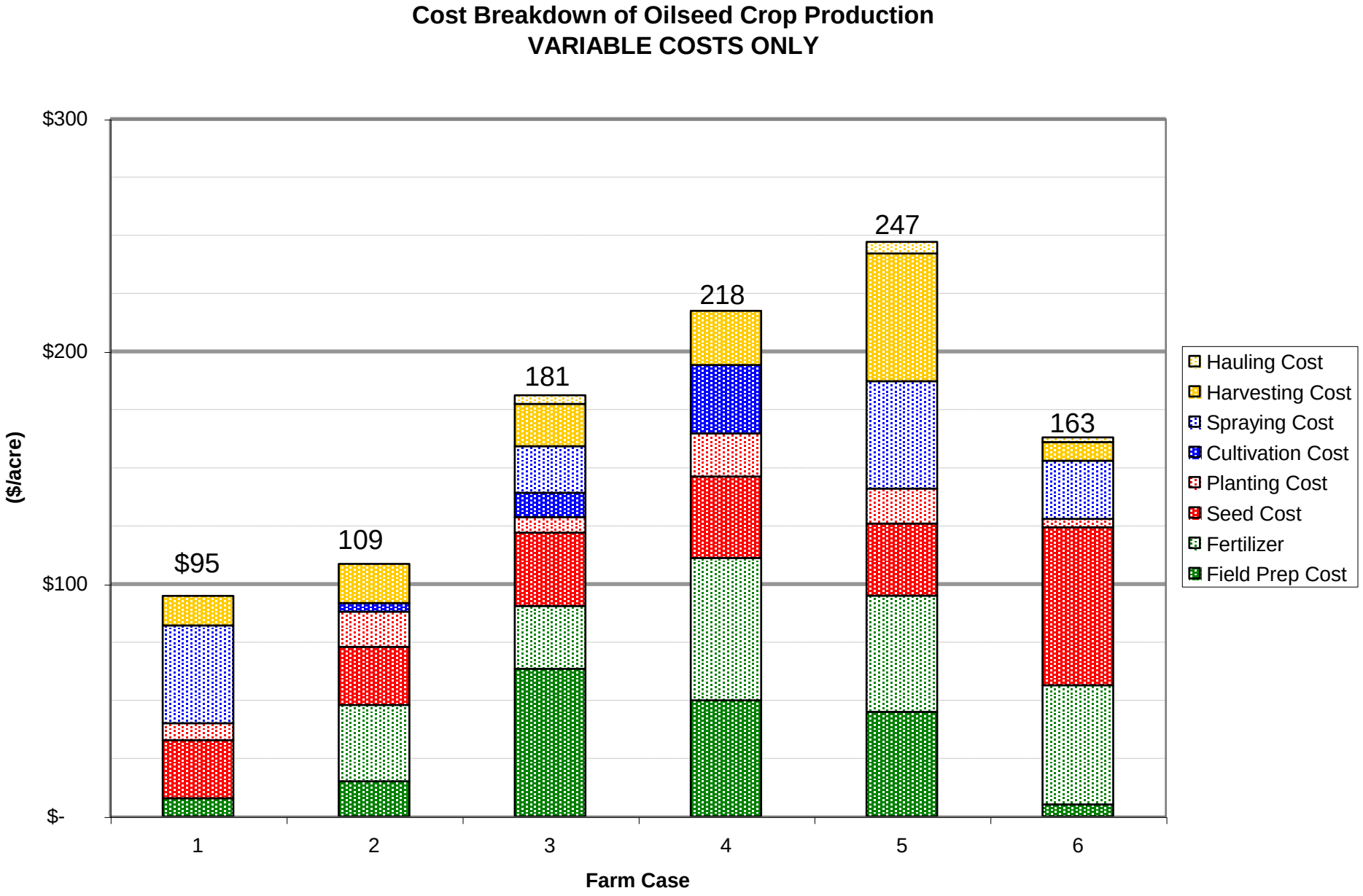
Comparison information for small oilseed presses

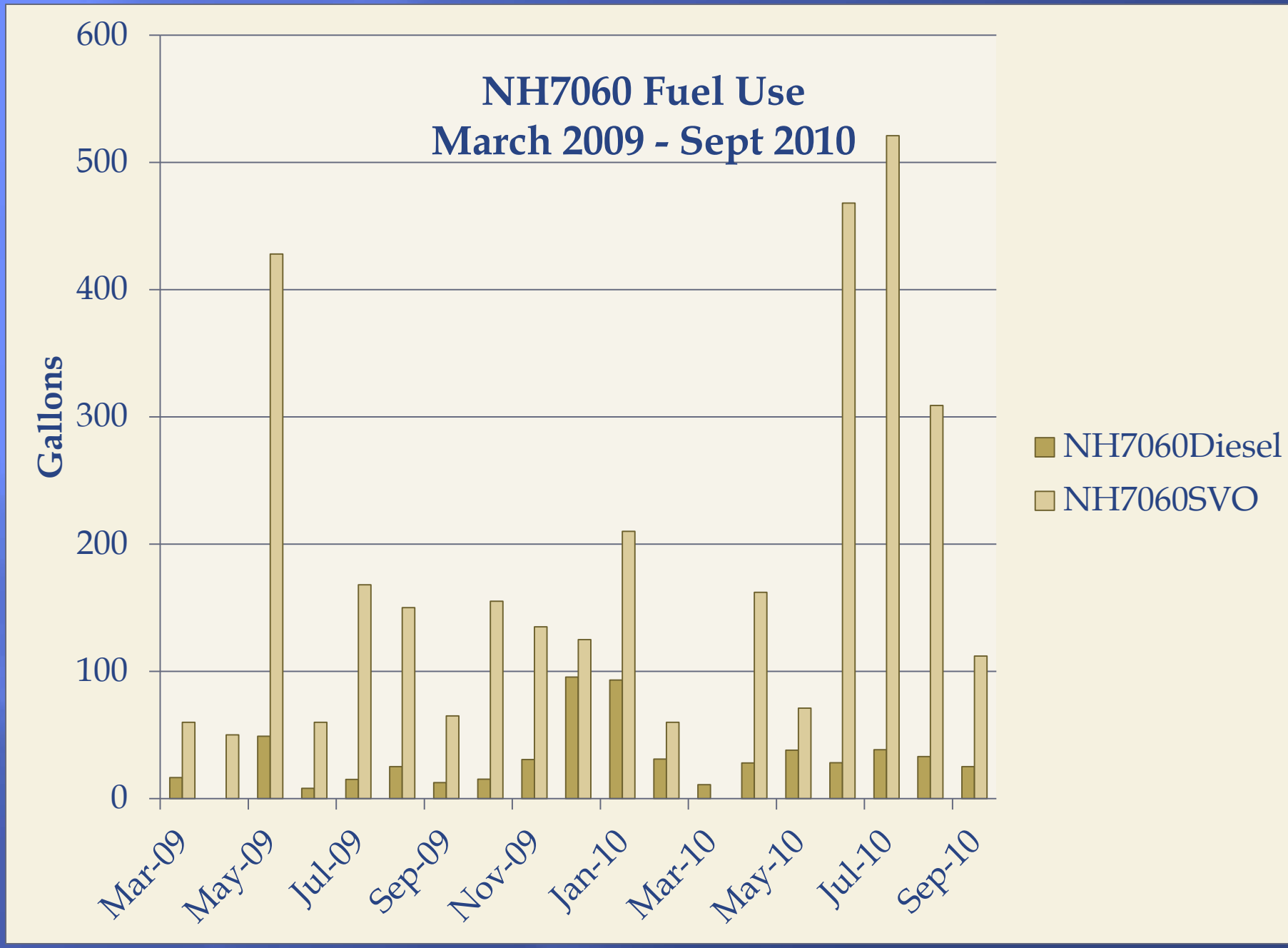
Presentations from current and past oilseed conferences

Yield results from oilseed crop field trials

Articles looking at various aspects of oilseed growth and use

Backup Slides


Cost Breakdown of Oilseed Crop Production
VARIABLE COSTS ONLY
$300
$200
$100
$-
($/acre)
$95
109
181
218
247
163
1
2
3
4
5
6
Farm Case
Hauling Cost
Harvesting Cost
Spraying Cost
Cultivation Cost
Planting Cost
Seed Cost
Fertilizer
Field Prep Cost


NH7060 Fuel Use
March 2009 - Sept 2010
Gallons
600
500
400
300
200
100
0
Mar-09
May-09
Jul-09
Sep-09
Nov-09
Jan-10
Mar-10
May-10
Jul-10
Sep-10
NH7060Diesel
NH7060SVO

NH 7060: Power vs. RPM for Diesel and SVO
December, 2011