E3A: Biodiesel Applications for the Home, Farm, or Ranch

Author: Schumacher, Joel; Sarah Hamlen, Mike Vogel, and Milton Geiger, eds. E3A Program


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Steps in the Biodiesel Series

1. Consumer Issues
2. Oilseed Processing
3. Production
4. Economics

Examining Biodiesel & Biodiesel Production for Personal Use

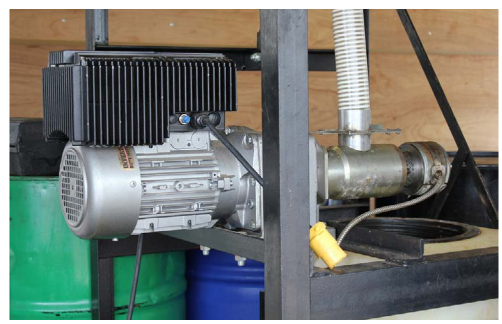
This series of factsheets examine biodiesel from oilseed processing, to biodiesel conversion, consumer issues and economics. The series is organized into the following four areas:

Consumer Issues

Biodiesel is a fuel produced by combining vegetable oil (or animal fat), alcohol and a catalyst through a process referred to as transesterification. Biodiesel can be used in most diesel engines without any modifications.

Oilseed Processing

Biodiesel is primarily created from vegetable oil, either new oil or recycled oil. The section explores oilseed processing technology and provides a framework for estimating the amount of oilseed feedstock needed to produce a given amount of biodiesel. This section also discusses oilseed meal which is an important co-product of oilseed processing.


Oilseed press
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Biodiesel Production

The vegetable oil secured in step 2 must now be converted to biodiesel. This section explores the key consideration for biodiesel production. Required equipment, inputs (oil, alcohol and catalyst), and fuel quality issues are presented.

Economics of Oilseed Processing & Biodiesel Production

Once the uses for biodiesel and the process to produce it are understood, then economics can be examined. This section focuses on understanding the capital equipment and operating costs for a biodiesel producer. This will help potential producers create an accurate assessment of the labor requirements, capital investment and operating costs for producing biodiesel.

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STEP 1

E3A: Biodiesel Applications for the Home, Farm, or Ranch

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CONSUMER ISSUES

Consumers are constantly in search of the best value for each product they purchase. This is especially relevant when prices of products are rising. In recent years, diesel fuel prices have risen, fallen, and risen again. Changing prices have encouraged consumers to examine diesel fuel purchases. Consumers can reduce their petroleum diesel use by driving less, purchasing a more fuel efficient vehicle or by purchasing an alternative fuel such as biodiesel. Each option has advantages and disadvantages. This article will explore the basics of biodiesel.

What is biodiesel?

Biodiesel is a fuel produced in a chemical reaction between a vegetable oil or an animal fat, an alcohol and a catalyst. One of the advantages of biodiesel is that in most cases, biodiesel can be used in a standard diesel engine. Consumers can switch between diesel and biodiesel at any time.

Is vegetable oil the same as biodiesel?

Biodiesel and vegetable oil are not the same product. Although vegetable oil is the main ingredient in most biodiesel, the vegetable oil must undergo a chemical reaction (transesterification) with alcohol and a catalyst before it can be considered biodiesel. Vegetable oil that has not been reacted with an alcohol and a catalyst is commonly referred to as waste vegetable oil (WVO), straight vegetable oil (SVO) or virgin oil.

Waste vegetable oil for biodiesel
Photo by Richard Wiswall, Cate Farm, Plainfield, VT
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Are engine modifications required to use biodiesel?

Biodiesel can degrade some natural rubber compounds that are used in fuel lines on older diesel engines (pre-1993). If you intend to use high blends of biodiesel (B20 or above) on a regular basis in an older vehicle then you may need to replace the fuel lines with synthetic fuel lines. Some seals are also made of natural rubber compounds and may need to be replaced. Most newer vehicles utilize synthetic fuel lines and gaskets so modifications are generally not required.

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A biodiesel heavy-duty vehicle in the City of Boulder fleet.
Photo by Pat Corkery NREL 18086
http://images.nrel.gov/viewphoto.php?imageId=6324736

Will biodiesel damage my engine?

Biodiesel that meets the appropriate fuel quality standards is unlikely to cause damage to a diesel engine. The fuel quality standards for biodiesel are defined by the American Society for Testing and Materials (ASTM) in standard "ASTM D6751." This standard includes acceptable levels for water and sediment, sulfur, free and total glycerin, flashpoint, cetane number and other specifications. Petroleum diesel fuel is also required to meet fuel quality standards. These standards are defined in "ASTM D975-05." Biodiesel produced for personal use is often not tested against these fuel standards. The quality of the biodiesel may vary depending on the quality control measures of the biodiesel producer.

Will using biodiesel void my engine manufacturer's warranty?

Engine manufacturers typically only warranty the engine for defects in "material and workmanship." Engine manufacturers also recommend the type of fuel the engine is designed to use. Any engine damage caused by fuel (of any type) is generally not the responsibility of the engine manufacturer. Many engine manufacturers have issued statements about their recommendations for biodiesel use. Some of these statements are available at: www.biodiesel.org/resources/oems.

What does B2, B5, B20 or B100 mean?

Biodiesel is usually blended with petroleum diesel before it is sold. Biodiesel is commonly sold as 2%, 5%, 20% or 50% blends with petroleum diesel. A fuel sold as B5 will contain 5% biodiesel and 95% petroleum diesel. A fuel sold as B20 will contain 20% biodiesel and 80% petroleum diesel. Biodiesel that is not blended with petroleum diesel is referred to as B100, neat biodiesel or pure biodiesel.

How much energy does biodiesel contain?

Biodiesel contains 118,296 BTUs per gallon. This is approximately 8% less than the 129,000 BTUs per gallon for Number 2 Petroleum Diesel. More information on energy content is available at: www.biodiesel.org/pdf_files/fuelfactsheets/BTU_Content_Final_Oct2005.pdf

Where can I buy biodiesel?

Biodiesel is not available at most retail fuel locations. The National Biodiesel Board maintains a list of biodiesel retailers across the country. This list is available at: www.biodiesel.org/buyingbiodiesel/retailfuelingsites.

Will biodiesel work in the winter?

Biodiesel has a higher cloud point and pour point than petroleum diesel. This means that biodiesel is more likely to gel in the winter than diesel fuel. Cold weather properties of biodiesel vary depending on the type of oil or animal fat that was used to produce the biodiesel. Most biodiesel is produced from soy oil. Soy oil based biodiesel (B100) has a pour point of approximately 32 degrees Fahrenheit while number 2 diesel fuel has a pour point of approximately negative 16 to 18 degrees Fahrenheit. Biodiesel produced from other feed stocks (such as canola or palm oil) will have different cold weather performance than soy based biodiesel. Additional information on cold flow properties can be found at: www.biodiesel.org or http://biodieseleducation.org/Home/index.html.

Do fuel taxes apply to biodiesel?

Yes, biodiesel is taxed liked petroleum diesel fuel. Biodiesel purchased at a retail station will have the taxes already included in the price. Biodiesel producers (even small producers) need to register with the state of Montana and pay the applicable fuel taxes. Biodiesel for off road use is eligible for a refund of a portion of the fuel taxes paid, similar to dyed diesel fuel.

Is biodiesel cheaper than diesel?

Commercially produced biodiesel tends be more expensive than diesel fuel. The price premium relative to diesel fuel varies over time but has ranged from $0.11 to $1.17 per gallon in recent years based on data from the Clean Cities Alternative Fuel Price Reports. The average price premium has been $0.58 per gallon. Small scale personal biodiesel producers that have access to free or low cost used vegetable oil can sometimes produce biodiesel for less than the price of diesel fuel.

Is biodiesel good for the environment?

In general, yes but it depends on a number of factors. Depending on which environmental attributes are measured and how you are measuring these attributes makes a significant difference in calculation of environmental benefits. It also depends on factors like the feed stock (soybean oil, palm oil, animal fat, etc.) that was used in the production of the biodiesel. For more information visit: http://biodieseleducation.org/Home/index.html

Where can I find out more information about biodiesel?

Continue reading the factsheets in this series or visit the eXtension Farm Energy Biodiesel webpage at: www.extension.org/pages/28783/farm-energy-biodiesel-table-of-contents

Photo by the United Soybean Board, CC BY 2.0 https://www.flickr.com/photos/unitedsoybean/albums/72157635284063701

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STEP 2

Steps in the Biodiesel Series

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OILSEED PROCESSING

In 2010, the most commonly produced oilseeds in Montana were; canola (17,500 acres), safflower (28,000 acres), flax (15,000 acres), camelina (9,900 acres) and mustard (16,500 acres).[1] Montana farmers also raise a small number of acres of other oilseed crops such as sunflower and soybeans. In other parts of the country, cotton seed, peanuts and other crops are processed for oils.

How much oil is produced per acre?

The amount of oil produced per acre depends on crop yield, oil content of the seed and processing efficiency. Common oilseed crops in Montana have average yields between 650 and 1,650 pounds per acre. (see Table)

Montana Oilseed Production		
Crop	Average Yield	
Canola	1,623	lbs./acre
Flax Seed	714	lbs./acre
Safflower	768	lbs./acre
Mustard	645	lbs./acre
Camelina	698	lbs./acre

USDA NASS Data: 2007 to 2010

Oil content is another key factor in calculating oil production per acre. Different oilseed crops have different levels of oil in the seed. Soybeans for example contain about 18% oil. Flax, Safflower, Canola and Camelina typically have oil content levels from 30 to 42%. Mustard seeds typically contain 25 to 30% oil. Only a portion of the oil in a raw oilseed can be extracted. Mechanical extrusion is capable of recovering 65 to 80% of the oil in a raw oilseed, while solvent extraction can recover over 95% of the oil. To estimate the recoverable oil per acre of an oilseed crop follow this formula:

Yield (lbs.) x Oil Content (%) x Recovery Rate (%) = lbs. of oil per acre

Example: 1 acre of camelina yielding 698 pounds with 35% oil content processed with mechanical extraction technology with a 75% recovery rate would result in 183 pounds of oil (698 x 0.35 x 0.75 = 183). A gallon of vegetable oil weighs approximately 7.5 pounds (this varies depending on the type of vegetable oil). By dividing 183 by 7.5 we can estimate that 698 pounds of camelina seed will produce approximately 24 gallons of oil.

Oilseed Processing Methods

Two types of processes are used to separate oil from an oilseed. The first process is mechanical extrusion, in which the seed is mechanically pressed, allowing the oil to be separated from the meal. The second process is solvent extraction, which is often used in conjunction with some form of mechanical extrusion. The solvent extraction

1 Acreage information was obtained from the National Agricultural Statistics Service.

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process applies a solvent solution to material that has been pre-pressed. The solvent bonds to oil in the pre-pressed material and an oil laden solvent solution is then separated and further processed to separate the oil from the solvent. Mechanical extrusion typically recovers between 65 and 80% of the oil contained in a seed. Solvent extraction recovers over 95% of the oil contained in a seed. Solvent processes are generally only used in plants with daily processing capacities of over 200 tons per day.

Mechanical Processing Technology

Oilseed processing equipment with a capacity of less than 50 tons per day typically employs a mechanical extraction process to separate the oil from an oilseed. Mechanical extraction processes apply pressure to separate oil from the meal in an oilseed. A common method for applying mechanical pressure is through a screw press.

Mechanical extraction processes have two main elements. The first is seed preparation. Seed preparation methods vary depending on seed characteristics. For example, seed preparation for canola often is limited to seed cleaning while other oilseeds may need to be cleaned, de-hulled, cracked, rolled, and/or flaked. Additional equipment may be required to complete seed preparation. A producer should identify the oilseeds that they are likely to process in order to determine exactly what equipment will be needed.

The second element is the removal of oil from the oilseed. In a screw press operation, seed is fed from a hopper into the screw press, which uses pressure to force oil contained in an oilseed through small openings in the side of the press. Meal that is too large to exit through the small openings is extruded through larger openings at the end of the press. Screw presses are capable of removing approximately 65 to 75% of the oil contained in an oilseed. Some mechanical presses preheat seed as it enters the press. Preheating may increase oil recovery rates up to 80%. Alternatively, if seed is processed at low temperatures (for example, below freezing) oil recovery rates may be less than 60%. Actual recovery rates will depend on press quality, press operation, seed quality, seed type and seed temperature.

Matthewsr2000 at English Wikipedia CC BY-SA 3.0 http://www.gnu.org/copyleft/fdl.html)], via Wikimedia Commons

Capital Costs

Equipment retailers may include various accessories with the basic processing equipment. It is important to consider exactly what equipment is included when comparing offers. The following is a list of basic equipment used for oilseed processing.

- Seed Preparation Equipment
- Mechanical Extractor
- Power Source for the Extractor
- Seed Storage Bin(s)
- Meal Storage Bin(s)
- Pumps, Filters and Plumbing for Oil Storage
- Oil Storage Tank(s)

Required seed preparation equipment varies, depending on the oilseed to be processed. For some oilseeds (for example, canola) very little seed preparation equipment is required. For other oilseeds, (for example, sunflower) additional equipment is required to remove hulls. Equipment manufacturers and retailers can assist producers in determining equipment requirements for a particular oilseed.

One of the largest capital expenditures for a small scale oilseed processor is the mechanical extraction press. These presses may be sold either with or without a power source. Small scale oilseed processing equipment is often sold without seed storage bins, meal collection bins, and oil storage tanks. Some buyers may utilize bins and tanks they already own to reduce their capital costs. However, some retailers offer complete systems that include a press, tanks, bins and a power source.

Installation, delivery and set up costs should also be considered. Shipping costs can be substantial because of the size and weight of presses, bins, and tanks. Purchasing bins and tanks from a local supplier may reduce shipping costs. Oil needs to be stored and filtered as part of the process, pipes, valves, tanks, pumps and filters may have to be installed for storage purposes.

Most oilseed processing equipment is electrically powered. Installation may require modifying or upgrading a buyer's current electrical system to accommodate the new equipment. Installation costs are sometimes overlooked but they can be an important consideration.

Operating Costs

Operating costs vary widely among different sizes and brands of processing equipment. Labor costs are one important source of these differences. Some presses are designed to operate without direct supervision. When direct supervision is not required, a press can be operated for hours without substantial labor requirements. Other presses require approximately 5 minutes of labor per hour for monitoring and other purposes when the press is operating. Although this may seem like a small amount of time, it requires the operator to remain relatively close to the press during its operation. Another consideration is the output per unit of labor input. For example, a 2-ton press requires essentially the same labor as a 5-ton press. This implies that on a per ton basis, labor costs for the 2-ton press would be 250% higher than for the 5-ton press.

Processor Capacity

Commercially available mechanical processors have daily processing capacities ranging from less than one ton to over 50 tons. Several important issues should be evaluated when determining the correct processing capacity for an operation. The capacity of the processor and the hours of operation determine the amount of seed that can be processed. Commercial plants often operate 24 hours per day for over 300 days each year, but smaller processors may operate for less than 12 hours per day and only a few months each year. Table 1 presents estimated annual processing volumes for three processors with different capacities, assuming that each is operated 24 hours a day for 320 days each year. Table 2 presents estimated processing volumes for the same three processors under the assumption that each is operated 12 hours per day for 120 days each year. These tables also provide estimates of the quantities of products produced by each processor.

Table 1: Estimated Annual Plant Output
Operating 24 hours per day, 320 days each year

Processor Daily Capacity	2 Tons	5 Tons	30 Tons
Operating Days Per Year	320	320	320
Operating Hours Per Day	24	24	24
Oil Content of Feed Stock	35%	35%	35%
Oil Recovery Rate	75%	75%	75%
Annual Seed Requirement (Short Tons)	640	1,600	9,600
Annual Oil Production (Gallons)	44,800	112,000	672,000
Annual Meal Production (Short Tons)	427	1,068	6,408

Table 2: Estimated Annual Plant Output
Operating 12 hours per day, 120 days each year.

Processor Daily Capacity	2 Tons	5 Tons	30 Tons
Operating Days Per Year	120	120	120
Operating Hours Per Day	12	12	12
Oil Content of Feed Stock	35%	35%	35%
Oil Recovery Rate	75%	75%	75%
Annual Seed Requirement (Short Tons)	120	300	1,800
Annual Oil Production (Gallons)	8,400	21,000	126,000
Annual Meal Production (Short Tons)	80	200	1,202

Availability of Feed Stock

An important issue for small scale oilseed processing operations is the required volume of feed stock. Farm based processors may be able to produce all or a significant portion of their feed stock requirements. Larger processing facilities will need to purchase most or all of their feed stock from other sources. Estimating on-farm oilseed production and the commercial availability of oilseeds in the region is a critical step in the planning process.

Product Markets

Oilseed processing produces two products, oil and meal. Oilseed meal is generally used as a feed product for livestock. The oil has a variety of uses, including human consumption, biodiesel, bio-lubricants, cosmetics, and many other applications.

Meal comprises over 60% of the seed processed. Identifying markets or uses for the meal before processing large amounts of feed stock may prevent storage and disposal problems. The characteristics of an oilseed meal are determined by the oilseed processed and the oil content of the meal. The characteristics of the meal produced vary. Thus, consideration of available markets for each specific meal product is important. Establishing local markets for the meal and seed reduces transportation costs. If local markets for meal are only available seasonally, additional meal storage may be required.

Oil extracted from an oilseed has numerous potential uses. Human consumption markets for the oil are often niche markets that offer high prices, but only for limited quantities. The bio-fuel market usually demands higher quantities but offers lower prices. If the oil produced from an oilseed is to be used for human consumption, a producer's processing equipment must meet State of Montana health and safety standards. Information about wholesale food manufacturing standards and other related issues is available on the Montana Department of Health and Human Services Web site (www.dphhs.mt.gov). Oil produced for industrial uses, such as bio-energy or bio-lubricants, is not required to meet these standards.

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STEP 3

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Steps in the Biodiesel Series

BIODIESEL PRODUCTION

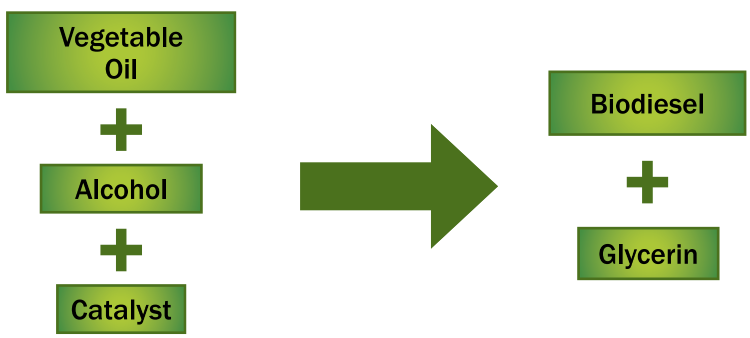
Biodiesel may be produced in small quantities for individual use or in larger quantities for commercial purposes. For smaller producers, biodiesel can be produced with readily available production equipment in batches of 15 to 400 gallons. Commercial scale production of biodiesel may utilize continuous flow production equipment with annual capacities in excess of one million gallons. The technical feasibility of producing biodiesel in both small and large quantities creates the potential for biodiesel to be produced in scales appropriate to feedstock availability and consumer demand.

Production Basics

Biodiesel is produced from a chemical reaction between a vegetable oil (or an animal fat), an alcohol, and a catalyst. Glycerin is produced as a byproduct during this process. Animal fats and vegetable oils are comprised primarily of triglyceride molecules. The reaction of the triglyceride molecules with an alcohol (typically methanol) in the presence of a catalyst is called transesterification. The transesterification process transforms vegetable oil, alcohol and a catalyst into biodiesel and glycerin. Common proportions required for this reaction are:

- Inputs: 100 units of vegetable oil;
  10 to 15 units of alcohol;
  0.5 to 2 units of catalyst
- Outputs: 100 units of biodiesel;
  10 to 15 units of glycerin

Transesterification Process



These proportions may be adjusted for differences in the chemical composition of the oils and fats to be processed, the type and purity of the alcohol used, and the technology employed to facilitate the reaction.

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Mobile Biodiesel Production
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Small Scale Production Process

Biodiesel production follows the same basic process, regardless of the quantity produced, although differences in inputs, equipment, and the desired quality attributes will determine the actual process used in any specific operation.[1] Biodiesel production is relatively simple; however, the simple nature of the process may tempt producers to overlook important process details.

Step 1: The production process begins with the pretreatment of virgin (new) oil or recycled oil. Recycled oil may need to be filtered to remove particles and dried to reduce water content. Virgin oil needs to be degummed during the pretreatment process.[2] Once the oil has been pretreated, a titration test is performed.[3] The results of the titration test are used to adjust the amount of catalyst required to successfully complete the transesterification process.

1 Some methods of producing biodiesel are not examined here. Those interested in a more detailed discussion of biodiesel production technology may want to read "Building a Successful Biodiesel Business" by Jon Van Gerpen, Rudy Pruszko, Davis Clements, Brent Shanks and Gerhard Knothe.

2 Degumming oil removes waxes, phosphates and other impurities in the oil.

3 A titration test measures several characteristics of the oil. Titration test results are used to adjust process parameters to ensure fuel of sufficiently high quality is produced.

Step 2: The next step is to mix a catalyst into an alcohol. If sodium hydroxide and methanol are used, the resulting mixture is referred to as sodium methoxide. The catalyst, alcohol, and mixture are all hazardous materials that should be properly handled. The catalyst and alcohol mixture is combined with oil to facilitate transesterification. In some cases the catalyst, oil, and alcohol are heated prior to, or during, or both prior to and during transesterification. Adding heat shortens the time required for processing and may increase the overall reaction rate.

Step 3: After the transesterification process is completed, the glycerin and biodiesel must be separated. Glycerin is heavier than biodiesel and settles to the bottom of a reaction vessel, allowing it to be separated from biodiesel. Larger production units may use a centrifuge to separate the two liquids (a centrifuge is more effective and quicker at separating the biodiesel and glycerin). At this point in the process, both the glycerin and biodiesel are contaminated with catalyst, alcohol, and oil that failed to react during the transesterification process. Soap generated during the process also contaminates the biodiesel and glycerin. Although glycerin tends to contain a higher percentage of contaminants, significant amounts of contaminants may also be present in the biodiesel.

Step 4: Removal of these contaminants is the final step in the production process. Excess alcohol is removed by heating biodiesel (or glycerin) to vaporize the alcohol. Commercial operations typically condense the alcohol back into liquid, which can be reused in the process. It is uncommon for small scale producers to recover the excess methanol. One method of removing contaminates from biodiesel is to wash the fuel with water.[4] Washing is accomplished by misting water over biodiesel or by bubbling water through it. The water droplets collect contaminates as they descend through the fuel. Finally, biodiesel is dried and filtered and the production process is complete.

Input Selection

Producers of biodiesel must decide what types of oil, catalyst, and alcohol they will use in their operation.

Oil Selection

The quality of oil used to produce biodiesel affects several aspects of the production process. If recycled oil is used, several additional steps are needed to ensure successful biodiesel production. First, the oil must be filtered to remove any solid contaminants such as bone and other food particles. Second, the oil's free fatty acid level and water content should be measured.

High free fatty acid content causes soap to be produced during transesterification. Water contained in the oil will also cause soap to be produced during processing. If water content is high, the oil may need to be dried before further processing. Virgin oils are unlikely to have high free fatty acid or water levels. However, virgin oils do need to be degummed before biodiesel production can occur. If virgin oils are purchased from a commercial processor, the oils have probably already been degummed. The consistency and low contamination levels of virgin oils make them ideal for biodiesel production, but typically they cost more than lower quality recycled oils.

A successful biodiesel producer has to obtain a reliable source of oil, regardless whether the oil is virgin or recycled. Recycled oils are usually obtained from local restaurants and food processors, often at a low cost.[5] Virgin oil can be obtained by processing oilseeds (such as canola, soybeans, safflower, camelina, flax, etc.) with small scale processing equipment or purchased from a commercial oilseed processing facility.

Alcohol Selection

Price and availability are key factors in determining which alcohol to use in the production process. Ethanol and methanol are the two most common options. High quality methanol is often cheaper and more readily available than non-denatured ethanol and, therefore, is used in nearly all biodiesel operations. Methanol can be obtained in quantities of 5 gallons or more from many bulk fuel distributors and from distributors of racing fuel. The price of methanol can vary substantially depending on the quantity purchased. The cost of methanol represents a relatively large component of total cost of producing biodiesel.[6] It also important to be aware of safety concerns when handling methanol or ethanol. Both are highly flammable and require careful handling to ensure a safe working environment.

Catalyst Selection

A catalyst is required to facilitate the reaction between the oil and the alcohol. The most common catalysts used in small scale biodiesel production are sodium hydroxide (lye) and potassium hydroxide. Catalysts such as sodium methoxide and potassium methoxide are also used. Availability and compatibility with processing equipment are the two main determinants of catalyst selection, although price is also a contributing factor.[7]

Equipment Selection

Small scale biodiesel production equipment can be purchased on a "ready-to-use" basis from numerous manufactures. Price, capacity and functionality are the main attributes with respect to "ready-to-use" processors. Here is a list of items to consider when comparing processors:

- How many gallons can be processed per batch?
- How long does each batch take to process?
- Is the system capable of heating the oil and/or the alcohol-catalyst mixture?
- Does the system include methanol recovery equipment?
- Does the system have the capability to wash and dry the biodiesel?
- Does the system require extra plumbing, fittings or pumps?
- Does the manufacture provide technical support?
- Does the system require that a specific catalyst be used?
- How much does the system cost?
- Does the quoted price of the system include shipping costs?

4 Washing and drying biodiesel improves fuel quality. However, some small scale producers choose to produce unwashed lower quality biodiesel for their personal use.

5 Permission should be obtained from the restaurant or food processor prior to collecting any used oil because they may already have an agreement in place for the disposal of their used oil.

6 The production of biodiesel requires between 10 to 20 gallons of methanol for each 100 gallons of biodiesel produced. If methanol is purchased for $2.00 per gallon, each gallon of biodiesel produced will contain $0.20 to $0.40 of methanol.

7 Many equipment manufacturers recommend catalysts appropriate for use with their specific equipment.

Final Products

The transesterification process produces two products, biodiesel and glycerin.

Biodiesel

Biodiesel quality depends on the inputs and processing techniques used in its production. The American Society for Testing and Materials (ASTM) has developed quality standards for biodiesel. Unfortunately for small scale producers, the cost of testing a batch of biodiesel is likely to exceed the value of the fuel produced. Fuel that has not been tested for ASTM standards generally cannot be marketed on a commercial basis. Most small scale producers will be limited to producing biodiesel for personal use.

Lack of ASTM testing does not necessarily imply that fuel quality is poor. Small scale producers must focus on accurate processing procedures to ensure fuel quality. These steps may include proper filtering, accurate catalyst measurement and fuel washing procedures.

Glycerin

Glycerin produced during the biodiesel process is crude and unrefined. Numerous markets are available for refined glycerin, but these markets are not generally available to small producers because of the cost of glycerin refining. Crude glycerin produced in small scale biodiesel operations typically contains unreacted oil, catalyst, methanol (if not recovered during processing) and some biodiesel. Glycerin and biodiesel are generally considered as environmentally friendly, but the catalyst and methanol contained in crude glycerin are not. Thus, a producer's alternatives for disposing of crude glycerin may be limited. One option is to use the crude glycerin as fuel oil. Another is to compost it. Large volumes of liquid glycerin are produced in the biodiesel process (10% to 15% of biodiesel production) and adequate planning is required for successful composting. Some biodiesel producers also use glycerin as a dust suppressant or for soap making.

Regulatory and Policy Issues

Biodiesel production is affected by two types of government policy. The first is regulatory policy. Local, state, and federal government agencies may require building and operating permits, licenses, and registration of different aspects of the biodiesel production process. Obtaining required permits and licenses is essential for successful biodiesel production. The second way in which government is involved is through tax and subsidy programs. State and federal agencies tax biodiesel but also offer incentives for biodiesel production.

- American Society of for Testing and Materials: www.astm.org
- University of Idaho's Bioenergy Website: http://www.uidaho.edu/engr/me/research/bioenergyresearchgroup

References

Van_Gerpen, J., R. Pruszko, D. Clements, B. Shanks and G. Knothe (2006). *Building a Successful Biodiesel Business.*

Notes

STEP 4

E3A: Biodiesel Applications for the Home, Farm, or Ranch

Author: Schumacher, Joel; Sarah Hamlen, Mike Vogel, and Milton Geiger, eds. E3A Program

Camelina pods
Photo: Ason de Koff, Tennessee State University. CC BY-NC 3.0 http://farmenergymedia.extension.org/

Steps in the Biodiesel Series

ECONOMICS

Biodiesel may be derived from oilseed feedstock (virgin oil) or recycled vegetable oil. In cases where oilseeds are used, it is important to understand the economic factors of oilseed processing and how they relate to the overall economics of biodiesel production.

Oilseed Processing Economics

The economics of an oilseed processing operation are substantially influenced by oilseed prices, vegetable oil revenues, oilseed meal revenues and labor costs.

Costs

Costs for an oilseed processing facility can be grouped into three general areas; 1) seed costs, 2) labor costs and 3) all other costs (equipment, maintenance and operating). Seed costs typically account for 80 to 90 percent of the total operating cost for an oilseed processor while labor costs account for 5 to 10 percent. Other costs including equipment, maintenance, and minor costs often account for less than 5 percent of total costs.

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Original available at: www.wyoextension.org/publications/

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Seed Costs

Oilseed processors have little control over commodity prices. In some cases, oilseed processors can utilize futures and options contracts to help manage the price risk associated with oilseed markets. Processors can also contract directly with growers to ensure a local supply and a fixed price. These contracts are typically one growing season in length. The short duration make it difficult to ensure a local supply of seed over longer periods of time. Oilseed processors may also choose to be a buyer in the cash market, which allows processors to purchase seed when it is profitable but does not require them to purchase seed. However, the cash market does not guarantee an available supply of oilseed feedstock. Most oilseed processors employ a combination of these tools to secure oilseed feedstock for processing. Historical oilseed prices can be obtained from the USDA National Agricultural Statistics Service. Montana specific prices are available at: www.nass.usda.gov/Statistics_by_State/Montana/Publications/croptoc.htm.

Labor Costs

Labor costs for small to medium scale oilseed processors involve two key issues. The first is that one employee can operate a 1 ton press or a 15 ton press. Increasing the size of the press doesn't change the amount of labor that is required to operate a press by a substantial amount. This fact is critically important to understanding the role of labor costs in oilseed processing. One hour of a worker's time utilizing a 5 ton per day press will result in about 0.21 tons of processed seed. The same worker with a 10 ton per day press can process 0.42 tons. The larger press reduces the labor cost by 50 percent. Purchasing a press that is sized appropriately can help ensure the best overall value.

The second key issue is the cost of labor. Nearly all commercial oilseed operations have employees. The company can easily determine the cost (per hour) of hiring an employee and utilize this cost in helping to determine the appropriate size of press to purchase (spending more money on a larger press will reduce labor costs). However many smaller oilseed processors opt not to employ labor and provide the labor themselves. It is much more difficult to assign value to labor in these situations. The value of proprietor's time is the opportunity cost of his or her time. If the proprietor hired an employee to help run his farm so that he could operate the oilseed press then the value of the proprietor's time is the cost of the hired employee's time. Some proprietors view their enterprise as a hobby or something they do in their spare time. In these cases, proprietors often place a very low opportunity cost on their time. Whether the labor is hired or not does not affect the fact that as the value of labor increases, the more financially attractive larger capacity oilseed presses will become.

Equipment and Operation Costs

Equipment and operating costs do not comprise a large portion of total costs but still need to be managed. Capital equipment purchases are commonly a large upfront expense for potential oilseed processors. It can be very tempting to purchase the least expensive equipment that is available. A better financial decision will also consider the labor costs associated with operating a press and the oil recovery efficiency of the press. These factors can have a large impact on the financial viability of the press over its life. Other costs like maintenance and electricity are typically a very minor part of total costs.

Revenues

Oilseed processing produces two marketable products, oil and meal. Both are important revenue streams for an oilseed processor.

For each 100 lbs. (35 percent oil content) oilseed feed stock, approximately 70 to 75 lbs. of meal and 20 to 25 lbs. of oil are produced. About 5 lbs. is lost during processing, mostly due to moisture reduction. Oilseed meal prices vary depending on the type of oilseed processed. Soybean meal is the most valuable while sunflower meal is often the least valuable. Recent prices have ranged from $200 to $350 per metric ton.

Oil prices also vary depending on the feedstock. Peanut oil is the most valuable while soybean oil tends to be the least expensive. Recent prices have ranged from $3.75 to $6.00 per gallon. Meal prices also vary depending on the feedstock. Recent oilseed meal prices have ranged from $120 to $320 per ton. Current prices for both can be found at: www.ers.usda.gov/Briefing/SoybeansOilcrops/data.htm. Current market prices will determine which product will contribute more revenue to the operation.

Biodiesel Economics

Potential biodiesel producers should have a basic understanding of biodiesel economics. The economics of biodiesel are dominated by two factors, cost of vegetable oil and biodiesel revenue.

Input & Operations Costs

The cost of purchasing vegetable oil typically accounts for 65 to 90 percent of the total costs of producing biodiesel. Labor costs may account for 3 to 10 percent of total costs.

Biodiesel production set up in farm barn.
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Methanol costs can account for 12 to 18 percent of total costs (larger operations may utilize a methanol recovery system that lowers this to 7 to 12 percent of total costs). Equipment costs vary substantially for small scale producers, but rarely exceed 15 percent of total costs (and may be much lower). Labor costs decline as the size of the operation increases, but even small operations rarely have labor expenses over 5 percent of total costs. Other costs (catalyst, electricity, maintenance, etc.) are commonly less than 5 to 8 percent of total costs.

Revenues

Sales of biodiesel are the main revenue stream for biodiesel producers. From 2002 to 2011, the average retail price per gallon premium for biodiesel over petroleum diesel has been $0.58 in the Rocky Mountain Region based on data from the Clean Cities Alternative Fuel Price report. Biodiesel producers will typically generate 95 percent or more of their revenue from biodiesel sales. In cases where the biodiesel is not sold but instead used directly by the producer, the value of the biodiesel is captured by reduced diesel fuel purchases.

In cases where biodiesel is being sold, additional revenue may come from the sale of glycerin. Unrefined glycerin is produced as a byproduct of the biodiesel production process. In some cases it refined for use in the production of cosmetics, soaps or other products. In other cases, it is used or sold as an unrefined product for use as a boiler fuel. In either case the revenue generated by this is very low (often less than $0.50 per gallon). Some producers compost their glycerin. This can be an effective disposal tool but a producer needs to keep in mind the volume they will be composting (about 10 to 20 gallons per 100 gallons of biodiesel produced). Small scale biodiesel producers may have difficulty finding a buyer or a use for this product. Careful planning for glycerin management should not be overlooked. Subsidies have been available periodically for biodiesel production. These subsidies have included grants for equipment purchases, tax credits and per gallon payments. If a biodiesel producer is able to obtain a subsidy of some type the revenue percentages mentioned above will be affected.

Oilseed Processing & Biodiesel Business Plan Software

Potential oilseed processor or biodiesel producers should develop a business plan and some projections on the financial viability of the proposed operation. Larger operations often hire specialist to help prepare this analysis. This is a great option for many businesses but may be impractical for small operations. Potential small scale biodiesel producers can utilize software developed at MSU to help create individualized financial projections. The software is free and available at: www.ampc.montana.edu. The software allows users to enter equipment, labor, oilseed, oil, methanol and other costs specific to their operation. It also allows for vegetable oil, oilseed meal, biodiesel and glycerin revenues to be entered. Based on the user provided information the software generates basic cash flow and financial information. Changing allows potential processors to get a feel for the implications of changing market conditions.

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