Bioenergy from farm byproducts

OVERVIEW:

By virtue of the diversity of crops grown and livestock raised in Michigan, farmers have several options to choose from if they desire to produce on-farm energy. The purpose of this publication is to help farmers sort through their options and make the best energy production choice for their farms. This publication will be updated as new research and technology information are made available.

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Anaerobic Digestion

During anaerobic digestion, microorganisms break down manure in an oxygen-free environment. Anaerobic decomposition occurs in four basic stages. Stage 1 is the conversion of complex organic compounds to simpler forms by *hydrolytic bacteria*. Principal end products of this stage are soluble sugars, amino acids, peptides, long-chain fatty acids and hydrogen (H_2).

Stage 2 is the metabolization of the products of hydrolysis by *acidogenic bacteria*. Principal end products of this stage are short-chain volatile organic acids (propionic, butyric, acetic and formic acids), carbon dioxide (CO_2) and H_2. In the third stage, the reduction of CO_2 and catabolization (the metabolic breakdown of complex molecules into simpler ones, often resulting in a release of energy) of short-chain fatty acids produced during acidogenesis is carried out by *syntrophic, acetogenic* and *homoacetogenic bacteria*. Principal end products of the third stage are acetate, CO_2 and H_2. The final stage is the conversion of H_2 and acetate to methane (CH_4) by *methanogens*. Methanogens belong to a group of microorganisms called Archaea. Archaea are not bacteria but have similar functions, and they must work closely with bacteria to bring about the destruction of organic matter. In addition to CH_4, end products are CO_2 and trace gases.

There are two main products that come from anaerobic digestion – biogas and digestate. From these two products come a host of value-added products including pipeline quality gas, compost, bedding and fertilizer. Biogas typically contains between 60 and 70 percent CH_4, 30 and 40 percent CO_2, and trace amounts of other gases. The primary benefits of anaerobic digestion are odor control and nutrient mineralization.

Types of digesters

A plug flow digester is an engineered heated tank and is typically built below ground with a gas-tight cover. The term "plug flow" describes a given mass of feedstocks entering the digester on a given day and traveling through the system as a "plug." Plug flow digesters typically operate best with higher percent solids content (11 to 13 percent) and cannot tolerate a significant amount of animal bedding, specifically sand bedding. Plug flow digesters are best suited for dairy manure. Low-fiber feedstocks do not digest well in this type of system. Most plug flow digesters operate in the mesophilic temperature range (around 100 ºF) and have a hydraulic retention time of about 15 days.

A mixed plug flow digester differs from a plug flow digester in two ways. First, biogas is recirculated throughout the system, causing solids and liquids to remain

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in suspension as feedstocks move through the digester. Second, a wider range of feedstocks with varying solids content (3 to 10 percent) can be accepted. This type of digester is an engineered heated tank that operates in the mesophilic temperature range and is typically built below ground with a gas-tight cover. It is often 16 feet deep with 18 inches of biogas storage. The advantages of a mixed plug flow digester over a plug flow digester are shorter retention time and higher biogas production.

A complete mix digester is an engineered system that consists of a large heated tank (usually above ground) made of steel or concrete with a gas-tight lid. The contents of the digester are agitated or mixed intermittently and can operate with some bedding. The complete mix digester operates best with 3 to 10 percent solids content slurry-type manure. However, they can operate with a solids content as high as 20 percent provided that sufficient agitation and retention time are designed into the system. The hydraulic retention time is typically 15 to 20 days. Biogas is collected at the top of the digester. Examples of the types of complete mix digesters include continuously stirred tank reactors, upflow anaerobic sludge blanket, completely mixed flow reactors and continuous flow stirred tank.

A fixed film digester uses a tank filled with bacteria on a plastic media that generates a thick layer of biofilm. When manure passes over the submerged biofilm, the bacteria convert both the soluble and particulate organic matter in the manure to biogas. The fixed film digester is best suited for very dilute manure and other agricultural waste streams with a Total Solids range of 0.5 to 3 percent. The number of fermenting bacteria and methanogens are higher in this type of digester than in typical complete-mix digesters. This advantage reduces the hydraulic retention time to two to six days and produces biogas with 80 percent CH_4 and 20 percent CO_2 content.

Generating electricity and producing pipeline quality gas

The Clean, Renewable, and Efficient Energy Act (PA 295 of 2008) established an integrated Renewable Portfolio Standard, which requires 10 percent of the electrical power used in the state of Michigan to come from renewable sources by 2015. PA 295 also addressed net metering policy in Michigan. Net metering allows small renewable energy generators to offset their energy usage with on-site production, credited at full retail value.

Individuals interested in generating renewable energy from biomass on farms should follow some basic steps to identify the most profitable usage. To start, the individual should identify the historical energy usage and the annual cost of energy, both electrical and thermal (natural gas or LP), for the facility where the project is being considered. Offsetting on-site energy needs will provide a pathway for maximizing the value of the renewable energy generated. After reviewing and determining the primary energy need of the farm, the decision maker should contact an experienced Extension educator, consultant, engineer or technology supplier to begin planning the energy utilization system.

For farms where the primary energy need is electricity, an interconnection application accompanied by a one-line diagram developed by a licensed professional engineer or electrical contractor will need to be submitted to the electrical utility that services the farm. The interconnection application is the first step in determining the overall cost of integrating a renewable energy system into the electrical distribution network. The utility will use the application to determine if an engineering review and/or distribution study is necessary and the cost for the study. Distribution network improvements or modifications and the associated cost to be paid by the renewable energy project are established during the review and study. There are fees associated with the interconnection application, engineering review and distribution study. If the applicant agrees to move forward with the project and the modification cost is determined during the distribution study, the utility will complete the improvements in a mutually agreed upon time period. Upon completion of the project, distribution system modifications and commissioning test, the utility will notify the farm of the interconnection approval and provide the interconnection agreement. Once the interconnection agreement is executed, the farm can begin operation of the electrical generation system. Refer to PA 295 and the local utility for additional information concerning electrical interconnections.

If thermal energy is determined to be the primary form of energy used on the farm, several options exist. For systems where the thermal load is constant throughout the year, a farm may elect to simply use biogas directly to offset purchased energy. Storage of biogas for seasonal thermal loads or interconnection with the natural distribution pipeline will require the biogas to be upgraded, which includes removal of impurities such as moisture, carbon dioxide and hydrogen sulfide, such that the composition meets the natural gas of the local gas distributor. Local gas distribution companies (utilities) use interconnection applications to determine if an interconnection is possible and the requirements for interconnection. An additional benefit of a biogas upgrading system is the option to use the natural gas quality product to replace transportation fuels in vehicles with short travel radiuses.

National, state and local regulations

The Michigan Department of Environmental Quality (MDEQ) regulates activities that affect the state's air, water and land resources. Currently (as of August 2009), how these regulations affect the operation of anaerobic digesters and the use of the digestate is not clearly defined in all situations. It is important to understand what regulations apply before construction begins, because a permit or authorization may be required. There are several regulatory areas of concern related to anaerobic digesters.

In Michigan, an air permit is required for any activity that generates an air contaminant unless that activity is specifically exempted from having to obtain an air permit under the Michigan Air Pollution Control Rules, Part 55, Air Pollution Control, of the Natural Resources and Environmental Protection Act (NREPA), 1994 P.A. 451, as amended (Act 451). Anaerobic digesters have the potential to generate air contaminants either directly via the digestion process or indirectly via the combustion of the gas generated from the digester. Therefore, whether a permit will be required must be determined before construction. Whether a permit is required depends on what happens to the gas that is generated. Generally, the gas is sent to a combustion device such as a flare, generator or boiler. The gas may also be cleaned and piped off-site. If the gas is piped off-site there will be no associated air emissions, so an air permit is not required.

A flare or boiler may be installed. A permit will not be required if the actual emission rate of sulfur dioxide (SO_2) will not exceed one pound per hour (You can find these rules at http://bit.ly/NREPARules). The SO_2 emission rate can be calculated using a worksheet available at www.animalagteam.msu.edu. If the emission rate of SO_2 is greater than one pound per hour, a Permit to Install from the MDEQ Air Quality Division is required before installing the flare or boiler.

If a generator is to be installed and if the generator has a maximum heat input capacity of less than 10,000,000 Btu/hr, a permit is not required (see R336.1285(g) in Part 55, NREPA). If the generator's heat input capacity is 10,000,000 Btu/hr or greater, a Permit to Install must be obtained. Note that 10,000,000 Btu/hr is equivalent to a 1,875 KW generator or a 1,320 brake-HP engine. If several generators will be installed, they may be excluded from the exemption because of the amount of emissions generated (see R336.1278 in Part 55, NREPA). If more than two exempt generators will be installed, contact the MDEQ district office to determine whether an air quality permit is required.

If improperly managed, digestate can affect groundwater and surface water quality. Most operations will not be required to obtain any additional water discharge permits or authorizations for a digester if only manure is being used as the primary feedstock for the digester. When other digester feeds such as food processing residuals, stillage syrup and glycerin are being used, the MDEQ Water Bureau and Waste and Hazardous Materials Division should be contacted to determine if a permit is required before any liquid or solid digestate is land applied. Surface water and groundwater permits may be required under Part 31 of NREPA, 1994 P.A. 451, as amended (Act 451). Waste and hazardous material authorizations are issued under Act 115 of NREPA, 1994 P.A. 451, as amended (Act 451).

If a farm is currently operating under a National Pollution Discharge Elimination System permit issued by the MDEQ Water Bureau, any liquid or solid digestate that is land applied should be included in that farm's nutrient management plan. The MDEQ will need to know the volume and types of materials proposed to be added to the digester and whether various contaminants of concern are present in the raw material. The contaminants of concern include, but are not limited to, volatile organics and various heavy metals.

A soil erosion and sedimentation control permit will be required for any earth change that disturbs one or more acres or is within 500 feet of a lake or stream. Counties have the primary responsibility for issuing permits. In some cases, cities, villages and townships have assumed permitting responsibility within their jurisdictions. Permit applications can be obtained from the respective county or municipal agencies. A list of county and municipal enforcing agencies can be found on the Soil Erosion and Sedimentation Control Web site at http://bit.ly/Soil-Sediment. Fees for soil erosion and sedimentation control permits are established by the country or local agency issuing the permit.

The MDEQ Land and Water Management Division (LWMD) regulates activities that may affect wetland areas. Part 303 of NREPA defines a wetland as "land characterized by the presence of water at a frequency and duration sufficient to support, and that under normal circumstances does support, wetland vegetation or aquatic life, and is commonly referred to as a bog, swamp or marsh." The definition applies to public and private lands regardless of zoning or ownership. If construction of the digester will occur in a possible wetland location, the MDEQ LWMD must be contacted. Further information can be found at http://bit.ly/LandWaterMgt.

Additionally there may be planning and reporting requirements. If chemical additives will be used in the digester or stored at the facility, they may need to be reported under the Superfund Amendments and Reauthorization Act of 1986 (SARA) Title III. These chemicals should be added when updating the farm's emergency management plan. Information about SARA Title III reporting requirements and emergency planning can be found by visiting www.michigan.gov/deqemergencyplan or by calling the Environmental Assistance Center at (800) 662-9278.

To maintain protection under Right-to-Farm, a farm operation must follow the applicable Generally Accepted Agricultural Management Practices (GAAMPs). The Manure Management and Utilization GAAMPs reference anaerobic digesters as a manure treatment option. It is in the best interest of a farm with a digester to ensure conformance to GAAMPs recommendations. In addition, the Nutrient Utilization GAAMPs provide guidance on soil testing and fertilization rates and should be adhered to for proper land application. Both GAAMPs manuals are found by going to www.michigan.gov/mda, clicking on "Farming" on the left side, and then clicking on "GAAMPs" under the "Environmental" heading near the bottom of the page.

Determining if a digester is right for your farm

The United States Environmental Protection Agency (USEPA) AgSTAR has a self-assessment tool designed to help producers determine the feasibility of an on-farm digester. Go to http://www.epa.gov/agstar/resources/handbook.html and download the AgSTAR Handbook and accompanying software. If a digester is determined to be feasible, chapter 6 in the handbook can be used to help producers work through selecting a consulting firm and developer. A list of consultants and developers compiled by the Michigan Department of Agriculture can be found at http://bit.ly/DigesterInfo.

Gasification

Gasification is a process that turns solids into a low energy gas, known as syngas, using high temperature combustion technology. Feedstocks, such as turkey manure, are metered into a high-pressure, high-temperature reactor (gasifier) containing steam and a limited amount of oxygen. The chemical bonds in the feedstock are severed by the extreme heat and pressure, and syngas is formed. Syngas is primarily a mixture of hydrogen and carbon monoxide, and may need to be cleaned to remove particulates, sulfur and trace metals. The type and moisture content of the feedstock being combusted and the type of gasifier being used greatly affect the quality and energy content of syngas.

"Only high quality syngas can be burned directly in an internal combustion engine or gas turbine. Compared to natural gas or propane, syngas is relatively low in energy. Some syngas-fueled engines use other common fuels to supplement the syngas in order to take full advantage of the engine's power capacity. Lower quality syngases, such as those produced by an updraft gasifier, will foul the moving parts of an internal combustion engine and result in excess wear and short lifespan. Lower quality syngases are best used in external combustion processes such as steam or Sterling engines in the generation of electricity or for the firing of heating systems" (DGH Engineering Ltd., 2006).

Syngas and fertilizer (phosphorus and potassium in the ash) are two byproducts resulting from gasification.

Gasification technologies

Two basic types of gasification units exist, updraft and downdraft. Downdraft units are characterized by their ability to produce a cleaner fuel, but require a solid or pelletized fuel. Updraft gasifiers generally produce a "dirtier" gas, but have the ability to burn a wide range of fuel formats. Although many designs have been developed, modern gasification technologies generally fall into three categories depending upon the flow conditions in the gasifier: (1) moving bed, (2) entrained flow and (3) fluidized bed.

In a moving bed situation, the carbonaceous fuel is dry-fed through the top of the reactor. As the fuel slowly descends, it reacts with the gasifying agents (steam and oxygen) flowing in a counter-current through the bed. The fuel goes through the various stages of gasification until it is ultimately consumed, leaving only syngas and a dry or molten ash. The syngas has a low temperature (752 to 932 ºF) and contains significant quantities of tars and oils.

With entrained flow, the fuel and gasifying agents flow in the same direction and at rates in excess of other gasifier types. The feedstock may be dry-fed (mixed with nitrogen) or wet-fed (mixed with water). It will go through the various stages of gasification as it moves with the steam/oxygen flow. The syngas exits through the top of the reactor and the ashes flow down the sides as a molten slag, which is removed from the bottom. Operating temperatures are very high (2192 to 2912 ºF).

Lastly, with a fluidized bed, the fuel, introduced into an upward flow of steam/oxygen, remains suspended in the gasifying agents while the gasification process takes place. "Since the operating temperature of the reactor (1472 to 1922 ºF) is less than the temperature at which the ashes from the fuel melt, these can be removed either in dry form or as agglomerate (Clean-energy.us, 2009).

National, state and local regulations

In Michigan, an air permit is required for any activity that generates an air contaminant unless that activity is specifically exempted from having to obtain an air permit under the Michigan Air Pollution Control Rules, Part 55, Air Pollution Control, of NREPA, 1994 P.A. 451, as amended (Act 451). The factor that determines whether or not a permit is required is syngas use. Syngas that is piped off-site has no associated air emissions, so an air permit is not required. If burned using a flare or boiler, a permit is not required if the actual emission rate of sulfur dioxide (SO_2) does not exceed one pound per hour (see R336.1282(g) in Part 55, NREPA). If the emission rate of SO_2 is greater than one pound per hour, a Permit to Install from the MDEQ Air Quality Division is required before installing the flare or boiler. If a generator is used and has a maximum heat input capacity of less than 10,000,000 Btu/hr, a permit is not required (see R336.1285(g) in Part 55, NREPA). If the generator's heat input capacity is greater than 10,000,000 Btu/hr, a Permit to Install must be obtained. Note that 10,000,000 Btu/hr is equivalent to a 1,875 KW generator or a 1,320 brake-HP engine. If several generators will be installed, they may be excluded from the exemption because of the amount of emissions generated (see R336.1278 in Part 55, NREPA). If more than two exempt generators will be installed, contact the MDEQ district office to determine whether an air quality permit is required.

On-farm Ethanol Production

When considering if ethanol production is a viable venture (even on a small scale), a number of variables must be considered prior to the production process: cost vs. benefit; the type of feedstock to be used in production; location of production unit and storage facilities; disposal/use/reuse of byproducts; the storage of ethanol and byproducts; and local, state, and federal laws and regulations. This is not something that should be jumped into casually. Careful consideration should be given to the reasons for producing ethanol before any ethanol is produced.

There are two main types of processes to create ethanol – the dry mill process and the wet mill process. The following are very brief descriptions of what steps take place during each process. Within each step there may be additional preparatory or post steps before moving on within the process. These steps are not included. The intent here is to only provide a very basic understanding of what takes place in producing ethanol.

Dry Mill Process

This process begins with receiving the feedstock, in most cases corn. Feedstocks are ground, water is introduced to create a slurry, and then it is cooked. This step produces what is referred to as mash. At this point enzymes are introduced to begin the fermentation process. The fermentation process creates two products, beer and CO_2. CO_2 can be captured (for very large scale facilities) and marketed. The beer is distilled to create ethanol. Additional processes may be required for the ethanol to reach a purity level required for a commercial fuel. The remaining material is run through additional processes to create dried distillers grain (DDG).

Wet Mill Process

The wet mill process can be broken into six basic steps. First, ground corn is steeped in water at a temperature of 122 ºF for 30 to 40 hours. Steep water is condensed and the captured products are used for animal feeds and are partially used in the ethanol fermentation process. The slurry then flows to the next process. Second, the germ is removed from the corn. Oil is extracted from the germ and refined into corn oil. The germ that is left over is sent on to the next step. Third, the remaining corn kernel and the germ from the previous step is ground finer and screened to release/separate the gluten and starch from the fiber. The fiber is removed and used as an animal feed. The gluten-starch mixture, referred to as mill-starch, is ready for the next step. Fourth, the gluten is spun out from the starch, usually by centrifuge, and is used in animal feeds. The starch goes through additional dilution and wash cycles to increase its purity. Fifth, the starch is processed and refined to create corn syrup used for a multitude of purposes, usually some form of sweetener. In the final step, dextrose is run through a fermentation and distillation process to create ethanol. CO_2, a byproduct of this process, can be captured and marketed. Any solids remaining after the fermentation process are collected and used as an animal feed.

National, state and local regulations

There may be a number of national, state, and or local laws and regulations that need to be followed before you begin constructing the production facility on the farm. Producers should investigate and determine what local municipality (township, city, county, etc.) ordinances (zoning, building, etc.) may be in place that would affect the site location, the construction of the building or facility, storage of product(s) and the actual production of the product. Do not rely on the oral response of local officials that something may or may not be acceptable. Provide written descriptions and plans of your facility, and request formal written responses with an approval or direction on what needs to be accomplished for approval of your intended facility. This acts as protection for you and for the local municipality to prevent any misunderstandings. This does take more time but usually results in fewer problems through the process.

The Alcohol and Tobacco Tax and Trade Bureau (TTB) was part of the Bureau of Alcohol, Tobacco and Firearms (ATF) at one time. It is now a part of the U.S. Department of the Treasury. The TTB requires the permitting of *all* ethanol facilities, regardless of size. Plants are divided into three categories – small, medium, and large alcohol fuel plants – based on the volume of proof gallons produced. The TTB defines proof gallon as "one liquid gallon of spirits that is 50% alcohol at 60 degrees F. Distilled Spirits (also known in beverage and industrial or fuel industries as alcohol or ethanol) bottled at 80 proof (40% alcohol) would be 0.8 proof gallons per gallon of liquid. At 125 proof, a gallon of liquid would be 1.25 proof gallons. In the industrial and fuel industries, most alcohol is at 190 or 200 degrees of proof. One gallon of alcohol that is 200 proof is equal to 2.0 proof gallons" (TTB.gov, 2009). Plants producing 10,000 proof gallons or less annually (July 1 to June 30 is considered a calendar year) are designated as small ethanol alcohol fuel plants (AFPs) and are not required to have a bond.

Medium AFPs are plants that produce between 10,000 and 500,000 proof gallons in a calendar year. A medium AFP requires a significant amount of paperwork, which may include but not be limited to:

- application of permit
- proof of permit or certification from the MDEQ and paperwork to allow all paperwork to be disclosed to the federal Environmental Protection Agency (EPA) (required)
- supplemental information on water quality considerations
- Distilled Spirits bond
- environmental information
- personnel questionnaire
- signing authority
- special storage requirements and proof of security measures (may be requested)

Large AFPs produce more than 500,000 proof gallons in a calendar year. A large AFP requires a significant amount of paperwork, which may include but not be limited to:

- proof of permit or certification from the MDEQ and paperwork to allow all paperwork to be disclosed to the federal EPA (required)
- supplemental information on water quality considerations forms (required)
- Distilled Spirits bond
- information on principle persons involved
- statement of investment and funding sources
- statement of type of business organization
- statement of business organizations officers
- organizational documents
- corporate documents
- Statement of Interest
- powers of attorney
- special storage requirements
- proof of security measures

As of January 2006, the bonding requirements for a medium AFP producing "(including receipts) between 10,000 and 20,000 proof gallons of spirits per year requires a bond in the amount of $2,000. For each additional 10,000 proof gallons (or fraction thereof), the bond amount is increased $1,000. The maximum bond for a medium plant is $50,000" (TTB, Title 27, Part 19, § 19.956, Amount of bond, 2006). A large AFP that produces 500,000 proof gallons "but not more than 510,000 proof gallons (including receipts)" must hold a bond of at least $52,000. For every 10,000 (or fraction) above 510,000 proof gallons, the bond value is increased by $2,000 to a maximum bond of $200,000.

There may be additional requirements that must be followed, such as those set by Occupational Safety and Health Administration (OSHA), the Michigan Right-to-Farm Act, building codes, etc. Additional permits, certifications, approvals and licenses may be required by local, state and federal organizations including but not limited to the MDEQ, EPA and TTB. Some of the items that may contain additional regulation include raw material transportation and storage, fuel byproduct storage, transportation and reuse, water withdrawal, quality and air quality.

On-farm Biodiesel Production

The National Biodiesel Board (NBB), a *trade association representing the* **biodiesel** *industry in the United States, defines* biodiesel as "a domestic, renewable fuel for diesel engines derived from natural oils like soybean oil, and which meets the specifications of ASTM D 6751" (National Biodiesel Board, 2009). In terms of use, the NBB asserts that biodiesel can be used in any concentration with petroleum-based diesel fuel in existing diesel engines with little or no modification. It is important to note that biodiesel is not the same thing as raw vegetable oil.

"Biodiesel is…made by chemically altering the molecular structure of any organic oil through the use of a catalyst and an alcohol. To do this, oil is heated to a designated temperature (to help with the chemical reaction) and then a mixture of a catalyst and an alcohol are added to the oil. The oil, catalyst, and alcohol mixture are mixed for a period of time and then allowed to settle. If successful, the chemical reaction between the oil, alcohol and the catalyst will have broken down the oil into three layers. The top layer will be biodiesel, chemically called an Ester, the next layer may contain soap, and the bottom layer will be glycerin. Once the layering has occurred, the glycerin and soap are drained off. The biodiesel is then washed with a mist-wash, a bubble-wash, or both. Washing is done to remove any additional soap, alcohol, or other impurities in the biodiesel. After it's been washed, it is then dried to remove any water. Commonly it is then filtered through fuel filters and is then ready to be used" (Utah Biodiesel Supply, 2009).

National, state and local regulations

There are no national regulations pertaining to on-farm biodiesel production. However, from a tax standpoint, if biodiesel is used as an on-road fuel in a vehicle, the operator may be subject to road taxes. Taxation laws change frequently, so check with your local tax consultant to identify which taxes biodiesel may be subject to. Currently, the first 400 gallons per quarter of homemade biodiesel is exempt from federal excise taxes. Anything over 400 gallons per quarter is subject to the normal tax rate.

State legislation is in the process of being drafted (as of December 2009). For more details go to http://bit.ly/MIHB4838. The intent of the proposed legislation is to "provide that an ethanol production facility is a use by right in any agricultural district" (House Bill No. 4838, 2009) if certain conditions are met. Biodiesel is included in this legislation. The legislation also sets the conditions for a special land use permit when "by right" conditions can't be met. Local control occurs when "by right" or special use permit conditions are not met. This legislation is closely modeled after the Michigan Right-to-Farm Act (for information on the Michigan Right-to-Farm Act, go to http://bit.ly/MIRTF).

CONCLUSION:

Biogas, syngas, ethanol and biodiesel can be produced on the farm and used to complete on-farm tasks that are currently being performed by petroleum-based fuels. An increase in biofuel use can lead to energy independence and may result in cost-savings for a farm. Careful consideration in selecting the type of system used to generate biogas, syngas, ethanol and/or biodiesel is the key to gaining those benefits. Familiarity with regulations, laws and ordinances pertaining to each form of energy is important to avoid penalties and unwanted publicity.

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