Renewable Energy Applications for Agricultural Enterprises

Prepared by The Center for Innovative Food Technology,
Rural Income Enhancement Program
October 2006

One of the most serious threats to the economic health of agricultural operations is the rapidly escalating cost of energy. The past several years have seen the cost of all forms of energy spiral upward at a rapid rate. Forecasts call for this upward trend to continue, possibly at an accelerated rate.

A number of options are available to help agricultural producers combat these rising costs, including renewable energy applications. Investments in emerging technologies such as wind power, solar power, biofuels, and the production of biogas are becoming more and more justifiable as conventional energy sources increase in price; as implementation technologies become more effective and affordable; and as programs to create incentives for their purchase become more widespread.

The purpose of this brief guide is to discuss and answer frequently asked questions about several renewable energy alternatives that apply to agricultural operations. This guide is not intended to be a complete analysis of renewable energy options, but it can serve as a tool to judge the initial feasibility of various options. Experts, some of whose names are listed, should be contacted for the most up-to-date and comprehensive information.

Another important consideration with all alternative energy solutions is that they represent only a part of a total energy efficiency solution. Selecting and installing the appropriate renewable energy technology requires experience with existing systems in order to integrate the renewable technique and maximize overall energy efficiency. Care must be taken to ensure that the proper solution is selected to maximize overall energy efficiency.

A brief discussion of some of the most popular renewable solutions follows, along with answers to frequently asked questions and other pertinent information.

Anyone requiring additional information or looking for assistance in planning a renewable energy installation, should contact the staff at EISC's Center for Innovative Food Technology (CIFT):

EISC's Center for Innovative Food Technology
Renewable Energy Program
419.535.6000 in the Toledo area
1.877.668.3472 toll-free
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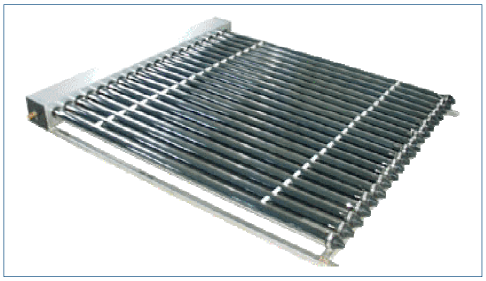

Many areas of the Midwest, including northern Ohio, have sufficient sunlight to support the operation of solar heating for hot water, thereby reducing the demand for fossil fuels, or perhaps for electricity. Typical uses for solar thermal heating include water heating for processes or sanitation, and in some cases, for hot water space heating.

The payback periods for solar thermal systems, which are among the simplest and most straightforward of all renewable energy solutions, tend to be five to ten years. Because solar thermal systems are often constructed from readily available components and have low maintenance costs and long useful lives, the payback period is less of an issue.

A typical system consists of solar collector panels, a working water storage tank, a heat exchanger to transfer energy from the panels to the water, a computer controller, sensors, and piping.

Frequently Asked Questions:

Q: How large or small are typical solar thermal systems?

A: Solar thermal systems are modular and can be scaled up based on system requirements. A convenient rule of thumb is that two 8-foot long by 4-foot wide solar panels, properly installed, can produce energy equivalent to the output of a 40-gallon residential hot water heater.

Q: Are there installation restrictions?

A: Yes, in order to maximize production, panels must be located to maximize sun exposure. They must also be mounted at specific angles, depending on the latitude of the installation. This data is readily available.

Q: What are the average constructions and maintenance costs investment that I can anticipate when incorporating a solar thermal water heating system into my operation?

A: The key consideration to effectively utilizing this renewable source of energy is the demand for hot water. While a simple two-panel hot water system could cost from $3,000 to $5,000, a five-panel space heating system with additional hot water storage and water circulation requirements could cost about $15,000-$20,000. Depending on hot water demand, the payback can range from 5 to 10 years. Given the simple nature of the systems, and the availability of replacement components, maintenance costs are extremely low.

Q: Are there grants, loans or other financial assistance available to companies or individuals that are considering solar thermal water heating systems?

A: Yes, there are a number of Federal and State programs available for solar thermal installations. Both grants and loans are available for installations. Additional information about renewable energy programs can be found via the web sites listed on page 12 of this document. In addition, a 30 percent Federal tax credit is now available for solar installations completed before December 31, 2007.

Electricity from Solar Photovoltaic (PV) Systems

Photo credit: www.eia.doe.gov

Solar panels capture the energy from the sun and convert it directly to electricity. If an operation, for example, reaches peak kilowatt (kW) demand levels through the day, the electricity generated by solar panels can be used to reduce peak kW demand, and can reduce total kW-hours consumed from grid electricity, significantly reducing monthly electric costs. Solar PV generates direct current (DC) electricity that can be utilized by special motors, lighting and other equipment specifically designed to operate on DC. Alternatively, output can be connected to an inverter, which converts the DC electric to alternating current for general use.

Solar photovoltaic installations are commonly used for traffic stop blinkers, portable illuminated traffic information signs, simple-to-install yard lighting along walkways, and other uses. A typical farm application for solar PV energy is to provide electricity for a remotely located pump that is not readily served by electrical connections. For example, water lift pumps, located near a storm water holding pond with no readily accessible electric power, are frequently powered by solar photovoltaic generating units.

Somewhat more complex solar photovoltaic systems (beyond simple, self-contained units) require a significant level of technical competence to support them. As always, they are most effectively used when they are used as a part of a comprehensive energy efficiency program.

Frequently Asked Questions:

Q: What are the space requirements for a system that generates solar PV energy?

A: The space requirement for a solar photovoltaic system varies according to system size and efficiency. For example, a very small, 1000-watt system would have a footprint of 150 square feet, depending on its operating efficiency.

Q: Can producers of solar PV energy legally sell back excess into the grid? Are there legal obligations by the utility to buy back excess energy?

A: Excess and unneeded electricity produced as a result of using solar PV power can be sent back to the utility's electric power grid, running the meter backwards in a net metering arrangement with the local electric utility company. In a net metering arrangement, it is usually most economical to use all electricity immediately in your operation to replace purchased electricity. Utility requirements vary in Ohio depending upon the structure of the local utility, i.e. investor owned, cooperative, or municipal system.

Q: What is the approximate investment for an on-farm solar PV system?

A: The cost per watt decreases as the size and output of the installation increases. For instance, a very small, 100-watt system could cost as much as $12 per watt of capacity. In its publication, *Get Your Power from the Sun*, the U.S. Department of Energy estimates that small systems require investments of:

System Size	Investment Cost
2 kilowatt system	$8-10 per watt
5 kilowatt system	$6 – 8 per watt

Wind Power, Large and Small Scale

Wind power installations fall into two categories: Large Wind Installations and Small Wind Installations. There are several definitions of each, depending upon the situation. A common classification is the one used by the USDA Renewable Energy and Energy Efficiency Grant Program discussed below, which defines each as follows:

Small Scale System: Up to 100 kW and Generator Hub Height less than 120 ft.
Large Scale System: Greater than 100 kW

For all of its grant and financing programs, the Department of Energy uses 100 kilowatts as the break point, up to 100 kW for small systems, and greater than 100 kW for large systems.

The feasibility of wind power installations depends on the level of wind in a region. The Department of Energy has mapped the nation to determine the average Wind Power Density (WPD) for all regions of the U.S. Much of northern Ohio has sufficient WPD at 50 meters (a typical height from the ground for wind installations in Ohio) to support the investment in wind power.

Photo credit: usinfo.state.gov

Typical agricultural applications for wind-based systems include 20-500 watt micro-turbines used for vehicle battery charging; 1-10 kilowatt turbines used in applications such as pumping water; and 10-100 kilowatt turbines that can be used to offset portions of site specific consumption. These installations must typically be supported with grid-connected net metering arrangements or large-scale battery storage.

Frequently Asked Questions:

Q: What considerations must be made in locating wind systems?

A: Wind power density increases with system height. Thus, relatively small investments in increasing system height may yield increasing returns from increased power generation. Increased height also removes interfering turbulence from nearby obstacles like trees and buildings on the ground. However, local ordinances governing tall structures must also be considered. Local entities often also have regulations that govern aesthetics and wildlife habitat interference. (In northern Ohio there is sometimes an issue with migratory birds. The Ohio Department of Natural Resources can provide specific information.)

Q: What does a typical system cost?

A: Small systems can cost between $3,800 and $5,000 per kilowatt. Generally speaking, the lower the output, the higher the installation cost. The installation cost of a large, 1-megawatt (1000 kW) system is around $1,000,000.

Q: How much space is required for an installation?

A: Space requirements vary with the size of the system desired. Bergey Windpower Co., one of the leading suppliers of small systems, recommends that at least one acre be dedicated to wind power systems.

Renewable Fuel Boilers

The increasing cost of fossil fuels has caused renewed interest in the use of corn and pellet burning systems. For rural operations, renewable fuel boilers offer the advantages of using a readily available material, such as shelled corn, as a fuel. In addition to shelled corn, most commercially available units can burn pelletized wood; cherry pits; pelletized grains such as wheat, alfalfa, and grasses; and other renewable fuels. With modification, these systems can also handle non-pelletized fuels such as wood, shredded wood, wood bark, straw, corn stover, animal manure, and other materials.

Available corn and pellet burners range in size, from small units that provide 100,000 BTU/hr. that are suitable for a residence or small out building, to larger boilers, up to 100 HP, that can be used for greenhouses, processing facilities, storage facilities, and hot water systems.

A major advantage to boiler systems is their simplicity. Although relatively low tech, renewable fuels can offer significant savings over fossil fuels. For example, a study performed at the University of Minnesota estimates that burning 15 percent moisture, $2.00 per bushel corn in a stove that operates at 65 percent efficiency would produce energy at a cost of $7.85 per million BTU. This compares to more than $13.00 for fuel oil and propane, around $10.00 for natural gas, and more than $23.00 for electricity.

Frequently Asked Questions:

Q: **What are the disadvantages to renewable fuel boilers?**

A: First, renewable fuel boilers must be recharged periodically or a more complex feeding system must be acquired. In either case, additional expenses will be incurred. Secondly, corn, wood, and other renewables contain more inert and non-combustible materials than natural gas, and therefore require ash removal and disposal on a daily or routine basis. Some more sophisticated boilers have automatic ash removal systems but still require ash disposal.

Q: What are the average construction and maintenance costs for renewable fuel boilers?

A: A small industrial corn/pellet burner can cost as little as $5,000, which is slightly more costly than a conventionally fired system. A 500,000 BTU per hour system may cost around $20,000. This size system would be suitable for a large building, a greenhouse, or other large system.

As is the case with all equipment, other related costs may exceed the cost of the system. A thorough analysis of maintenance costs, environmental impacts, and byproduct disposal fees should be considered.

Q: How much energy can a corn burner produce?

A: Shelled corn contains about 7,000 BTU per pound at 15 percent moisture, or about 392,000 BTU per 56 lb. bushel. This means that a small, 50,000 BTU per hour unit would consume a bushel of corn in around eight hours.

Q: Should a corn burner be considered as a primary heat source?

A: This depends on the circumstances, but the Ontario Ministry of Agriculture, a leading authority on these systems, recommends that they are better used as a supplemental system.

Biogas Production

Wastewater and solid wastes from food processing and animal operations can produce a significant amount of energy in the form of a methane rich biogas. Anaerobic digestion is widely practiced today in systems engineered to handle sludge generated by municipal wastewater treatment plants. Municipal wastewater has a relatively low concentration of organics as compared to agricultural wastewater from dairy, beef, poultry, or hog operations, which can approach extremely high concentrations in some cases.

Although the highly concentrated wastewater discharged by food processing and animal agricultural operations requires specialized equipment and processing, it can yield very large quantities of energy in the form of a methane rich biogas. This biogas can then be burned directly as fuel for a boiler; burned directly in other equipment; or biogas can be used as fuel for an engine connected to an electric generator.

Photo credit: www.ci.longmont.co.us

Anaerobic digestion is a natural biological process that occurs simply in large lagoons or tanks at a relatively slow rate. Constructing a sufficient lagoon or tank to process the wastes over a period time can produce a significant amount of energy as well as stabilize the wastes so they can be handled and disposed of without adverse environmental impacts. A cover over the lagoon or tank is necessary to capture the methane rich biogas. The lagoon or tank needs to be sufficiently large to hold and process the incoming flow of wastes over a period of 30 to 100 days or longer in order to achieve effective processing. Construction of large tanks can be costly and can make this approach financially unattractive to agriculture enterprises.

The rate of anaerobic digestion also can be accelerated using concentrated waste streams in smaller tanks with engineered mixing and more sophisticated process and temperature controls. This approach can potentially reduce the capital cost of the tanks and related equipment and provide a more attractive return on investment ratio of costs versus useful energy generated.

Frequently Asked Questions:

Q: What types of biogas production equipment are most frequently used?

A: Dairy farms commonly use subsurface lagoons. The main advantage of a lagoon is reliability, but a main disadvantage is a long retention time needed to process the wastes into biogas. Tanks with an engineered mixing system and process controls are increasing in use and can substantially reduce the retention time needed to process the waste into biogas. Mixed and controlled tanks have shorter processing times and can be smaller, less costly and produce more biogas than large lagoon systems.

Q: How much residual material remains after processing, and how can it be used?

A: The wastewater discharge from an anaerobic digester can be separated from the residual solids and is much lower in nutrients than the incoming wastewater. The discharged water is typically pumped onto fields with spray irrigation systems. The residual solid materials (representing a 40 percent reduction in volume from the incoming wastewater) can be used as bedding material for dairy cows or can be easily composted.

Q: Are digesters feasible for small operations?

A: Currently, biogas systems are installed at relatively large operations with 1000 cows or more. Biogas systems suitable for the equivalent of a 100 dairy cow operation or small food processor are being developed with the appropriate automation and controls to make them cost effective**.**

Q: How does this system affect the odors often associated with animal and food processing wastes?

A: Odor control is one of the main advantages of this type of waste treatment. In addition to producing energy from the wastes, digesters significantly reduces odors.

Biofuels

Currently, there are two major bio-based fuels in production. The first, and most widely produced, is ethanol, which is manufactured by a fermentation process that uses corn as its starting material. Currently, nearly 20 percent of the U.S. corn crop is being converted into ethanol. There are more than 100 ethanol plants in operation in twenty states. The Renewable Fuels Association estimates that 50 additional ethanol plants are under construction.

Ethanol production requires a large capital investment. (Some experts suggest that large facilities, those with greater than 50 million gallon annual production capacity, costing from $80 to $100 million, are required to maximize efficiency). They also produce significant quantities of byproducts such as distiller grains (17 pounds per bushel of corn). The profitable sale of these byproducts often determines the profitability of an operation. Facilities also have issues with energy usage, permitting, and transportation. For these and other reasons, investment in ethanol production is not particularly attractive to individual or groups of growers. The United States Department of Agriculture estimates that ethanol production will provide a significant price support for corn for the next 10 to 20 years, which appears to be the major benefit from ethanol.

Photo credit: www.ens-newswire.com

The other major biofuel in use is biodiesel, a substitute for petroleum diesel. More than 90 percent of U.S. biodiesel production comes from soybean oil, but other sources such as alternative oilseed crops, palm oil, animal fats, and recycled oils are also used. Biodiesel is produced from a transesterification process, which avoids many of the problems associated with the production of ethanol. The investment and operating costs associated with biodiesel are also significantly lower, so small operations can be profitably operated. In fact, existing biodiesel plants have annual capacities that range from 200,000 to 30 million gallons per year. (Only seven current plants have annual capacity above 15 million gallons). Biodiesel production can be economically viable on a small scale.

Frequently Asked Questions:

Q: Is there a rule of thumb for investment costs for biodiesel plants?

A: Yes. A common rule of thumb for estimating investment in biodiesel plants is about $1 per gallon of annual capacity. This estimate is based on a $5,000,000 investment for a 5 million gallon capacity plant. For smaller plants (approx. 1 million gallon and lower annual capacity), the investment increases to around $1.50 per gallon of capacity.

Q: How is biodiesel typically sold?

A: Most biodiesel produced today is sold to various fleets: government fleets, urban bus fleets and school buses. Biodiesel also is sold increasingly through dealers for farm equipment, marine engines, and furnaces as a replacement for heating oil.

Q: Can biodiesel be used in existing equipment?

A: Biodiesel can be used in most diesel engines with little modification. Because it has similar properties to petroleum diesel, it can be blended in any ratio with petroleum diesel. B-20, a blend of 20 percent biodiesel, is commonly used.

Q: What are normal operating costs for a biodiesel production facility?

A: The largest component of biodiesel processing costs is the cost of feedstock. Soybean oil at current prices costs about $1.95 to produce one gallon of biodiesel. Processing costs for a typical facility are typically $.50 per gallon (for a 5 million gallon plant, higher for a smaller facility). The total production costs, excluding capital, would then be around $2.45.

Government Installation Incentive Programs

Financial support is available from a number of State and Federal government agencies for renewable energy installations. Support is offered in the form of loans, loan guarantees, tax credits, and in some cases, grants. A partial list of incentives available for those considering a development in Ohio include the following.

Grants are available from the USDA Rural Development Renewable Energy Systems and Energy Efficiency Improvements Programs. These annual programs were enabled by Section 9006 of the 2002 farm Bill and can provide up to $500,000 for renewable energy projects and $250,000 for energy efficiency projects. In Ohio, the Ohio Department of Development's Office of Energy Efficiency also offers renewable energy grants to anyone in Ohio considering an alternate energy installation. Applicants must be a customer of one of Ohio's four investor-owned utilities.

Loans for renewable projects also can be secured from several State and Federal sources. USDA Rural Development administers direct loans and loan guarantees for qualifying individuals and businesses. Ohio's Office of Energy Efficiency also administers a Renewable Energy Loan Program for projects within the state.

Currently, both Federal and State **tax credits** are available in a number of areas for investors, owners, and operators of renewable energy systems.

Useful Internet Links

There are currently many other sources of information on the renewable energy systems discussed above. Among the most useful sources are the following:

NREL - National Renewable Energy Laboratory
http://www.nrel.gov/

ORNL - Oak Ridge National Laboratory
Energy Efficiency & Renewable Energy Program
http://www.ornl.gov/sci/eere/renewables/index.htm

EERE - U.S. Department of Energy
Energy Efficiency and Renewable Energy
http://www.eere.energy.gov/

U.S. Department of Agriculture, Rural Development
2002 Farm Bill Initiative: Title IX, Section 9006 --
The Renewable Energy and Energy Efficiency Program
http://www.rurdev.usda.gov/rbs/farmbill/index.html

GEO - Green Energy Ohio
http://www.greenenergyohio.org/

OEE - Ohio Department of Development
Office of Energy Efficiency
http://www.odod.state.oh.us/cdd/oee/

Ohio's Clean Power Estimator
An economic evaluation tool that provides an estimate of the benefits and costs associated with a renewable energy system
http://www.clean-power.com/cleanpowerestimator/odod.htm

TIAP - Tax Incentives Assistance Project
Provides information on federal income tax incentives, passed by Congress as part or the Energy Policy Act of 2005, for energy efficient products and technologies
http://www.energytaxincentives.org/

Ohio Energy Loan Fund Programs
Grants & Loans
http://www.odod.state.oh.us/cdd/oee/GrantsLoans.htm