OHIO STATE UNIVERSITY EXTENSION

COMMUNITY DEVELOPMENT FACT SHEET

CDFS-4101-14

Farm Energy Fact Sheet Series

An Introduction to On-Farm Solar Electric Systems

Eric Romich, OSU Extension Field Specialist, Energy Development

Introduction

According to the U.S. Energy Information Administration 2013 Annual Energy Outlook Report, the national average cost for electricity in the industrial sector, which includes agricultural and irrigation, is projected to increase from 6.4 cents per kWh in 2013 to 12.8 cents per kWh in 2040 (U.S. Energy Information Administration, 2013). An increase in energy costs will generally raise the prices of agricultural products and reduce farm income, limiting the potential for growth. Energy inputs are important to agriculture, with direct and indirect energy-related expenses representing an average of more than 13 percent of total farm production expenses in 2005–08 (U.S. Department of Agriculture, 2011).

Implementing on-farm solar electric systems can be an excellent way for farmers to reduce and stabilize electricity costs, allowing them to remain profitable and grow for future generations. According to the 2009 On-Farm Renewable Energy Production Survey, it is estimated there are 115 farms in Ohio that have installed a solar electric system to generate electricity (U.S. Department of Agriculture, 2011). According to the study, solar energy was the most prominent way to produce on-farm renewable energy.

Farmers have traditionally been stewards of the land, and an investment in renewable energy supports their role in protecting the land, air and water (Xiarchos, I. M., Vick, B., & United States, 2011). This fact sheet provides an overview of renewable energy policy drivers, introduction to photovoltaic solar technology, on-farm applications, and outlines considerations and references to guide you in the decision-making process.

On-Site Energy Generation and Net Metering

Distributed energy generation (DEG) systems refers to on-site, small-scale electric generation systems typically owned by customers and interconnected to the grid to reduce the amount of electricity they purchase from the utility (Romich, 2013). For the purpose of this fact sheet series we will refer to distributed energy generation systems as on-site or on-farm solar electric systems. To foster the implementation of on-site energy systems, many states including Ohio have established a net metering policy.

Ohio's net-metering law was enacted in July 1999 as part of the state's electric-industry restructuring legislation. The law has since experienced a number of amendments, most recently in May 2008 when S.B. 221 removed a capacity limit for all customer-generators and removed all limitations related to energy generation technology and system size on systems sited at hospitals (Database of State Incentives for Renewables and Efficiency, 2012).

Net metering is a billing arrangement that allows customers to install on-site generation systems to produce their own electricity and receive a credit for any extra electricity produced by the system that flows back onto the electric utility's distribution system. Credits accumulated under a net metering agreement can be carried forward and applied toward billing charges in future months. In Ohio, net metering credits transferred from one month to the next apply only to kilowatt-hour generation charges and do not reimburse system owners for distribution or transmission service fees. However, to the extent that solar systems offset electrical usage during a monthly billing period, a customer would receive the equivalent of the full cost of electricity.

In Ohio, net metering is applied differently by different publicly owned utilities of which there are four. In addition, rural electric and municipal utilities are not governed by Ohio net metering laws but by federal rules that require them to interconnect distributed generators. This means that utilities apply many varied and different rules to net metered customers. For example, some rural utilities (e.g. Holmes Wayne) may require insurance policies before they will grid-tie a system. Publicly owned

utilities may charge as much as a thousand dollars to replace one way with two way meters at the customer's expense. Understanding how your utility implements grid interconnection and net metering is essential to understanding the return on a solar system investment.

Net metering systems must be connected to and operate in parallel with the local electric utility system. If you are interested in developing an on-site generation system, you must contact your local electric utility and request an application for interconnection service. Contact information for your utility can be found on your bill.

Photovoltaic Solar Technology

According to the first USDA On-Farm Energy Production Survey, solar panels have been the most common way to produce on-farm renewable energy (U.S. Department of Agriculture, 2011). Solar electric systems require a significant upfront capital investment. However, once the initial capital investment is recovered, on-site solar electric systems have many benefits including a free renewable fuel source (sunlight) and no moving parts, which results in low operational and maintenance costs.

Photovoltaic (PV) solar gets its name from the process of converting light (photons) into electricity (National Renewable Energy Laboratory of the U.S. Department of Energy, 2012). In general terms, light absorbed by a photovoltaic panel knocks loose electrons from semiconductor materials creating free positive and negative charges. The freed charges have energy or "voltage" that results in an internal electric field pushing charges through the cell, creating an electric current. The electric current flows from the cell to the load. For the purpose of this fact sheet series, we will refer to photovoltaic solar as solar electric systems.

The two primary types of solar panels include crystalline silicon and thin film. Due to its abundance, the most common solar cell material is silicon. Solar cells are made with polycrystalline, monocrystalline and amorphous silicon. The most efficient (44%) and expensive cells have multiple layers made from compounds of multiple elements, such as indium and gallium. Amorphous silicon in general has a lower efficiency (8 to 13%) than crystalline silicon panels (16 to 24%) but usually cost the same on a per watt basis than crystalline silicon panels. However, amorphous silicon panels can be flexible and easier to install than crystalline panels.

Solar Electric Systems

Solar electric systems involve three primary components: the solar modules, the inverter and the Balance-of-System (BOS). A collection of solar cells are wired together and organized in a rigid frame to form a panel, and multiple panels are often mounted together to produce a solar array. The panels are connected to an inverter, which converts the DC electricity of the panels to AC electricity used for most applications. Additional components of a system are referred to as the balance-of-system (BOS). The BOS requirements vary between applications due to site-specific capacity and design. Common BOS components include:

- Meter(s)
- Safety equipment (disconnect switches, etc.)
- Conduit, cables, and combiner boxes
- Racking and tracking gear

Image 1: Ground Mount Solar Electric System on a Grain Dryer

Image 2: Rooftop Solar Electric on Swine Barn

Photos courtesy of (top) Jess Ennis, Ecojiva Solar and (bottom) Eric Romich, OSU Extension Field Specialist.

Solar Energy and Agricultural Applications

Historically, agricultural applications of solar electric systems were used at remote locations to power fences, remote water pumps, and irrigation systems where it was too costly to install a power line to the isolated site. In recent years, however, on-farm solar electric systems are expanding to include grid tied applications to provide electricity to applications with much greater electrical demand. In addition to general indoor lighting in shops and sheds, on-farm solar electric systems can offset the electricity demands for grain drying bin circulation fans and livestock production buildings' ventilation and cooling systems. In Ohio, some of the first examples of large-scale agricultural operations utilizing electricity from on-farm solar systems include animal housing (swine and beef cattle) and drying bins, as shown in

images 1 and 2. Some on-farm solar electric applications may include, but are not limited to:

- Lighting
- Electric fence
- Feed handling
- Refrigeration
- Building ventilation fans
- Fans for crop drying
- Livestock water pumping
- Irrigation water pumping

In recent years, a growing number of Ohio farmers have invested in the development of on-farm solar electric systems to offset a portion of their electrical needs. Given the high demand for electricity in many agricultural operations and the access to open space, Ohio farmers are well positioned to implement on-farm solar electric systems.

Working With Your Utility Provider

Once you have researched solar electric systems, identified an application on your farm, and conducted a site analysis, if you are still interested in proceeding, your first step is to contact your local electric utility provider to discuss your plans. An on-farm solar electric system with a net metering agreement must be connected to the electric utility's distribution system, which may present a number of issues and challenges that should be considered before making a final decision to invest in a system. As a result, you should contact your utility representative early in the process to discuss your vision for the project, potential barriers, and requirements for proper interconnection procedures. The Public Utilities Commission of Ohio (PUCO) website (**puco.ohio.gov/puco/index.cfm/consumer-information/consumer-topics/net-metering-faq/**) has a number of resources available to assist you in understanding net metering and the interconnection application process.

Selecting a Solar Developer

Investing in an on-farm solar electric system is a major decision that requires a significant upfront capital investment. Each solar electric system is unique due to site-specific variables, and system cost and reliability will greatly depend on the experience of your installer and design of your system. So how do you locate a qualified solar electric developer/installer? As a first step, you may conduct a search on the Internet to identify some options. Another approach is to contact your electric utility provider and ask if they can provide you a list of solar developers they have worked with in the past. Perhaps the best option is to contact someone in your area who has installed a system and ask them who they considered and whether they can recommend their installer. Green Energy Ohio, a non-profit corporation, also has lists of Ohio installers at (**greenenergyohio.org/page.cfm?pageId=315**). Regardless of how you find a solar developer/installer, it is essential that you identify a company you are comfortable with personally, and who demonstrates experience in solar electric systems and a familiarity with local electric utility providers' interconnection application process. Potential questions to consider asking a developer or installer include:

1. How long have you been in business and what license/certifications do you have (i.e. North American Board of Certified Energy Practitioners)?
2. How many grid-connected PV systems has your company installed?
3. What type of insurance do you carry?
4. What do you know about zoning, building and electrical codes (i.e. Institute of Electrical and Electronics Engineers IEEE 1547 Standard) in your area?
5. Do you handle paperwork and processing for federal and state incentives?
6. Do you handle the application and registration processing for Solar Renewable Energy Credits (SRECs) and do you purchase or broker the SRECs? What is the value?
7. Do you offer ongoing operations and maintenance agreements?
8. What system warranties do you offer?
9. What assumptions do you make in your system payback projections (i.e. grants, percentage of energy offset, utility cost of electricity, projected rate increases)?
10. Can you provide me with a list of referrals?

Summary

The agriculture sector was an early adopter of off-grid solar electric solar systems as a remote energy source. Over the last decade, high costs have limited the widespread adoption of on-farm solar electric systems that are connected to the grid. However, recent technology advancements, renewable portfolio standards, and the increased scale of market development have stimulated a reduction in the cost of solar. According to a U.S. Department of Energy Sun Shot Report, the average installed solar price for midsized systems (between 10 kW and 100 kW) has dropped by 6% to 7% annually from an average installed cost of more than $10 per watt in 2000 to $4.62 per watt in 2012 and $3.50 in 2014.

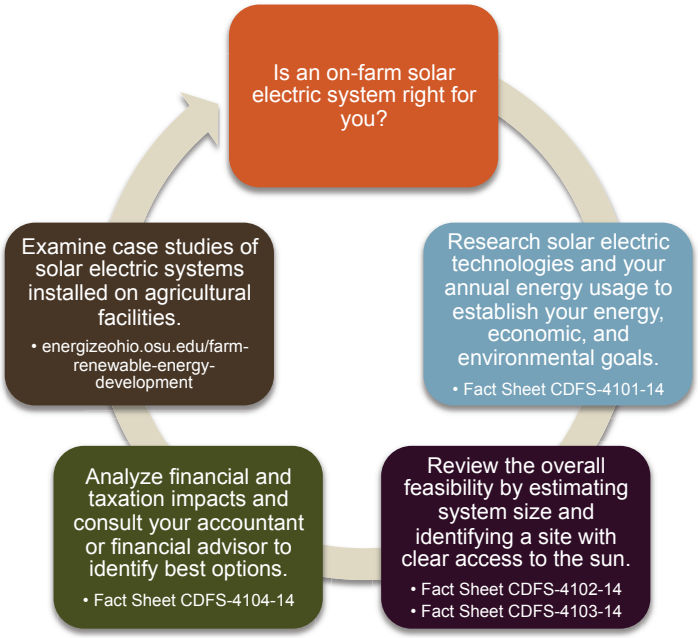
In general, solar electric systems are very compatible with agriculture operations, as farmers have access to open land and often have high electricity demands. Additionally, many farmers are supportive of solar electric because it fixes a portion of future energy costs, has low

maintenance costs, positive environmental attributes, and once the initial capital investment is recovered, the fuel is free. According to the 2009 On-Farm Renewable Energy Production Survey, solar projects are the most common way to produce on-farm renewable energy, as they are present in 93% of farms with on-farm renewable energy production (U.S. Department of Agriculture, 2011). However, the continued expansion of grid connected on-farm solar electric applications will ultimately depend on the continued decline in the cost of solar systems and the rise in the cost of electricity.

As solar electric systems have become more economical, a growing number of farmers are considering on-farm solar electric systems. The purpose of the on-farm solar electric energy fact sheet series is to provide farmers additional information on solar electric to assist them in the decision making process. Figure 1 outlines critical steps in the decision-making process and provides a reference to OSU Extension fact sheets to inform each step.

The cost of an on-farm solar electric system is significant and, depending on a number of factors, including your cost of electricity, average electricity usage, and financial incentives, it may or may not be economical. However, a growing number of Ohio farmers are analyzing projects, with many projecting an acceptable payback period worthy of an investment. If you are considering investing in solar electric, it is essential to review the benefits and challenges related to on-farm solar electric and your specific application to determine if it is a good fit for you.

Figure 1: Is On-Farm Solar Electric Right for You?



References

Database of State Incentives for Renewables and Efficiency. (2012, September 19). *Ohio Incentives/Policies for Renewables & Efficiency*. Retrieved December 31, 2013, from DSIRE: **dsireusa.org/incentives/incentive.cfm?Incentive_Code=OH02R**

National Renewable Energy Laboratory of the U.S. Department of Energy. (2012, May 18). *Solar Photovoltaic Technology Basics*. Retrieved January 2, 2014, from NREL Learning About Renewable Energy: **nrel.gov/learning/re_photovoltaics.html**

U.S. Department of Agriculture. February 2011. *USDA's 2009 On-Farm Energy Production Survey*. National Agricultural Statistical Service (NASS), United States Department of Agriculture (USDA). Retrieved December 31, 2013, from agcensus.usda.gov: **agcensus.usda.gov/Publications/2007/Online_Highlights/On-Farm_Energy_Production/index.php**

U.S. Department of Energy. (2007, March 1). *The Potential Benefits of Distributed Generation and Rate-Related Issues That May Impede Their Expansion*. Retrieved December 31, 2013, from energy.gov: **energy.gov/oe/downloads/potential-benefits-distributed-generation-and-rate-related-issues-may-impede-its**

U.S. Energy Information Administration. (2013). *The Annual Energy Outlook 2013 (AEO2013)*. U.S. Department of Energy, U.S. Energy Information Administration. Office of Integrated and International Energy Analysis.

Xiarchos, I. M., Vick, B., & United States. (2011). *Solar energy use in U.S. agriculture: Overview and policy issues*. Washington, DC: U.S. Department of Agriculture, Office of the Chief Economist, Office of Energy Policy and New Uses.

Romich, E. (2013). *Fact Sheet CDFS-DEG1-13: Distributed Energy Generation Series: Producing Your Own Electricity in Ohio*. Columbus: The Ohio State University.

Ohio State University Extension embraces human diversity and is committed to ensuring that all research and related educational programs are available to clientele on a nondiscriminatory basis without regard to age, ancestry, color, disability, gender identity or expression, genetic information, HIV/AIDS status, military status, national origin, race, religion, sex, sexual orientation, or veteran status. This statement is in accordance with United States Civil Rights Laws and the USDA.

Keith L. Smith, Associate Vice President for Agricultural Administration; Associate Dean, College of Food, Agricultural, and Environmental Sciences; Director, Ohio State University Extension; and Gist Chair in Extension Education and Leadership.

For Deaf and Hard of Hearing, please contact Ohio State University Extension using your preferred communication (e-mail, relay services, or video relay services). Phone 1-800-750-0750 between 8 a.m. and 5 p.m. EST Monday through Friday. Inform the operator to dial 614-292-6181.

Copyright © 2014, The Ohio State University