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Electricity purchase agreements and distributed energy policies for anaerobic digesters

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HIGHLIGHTS

- ▸ Anaerobic digester net present value was examined over a range of herd sizes.
- ▸ Standby charges reduce electricity sales revenues by an average of nearly 20%.
- ▸ Net metering rules reduce profitability by restricting engine–generator size.
- ▸ Feed-in-tariffs for digesters are significantly affected by project size.

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ABSTRACT

Anaerobic digestion is increasingly recognized for its ability to produce renewable energy and reduce greenhouse gas emissions from livestock operations. In 2010, there were 2645 U.S. dairy farms with herd sizes large enough to support anaerobic digesters, yet only 156 systems were in operation (U.S. Environmental Protection Agency (U.S. EPA), 2010a. Market Opportunities for Biogas Recovery Systems at U.S. Livestock Facilities. AgSTAR Program; U.S. Environmental Protection Agency (U.S. EPA), 2011. Operational Anaerobic Digesters, Sorted by State (Dairy). AgSTAR Program.).[1] This study analyzes the net present value of digester systems under alternative electricity purchase agreements and how returns are affected by standby charges, net metering policies and the use of feed-in-tariffs. In order for digester potential to be fully realized on a state or national level, changes to distributed energy policy are required. Results indicated that standby charges can reduce revenues from offsetting electricity by an average of nearly 20%. Net metering rules limit participation among larger farms and negatively affect profitability by restricting engine–generator size. Lastly, the effectiveness of a fixed price feed-in-tariff policy for digesters is significantly affected by project size differentiation. Digester energy policies are similar nationwide, making this study useful for government regulatory agencies and digester owners throughout the U.S.

1. Introduction

Anaerobic digestion of organic matter is receiving a great deal of attention as a source of renewable energy and a method to reduce greenhouse gas (GHG) emissions (Michigan Department of Agriculture (MDA), 2009; Safferman and Faivor, 2008). Nationally, an average of eight percent of GHGs comes from production agriculture (Wightman, 2006). Seventy-five percent of production agriculture emissions are methane and nitrous oxide; gases with 23 and 310 times the heat trapping ability of carbon dioxide, respectively (Wightman, 2006). Dairy farms in particular have been identified as significant sources of GHGs and reducing their environmental impact is a focus of dairy industry groups and the United States Department of Agriculture (USDA). A 2009 memorandum of understanding between the USDA and The Dairy Innovation Center outlined a partnership to reduce emissions by 20% by 2020 (U.S. Department of Agriculture (USDA), 2009). Anaerobic digesters could greatly contribute to this goal.

In contrast to conventional liquid and slurry management systems, anaerobic digesters provide multiple environmental benefits such as odor control, improved air and water quality, improved nutrient management flexibility and the opportunity to capture biogas for renewable energy use (U.S. Environmental Protection Agency (U.S. EPA), 2002). While biogas storage exists, it is mostly used on-site for the production of electricity

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[1] The EPA AgSTAR program considers farm sizes of least 500 cows to be feasible to support an anaerobic digester.

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(Krich et al., 2005). According to the EPA AgSTAR Program, over 85% of the operational dairy digesters in the U.S. in 2010 involved the production of electricity (U.S. Environmental Protection Agency (U.S. EPA), 2011). If all dairy farms with sufficient manure production to support digesters were operational, total nationwide electricity production could potentially contribute 6.8 million MW h/year to the grid (U.S. Environmental Protection Agency (U.S. EPA), 2010a), powering nearly 600,000 homes on an annual basis.[2]

Past research has found that on-farm digester systems are marginally unprofitable under existing energy policies without creative uses for digester by-products such as animal bedding, compost and high quality fertilizer (Leuer et al., 2008; Gloy and Enahoro, 2008) or a combination of financial incentives and electricity rate subsidies (Wang et al., 2011). In order for the potential of anaerobic digesters to be fully realized on either a state or national level, changes to distributed energy policy are required. While many states have improved existing policies for small wind and solar technologies, anaerobic digesters have not received equal consideration. Electricity purchase agreements are the focus in this research. These agreements tend to be of three types: buy all-sell all, surplus sale or net metering (Lazarus, 2008). While the specifics (such as electricity purchase price and administrative charges) vary with the utility company, the basic business model of each agreement type is the same throughout the country. According to a survey of 64 producers across the U.S., negotiating these contracts was the biggest challenge faced by dairy producers with anaerobic digesters (Lazarus, 2008). In addition, some utilities impose demand or standby charges to pay for the availability of electricity to the farm when the digester system is not running (standby charge). In many cases, difficulties related to negotiating with utility companies discouraged farmers from installing digesters that had been planned (Lazarus, 2008).

This study examines policy options associated with the sale of electricity to the grid. A capital budgeting model was developed to analyze purchase agreement options while providing insight for policy makers and digester owners. Policy tools such as Renewable Energy Credits (RECs) and carbon credits were incorporated into the model.

Representative Michigan dairy farm situations were used as a basis for analysis. Michigan is of interest, since it is among the top ten states for dairy farm digester potential yet has only six operational (U.S. Environmental Protection Agency (U.S. EPA), 2010a). The model could be applied to other states as well as other types of agricultural operations that could utilize anaerobic digesters.

Five hundred cows is considered the minimal size for a profitable digester and the analysis included three scenarios accommodating lactating herd sizes between 500 and 4000 cows (U.S. Environmental Protection Agency (U.S. EPA), 2010a). In 2010, there were 2645 U.S. dairy farms with herd sizes large enough to support anaerobic digesters (U.S. Environmental Protection Agency (U.S. EPA), 2010a). The first scenario examined the net present value (NPV) of digesters with each agreement assuming typical system performance.[3] A positive NPV indicates that the project would be profitable given the opportunity cost of capital required by the farmer. A negative NPV indicates the opposite conclusion. Unlike previous studies, electricity sale options were compared while taking into account standby and other utility charges. A second scenario, examined the Michigan net metering program. Net metering is currently offered in 11 of the 12 Midwestern states, but the emphasis has been primarily on small wind and solar technologies (Database of State Incentives for Renewables & Efficiency, 2011; U.S. Census Bureau, 2012).[4] The last scenario examined feed-in-tariff (FIT) policy design in the region and its potential to increase the adoption of digester systems. FITs are the most widely used policy mechanism to increase renewable energy generation globally and five Midwestern states (Michigan, Indiana, Illinois, Wisconsin and Minnesota) have proposed FIT legislation within the last three years (Couture et al., 2010).

2. Anaerobic digestion

Anaerobic digestion is the breakdown of organic material, in this case dairy manure, by bacteria in the absence of oxygen resulting in the production of biogas (Bracmort et al., 2008). On-farm anaerobic digesters are the most common use of the technology with the vast majority occurring on dairy farms (Lusk, 1998; U.S. Environmental Protection Agency (U.S. EPA), 2010a). The technology has been around for centuries, but the first farm-based digester in the U.S. was not built until 1972 (Lusk, 1998). During the 1970s, a number of digesters were constructed, but many failed due to poor system design, improper system installation and unsatisfactory system management. Beginning in the mid 1980s, there were improvements in digester designs (Lusk, 1998). In recent years, the need for odor control, reduction of GHG emissions and residuals management has led to a resurgence of interest in anaerobic digester technology.

Biogas is a by-product of anaerobic digestion and is a combination of methane (50–70%), carbon dioxide (30–40%), water vapor and trace amounts of other gases such as hydrogen sulfide (H_2S) (U.S. Environmental Protection Agency (U.S. EPA), 2002). H_2S is very corrosive and can cause damage to engines, boilers and other digester components. Only the methane component of biogas has energy value.

Anaerobic digestion systems include feedstock (manure) collection and handling, reactor(s) and the recovery/use/storage of biogas and by-products (Fulhage et al., 1993). Dairy manure is generally collected by scrape or flush from freestall barns two or three times a day. Manure characteristics and collection methods determine the type of digester technology used. U.S. livestock operations currently use four types of technologies: plug-flow, complete mix, fixed film and covered lagoons (Wilkie, 2005). The system parameters are site-specific and may vary significantly across livestock operations (Wilkie, 2005). In this study, the model is based on a complete mix digester since it is best suited for the Upper Midwest climate.

While livestock manure is the main feedstock for farm-based digesters, other feed stocks (e.g., food processing waste, ethanol syrup, crop residues) can be added to increase biogas production. This is referred to as co-digestion. The goal of co-digestion is to maximize biogas production per unit volume of the digester system, while staying within an acceptable carbon to nitrogen ratio. The overall nutrient ratio in waste materials is of major importance for an efficient and stable microbial biodegradation process (Steffen et al., 1998). Increased biogas production resulting from co-digestion can significantly increase the system's NPV.

Odor reduction also contributes to the value of the digester. The process of digestion itself converts volatile organic acids in manure to more stable forms that can be land-applied with fewer

[2] This assumes that a household uses an average of 958 kW h per month (U.S. EIA, 2011).

[3] Typical system performance refers to parameters related to biogas production, electricity generation, digester heating and tank design characteristics.

[4] The Midwestern states referred to here are those defined by the U.S. Census Bureau.