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Project Title: **Optimizing Renewable Electric Energy Generation on Minnesota Dairy Farms**

Contract Number: RDF4-2 Milestone Number: 3 Report Date: 4/5/2017

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Congressional District: (Corporate office) 5th District

Congressional District: (Project location) 7th District

MILESTONE REPORT

Executive Summary:

This project has three primary goals: to increase the market penetration of renewable electric energy resources on Minnesota dairy farms by developing an optimized and integrated on-site electrical generation system, to support Minnesota companies through field testing and validation of their commercial, or soon to be commercial, renewable electric generation systems and components, and to reduce the carbon footprint and increase the long-term profitability of Minnesota dairy farms through on-site renewable electricity generation.

The third milestone for this project involves completing the contracts for solar PV and small-scale wind renewable energy systems and beginning construction. Another deliverable is a completed contract for the control and data acquisition system.

Construction of the solar PV array is complete and was interconnected to the utility grid on October 4th, 2016. Wind turbine tower systems have been assembled and set in place. Turbines are expected to be mounted soon pending resolution of a certification issue with the power inverters. Control and data acquisition systems have been installed and commissioning is underway.

Technical Progress:

The ground-mounted solar array is comprised of Minnesota made tenKsolar panels and inverters. Construction of the 50 kW solar array was started in mid-July. The process consisted of drilling 44 helical earth anchors 8 feet into the ground in a grid pattern with a large boom truck (see Figure 1). The anchors support large rails provided by the solar panel manufacturer which in turn support small clips that attach directly to the solar modules (Figure 2). The array passed the final electrical inspection and islanding test and was

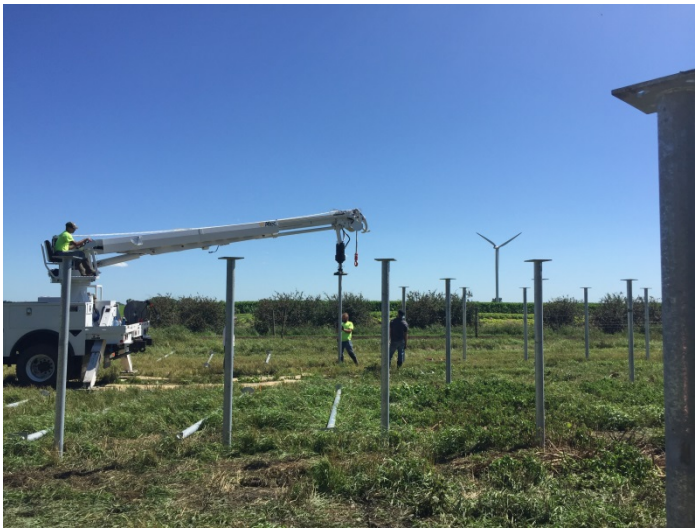

Figure 1. Installing Solar Array Earth Anchors

interconnected on October 4th.

Each wind turbine system consists of an 80 foot tall tower made by ARE Telecom, a 10 kW turbine made by Ventera, and an inverter to condition the generated electricity and feed it to the utility grid. There is also a disconnect switch mounted near each tower base to allow a quick shut down of the turbine in the event of an emergency. Usually, a two-way meter will be installed by the utility to measure production of the turbine for proper billing credit. The turbine located in a cow pasture (north tower site) will also have 4 kW or solar PV panels mounted to poles at its base and a separate inverter and disconnect switch. This tower site was chosen for the wind/solar hybrid installation because it has much better southern sunlight exposure than the other site.

Figure 2. Solar Array Rail Mounting

Tower/foundation components were delivered to the WCROC and assembled on-site during the first 2 weeks of December. The foundations were assembled inside the farm shop due to particularly cold and windy weather. The foundation assemblies were then moved to the prepared sites with a telescoping fork lift and filled with soil removed during preparation of the sites (see Figures 3 & 4). The foundation is

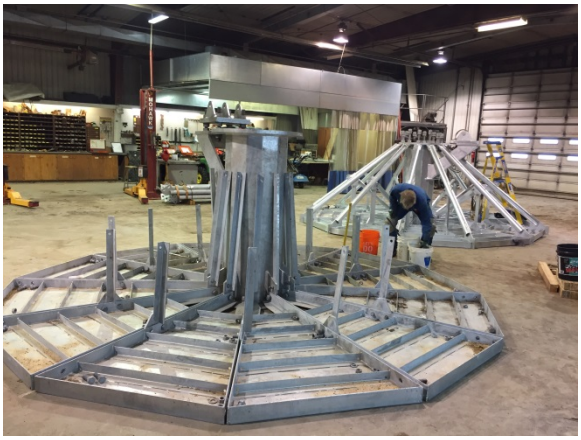

Figure 5. Wind Tower Foundation Assembly

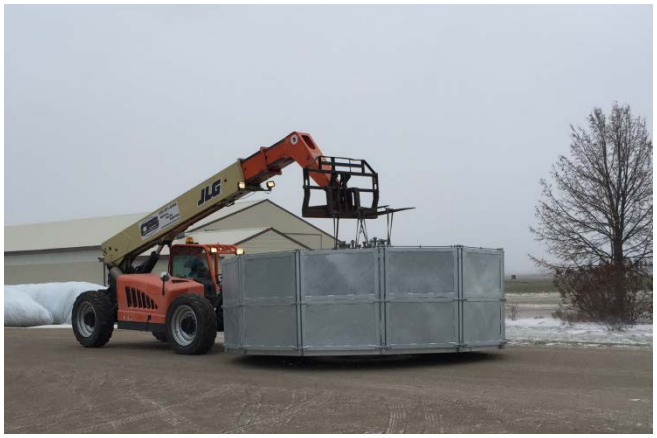

Figure 5. Bringing Tower Foundation to Site

designed to hold 50,000 lbs of fill to prevent the tower from overturning. The north turbine site with the pole mounted solar arrays totaling 4 kW DC is shown in Figure 5. Wind turbine installation and electrical connections are expected to be complete within the next month.

A delay in turbine delivery has resulted from issues getting the proposed power inverter approved for interconnection by the electric cooperative. The utility is looking for UL listing 1741 which ensures equipment meets the standards set out in the IEEE 1547 Standard for Interconnecting Distributed Resources with Electric Power Systems. The proposed inverter does not have that listing so the turbine manufacturer will find a different inverter or contract with a professional engineer to assess the installed equipment and provide a signed document

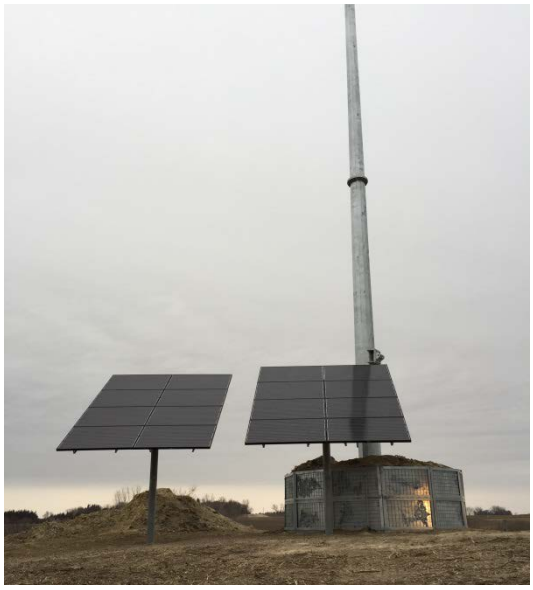

Figure 3. North Site with 4kW Solar Array

attesting that it meets the requirements of the standard. Either approach is acceptable to the utility.

Small wind turbines usually do not have a gear box that regulates how fast the turbine rotors spin so they generate power that is called “wild AC”. Wild AC means the frequency of generated power varies with wind speed allowing the frequency to vary between values that are much lower and higher than the regulated 60 hertz of the utility grid. Wind turbines need a power inverter to convert the wild AC into DC so it can be conditioned and inverted back into AC matching the characteristics of the utility grid. The UL listing ensures the utility that proposed equipment meet the necessary performance standards.

Commissioning is underway on the supervisory control and data acquisition (SCADA) system for new energy systems installed in the dairy parlor (see Figure 6). The control system operates a heat pump to remove heat from milk as it is transferred to bulk storage tanks and stores the heat in an insulated thermal storage tank filled with water. The control system also operates pumps for a solar thermal system, which also adds heat to the storage tank, and pumps to use heat from the storage tank to preheat water used to clean the dairy parlor. The data acquisition system monitors the flow rate and temperatures across every heat exchanger so the amount of energy harvested, stored, used, and lost can be evaluated. The amount of electricity being used to power all of the pumps, water heaters, and equipment is also being monitored so an overall assessment of system efficiency can be determined. Data will also allow a comparison to be made between the system energy load curve and the power production curves from the solar and wind generation systems.

One problem discovered during commissioning is the heat pump used to chill freshly harvested milk was faulting with high refrigerant pressure and sometimes freezing the milk. This is due to the desire for the heat pump to produce the hottest water possible for storage and the intermittent nature of milk production. The milk flow rate changes as the milking units are switched between cows in a batch process. Additional refrigerant pressure sensors and an ultrasonic milk flow rate sensor have been ordered and will be installed to facilitate control system programming changes that will prevent heat pump faults.

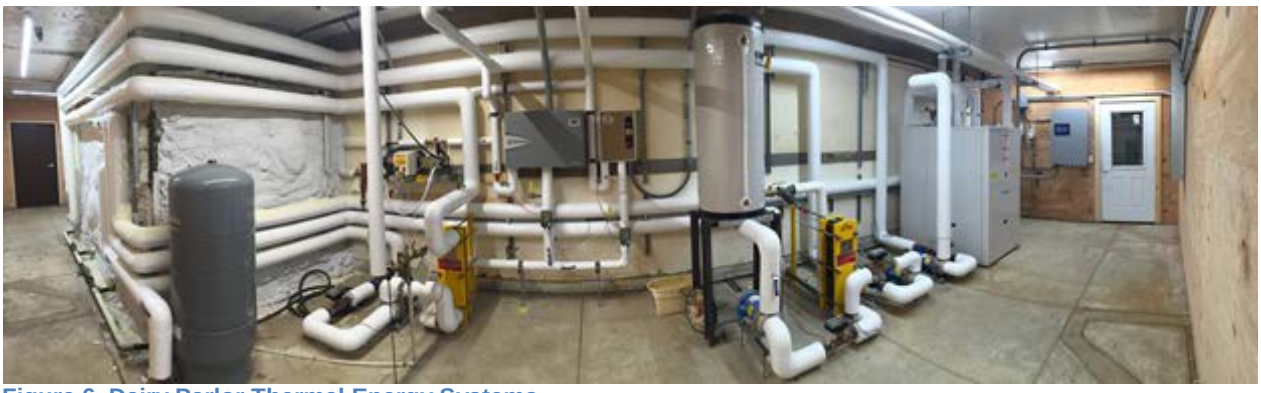

Figure 6. Dairy Parlor Thermal Energy Systems

Additional Milestones: Work continues on Milestone 4 (completion of the renewable energy installations). There has been a delay in the schedule to install two 10 kW wind turbines due to utility acceptance of the proposed power inverter. A new model made by Bergey Wind Systems has been identified that meets utility requirements and has been ordered.

Project Status: The project is a little behind schedule due to the delays in procuring the wind tower systems and turbine/inverter systems, but there is still sufficient time to complete all research goals.

LEGAL NOTICE

Project funding provided by customers of Xcel Energy through a grant from the Renewable Development Fund.