Doing more with less energy

Opportunities exist on today's dairy farms to become more energy efficient, saving resources and money.

by Brad Heins

THE typical dairy uses a large amount of energy, especially during milking. This stems from milking frequency, cooling milk, and cleaning equipment with hot water. Renewable energy systems generally become more economically efficient as energy demands rise, making farms a great place to incorporate renewable energy.

Dairy farms have not typically been set up with energy efficiency in mind and often use relatively expensive fuel sources like heating oil or propane to heat water. One of the difficulties with renewable energy systems is the intermittent generation of wind and solar energy whereas the energy load on a dairy farm is very consistent since cows are milked two or three times every day.

An efficient way to store energy has long been sought to tie energy production and consumption together. A dairy farm's need for both electricity and heat provides an ideal situation to generate electrical energy on-site to meet current electrical requirements, displace conventional thermal fuels with electrical energy, and evaluate thermal storage as a solution to wind and solar electrical generation.

Our team at the University of Minnesota West Central Research and Outreach Center (WCROC) in Morris, Minn., has been monitoring water and energy usage since the fall of 2013. The Morris dairy operation milks between 200 and 270 cows twice daily and is representative of a mid-size Minnesota dairy farm. The cows are split almost evenly between a conventional and a certified organic grazing herd, and all cows spend the winter outside in lots near the milking parlor.

The existing dairy equipment reflected similarly sized dairy farms but included none of the commonly recommended energy efficiency enhancements such as a plate cooler, refrigeration heat recovery, or variable frequency drives (VFD) for pump motors. The goal of our 2013 project was to raise renewable electric energy generation on dairy farms by establishing a "net-zero" energy milking parlor.

A data logger (Campbell Scientific CR3000) was installed in the utility room of the milking parlor in August 2013 and monitored 18 individual electric loads, 12 water flow rates, 13 water temperatures, and two air temperatures. Average values were recorded every 10 minutes for the last 2.5 years. The milking parlor has gas and electric meters that measure the total consumption of natural gas and electricity within the parlor.

The data helped us evaluate energy and water usage of various milking appliances. Some small energy loads were not measured in unused parts of the barn, or were not directly related to the milking operation. These loads fall into miscellaneous categories and are estimated by subtracting all the measured energy use.

Where the energy goes

Overall, the milking parlor currently consumes about 250 to 400 kWh in electricity and uses between 1,300 and 1,500 gallons of water per day (see figures). The parlor currently uses about 110,000 kWh per year (440 kWh per cow per day) in electricity and 4,500 therms per year in natural gas. A majority of the electricity used is for cooling milk (27 percent), followed by ventilation and fans (16 percent).

Our dairy uses about 600 gallons of hot water per day, with a majority used for cleaning and sanitizing milking equipment, followed closely by cleaning the milking parlor. Energy and water usage fluctuates throughout the year because our dairy calves 60 percent of our cows from March to May and 40 percent from September to December. Therefore, water and energy use escalates dramatically during April.

Our first energy efficiency upgrade was a variable frequency drive for the vacuum pump. Before the upgrade, the vacuum pump used 55 to 65 kWh per day. After the September 2013 installation, the vacuum pump used 12 kWh per day, a 75 percent reduction in energy usage. The data show a large drop in daily electricity usage by the pump providing a vivid example of the kind of energy savings that can be achieved with relatively simple upgrades.

Furthermore, because of our organic and conventional systems, the dairy has two bulk tank compressors: one scroll and one reciprocating. The scroll compressor is the newest and uses 15 kWh per day versus 40 kWh per day for the reciprocating compressor. Based on milk production, the scroll compressor costs 73 cents kWh per cwt. versus $1.08 kWh per cwt., indicating the scroll compressor is more efficient.

In terms of fossil energy use, milk harvesting consumed more energy than feeding and maintenance. This suggests that fossil energy use per unit of milk could be greatly reduced by replacing older equipment with new, more efficient technology or substituting renewable sources of energy into the milk harvesting process.

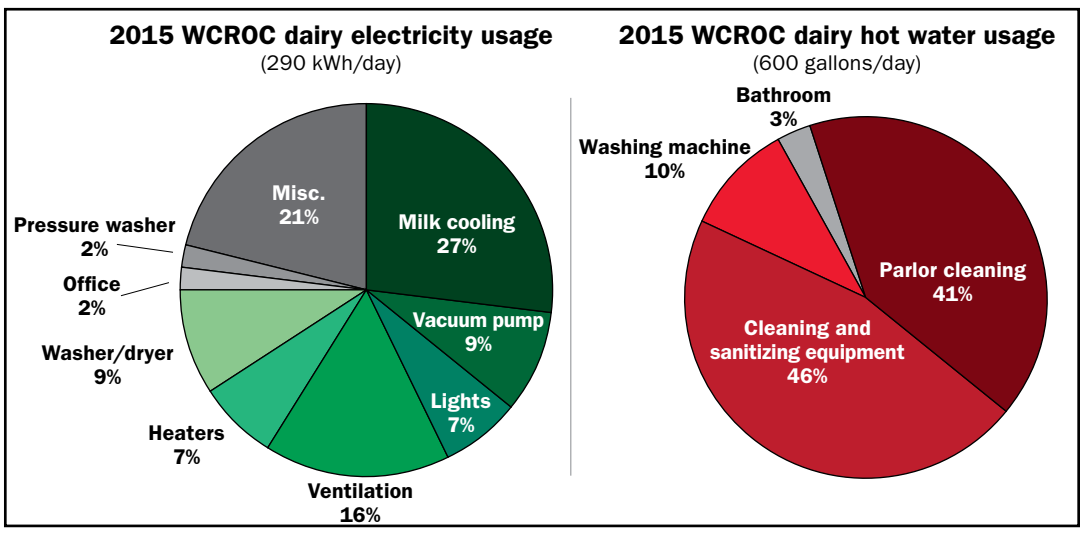
Uncover the savings

To improve energy efficiency, begin with an audit to gather data and identify energy-saving opportunities. Some energy efficiency options that may be installed on dairy farms include refrigeration heat recovery, variable frequency drives, plate coolers, and more efficient lighting and fans. A majority of these upgrades have immediate to two- to five-year paybacks.

Make all electrical loads as efficient as possible, yet practical. Consider converting all thermal loads to electricity by the use of heat pumps that allow for cooling of milk. In the future, we have plans to harvest energy from our manure lagoon and store electricity as heat by use of heat pumps.

Renewable energy options also can improve energy efficiency. These include solar thermal collectors to preheat water, solar photovoltaic panels for generating electricity, small-scale wind turbines for electricity, and large insulated tanks for thermal energy storage.

During the summer of 2016, we will install a 50 kW DC ground mount solar photovoltaic array and two 10 kW wind turbines to meet our dairy's energy demands. A 2,200 thermal storage system employing an electric heat pump will also be installed to recover heat from the milk refrigeration system and solar thermal collectors. Our "greening" of the dairy energy project will investigate energy storage technology that could significantly improve the feasibility of renewable energy on farms in the future.



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