Comparing Energy use on Different Types of Dairy Farms

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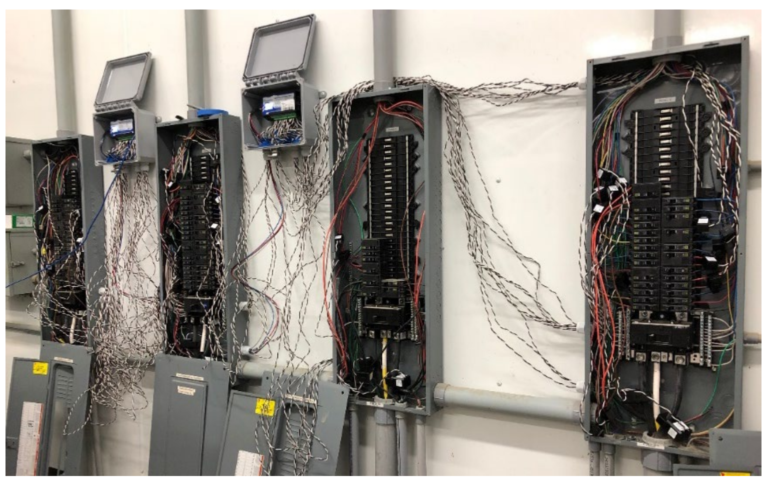
Purpose

Consumer interest and concern is growing in regards to sustainability of food production systems. Demand for increased sustainability and reduced carbon emissions within agricultural systems has been rising along with increasing demand for food products. However, baseline fossil fuel consumption data within agricultural systems, including dairy production, is scarce. Therefore, there is a need to discern where and how fossil energy is being used within dairy production systems. Determining baseline energy use is the first step in investigating where and how demands for sustainability can be met within dairy production systems. The objective of this study was to measure total electricity use as well as determine specific areas of high energy consumption in commercial dairy barns located in the Midwest.

What did we do?

Four commercial dairy barns representative of typical Midwest dairies and located in west central Minnesota were used in the study. All dairies were freestall barns: one 9,500 head, cross-ventilated barn with a rotary parlor (A), one 300 head, naturally-ventilated barn with stirring fans for air movement and an automatic milking system (B), one 200 head, naturally-ventilated barn with stirring fans for air movement and a parabone parlor (C), and one 400 head, naturally-ventilated barn with stirring fans for air movement and a parallel parlor (D).

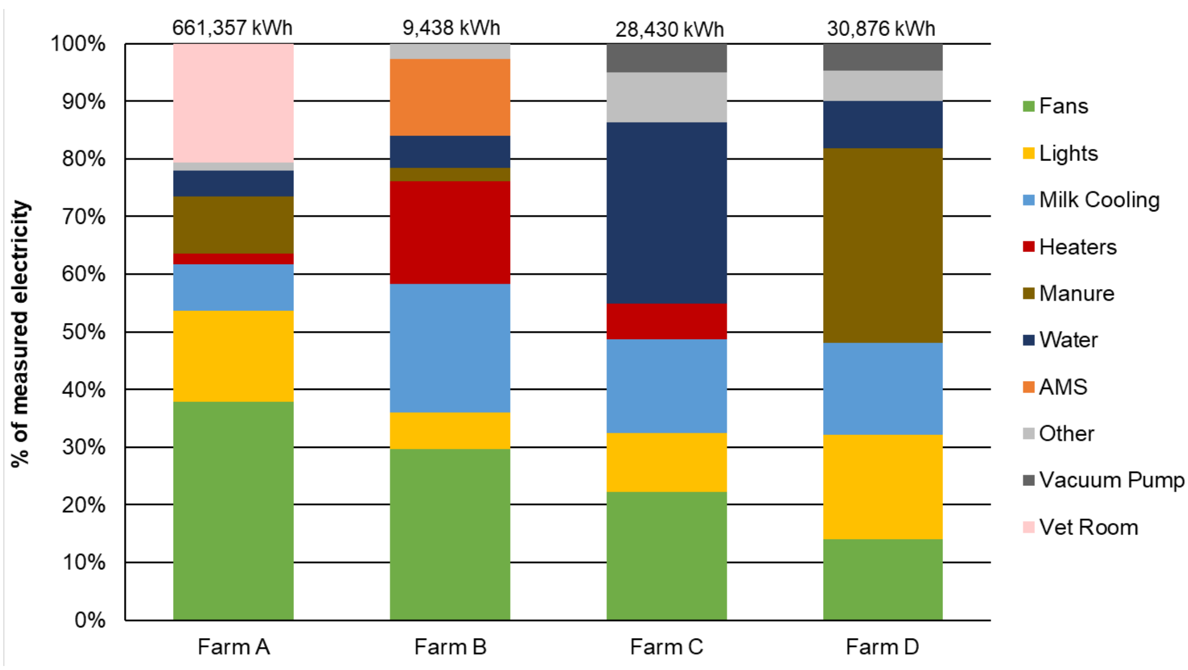


Data loggers with electric current sensors connected and installed in Farm B's circuit panel boxes.

Electricity use was monitored from July 2018 to December 2019. A total of 292 electric loads across the four farms were monitored on the farm side of the electric utility meter to reveal areas of highest usage. Some examples of monitored loads included: freestall fans, water heaters, compressors, chillers, manure pumps, pressure washers, etc. The electric loads were monitored by data loggers (eGauge, Boulder, CO) and electric current sensors at the circuit panels. Electrical use data measured in kilowatt-hours (kWh) of each load were collected and analyzed on a monthly basis. In addition, monthly inventory of cows in the barns, cows milked per day, and milk production was recorded. Bulk tank production records (milk, fat percentage, protein percentage, and somatic cell count) were also recorded.

What have we learned?

Across the four farms, we have found similarities and differences in electricity usage. Despite barn design and capacity differences, during the summer months, fans were the largest electrical load across all four barns. Fan usage in the summer ranged from 20 to 54% of the total electricity measured by data loggers. Regular maintenance, proper control settings, design, sizing, location, selecting energy efficient fans and motors, and other factors all could influence the efficiency of these ventilation systems. On average, dairies B, C, and D used more electricity across all months for milk cooling (compressors and chillers) than Barn A. This is likely due to the fact that Barn A does not utilize bulk tanks to store milk, but instead sends milk directly to milk trucks for shipment. Lighting use ranged from 3 to 37% of the total electricity use measured across the four barns, which suggests there is potential to reduce this usage by upgrading to more efficient lighting such as LEDs. One surprising find was the relatively high use of electricity for heating. This category includes water heating, heating units in the parlor or work rooms, waterer heating elements, and generator engine block heaters. Average monthly heating use ranged from 0% of electricity used in Dairy D to 42% of electricity used in Dairy B.



The average monthly electricity use measured by data loggers and the percent used by each electrical load category. The average monthly total electricity in kWh is displayed at the top of each bar.

Future plans

Based on the analysis of the data, clean energy alternatives and energy-optimized retrofits will be modeled as clean energy alternatives for Minnesota dairy facilities. An economic analysis will also be conducted on the clean energy alternatives and retrofits. Within the model, potentially all energy loads may be converted to electricity and these loads could be made as small as possible with efficiency upgrades. Potential on-site renewable electric generation could supply some or the entire electric load allowing the buildings to approach net-zero (producing as much energy as is used).

The results of this study provide some of the first actual, measured data that can be used for farm energy efficiency benchmarks, agricultural energy policy, economic evaluations, and further research into dairy farm energy studies. The data will also be useful to producers who are searching for areas for reduced energy usage in their own production systems. Improving the efficiency of electrical components in dairy operations could provide opportunities to improve the carbon footprint and sustainability of dairy production systems.

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Additional information

The West Central Research and Outreach Center (WCROC) has developed a Dairy Energy Efficiency Decision Tool to help provide producers a quick way to estimate possible energy and costs savings from equipment efficiency upgrades. The tool can be used to quickly see what areas of a dairy operation may provide the best return on investment. Furthermore, we have developed a U of MN Guidebook for Optimizing Energy Systems for Midwest Dairy Production. This guidebook provides additional information about some of the topics that were mentioned in this article, as well as a decision tool. More information may be found at https://wcroc.cfans.umn.edu/energy-dairy

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