Extension
UNIVERSITY OF WISCONSIN–MADISON

Ventilation in Dairy Buildings

Nesli Akdeniz, Jackie McCarville, Heather Schlesser, Lyssa Seefeldt and Ryan Sterry

Ventilation is an important part of managing a dairy barn for maintaining air quality, removing heat and moisture, and providing a comfortable environment for dairy cattle. There are typically three types of ventilation systems used in dairy buildings: natural, mechanical, or a combination of the two. Natural ventilation relies on the wind and temperature gradients within the barn to create airflow. Mechanical ventilation uses fans to control the amount of air delivered to the barn. In some cases, a combination of natural and mechanical ventilation is used to provide optimal ventilation rates, which may involve using natural ventilation during cold weather conditions and switching to mechanical ventilation during summer months or when additional ventilation is needed.

Tunnel and cross ventilation are two common types of mechanical ventilation used in dairy barns. Tunnel ventilation involves using fans and inlets to create a continuous flow of air through the length of the barn. In cross ventilation, the air is drawn parallel to the stalls, creating a “cross” airflow.

Types of fans

All fans are different. Circulation fans are designed to move air within a barn to create more uniform temperature and humidity conditions. An exhaust fan provides fresh air from outside of the barn. Fans are also built differently. Belt-driven fans are typically more efficient than direct-drive fans because they use a belt and pulley system to transmit power from the motor to the fan blades. However, they require maintenance and periodic belt replacement. Direct-drive fans have a lower efficiency compared to belt-driven fans, but they do not require belts, which reduces maintenance needs. Variable-speed fans are gaining attention because they improve energy efficiency, reduce noise levels, and provide more precise control over airflow.

The housing of a fan can be metal, fiberglass, or durable plastic. Humidity and corrosive gases are common issues in livestock buildings, and they can cause damage to fan components over time. For this reason, selecting fan materials and components that are durable and resistant to corrosion is important. Shutters are needed to prevent backflow on cold days. Guards help prevent accidental contact with the moving parts of the fans.

Nesli Akdeniz: nesli@wisc.edu

Fan efficiency

Air exchanges refer to the number of times the entire air inside a building is replaced with fresh outside air per hour. According to the Midwest Plan Service guidelines, barns need to be ventilated at a rate of around 4 air changes per hour to achieve good air quality in the winter. This means that the entire volume of air in the barn should be replaced every 15 minutes. During the summer, the need for ventilation increases significantly as heat stress can cause animals to become uncomfortable and reduce their feed intake. The recommended ventilation rate during the summer is around 40 to 60 air changes per hour.

Ventilation Efficiency Ratio (VER) is a measure of the efficiency of a ventilation system, which is defined as the ratio of the volume of air moved per unit of time (measured in cubic feet per minute or CFM) to the energy consumed by the ventilation system (measured in watts). Static pressure is the force that opposes air flow in a ventilation system. High static pressure can reduce airflow and increase energy consumption. Stalls, baffles, and anything inside the barn affect the static pressure. Inlets that are too small make it hard to move air, increase static pressure, and may restrict the fans from achieving their targeted exchange rates. It is desirable to keep static pressure low to ensure optimal airflow rates. A commonly accepted static pressure level is less than 0.15 inches H_2O, with levels above 0.20 inches H_2O being undesirable.

Ventilation costs and associated greenhouse gas emissions

The Biological Engineering Sustainable Systems (BESS) Lab at the University of Illinois at Urbana-Champaign provides the ventilation efficiency ratios (VER) of various types of fans used in livestock buildings. When selecting a fan for a dairy barn, choosing a fan with a higher ventilation efficiency ratio (VER) would help reduce electricity costs and improve overall ventilation performance. In addition, the electricity used to power ventilation systems in livestock buildings contributes to greenhouse gas emissions. By reducing electricity consumption in ventilation systems, it is possible to decrease the associated greenhouse gas emissions.

The following table displays the ventilation costs and associated greenhouse gas emissions for a dairy building that houses 700 mature cows. The table highlights the difference between the two fans, which are both 36-inch fiberglass fans but with different ventilation efficiency ratios.

	Fan A	Fan B
Fan efficiency @ 0.05 in H_2O	BESS lab **16 cfm/watt**	BESS lab **18.9 cfm/watt**
Energy consumption in summer*	$\frac{1{,}000\,\frac{cfm}{cows} \times 700\ cows}{16\ \frac{cfm}{watt}} \times 1{,}682\ h$ $= 73{,}588\ kwh$	$\frac{1{,}000\,\frac{cfm}{cows} \times 700\ cows}{18.9\ \frac{cfm}{watt}} \times 1{,}682\ h$ $= 62{,}296\ kwh$
Electricity costs	$73{,}588\ kwh \times 10.97\,\frac{¢}{\text{kwh}}$ $= \$8{,}074\ per\ summer$	$62{,}296\ kwh \times 10.97\,\frac{¢}{\text{kwh}}$ $= \$6{,}834\ per\ summer$
Associated GHG emissions	COMET Energy Tool **54.1 metric tons CO_2 eq.**	COMET Energy Tool **45.8 metric tons CO_2 eq.**

*1,682 is the total number of hours in a year with outside temperatures above 20°C (68°F) in Wisconsin.

Maintenance

Regular maintenance of fans is essential for optimal performance and to increase air movement in dairy buildings. Although it is not possible to keep fans completely dust-free, even a thin layer of dust can significantly reduce fan efficiency. Research has shown that dirty fans, particularly shutters, can decrease airflow and efficiency by 10-40%. Therefore, it is important to keep the fans as clean as possible. Performing recommended maintenance on the fans before the summer season helps ensure they operate at their peak performance when needed the most. Please do not forget to disconnect the power supply before working on the fans. Check the fans carefully for cracks, worn belts, and loose screws and bolts. Pulleys should also be inspected for excessive wear and tear, and pivot points should be adequately lubricated.

Final thoughts

- Consider the number and type of animals housed in the facility, the structure and layout of the barn, the season, and other environmental conditions to ensure optimal ventilation in dairy buildings.
- Install air inlets properly, as incorrectly sized or placed inlets can increase static pressure and reduce the ventilation system's performance.
- Look for a BESS lab certification when purchasing a fan, and select a fan with a high VER to minimize energy consumption and the associated greenhouse gas emissions.
- Keep ventilation fans clean and well-maintained.

More information is available at:

Bioenvironmental and Structural Systems (BESS) Laboratory- Agricultural Ventilation Fans

COMET Energy Tool- Colorado State University, USDA-NRCS

Dairyland Initiative- School of Veterinary Medicine, UW-Madison

Midwest Plan Service (MWPS 32)- Mechanical Ventilating Systems for Livestock Housing

.