Economics of dairy cow cooling – trading a cool breeze for milk

Heat stress hinders cows from producing at their full potential, negatively affecting milk production, reproduction, and overall health. Because cow cooling can mitigate these effects, some type of cow cooling system almost always makes sense economically.

However, cow cooling equipment can also represent a significant investment and have ongoing operation and maintenance costs.

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As new products and barn designs for enhanced cow cooling emerge, the task of determining which options will improve production at the least cost becomes more complex.

Finding the system that will provide the greatest economic benefit to a particular dairy depends on an accurate estimation of how much the herd's performance will improve with respect to each cooling option, as well as how much each system will cost to implement, operate, and maintain.

Much of the current understanding regarding the economics of cow cooling systems has been derived from a 2003 study (St-Pierre et al.) that quantified the overall costs of heat stress and the relative effectiveness of several cooling options in naturally ventilated structures across the continental US.

To give an overview of the economics of heat stress and common cow cooling systems, we have reviewed the results of St. Pierre et al's analysis and the relevant outcomes obtained by several other studies.

Costs of heat stress

Heat stress would cost the US dairy industry an estimated $1.5 billion if cows only had access to minimal heat stress abatement.

This figure was achieved by first determining mathematical relationships between the temperature humidity index (THI) and the consequent changes in milk production, dry matter intake, days open, reproductive culls, and deaths.

Weather data was then used to estimate the magnitude of these effects for each state. Because solar radiation was not accounted for and the ambient temperature and humidity were used, 'minimal heat stress abatement' represents access to shade and good air exchange, but no additional cooling.

Table 1 provides the results for dairy cows in Wisconsin, Arizona, and Florida. Fig. 1 graphically presents the average distribution of these costs in the continental US.

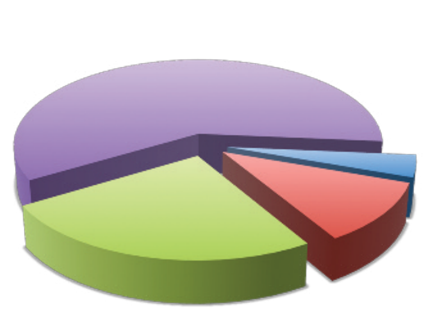

Fig. 1. Average distribution of costs from heat stress with minimal heat stress abatement (based on data from St-Pierre et al., 2003).

Effectiveness of cooling

Mathematical relationships were also developed to predict the reduction in apparent THI (as a function of temperature and humidity) of three basic cooling systems when combined with shade and good air exchange:

- Moderate (circulation fans).
- High (circulation fans and sprinklers).
- Intense (high-pressure misters mounted on fans).

Each cooling system was assigned a capital cost (which was annualised) and an operating cost per hour of heat stress. Then, the total costs attributable to heat stress were calculated for each cooling system in each state, and the system achieving the lowest total costs was determined.

Fans and sprinklers resulted in the lowest total costs of heat stress in all but five hot and dry states (Arizona, Kansas, New Mexico, Oklahoma, and Texas), where the added costs of high-pressure misters mounted on fans were deemed worthwhile.

By employing the optimal cooling intensity, the estimated costs of heat stress (including the cost of its mitigation) to the US dairy industry were reduced to $900 million.

Table 2 presents the optimal cooling intensity for Wisconsin, Arizona, and Florida, as well as the savings it was estimated to provide.

The results from St-Pierre et al's analysis have provided relationships of key importance when predicting the overall costs of heat stress based on climate and the effectiveness of several systems designed to mitigate these costs.

However, 13 years have passed since that analysis was conducted, and much has changed, including milk and feed prices, available systems, and the productivity (and therefore susceptibility to heat stress) of the average dairy cow.

In addition, St-Pierre et al's study considers 'typical' cows and cooling systems and therefore ignores the differences that exist between herds (for example breed and productivity) and between systems (not all fan and sprinkler systems function equally).

What is more, because low-profile cross-ventilated (LPCV) barns have become a preferred choice for many new, large-scale operations and some naturally ventilated facilities are converting to tunnel ventilation, there is a need to

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Table 1. Annual costs from heat stress for dairy cows with minimal heat stress abatement in Wisconsin, Arizona, and Florida (based on data from St-Pierre et al., 2003).

State	Reduced milk production (lb)	Reduced DMI (lb)	Additional days open	Additional reproductive culls (per 1000)	Additional deaths (per 1000)	Average cost per cow ($)
Wisconsin	403	201	8.7	6.3	1.3	72
Arizona	1607	798	25.6	24.7	5.2	265
Florida	3974	1971	59.2	79.9	17.2	676

State	Optimal cooling intensity*	Average cost per cow under minimal heat stress abatement ($)	Average costs per cow with optimal cooling intensity* ($)	Annual savings (%)*
Wisconsin	High	72	43	41
Arizona	Intense	265	105	60
Florida	High	676	323	52

Table 2. Optimal cooling intensity, cost per cow under minimal heat stress abatement, cost per cow under optimal cooling intensity, and percent annual savings in Wisconsin, Arizona, and Florida (based on data from St-Pierre et al., 2003, *Includes estimated costs of cow cooling system).

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incorporate these mechanically ventilated options into comparative analyses.

Economics of the systems

Several analyses have demonstrated that mechanically ventilated facilities can provide economic benefits, if they lead to improved performance. For example, Gooch et al. (2000) used a cash flow analysis to show that very modest improvements (as low as 1.8 pounds per cow per day) in milk production could pay for a tunnel ventilation system in five years.

Similarly, Dhuyvetter et al. (2008) predicted that annual returns gained from an LPCV barn would be $100 greater per cow than from a naturally ventilated barn with fans and sprinklers, assuming cows in the LPCV barn produced an average of 1,000 pounds per year more.

However, it is difficult to predict just how much more milk cows housed in these systems will produce, if any.

Smith et al. (2006), compared the milk production of four groups of cows over two summers in northern Mississippi, two groups housed in a tunnel-ventilated barn equipped with evaporative cooling pads and the other two housed in a naturally ventilated facility equipped with only fans the first summer and fans and sprinklers the second.

The groups housed in the tunnel-ventilated barn produced an average of six pounds per cow per day more over the 10-week test period.

On the other hand, Shiao et al. (2011) report an average increase of only 1.5 pounds per cow per day from cows housed in a tunnel-ventilated barn in Taiwan equipped with both evaporative pads and sprinklers, compared to cows in a naturally ventilated barn with fans and sprinklers.

Moreover, this increase was only seen after the tunnel-ventilated barn was remodelled to increase air velocity, following the initial design's negative effects on milk production.

Conclusion

Clearly, a dairy cow will give more milk in exchange for a cool breeze. The question is, how best to provide that breeze. St-Pierre et al's analysis provided us with estimates of the overall costs of heat stress, as well as which type of system is likely to work best in a naturally ventilated structure by US state.

Additional studies have provided analyses for mechanically ventilated cooling systems. However, we should always be careful to consider the specific climate, herd, and management practices before applying the results from any study to the task of predicting the benefits of investing in a particular cooling system. ■

References are available from the author on request

The authors of this article recently published a white paper,

Dairy Cooling: The Benefits and Strategies (Atkins et al., 2015),

which gives an overview of heat stress, its costs, and available systems for its mitigation. Climate-specific guides containing design guidelines will also be released soon. Schaefer Ventilation provided technical and financial support for these white papers.