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Lighting and daylighting in agricultural buildings for dairy cows

Curious about livestock facilities for cows in a Nordic country? Excellent! Countries all over the world pursue efforts to reduce their energy demands. But what about the cows? In agricultural buildings housing dairy cows, there is a large potential to reduce the energy demand for electric lighting. Efficient electric lighting and daylighting through daylight harvesting systems have great potential to lower the energy use. The varying impact of light on different species is a fascinating example of nature's evolutionary design. Lighting can be designed to increase milk production in dairy cows while being energy efficient. The lighting plays a crucial role not only from an energy point of view, but also for the circadian conditions inside the buildings. The lighting affects the circadian clock through special retinal cells in the eyes, regulating the sleep-wake cycle through the release of the hormone melatonin. The interesting physiological changes cows undergo under the influence of light, found in assorted literatures, forms the basis of this study on energy use and lighting conditions in agricultural buildings.

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Switching from fluorescent lights to LEDs has the potential to reduce energy use for lighting by 48 to 63%. Daylight harvesting can also contribute to energy savings, with reductions of up to 57%. This is done through sensors adjusting lights according to daylight levels by either turning them on and off or by dimming them. Fenestration is crucial in these building. Natural light through windows, and most importantly skylights, not only saves energy, but also outperforms electric lighting in regulating circadian rhythms.

This work is an investigation of three livestock buildings for cattle, with a total area of 8057 m^2, constructed between 1990 to 2014 at Rosdala Gård in southern Sweden. Information from on-site measurements was utilized to assess daylighting, electric lighting, and circadian lighting conditions through various simulation software. Improvements on building design and electric lighting were investigated, aiming to reduce energy use and improve lighting conditions. Both cows and human caretakers will benefit from the improved designs, which impacts both the fenestration and electric lighting.

The benefits of reducing current energy use lie not only in achieving environmental goals but also in reducing electricity costs for the dairy industry. The number of dairy cows in Sweden is not insignificant, amounting to nearly 300,000 cows, while the total number of cattle is 1.5 million. As a reference the capital, Stockholm, has a population of approximately 1 million humans. Providing good conditions for the cows is important not only to maintain high quantity and quality of milk but also to ensure the social sustainability of the industry.

This study can be used to estimate the impact of replacing fluorescent lighting with LED lighting, as well as the effectiveness of similar buildings in utilizing daylight harvesting. The study results provide insight into how lighting affects the circadian conditions inside the buildings and the importance of daylight for these conditions. The literature review provides information on how cows are affected by the lighting conditions.

While light studies with humans often encompass both health and productivity, studies involving cows focus primarily on productivity, either in terms of milk yield or quality. Additionally, these studies use metrics aimed at describing human visual perception of light. Not only does this not capture the cow's perception, even when studying humans this does not describe the full effect of the light. The non-visual effects of light are controlled by different photoreceptors in the eye, sensitive to different wavelengths.

In our study it was found to be important to pay special attention to achieving even light distribution. If the light is too uneven, cows may move slower or even refuse to move at all, as their visual acuity is poorer than that of humans. They cannot distinguish between a shadow or a hole in the ground. Both the placement of the light fixtures and the angle at which the fixtures spread the light are important to consider. In our study, the fixtures selected had too narrow distribution angle, leading to poor uniformity and failing to meet the requirements.

It was surprising to find that cows and humans are not so different from each other when it comes to circadian responses. Only a 6 to 12% difference in melanopsin irradiance was found for the electric light sources. Peak sensitivities are at very similar wavelengths, and the melatonin suppression thresholds occur at similar light levels. The study of the non-visual effects of light based on species-specific sensitivities is a novel and fascinating field of research in agricultural science. With the opportunity of more precise, comparable, and optimised results, the future looks bright for the cows.