Wind more effective than cold air at cooling rooms naturally

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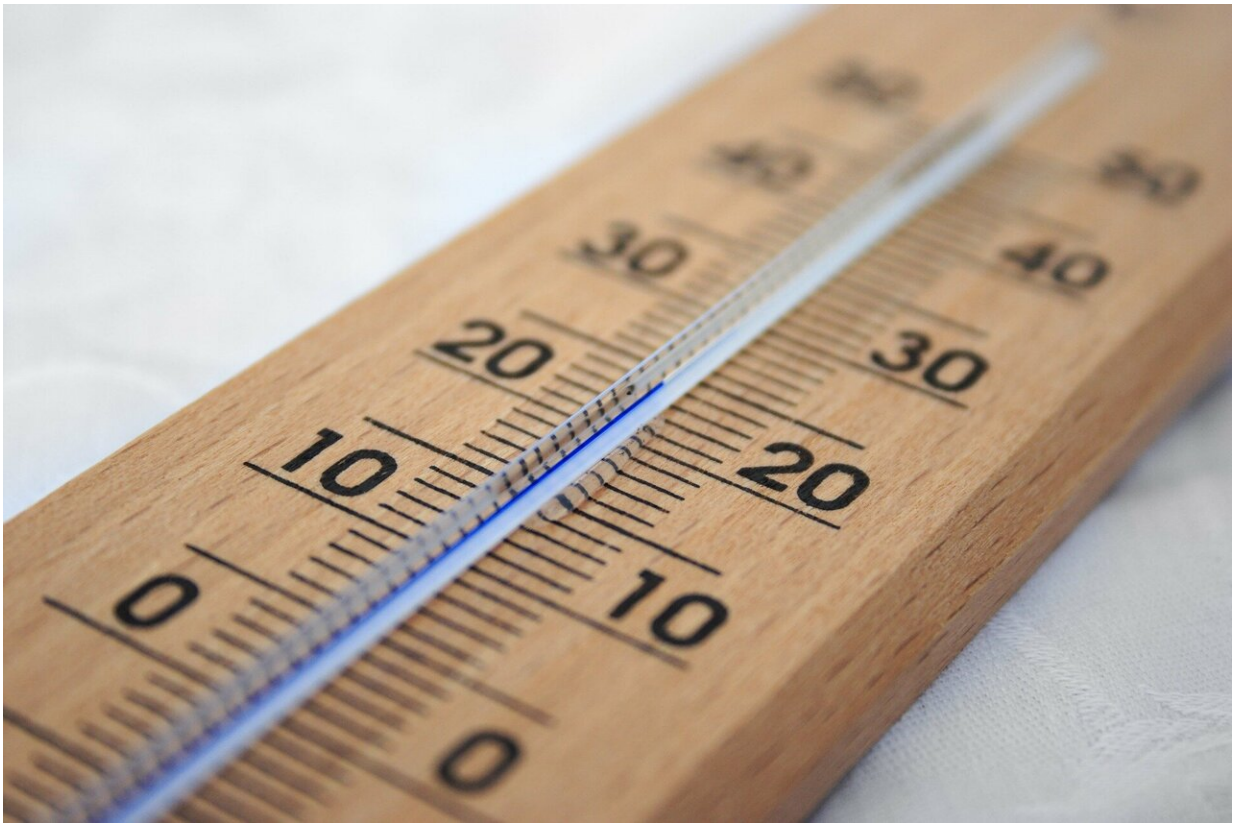

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The effectiveness of non-mechanical, low-energy methods for moderating temperature and humidity has been evaluated in a series of experiments by researchers from the University of Cambridge.

The researchers found that a temperature difference between inside and outside has a remarkably small effect on how well a room is ventilated when ventilation is primarily driven by wind. In contrast, wind can increase ventilation rates by as much as 40% above that which is driven by a temperature difference between a room and the outdoors. The exact rate of ventilation will depend on the geometry of the room.

The results, reported in the journal *Building and Environment*, could be used to help designers and urban planners incorporate natural ventilation principles into their designs, so that buildings can be kept at a comfortable temperature while using less energy.

Heating and cooling account for a significant proportion of energy use in buildings: in the US, this is as high as 50 percent. In addition, as global temperatures continue to rise, demand for air conditioning—which emits greenhouse gases—rises as well, creating a damaging feedback loop.

Natural ventilation, which controls indoor temperature without using any mechanical systems, is an alternative to traditional heating and cooling methods, which reduces energy use and greenhouse gas emissions.

"Natural ventilation is a low-energy way to keep buildings at a comfortable temperature, but in order to increase its use, we need simple, accurate models that can respond quickly to changing conditions," said lead author Dr. Megan Davies Wykes from Cambridge's Department of Engineering.

There are two main types of natural cross-ventilation: wind-driven and buoyancy-driven. Cross-ventilation occurs in rooms that have windows on opposite sides of a room. Wind blowing on a building can result in a high pressure on the windward side and a low pressure at the leeward side, which drives flow across a room, bringing fresh air in from outside and ventilating a room. Ventilation can also be driven by temperature

differences between the inside and outside of a room, as incoming air is heated by people or equipment, resulting in a buoyancy-driven flow at a window.

"We've all gotten used to having a well-controlled, narrow temperature range in our homes and offices," said Davies Wykes. "Controlling natural ventilation methods is much more challenging than switching on the heat or the air conditioning, as you need to account for all the variables in a room, like the number of people, the number of computers or other heat-generating equipment, or the strength of the wind."

In the current study, the researchers used a miniature model room placed inside a flume to recreate the movements of air inside a room when windows are opened in different temperature and wind conditions.

Using the results from lab-based experiments, Davies Wykes and her colleagues built mathematical models to predict how temperature difference between inside and outside affects how well a room is ventilated.

The researchers found that the rate of ventilation depends less on temperature and more on wind. Anyone who has tried to cool down on a hot night by opening the window will no doubt be familiar with how ineffective this is when there is no wind.

This is because in many rooms, windows are positioned halfway up the wall, and when they are opened, the warm air near the ceiling can't easily escape. Without the 'mixing' effect provided by the wind, the warm air will stay at the ceiling, unless there is another way for it to escape at the top of the room.

"It was surprising that although temperature differences do not have a strong effect on the flow of air through a window, even small

temperature differences can matter when trying to ventilate a room," said Davies Wykes. "If there are no openings near the ceiling of a room, warm indoor air can become trapped near the ceiling and wind is not effective at removing the trapped air."

The next steps will be to incorporate the results into building design, making it easier to create well ventilated, low energy buildings.

More information: M.S. Davies Wykes et al, The effect of an indoor-outdoor temperature difference on transient cross-ventilation, *Building and Environment* (2019). DOI: 10.1016/j.buildenv.2019.106447

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