Using heating systems to provide effective cooling

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View of the corner of the test room with radiator. Credit: Fraunhofer-Gesellschaft

Climate change is causing a persistent increase in the number of hot summer days. Offices and homes are getting hotter, and the nights bring

little respite from the heat. Against this backdrop, a significant increase in new cooling systems installations is anticipated, which in turn will give rise to increased energy consumption. One potential cost-effective alternative is to use existing heating systems. According to an analysis by the Fraunhofer Institute for Building Physics IBP, the heat pumps in these systems can be reverse operated to provide effective cooling.

Global energy consumption from air conditioning systems continues to rise. According to information from the International Energy Agency (IEA), the total energy used to cool residential and office buildings in 2016 was around 2000 terawatt hours. That is an estimated 10 percent of the world's total power consumption. This amount could triple by 2050: By then, ten air conditioning systems will be sold every second. In Germany, experts expect energy consumption for cooling residential buildings to double over the next 20 years. For non-residential buildings, the German Environment Agency expects an increase of 25 percent.

How can this expected surge in new cooling system installations be prevented? This is the issue being addressed by a team of researchers at Fraunhofer IBP. "In existing buildings, if a heat pump—i.e. the heat generator—that is already installed can be reverse operated to provide air conditioning, the same system that is already being used for heating could be used for cooling as well," says Sabine Giglmeier, a scientist at Fraunhofer IBP. This would remove the need to purchase new cooling systems and save energy.

Assessment of the potential of radiators and underfloor heating systems

To assess the extent to which this technology can be used to avoid overheating in summer, the engineer and her team assessed the potential of two heating systems: They investigated whether radiators and

underfloor heating systems—heat distributors—could replace the air conditioning units that are often used in existing buildings. These units dissipate their waste heat via a tube through the window or an opening in the wall.


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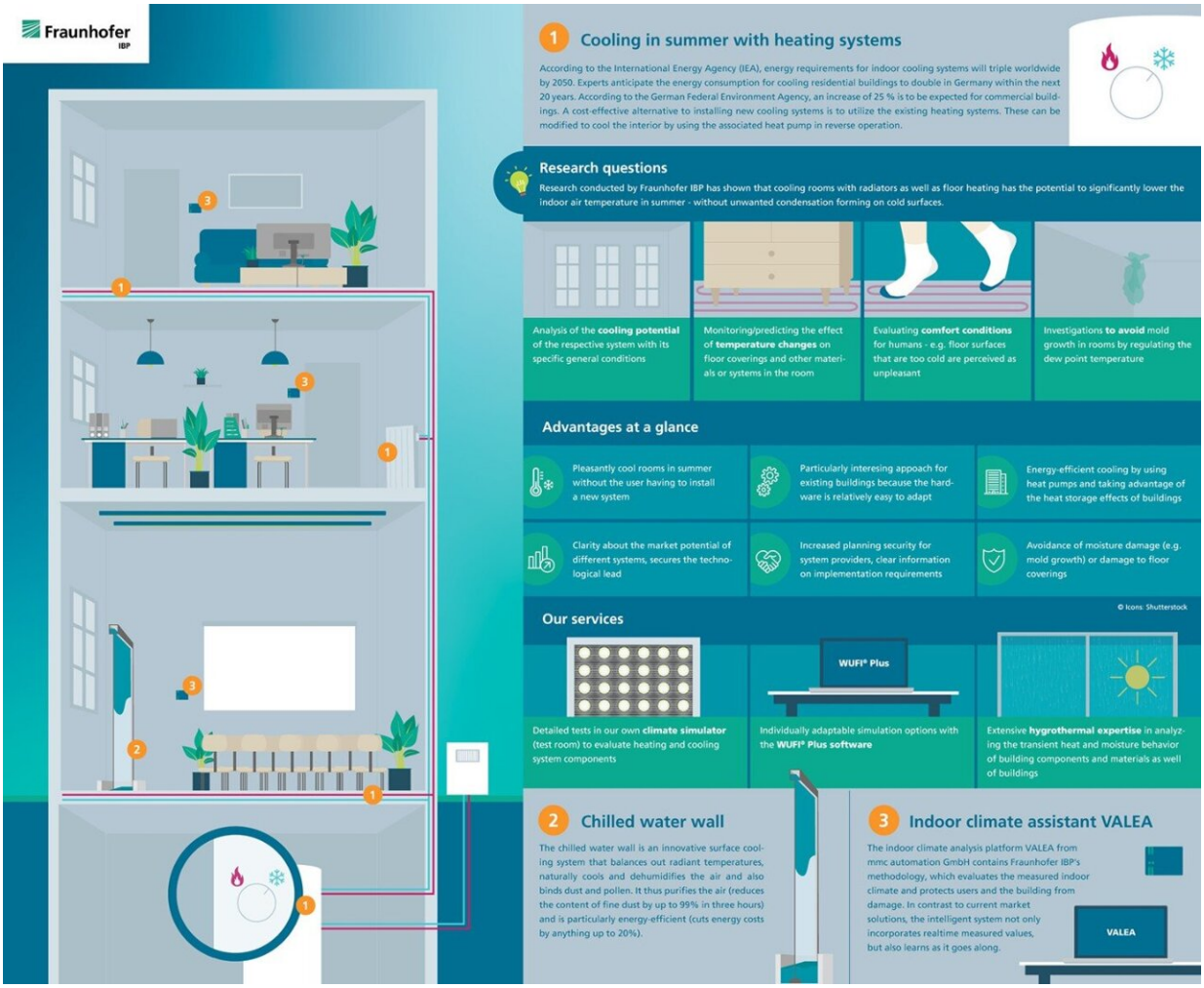
As part of the trial, the researchers collected a large amount of indoor climate data, which they then used to validate the digital twin. Credit: Fraunhofer-Gesellschaft

"Not only do these air conditioning systems use a lot of power, they are also loud and create drafts. They can also cause hygiene problems if they are not properly maintained," explains the researcher.

Simulations with WUFI Plus

To determine whether heat pumps can be combined with radiators or underfloor heating systems for use as a cooling system, the researcher and her team conducted initial tests under laboratory conditions in the climate chamber with radiators and underfloor heating systems. Digital twins of the heating systems were then tested using the building simulation software WUFI Plus to determine whether the laboratory measurements matched the software calculations. "We can use the digital twins to produce a valid representation of reality and calculate the effect of the overall system in a wide range of application scenarios. This allows us to identify the specific areas where heat pumps plus radiators or underfloor heaters are most effective." The simulation software creates a (hygric) link between heat and humidity in the calculation. The simulations can be scaled to any type of building, taking into account a range of parameters such as room and window size, the size of the heating elements, the external temperature and the design and number of windows. The researchers can examine other parameters, such as energy requirements and comfort. This allows for a comprehensive evaluation of heating and cooling systems.



Infographic: Cooling in summer with heating systems. Credit: Fraunhofer-Gesellschaft

The tests found that both radiators and underfloor heating systems have the potential to reduce the ambient air temperature in the summer significantly and to produce a pleasant cooling effect in office spaces with a standard size of 16 m^2, windows of up to 3 m^2 and two workers, without unwanted condensation forming on cold surfaces. The inflow temperature of the system must be regulated depending on the dew point

of the ambient temperature in order to avoid structural damage from condensation. "The dew point temperature is a critical figure that we need to take into account in our calculations. This is because moisture condenses on a surface when the surface is colder than the dew point temperature of the air. This is why it is important to consider the dew point temperature when cooling. In other words, if the dew point temperature is 13 degrees Celsius, the water we feed through the heating system cannot be any colder than that, otherwise the water from the air will condense on the heating element and supply lines, causing damp."

Up to 65 percent reduction in over temperature degree hours

Another important criterion for the calculations is over temperature degree hours. This unit of measurement refers to the number of hours and kelvins above the limit temperature of the room, which is 26 degrees Celsius, in the year. A maximum of 1200 over temperature degree hours per year are permitted in residential buildings, and just 500 in offices. The researchers' calculations showed a reduction of over 40 percent in over temperature degree hours for radiators measuring 70 cm by 1 m. For radiators twice that size, a 65 percent reduction can be achieved compared to an uncooled room.

"All in all, we demonstrated that the cooling performance achieved using radiators is sufficient with a moderate window surface area share. However, a higher window surface area share requires a larger cooling area to achieve comfortable indoor climate conditions. This area can be provided using underfloor heating systems, which also produce a significantly greater cooling effect, as our tests have shown," says Giglmeier in summary. Heat pumps with cooling functions could be an alternative to expensive cooling systems in existing buildings.

The extent to which the overall system affects the user's comfort—for example, whether floors become too cold or temperature changes affect floor coverings and other materials in the room—remains to be investigated.

Provided by Fraunhofer-Gesellschaft