Air leak detection system visualizes building drafts with the click of a camera

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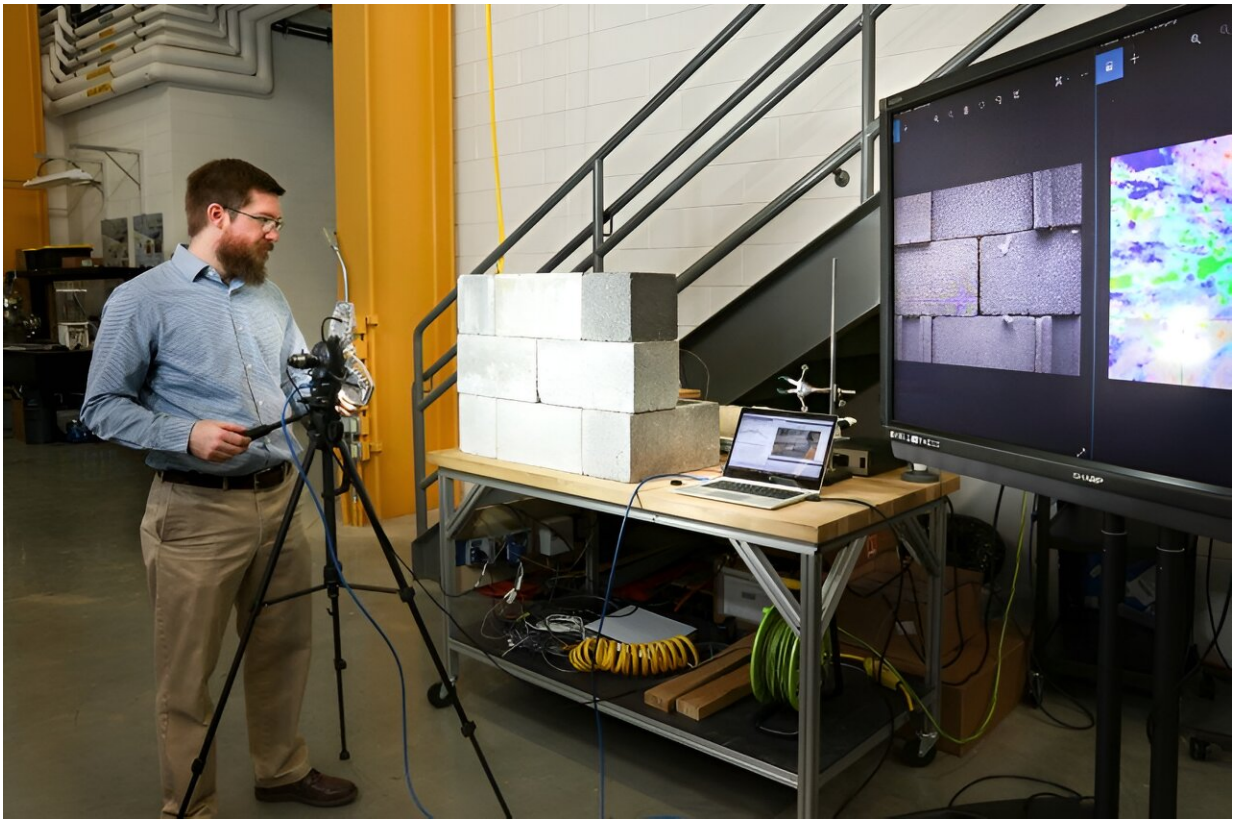

Buildings technologies researcher Philip Boudreaux uses a camera and a technique known as background-oriented schlieren photography to identify air leak sources in a concrete block wall mock-up. Credit: ORNL, U.S. Dept. of Energy

Researchers at the Department of Energy's Oak Ridge National

Laboratory have created a new detection system that allows home energy auditors to see air leaking from a building in real time with the help of a camera. It's an advancement that could provide more accurate readings far more quickly than current diagnostic tools allow.

Leaky buildings signal dwindling energy efficiency and higher utility bills to homeowners. Air that escapes from a home through windows, doors and walls creates a drain on finances and impacts the environment. Solving the problem means pinpointing exactly where air is escaping so that cracks can be sealed—a process that can be expensive, time-consuming and cumbersome.

Blower door testing is the traditional way to detect a leak. Smoke is sometimes used in conjunction with a blower door during which a smoke machine fills the building, and afterward, the blower machine pressurizes the building so that from the exterior, smoke can be seen exiting through the leaks. Smoke pencils can also be used in the interior, where auditors walk around in rooms to see the areas where the smoke travels to define the leakage points. Other detection techniques that have been pursued in recent years include using pulsed lasers, acoustics, ultrasound technology and even vitamins.

ORNL's air leakage detection system, which was one of seven new technologies highlighted during the lab's recent Technology Innovation Showcase for products close to commercialization, is based on background-oriented schlieren photography, a process used to capture fluid flow. Dating back to the 1860s, schlieren photography has most recently and more widely been used to photograph the flow of air around aeronautical objects.

According to lead ORNL researcher Philip Boudreaux, the technique uses small shifts in the background of a sequence of images to visualize leaking air that has a different temperature than the surrounding air. This

temperature difference creates what Boudreaux refers to as a mirage when viewed in front of a building's facade.

"Even though this mirage is too small to be seen with the naked eye, it can be imaged by a camera," he said. "The mirage looks just like wavy patterns you might see rising up from the pavement on a hot day or in the hot exhaust of a car tailpipe."

Detecting and measuring

Boudreaux is working with a research team to ensure that leaks are not just visualized but that the amount of leakage is measured, too. This will allow building owners to better prioritize areas that most need sealing. "Being able to triage the biggest leaks saves time and allows for the energy reduction and carbon burden of buildings to be quickly addressed," he said.

With almost 130 million buildings in the U.S. consuming approximately 40% of the nation's total energy supply and 75% of its electricity, reducing energy consumption is essential as the country moves toward a clean energy future. Leakage from buildings accounts for about 4% of U.S. annual energy consumption. For residential homeowners, that amounts to hundreds of dollars a year in wasted money.

"There are health impacts, too, because leaks contribute to mold that can cause respiratory issues," Boudreaux said. "Leaks decrease occupant comfort and durability of the dwelling."

Air has multiple avenues of escape in a typical two-story single-family home with a basement. Walls, windows and doors are obvious sources, but dryer vents, outdoor faucets, vent fans, dropped ceilings, plumbing vent stacks, crawl spaces, attic hatches, duct registers and areas where walls and floors join are also sources of air either leaking out or leaking

into the structure from the outside.

The camera fix

By using a modest digital video camera and applying what Boudreaux terms natural background-oriented schlieren photography, leaks can easily be seen from the inside or outside of the building.

"It's using refraction, where a fluid with a different refractive index than the surrounding area is visualized based on the distortion of a background," he said. "We've also developed custom software for real time visualization of the leak with algorithms that measure the velocity and flow rate. "

Boudreaux and team applied this approach to visualize leaks through three different types of cladding—brick, vinyl siding and concrete masonry blocks. Visualization experiments were performed under two different lighting conditions—sunny and cloudy.

"We had a small test area of cladding with a crack in the center and a ceramic heater blowing hot air through the crack to serve as a surrogate for the leak point," he said. "We would experiment with the heater turned off and varying temperature ranges between the air at the exit of the crack and the surrounding air."

The visualization experiments, which Boudreaux calls "looking for the wiggles" in the air, showed that leaks could be detected when the temperature difference was as low as 12°C to 15°C on the concrete block and brick claddings.

"We were able to get a sufficient temperature difference between the air around the leak area and the ambient air. Through ongoing research, we intend to get that leak detection temperature limit down to 5°C," he said.

It's taken several years for the research team to develop, perform and quantify the experiments conducted to date. Boudreaux said the initial idea for a camera-based leak detection system was born in 2019.

"Four years later, and we know that a background-oriented schlieren approach for visualizing leakage is reliable at certain temperatures, and it's showing promise now for quantifying, too," he said. "We're going to continue measuring the air flow but the results so far are overall favorable."

Provided by Oak Ridge National Laboratory