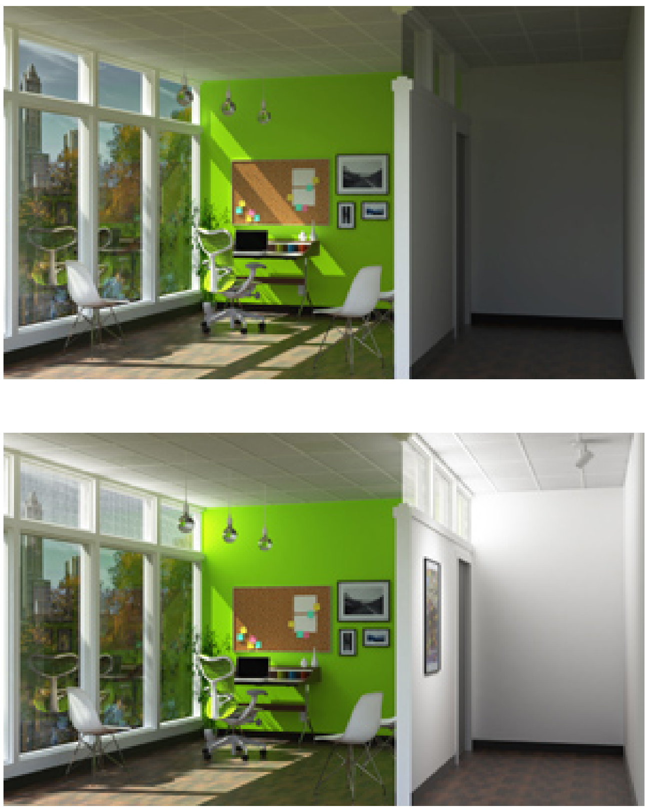
SmartLight more than a bright idea, it's a revolution in interior lighting ready to shine, according to researchers

November 6 2013, by Tom Robinette



This rendering depicts how an office might appear with the University of Cincinnati's SmartLight off (above) and on (below). Sunlight is directed to different spaces, including to a "SmartTrackLight" in the outer hallway. Credit: Timothy Zarki

A pair of University of Cincinnati researchers has seen the light – a bright, powerful light – and it just might change the future of how building interiors are brightened.

In fact, that light comes directly from the sun. And with the help of tiny, electrofluidic cells and a series of open-air "ducts," sunlight can naturally illuminate windowless work spaces deep inside office buildings and excess energy can be harnessed, stored and directed to other applications.

This new technology is called SmartLight, and it's the result of an interdisciplinary research collaboration between UC's Anton Harfmann and Jason Heikenfeld. Their research paper "Smart Light – Enhancing Fenestration to Improve Solar Distribution in Buildings" was recently presented at Italy's CasaClima international energy forum.

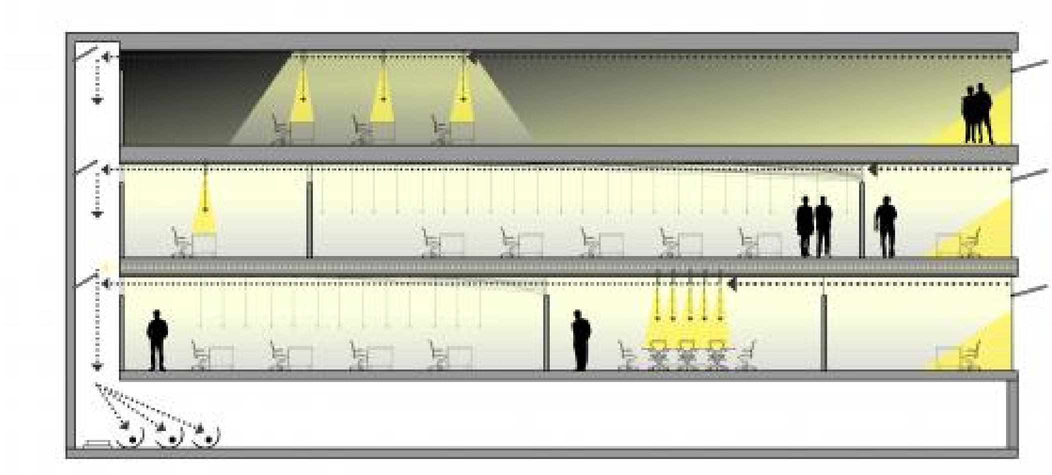
"The SmartLight technology would be groundbreaking. It would be game changing," says Harfmann, an associate professor in UC's School of Architecture and Interior Design. "This would change the equation for energy. It would change the way buildings are designed and renovated. It would change the way we would use energy and deal with the reality of the sun. It has all sorts of benefits and implications that I don't think we've even begun to touch."

Major improvement through minimal adjustments

There's a simple question SmartLight addresses: Is there a smarter way to use sunlight? Every day the sun's rays hit Earth with more than enough energy to meet many of society's energy demands, but existing technologies designed to harness that energy, such as photovoltaic cells, aren't very efficient. A typical photovoltaic array loses most of the sun's energy when it gets converted into electricity. But with SmartLight, Harfmann says the sunlight channeled through the system stays, and is used, in its original form. This method is far more efficient than converting light into electricity then back into light and would be far more sustainable than generating electric light by burning fossil fuels or releasing nuclear energy.

The technology could be applied to any building – big or small, old or new, residential or commercial. But Harfmann and Heikenfeld believe it will have the greatest impact on large commercial buildings. The U.S. Department of Energy's Energy Information Administration shows that 21 percent of commercial sector electricity consumption went toward lighting in 2011. Harfmann calls the energy demand for lighting in big, commercial buildings "the major energy hog," and he says energy needed to occupy buildings accounts for close to 50 percent of the total energy consumed by humans.

SmartLight could help shift that energy imbalance. It works like this: A narrow grid of electrofluidic cells which is self-powered by embedded photovoltaics is applied near the top of a window. Each tiny cell ¬– only a few millimeters wide – contains fluid with optical properties as good or better than glass. The surface tension of the fluid can be rapidly manipulated into shapes such as lenses or prisms through minimal electrical stimulation – about 10,000 to 100,000 times less power than what's needed to light a traditional incandescent bulb. In this way, sunlight passing through the cell can be controlled.



This diagram shows how the University of Cincinnati's SmartLight can direct sunlight from the outside of a building (far right) to the inner part of a building and to a centralized harvesting- and energy-storage hub (far left). Credit: Anton Harfmann, UC

The grid might direct some light to reflect off the ceiling to provide ambient room lighting. Other light might get focused toward special fixtures for task lighting. Yet another portion of light might be transmitted across the empty, uppermost spaces in a room to an existing or newly installed transom window fitted with its own electrofluidic grid. From there, the process could be repeated to enable sunlight to reach the deepest, most "light-locked" areas of any building. And it's all done without needing to install new wiring, ducts, tubes or cables.

"You're using space that's entirely available already. Even if I want to retrofit to existing architecture, I've got the space and the ability to do so," says Heikenfeld, professor of electrical engineering and computer systems and creator of the Smart Light's electrofluidic cells. "And you don't need something mechanical and bulky, like a motor whirring in the corner of your office steering the light. It just looks like a piece of glass that all of a sudden switches."

Smart approach allows dynamic response

As for switching, Harfmann envisions a workplace where physical light switches join other anachronistic office equipment like mouse pads or bulky CRT monitors. Plans call for SmartLight to be controlled wirelessly via a mobile software application. So instead of manually flipping a switch on a wall, a user would indicate their lighting preferences through an app on their mobile device, and SmartLight would regulate the room's brightness accordingly. SmartLight could even use geolocation data from the app to respond when a user enters or leaves a room or when they change seats within the room by manipulating Wi-Fi-enabled light fixtures.

"SmartLight would be controlled wirelessly. There would be no wires to run. You wouldn't have light switches in the room. You wouldn't have electricity routed in the walls," Harfmann says. "You would walk into a room and lights would switch on because your smartphone knows where you are and is communicating with the SmartLight system."

But what happens at night or on cloudy days? That's where SmartLight's energy storage ability comes in. On a typical sunny day, sunlight strikes a facade at a rate that's often hundreds of times greater than what is needed to light the entire building. SmartLight can funnel surplus light into a centralized harvesting- and energy-storing hub within the building. The stored energy could then be used to beam electrical lighting back through the building when natural light levels are low. The SmartLight's grid is so responsive – each cell can switch by the second – it can react dynamically to varying light levels throughout the day, meaning office lighting levels would remain constant during bright mornings spent catching up on email, stormy lunch hours spent eating at your desk, and late nights spent reviewing the budget.

With such potential for energy storage, a building's electrical network also could tap into the centralized hub and use the stockpiled energy to power other needs, such as heating and cooling. And if centralized collection of surplus sunlight isn't possible inside some existing structures, the light could even be sent straight through a building to a neighboring collection facility.

A user could control SmartLight through a mobile app, as depicted in this rendering. Credit: Anton Harfmann

Partnering for a brighter future

Heikenfeld says much of the science and technology required to make the Smart Light commercially viable already exists. He and Harfmann have begun evaluating materials and advanced manufacturing methods.

The only thing missing at this point is enough funding to create a large-scale prototype which could call the attention of government or industry partners interested in bringing SmartLight to market.

"We're going to look for some substantial funds to really put a meaningful program together," Heikenfeld says. "We've already done a lot of the seed work. We're at the point where it would be a big, commercially driven type of effort. The next step is the tough part. How do you translate that into commercial products?"

Harfmann and Heikenfeld originally began developing the idea for the Smart Light years ago. Harfmann was one of the leaders on UC's team in the 2007 Solar Decathlon, a global competition to build the planet's best solar house. Harfmann, an associate dean in UC's College of Design, Architecture, Art, and Planning, collaborated with faculty from other disciplines, including the College of Engineering & Applied Science. That led to his relationship with Heikenfeld and eventually the first discussions of the SmartLight concept.

The cross-college efforts of Harfmann and Heikenfeld align with the university's UC2019 Academic Master Plan goal of expanding collaborative engagement to advance the common good. Additionally, the SmartLight project exemplifies the UC2019 vision by transforming the world through research and creating a deliberate and responsible approach to our environment, resources and operations.

The innovation that results from similar collaborations taking place everywhere at UC, Heikenfeld says, is part of what helps make the university a leader in so many fields.

"A step beyond just working with someone in a multidisciplinary fashion, and where a lot of these partnerships go well, is when you take the time to learn enough about someone else's discipline that you can then begin to inject innovation into it, but not independently," Heikenfeld says. "It's more than just bringing multidisciplinary folks together. You have to stretch yourself to the point where you begin to understand the drivers and some of the fundamentals of the other disciplines as well. One of UC's greatest strengths is our diversity, this is in the classic sense of the term, but also in terms of academic thinking and expertise, which is a great melting pot for big, new ideas."

More information: www.klimahaus.it/en/climatehouse/1-0.html

Provided by University of Cincinnati