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Connected Lighting Test Bed advancing smart, adaptive lighting

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Pacific Northwest National Laboratory researchers at the Connected Lighting Test Bed study and advance smart and energy-efficient connected lighting systems. PNNL lighting engineer Michael Poplawski is shown here with connected outdoor streetlights. Credit: Andrea Starr / Pacific Northwest National Laboratory

Long gone are the days when light bulbs simply shine in the darkness.

Now they can also report their own energy usage, get brighter when people walk by, and even tell you when the conference room is available at work. Light-emitting diodes, also known as LEDs, interact with sensors, microcomputers and other components to offer a long list of potential applications as part of an emerging field called connected lighting.

A new research facility has been established in Portland, Ore. to study and advance these smart, energy-efficient lighting systems. Managed by Pacific Northwest National Laboratory for the Department of Energy, the Connected Lighting Test Bed is a large warehouse space filled with a variety of lights, cables, controllers and computers. PNNL staff there conduct independent research to better understand and improve new connected lighting systems.

"Connected lighting has huge potential to improve lighting quality, save energy and provide new services," said Michael Poplawski, a PNNL engineer who manages the test bed. "But the convergence of LEDs and networking capabilities makes for a complex technology landscape. That's where we can help."

On neutral ground

Lighting and networking engineers at the Connected Lighting Test Bed conduct research to ensure the burgeoning technology meets the needs of the nation's biggest lighting consumers: commercial users such as hotel chains and big box stores. Because commercial buildings use nearly 20 percent of the energy consumed in the U.S., installing connected lighting systems in these large buildings could result in significant nationwide energy savings.

Study results from the test bed are publically available online, which helps speed the learning curve for lighting manufacturers, building owners and other potential connected lighting users. Manufacturers, on the other hand, typically keep test results of their products private and don't always use uniform test methods. The independent data collected at this facility provides timely feedback to manufacturers, technology developers and industry standards organizations.

Poplawski and his colleagues evaluate connected lighting systems that are either already on the market or still under development. To test indoor lights, the group uses a drop-down ceiling that can be raised and lowered with the flip of a switch so staff can easily swap out components and change circuits. They have also wall-mounted connected outdoor streetlights that are equipped with sensors and controls.

PNNL staff select specific technologies to evaluate at the facility based on each system's potential to measure energy use, communicate with other systems and provide other services beyond lighting—including inventory control at warehouses or remembering a worker's preferred office temperature.

Evaluating energy efficiency

The test bed's primary goal is to evaluate energy use in connected lighting systems. For traditional lighting technologies, such as incandescent and fluorescent bulbs, it's straightforward to assess energy consumption. But LEDs have many potential modes and settings—including different colors, dimming and light temperatures that vary from daylight to soft white. So it is challenging to estimate how much energy they use.

The networked nature of connected lighting systems means they should be able to report their own energy usage. There's a catch, though: How connected lighting energy data is collected, formatted and retrieved is not standardized. To alleviate this issue, test bed researchers are developing reliable methods to evaluate connected lighting systems' ability to accurately report their own energy consumption.

An example of this research area is a February 2017 PNNL report for DOE on energy reporting by LEDs with Power over Ethernet systems, which use Ethernet cables to provide both network communications and low-voltage power.

Calculating communication

PNNL is also interested in how well the individual components in any given system communicate with each other and with other systems, a feature called interoperability. It's difficult to buy all the components of a connected lighting system from one manufacturer. So it's important for all parts to talk with each other, regardless of who made them.

"How can you test how well these are communicating? That's much fuzzier," Poplawski said. "Just think about two human beings trying to talk together. Do they understand what the other is trying to say?"

To test for interoperability, the team has developed a series of scenarios that require effective communication between components. The researchers ask lighting systems to complete a task, such as dim the output of their lights or report on how much energy they used in an hour. Then the scientists evaluate how easy it was to complete the task, what the responses looked like, and how well the components worked together to achieve the result. From there, they can start to characterize system features and capabilities in terms of how well they facilitate interoperability.

A bright future

Poplawski and his team are also investigating cybersecurity risks in connected lighting systems. As with any networked equipment, this technology is potentially at risk for cyberattacks. And, as the number of connected devices throughout our homes and buildings grows exponentially, such cyberrisks could increase. PNNL is developing methods to evaluate cybersecurity risk for connected lighting systems in collaboration with the Industrial Internet Consortium and Underwriters Laboratories.

PNNL's test bed currently focuses on how systems perform under the same, carefully controlled conditions inside the facility. Such small-scale tests will help Poplawski and his colleagues better understand the details of connected lighting. They may later progress to field studies that would test connected lighting at hotels, grocery stores or other real-world locations.

Reports based on studies conducted at the Connected Lighting Test Bed can be found on DOE's Solid-State Lighting website. Those interested in partnering with PNNL in its connected lighting research can contact Michael Poplawski.

Provided by Pacific Northwest National Laboratory