▲ The Swedish Medical Behavioral Health Unit found that tunable LED lighting systems can provide significant energy savings. Photos courtesy of DOE

Welcome to the Next Lighting Revolution

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The early days of light-emitting diode (LED) lighting were often likened to the Wild West because the prevailing mentality seemed to be "anything goes."

The development of standards and metrics has changed that. What's more, LED lighting presents an opportunity to improve the performance and value of lighting through enhanced controllability, new functionality, application-specific lighting performance, novel form factors, and targeted improved well-being and productivity.

New functionality within lighting systems can add value by providing optimal lighting through real-time controls, programmed sensor-driven responses, or learning algorithms. LED technology also enables precise control over the delivery of light to reduce glare and light trespass. And, unlike other lighting technologies, it offers the prospect of full color control over the light spectrum.

Although LED lighting is enabling unprecedented advances, new Wild West fronts are emerging.

Horticulture and Color Tuning

At a recent U.S. Department of Energy (DOE) Solid-State Lighting Technology R&D Workshop in Portland, Oregon, Nick Klase of Fluence, a manufacturer of LED horticultural lighting, said our understanding of the science in the area of horticultural lighting is so rudimentary that, in football terms, we're only at our own one-yard line. Almost nothing we know about architectural lighting properties and metrics applies to this burgeoning field, which is being driven by a growing world population. Mr. Klase noted horticultural lighting's impact on the electrical grid, with indoor horticulture alone consuming one percent of the nation's electricity. Although most horticultural lighting today is high-pressure sodium, LEDs have the potential to save energy and provide greater controllability, which is important for increasing crop yields.

While there's a great deal of interest in manipulating light's spectral content to improve human health, productivity, and mood, the scientific evidence to support these benefits is still at an early stage, which leaves room for unverified claims. That's why DOE funds research projects to fill the knowledge gap. Two recently completed GATEWAY evaluations[1] highlight some of the challenges involved in specifying, installing, commissioning, and using color-tunable lighting systems as well as the challenges of predicting and evaluating their nonenergy benefits and their energy performance.

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1 https://energy.gov/eere/ssl/gateway-evaluations

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Another study, at Seattle's Swedish Medical Behavioral Health Unit, found that tunable LED systems can provide significant energy savings compared to non-tunable alternatives, based on the dimming typically incorporated into tunable applications. It also found that achieving design goals related to circadian and other biological and behavioral effects may require higher illuminances than those recommended for visual tasks and consequently may increase energy use during the hours when high illuminances are needed. Another conclusion was that developing a detailed specification of the desired control sequences and outcomes early in the design process can help identify potential shortcomings with the specified control solution and can make the commissioning process more efficient.

The other GATEWAY evaluation involved a trial installation of a tunable-white LED lighting system in three Texas classrooms. The reduction in input power for the new system was estimated to be 58 percent relative to the incumbent fluorescent system and was attributable to the higher efficacy of the LED luminaires and a reduction in illuminances, which previously exceeded IES-recommended levels. Dimming furthered the energy savings in each classroom, but the dimming level was varied more regularly when the control locations were more easily accessed by the teachers, who felt the lighting system improved the overall learning environment.

Human-Physiological Lighting

At the DOE Portland workshop, researchers described two other DOE-funded studies. In one, Ron Gibbons of the Virginia Tech Transportation Institute (see "Roadway LEDs Address Unintended Effects on Flora and Fauna," page 16) outlined how he and his team will investigate the health impacts of outdoor lighting on drivers, pedestrians, and sleepers under carefully controlled conditions. He noted that although there are about 90 scientific papers on the topic, many of those laboratory studies are based on unrealistically high dosage levels, calling the application of the results into question for typical lighting situations.

For the second project, neuroscientist Gena Glickman of the University of California at San Diego discussed how she and her team are working to understand the effects of indoor lighting by studying ways that light impacts the health and performance of night shift workers. She, too, emphasized the importance of realistic parameters, cautioning that a controlled lab environment doesn't necessarily translate to real life.

Connected Lighting

A number of studies have already been conducted in Portland at DOE's connected lighting test bed (CLTB), which features setups designed to examine the energy reporting capabilities of Power over Ethernet and other connected lighting systems and how application programming interfaces (APIs) are facilitating interoperability. These findings have already resulted in various technical recommendations for technology developers, API developers, and lighting manufacturers.

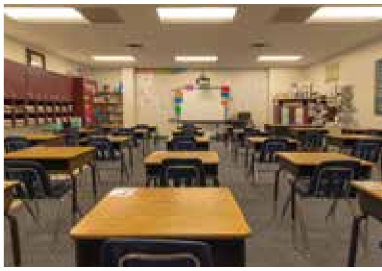
On a tour of the CLTB just prior to the Portland workshop, Pacific Northwest National Laboratory's Michael Poplawski demonstrated the variation in response time to a lighting-change request sent via API to six different connected lighting systems and highlighted the fact that these first studies are generating valuable data to inform the efforts of standards committees, task groups, and consortia and are identifying issues that require further investigation.[2]

Another approach to taming the Wild West of connected lighting is being taken by the Next Generation Lighting Systems (NGLS) competition, which is co-sponsored by DOE, the Illuminating Engineering Society, and the International Association of Lighting Designers. An NGLS living lab has been set up at Parsons School of Design, The New School, where 12 different connected lighting systems were installed in classrooms and are being evaluated for performance and ease of installation from the perspectives of specifiers, contractors, and end users.

While the systems were marketed as "easy to install and configure," the experiences of the electrical contractors and NGLS evaluators paint a very different picture and offer valuable feedback for manufacturers and specifiers. The first NGLS outdoor competition begins later this year, at Virginia Tech Transportation Institute and Virginia Tech Smart Outdoor Lighting Lab, and will focus on parking lot connected lighting. (See www.ngldc.org for more details.)

As we explore these new lighting frontiers and increase our knowledge of the underlying science, a whole new set of questions and technological challenges emerges. So *vive la revolution*—and hold on to your Stetson.

2 https://energy.gov/eere/ssl/connected-lighting-test-bed



Teachers felt the tunable lighting system improved the overall classroom learning environment. Photos courtesy of Acuity Brands Lighting