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Better Living Through

LIGHTING

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	Current Conditions (Compared to Previous Month)	Conditions Six Months from Now (Compared to Current Conditions)
EBCI	66.7 ▼	73.3 ▼
% Better	40% ▼	53% ▼
% Worse	7% ▼	7% ▼
% Unchanged	53% ▲	40% ▲

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FROM THE CHAIRMAN

As the 2018 Chairman of the NEMA Board of Governors, I am honored and eager to play a role in facilitating the advancement of the electroindustry and medical imaging industry for the years ahead.

If you look at the lights around you, ten years ago they were probably traditional incandescent, halogen, or perhaps compact fluorescent. Today, it is highly likely that a lighting system nearby uses at least one light-emitting diode (LED). A lot has happened in the lighting industry in less than a decade—and a lot more is about to happen.

In those ten years, consumers have come to expect that energy-efficient lighting systems can boost productivity and even contribute to better health. Now, lighting is quickly becoming increasingly connected. This will have a positive impact on domestic job creation because U.S.-based manufacturers have established a relative competitive advantage in these systems.

In this regard, connected lighting is a bellwether of the trend to integrate control of buildings, roadways, utilities, and more. This integration serves as a catalyst for increased data collection and analysis that, when put into the hands of engineers, government officials, and even homeowners, empowers them in new and growing numbers of ways.

We are at the very beginning of adapting this technology for other aspects of today's economy and society. And sophisticated controls built by NEMA Members will accelerate precisely that. We can see that in the connected building and industrial automation systems as they define and make tangible the capability inherent in the Internet of Things.

More than anything else, using connected-enabled technology to respond dynamically to changing conditions and demands will be one of the defining characteristics of our times. Think, for instance, how connectivity will enhance the diagnostic value of medical imaging by seamlessly sharing medical images across medical settings anywhere in the world. Beyond that, MITA companies are on the forefront of post-image processing, thereby adding rapid analytical power to ensure accurate and early diagnoses.

Whether it is energy efficiency, digital connectivity, or imaging advancements, NEMA and its Members are bringing the promise of technology to the market and promoting a better quality of life through their state-of-the-art products and systems. Again, I am honored to serve you as Chairman and have but a single request: I ask all Members to get involved in the association. Your individual contribution will make our collective work more valuable as our industry enlightens the third century of electrification. Ⓢ

David G. Nord
Chairman, NEMA Board of Governors

Coming Together for Meaningful Change



In the early days of personal computers, a familiar quote circled: “If cars advanced at the rate of personal computers, they would get 1,000 miles per gallon and cost \$25.” While this is a humorous exaggeration, it nonetheless highlights the astounding rate of advancement in solid state technology. In 2018, we find ourselves in a similar situation with solid state lighting and controls.

Just as in the computing realm, light-emitting diode (LED) technology continues to make great advances in capability and efficiency that would have been unheard of in the past. Similarly, thanks to the rapid development and propagation of wireless protocols and cloud technology, controls now perform advanced functions—easily programmed by the installer using a smartphone or tablet—that previously involved cost and complexity. The convergence of these technologies, “intelligent lighting,” holds the promise to collectively compound the gains they provide individually.

Merging lighting and controls, and the simplicity and ease of use it entails, lowers the barrier to adopting high performance lighting and will help us realize meaningful contributions to energy efficiency, performance, and productivity that intelligent lighting can offer. The broader adoption of intelligent lighting creates the foundation for further convergence in the built environment. Data gathered by individual luminaires will contribute to the efficient use and performance of HVAC and other building systems. This same information supports business efficiency through the ability to analyze space utilization, customer traffic patterns, and other facility use metrics.

While the promise of the ultimate capabilities of intelligent lighting may seem far off, reflect for a moment on the opening quote. These possibilities do not seem nearly as speculative or distant. Working together, our industry can, should, and will bring about this innovation. ☺

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Now It's Easy to Find LED Bulbs and Dimmers that Work Together



A consumer walks into a store and asks for help buying dimmable light-emitting diode (LED) bulbs. The salesperson asks, "What kind of dimmers do you have?" The consumer responds, "I don't know; I have one that slides up and down and one with a knob that turns."

Does this sound familiar? Unfortunately, it's all too common as customers look to upgrade their homes with LED lighting. Consumers find LEDs with many different options when they go to the lighting aisle of a retail store. They can compare lamps side by side for wattage, color temperature, and energy consumption. They can find lamps for the fixtures inside their homes and for outdoor applications. They can look for the ENERGY STAR® logo, which 85 percent of consumers recognize as a symbol for energy efficiency. They might know that lamps with the ENERGY STAR logo are powered by LED technology. They might even look for dimmable lamps for their existing fixtures, and they can find lamps that dim down to different levels.

What they might not realize is that LEDs operate best on a dimmer designed specifically for the technology. This compatibility issue is key to consumer satisfaction with LED lighting. Consumers expect their lighting to have the same or better performance as the lamps they are replacing. Much of the time they're thinking about the lamp on its own, and when it doesn't dim exactly like their old incandescent lamp did, they assume the problem is with the LED. There has been little communication to help consumers understand that LEDs don't always work on dimmers designed for an older technology.

Continued on page 6



PAIR
BULB + DIMMER

Look for this logo to find LED bulbs and dimmers that work together.

Jennifer R. Dolin,
Manager of
Sustainability and
Regulatory Affairs,
LEDVANCE

Ms. Dolin chairs the NEMA Dimming Compatibility Working Group. She is also the IES co-vice chair to the ASHRAE SSPC 189.1 standard for high performance buildings and the manufacturer representative to the Product Care USA Board of Directors.

Continued from page 5

NEMA Has a Solution

A NEMA working group has created a Dimming Compatibility Program to help consumers easily find LED lamps and dimmers that are compatible. Consumers need only look for the compatibility mark on packages of LED lamps and packages of dimmers to know they will work better together. The mark also draws attention to the fact that LED lamps should be installed with newer dimmers for optimal performance.

The mark was focus-tested with online consumers, and 64 percent surveyed responded that the mark communicated the intended message well or extremely well. An optional statement, “Look for this logo to find LED bulbs and dimmers that work together,” supports the mark at the point of purchase. In the focus tests, adding this statement increased the understanding of the intended message to 80 percent.

The ENERGY STAR program, in anticipation of the development of NEMA SSL 7A *Phase-Cut Dimming for Solid State Lighting: Basic Compatibility*, included a placeholder in the specification for lamps, offering an alternative path to testing for dimming compatibility once marketing guidelines were created. The NEMA dimming compatibility program offers manufacturers an opportunity to use the mark to demonstrate compliance with these requirements.

Join the Effort

The NEMA program is open to all manufacturers and applicable to any qualified LED lamp or dimmer—a manufacturer is not required to be an ENERGY STAR partner, and the product does not need to be ENERGY STAR certified in order to bear the mark.

Qualified LED lamps must meet the requirements in the ENERGY STAR specification for dimming and audible noise, the dimming requirements in NEMA SSL 7A-2015, and the flicker requirements in NEMA 77-2017; they also must be listed to UL 1993 or CSA C22.2 No. 1993-17. Qualified dimmers must meet the dimming requirements in the aforementioned NEMA standards and be listed to UL 1472 or CSA C22.2 No. 184.1-15.

Dimmable LED lamps and dimmers must meet the requirements in NEMA SSL 7A-2015 and NEMA 77-2017 to qualify for use of the logo.

Purchase NEMA standards at www.nema.org/standards-store.

NEMA Members always receive a 20% discount.

To use the mark on packaging of qualified products, brand owners must sign a joint Memorandum of Understanding with NEMA, pay the required usage fees, provide a list of brands on which the mark will appear (along with a URL providing information to consumers about the program), and agree to the mark usage guidelines.

NEMA Members benefit from reduced fees—a one-time usage fee covers all of the Members’ brands. Nonmembers are charged an additional annual fee per brand. These fees cover administrative costs of the program and periodic verification testing to maintain program integrity. Like the ENERGY STAR program, a brand owner is considered a “licensee” and must sign the MOU. This includes retailers with private label brands, regardless of who manufactures their lamps.

A true NEMA Member effort, the program was created by a working group comprising representatives from Cree, GE, LEDVANCE, Legrand, Leviton, Lutron, Philips, and Westinghouse. While waiting for the completion of NEMA SSL 7A and NEMA 77, the group developed the logo and marketing materials to roll out the program, including a one-pager to help retailers train their sales staff.

A webpage, www.nema.org/led-dimming, walks brand owners through the program and provides information on joining the program. A video demonstrates how lamps dim to the program minimum of 20 percent and shows how many lamps can dim to 10 percent or even lower.

The completed program was rolled out to NEMA Members at the Lighting Division meetings in October 2017. At the ENERGY STAR annual partner meeting in Chicago the following week, the program was officially launched to the full manufacturing community. In upcoming months, Natural Resources Canada (NRCan) will promote the program to their ENERGY STAR partners.

Visit www.nema.org/led-dimming to learn more about the program, read the one-pager on answering consumer questions, watch the video created by the skilled media team at Lutron, and find contact information for speaking with Madeleine Bugel about joining the NEMA LED Dimming Compatibility Program and obtaining a copy of the MOU. Sign it, send it, and start using the mark to help consumers find LED lamps and dimmers that work better together. ☼





▲ 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

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 evaluations¹ 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.

Continued on page 8

James Brodrick,
Solid-State Lighting
Technology
Manager, U.S.
Department of
Energy

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

FEATURE BETTER LIVING THROUGH LIGHTING

Continued from page 7

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.

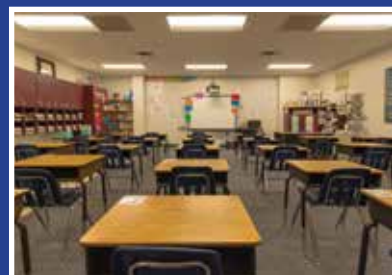
On a tour of the CLTB just prior to the Portland workshop, Pacific Northwest National Laboratory's Michael Poplawski demonstrated the variation in response time to a lighting-change request sent via API to six different connected lighting systems and highlighted the fact that these first studies are 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.nglsc.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

Success Begins with Flexible Lighting Controls

Advanced lighting control solutions offer powerful benefits for commercial building owners and occupants by delivering a more energy-efficient, comfortable, and productive environment. Yet there are barriers to widespread adoption of integrated lighting control solutions.

Codes and standards, which are updated on a regular basis, vary by state and municipality, and keeping up with them can be overwhelming. It may be tempting, then, to forgo advanced lighting controls in favor of the simplest system possible to meet required codes, but this trade-off has long-term ramifications. Specifiers and contractors must also ensure that lighting control systems meet rigorous occupant performance requirements.

Smart, flexible, scalable lighting control solutions may increase initial installation costs, but they guard against expensive, time-consuming, and labor-intensive updates. They facilitate the addition of smart features and easy software upgrades as they become available, providing a direct, positive impact on energy use, occupant comfort, and effective space utilization. Solutions that incorporate light-emitting diode (LED) drivers along with wireless sensors and controls can make future lighting retrofits, rezoning, and repurposing easier and faster.

Although code information is available online at code-specific websites, such as the International Energy Conservation Code® (<https://www.iccsafe.org>) and ASHRAE (<https://www.ashrae.org>), more targeted energy code lookup tools can make quick, easy work of finding state and local energy codes. Manufacturers' websites, for example, can ease the path to code-compliant lighting and control solutions that meet customers' needs, within budget and without sacrificing lighting performance.

Advanced solutions in the workplace go beyond energy savings to focus on strategies that improve employee satisfaction and productivity. This idea is broadly known as the 3/30/300 formula: organizations spend approximately \$3 per square foot per year for energy, \$30 for rent, and \$300 for personnel. Since people are a company's most valuable asset, improving the occupant experience delivers the greatest return on investment. Advanced lighting control solutions enable data collection and analysis that can positively impact



Pekka Hakkarainen,
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Dr. Hakkarainen, a
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Kite & Key Award,
chairs the NEMA
Standards Strategy
Working Group.

all three aspects of building cost by reducing energy use, improving building operations, and enhancing employee comfort and productivity.

Reaping Returns

For years, utility rebates have largely been component-based, offering, for example, a specified rebate per sensor or luminaire. With the proliferation of LED lighting and expanded wireless capabilities, utilities are encouraged to find new ways to encourage energy savings beyond mandated code.

In May 2016, the DesignLights Consortium released V.1.0 of its Networked Lighting Control Systems Specification to provide utilities and energy-efficiency programs with a way to qualify networked lighting control systems for inclusion in commercial sector lighting rebate programs. In June 2017, that coverage was expanded and the first participants introduced rebates for networked lighting controls.

This indicates the beginnings of a trend that can reduce the cost of advanced lighting control systems and provide impetus for broad adoption of networked control solutions.

Lighting control manufacturers remain committed to helping specifiers and contractors deliver the best user experience to clients and end users. Successful installations start with resources and products that not only make it easier to provide code-compliant solutions but also offer expandable, value-added solutions that improve the overall customer experience. ☎

Better Lighting

BETTER LIVING

Pat Walsh,
Editor in Chief,
electroindustry
magazine, NEMA

Ms. Walsh, a
Hermes platinum
award-winning
writer, is also
the director of
publications
at NEMA.

Since a roadmap presupposes a destination, what endpoint does Jan Denneman see as he steps down as president of the Global Lighting Association?

“The world will be better lit than now,” he said in announcing GLA’s Strategic Roadmap of the Global Lighting Industry.¹ “We will see better lighting.”

When we sat down to talk at NEMA, Mr. Denneman suggested that we open the blinds to let in more natural light. It reminded this writer of Johann Wolfgang von Goethe, who had a lifelong fascination for the physical and metaphorical effects of light on humans. Legend has it that Goethe cried, “Mehr Licht!” (More light!) on his deathbed; in fact, he said, “Do open the shutter so that more light may enter.”

“We are diurnal animals,” Mr. Denneman explained, expounding on a discovery in the 1990s of a third photoreceptor in the brain that accounts for the effects of light on circadian rhythms. “Good quality of light mimics daylight. It affects alertness, cognitive performance, energy, and creativity. Indoors, light should be dynamic. Give everyone the right light for what he or she is doing.”

Jan Denneman envisions an
industry moving toward systems
solutions and human well-being.
Photo by Pat Walsh



An Eco Design Consultants study² supports this, indicating that the well-being of building occupants increases with better light, air, acoustics, integration of nature, and personal control.

Using the concept of lux, which is equal to one lumen per square meter, Mr. Denneman clarified this point. A sunny day registers 100,000 lux outdoors. Even an overcast day has at least 5,000 lux. The standard office suite, by comparison, is about 500 lux. Schools rate even lower at 300 lux.

“Just as we talk about air purity, temperature, draft, and so on, the same comparisons can be made to lighting,” he said. “We were once champions of energy efficiency. Now we add to that a well-being revolution,” which is the result of the disruptive nature of light-emitting diodes (LEDs) and intelligent light systems, he says.

“LEDs are rapidly replacing conventional light sources, indoors and out. They are efficient, tunable, dynamic, long-lived, flexible, integrated, and cost-effective. Their connectivity enables the automated collection of data that is converting the component- and hardware-based industry to a digitalized one.”

The digitalization of lighting has enabled intelligent lighting systems and global integration with the Internet of Things, which Mr. Denneman likes to call the Internet of Lighting. To accomplish that, the GLA advocates for harmonized, interfaced standards—like those that enable smartphones—and fewer, well-enforced rules.

Standards provide the rationale behind the roadmap, ensuring consumers that when they open their windows and open up buildings, more light may enter. ☺

External Power Supplies Rule Enacted

Last month, President Trump signed into law HR 518/S 226, the External Power Supply Improvement Act. It was introduced in the House by Reps. Diana DeGette (D-CO), Brett Guthrie (R-KY), Doris Matsui (D-CA), and Charlie Dent (R-PA), and in the Senate by Sens. Rob Portman (R-OH), Maria Cantwell (D-WA), and Jeanne Shaheen (D-NH).

Members of the NEMA lighting division commend the authors and co-sponsors who led the effort to pass this bill. The availability of LED drivers in the marketplace facilitates the transition to more energy-efficient lighting. The legislation removes regulatory uncertainty regarding current federal regulations affecting solid state lighting drivers, which could have dampened further investments and limited consumer choice.

Read more at www.nema.org/eps-act. ☺

¹ available at www.globallightingassociation.org

² www.ecodesignconsultants.co.uk/healthy-buildings and <https://www.cbre.nl/en/healthy-offices-research>

New Syllabus for Top Schools Includes Smart Lighting

Providing children with a quality education is a national priority. Curriculum, school culture, teacher effectiveness, and test scores have long been used as measurements for school success and student performance. However, another aspect is now being considered—the buildings where education occurs.

According to the National Institute of Building Sciences' *Whole Building Design Guide*® (WBDG), "More than other building types, school facilities have a profound impact on their occupants and the functions of the building, namely teaching and learning. Children in various stages of development are stimulated by light, color, the scale of their surroundings, even the navigational aspects of their school."¹

A critical component of a high performance school is proper lighting. Research supports the connection between classroom performance and proper lighting, and a study by the Heschong Mahone Group revealed that students exposed to high levels of natural light achieve as much as 18 percent higher test scores than those exposed to minimal natural light.²

The Department of Energy's EnergySmart Schools report shows that K-12 schools spend more than \$8 billion annually on energy—the second-highest operating expenditure after personnel costs. It is one of the few expenses that can be decreased without negatively impacting classroom instruction.³

Therefore, lighting can be an ideal way for schools to cut costs and improve student performance. Of course, customizing lighting for the needs of each classroom is essential, as the needs of preschoolers differ from those of high school students. Lighting control systems provide the ability to personalize and control lighting at the campus, building, classroom, and individual level.

Customizing Learning

An example of a school leveraging advanced lighting control to enhance the learning environment is the Hurst-Euless-Bedford (HEB) Independent School District in Texas. The district employs a light management system that provides customized lighting to meet each classroom's requirements and can easily be scaled when classrooms and buildings are added over time. For example, lighting is programmed in

the pre-kindergarten classroom to accommodate nap time—all lights are shut off except those over the teacher's desk. Additionally, a special education classroom leverages a mild lighting setting to protect students from overstimulation.

Occupancy sensors are employed so that lights automatically shut off when a room is unoccupied. This significantly reduces energy consumption in buildings that are often empty during evenings, weekends, and vacations. Additionally, when classes are in session, corridor lights are set to 30 percent and automatically brighten when someone enters the hallway.



By installing a light management system, HEB is now one of the most energy-efficient school districts in the state, with 57 percent to 65 percent energy savings realized.

The advantages of high performance schools are indisputable. By incorporating innovative strategies in new building design and retrofits, learning environments can be enhanced, the health of the school community improved, and operating costs reduced. ☼

Charles Piccirillo,
Product Group
Manager, OSRAM
Digital Systems

Photo courtesy of
OSRAM Digital Systems

1 Ellen Larson Vaughan, Steven Winter Associates, Inc., "Elementary School," *Whole Building Design Guide*, National Institute of Building Sciences, March 27, 2017, <https://www.wbdg.org/building-types/education-facilities/elementary-school>

2 *Windows and Offices: A Study of Office Worker Performance and the Indoor Environment*, CEC PIER 2003, Heschong Mahone Group, 2012, <http://h-m-g.com/projects/daylighting/summaries%20on%20daylighting.htm>

3 "Guide to Financing EnergySmart Schools," Office of Building Technologies, U.S. Department of Energy, https://www1.eere.energy.gov/buildings/publications/pdfs/energysmartschools/ess_financeguide_0708.pdf

Rewriting Lighting for Healthcare

Applying Emerging Technologies for Circadian Support and Patient Well-Being

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specialty in lighting
control design and
applications.

Ms. Rizzo's focus is
on bridging lighting
research and
design practice.

Healing, sleep, patient and staff satisfaction, circadian regulation, universal design, and energy efficiency are all important considerations for healthcare design.

How do we juggle these priorities and provide an elegant system solution that is sensitive to patient, family, caregiver, and facility operator needs? Is it possible to balance all of these seemingly conflicting priorities and provide a system that suits everyone?

As the recipient of the U.S. Department of Energy's SSL R&D Program's first application-based research award, Philips Lighting was challenged to explore these questions, move beyond the healthcare lighting status quo, and redefine lighting for the patient room application.

The goal was to deliver an innovative light-emitting diode (LED) patient suite (i.e., patient room and bathroom) lighting system solution that was 40 percent more energy efficient than traditional fluorescent technologies; would meet all the visual and nonvisual needs of patients, caregivers, and visitors; and would improve the patient experience. The solution was built upon application- and stakeholder-driven value propositions that considered 21st-century design best practices, end-user and owner attitudes and expectations, visual and nonvisual needs, health and well-being, and policy and regulatory requirements.



6 am to 9 pm

A completed full-scale mockup operating in circadian support mode.
Photos courtesy of Philips Lighting

This project was partially funded by the U.S. Department of Energy for comprehensive application-specific system development opportunities. The authors thank the U.S. Department of Energy (Award No. EE0006704) for its support of this work.



Supporting Natural Rhythms

The system concept was created by first developing a lighting design that demonstrated best practices for patient room lighting—illuminance and uniformity for task performance, reduced glare, and intuitive controls—and gave patients control over the lighting in their environment. A framework was defined to deliver circadian support via software behaviors. Through that process, luminaires were identified that could accommodate multichannel LED platforms, provide uniform color mixing, and deliver target design light levels. A skylight luminaire was selected for the patient bed area to give the illusion of the sky while providing white light on the patient bed. Luminaires used either tunable white or tunable color LED platforms as well as Power over Ethernet (PoE) drivers.

Software that was flexible and nuanced in its complexity was written to set behaviors for myriad lighting scenes in the room throughout the 24-hour day, all of which could be overridden by manual controls. This included a dynamic tunable white program, three color-changing automatic programs that simulated degrees of sunrise to sunset palettes, and an amber night lighting system that offered visual cues for postural stability to minimize the risk of falls.

All programs were carefully designed to provide visual comfort for all occupants, support critical task performance for staff, and support the patient's 24-hour diurnal rhythms. A full-scale mockup room was constructed in Philips Lighting's Research and Development labs in Cambridge, Massachusetts. The lighting system was installed and tested and its functionality was demonstrated to ensure smooth operation of system components: luminaires, drivers, switches, wall controls, patient remote, and daylight and occupancy sensors.

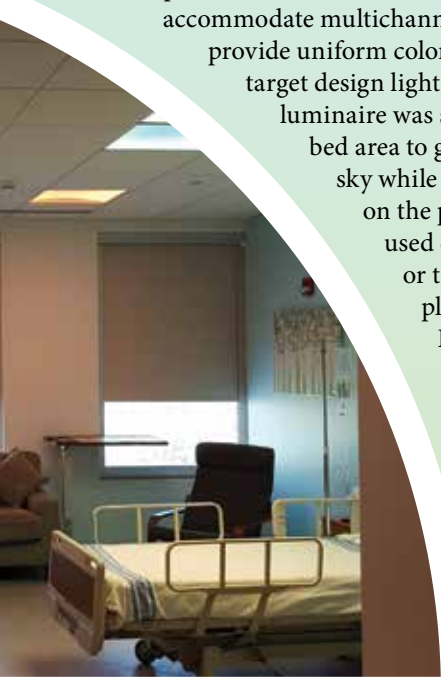
Redefining Standard of Practice

How did the system perform? It met visual criteria, confirmed by calculations, simulations, and measurements in the mockup. It met nonvisual criteria, confirmed by setting circadian stimulus targets and performing calculations using the calculator developed by the Lighting Research Center. Finally, human factors validation studies were conducted to gain insight from healthcare professionals. The general consensus was positive, with requests to pilot the system in hospitals.

The importance of the research completed under this grant is that it allowed the exploration and development of a unique lighting system, one that would deliver a blend of visual and nonvisual benefits in patient room design for today's healthcare environment. The research investigated the area of multichannel LED technology, multichannel PoE drivers, and integration with automatic and manual controls as a system. It married visual needs of patients and staff with support for 24-hour rhythms, placing value on the well-being of the patient while successfully saving energy over incumbent technologies.

The project outcomes redefined the standard of practice for lighting the individual patient room suite in U.S. hospitals and demonstrated that patient-centered design for light color and quality, tunability, and health and well-being can—and should—be elevated in importance over energy efficiency. The outcome was a novel patient suite portfolio that maximized energy efficiency while providing spectral tuning and control functionality for delivering health and well-being benefits not previously accomplished with traditional systems in the U.S.

Its value to the public can best be expressed by a patient experiences director who, after spending several hours immersed in the environment, analyzing all its features, commented: "This rewrites lighting for healthcare." ☺



Spotlighting a Secure Future for Smart Cities



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As smart cities transform the way we live, work, and interact, the spotlight is on cybersecurity.

Our physical and digital worlds are interconnected in ways we never imagined: voices can control thermostats, there's a Wi-Fi connection in every public building, and we can digitally navigate any urban environment. We are living in the Internet of Things (IoT) enabled by light-emitting diodes (LEDs).

Smart cities create new ecosystems for commerce and civic engagement. According to a Frost & Sullivan report, the global intelligent city market will be valued at \$1.5 trillion by 2020. Big data also means big cybersecurity challenges. As light poles in cities become gateways for intelligent lighting systems, it's critical to build an infrastructure to protect citizens, businesses, and governments.

U.S. cities are in the process of digital transformation. San Diego, for example, is installing what it calls the world's largest Smart City IoT Platform by adding 3,200 intelligent nodes to existing infrastructure. It is also moving from a sole-use outdoor wireless control network to a multiapplication network for the IoT to better collect metadata and provide smarter services. These intelligent networks will use sensors to collect real-time data to direct drivers to parking spaces; guide fire, ambulance, and police responses; and provide weather data.

Smart street luminaires provide the ability to change light levels, track energy usage, and provide luminaire maintenance information—all while saving significant

energy with LED street lighting systems that use utility-grade energy measurement per pole to pay only for what is used instead of fixed utility costs per pole.

As more municipalities explore strategies to integrate innovative solutions, it's necessary to factor in the cost of a security breach. Industrial-grade multilayered cybersecurity measures must address three essential pillars of any smart city solution: edge security, connectivity security, and cloud security.

EDGE SECURITY

Edge security protects local data and secures access to the larger system. First, every node should have a unique, trackable identity that can be remotely authenticated using the device's unique certificates stored within its trusted platform module. Second, every removable module should be authenticated using a reverse engineering-resistant crypto-chip carrying the module identity. These efforts, along with the secure boot sequence, enable a tree of trust expanding from the semiconductor components to the encrypted file system. This ensures that any security infringements are limited to the loss of the single node, even if the perpetrator possesses the node. As a final precaution, continuity of the security can be ensured by signing and verifying software patches.

CONNECTIVITY SECURITY

It is critical to build solutions that secure transmitted data and prevent the potential of the infrastructure mounting an attack on third-party systems. For example, a cybersecurity team may use an encrypted, two-way transport layer secure protocol and transmit only via secure tunnels with source and destination inspection at the interface points.

CLOUD SECURITY

Smart cities must embed security at every level of the cloud stack. Additional software systems can be built on top of a multiapplication cloud to ensure compliance standards and contractual clauses related to data. These types of security systems should use 24/7/365 monitoring of the cloud infrastructure, the software applications, and application programming interfaces that allow for constant oversight and provide internal teams with the ability to find vulnerabilities before potential attackers do.

When security needs for each pillar—edge, connectivity, and cloud—are properly implemented as part of a smart city's blueprint, the foundation is established for a truly limitless future. ☼

Leveraging Online Tactics for *Brick and Mortar Retail*



As retailers continue to embrace the convergence of online and offline channels, they are faced with the enormous challenge of creating a single shopping experience for their customers, regardless of the channel they use.

Retailers are looking for innovations that build on the instant gratification of an in-store purchase by attaching it to an online shopping experience. An example of this hybrid channel innovation is buy online / pick up in store (BOPIS), in which retailers use their brick and mortar (B&M) stores—sometimes with self-serve kiosks—as pickup locations for online orders.

B&M retailers seeking to merge online and offline customer experiences are increasingly turning to Internet of Things technologies, such as using the store's existing light-emitting diode (LED) lighting infrastructure outfitted with advanced sensing beacons to enable precise indoor positioning—down to a specific aisle and shelf. With indoor positioning technology deployed throughout a physical store, a retailer can create merchandising action zones, which are precise geofences generated around a product location.

Action zones function like a merchandising box. As a shopper stops to investigate a product, a coupon or other relevant message can be instantly delivered to her mobile device via the store app or connected

shopping cart, similar to the chat feature used by many e-commerce channels. Action zones help eliminate friction in the buying process, increasing the potential for an in-the-moment sale. They can also boost upsells by pushing the same “frequently bought together” and “customers who bought this item also bought...” recommendations shoppers are accustomed to online.

In addition to BOPIS, retailers can take advantage of action zones to drive pure in-store interactions that closely mirror the online experience. It introduces a virtual “Buy It Now” button that is the Holy Grail for most retailers today. And because this seamless connection between online and in-store is based on existing lighting infrastructure, it's easier than many retailers realize.

Indoor positioning technology is helping retailers create a single shopping experience—whether that's online, on mobile, in-store, or some combination of all three—serving customers however and wherever they choose to shop. With all of its channels working harmoniously, a retailer can shift focus and resources toward making its brand the loyalty driver and revenue producer. 📶

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Roadway LEDs Address Unintended Effects on Flora and Fauna

Immature soybean growth can be seen behind each HPS roadway lighting fixture. Photo courtesy of Virginia Tech Transportation Institute

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Mr. Palmer has
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aspects of roadway
lighting technology.

Dr. Gibbons has
researched and
written policy
and guidelines for
roadway lighting.

The transition to light-emitting diodes (LEDs) reminds us that roadway lighting often influences flora and fauna in unforeseen and unintentional ways. Given the measurable safety benefits of lighting, especially where vehicles and other roadway users come into conflict, there is a clear need to balance lighting's positive and negative effects. Fortunately, a variety of tools are now available that roadway lighting designers can use to minimize adverse influences on flora and fauna.

Flora

In the U.S., soybeans are an important part of the crop rotation needed to fix nitrogen in the soil. Soybeans are an annual plant; at the end of the season, they recycle all of the energy used to grow by pushing nutrients and sugars into the seeds and dying.

Soy plants grow taller in the vicinity of roadway lighting but never mature and produce fewer and lower-value beans. The effect of roadway lighting on soybeans can be seen driving down any lighted road in the Midwest during August and September. Light—more specifically, the lack of light caused by the shortening of the day—triggers the plant to know it is time to finish the seeds.

As the majority of a field starts turning yellow, and later brown, semicircles of green plants remain near streetlights due to house-side light trespass. High-pressure sodium (HPS) lighting can cause the plants to grow up to 50 percent taller than normal and can reduce production by measurable amounts, depending on illuminance levels.¹

Farmers cannot include immature seeds in their harvests because they will receive a lower price per bushel from buyers. To top it off, the green plants often clog the combines used for harvest. Research is underway by the Virginia Tech Transportation Institute to determine if LED luminaires are better for soybeans since the primary sensitivity of soy is in the blue and red wavelengths.

Rice plants also rely on changes in the duration of light to trigger the production of the seed. Based on a study between 2009 and 2013, Yamaguchi University determined the aspects of roadway lighting that result in a 20 percent reduction in rice production. This led to the creation of an LED luminaire to minimize the effect.

¹ Matthew Palmer, Ronald Gibbons, Rajaram Bhagavathula, David Holshouser, and Daniel Davidson, "Roadway Lighting's Impact on Altering Soybean Growth: Volume 1," *Illinois Center for Transportation Series*, no. 17-014, June 2017

The luminaire combines a blue LED with a yellow-green LED and pulses the lighting at a frequency not visible to humans. With it, the harvesting of crops illuminated with as much as 10 lux of horizontal illuminance was delayed by only three days compared to nonilluminated crops.

Fauna

Animals are also adversely affected by roadway lighting. The Route 462 bridge over the Susquehanna River between Columbia and Wrightsville, Pennsylvania, was recently upgraded with luminaires that are replicas of the originals installed in 1930 but with LEDs. Adult mayflies are drawn to the new lights, where reproduction occurs. The female, however, is not able to navigate back to the water's surface to lay her eggs before dying.² Most of the mayfly's lifespan is spent in the larval stage, and these larvae control algae growth, which keeps rivers clear and provides food for fish, so a reduction in the number of mayfly larvae can have a cascading disturbance to a river ecosystem.

Artificial lighting has a devastating effect on sea turtle hatchlings. To a hatchling's eyes, short or full spectrum lighting resembles the moon and causes confusion—it is believed that turtles rely on the moon to navigate from their sandy nests to the ocean. Many municipalities have laws preventing excess lighting near the shore, and turtle watchers use red lights to avoid disturbing hatchlings. Several municipalities have specified lighting with lower correlated color temperature (CCT) to reduce the effects on turtle hatchlings.

Birds that migrate at night use the stars for navigation. Uplighting from luminaires in urban areas confuses them, as does illumination on antennas, power lines, ship masts, and lighthouse beacons. Navigation confusion can trap birds in urban environments, potentially resulting in fatigue, exposure to the elements, and increased vulnerability to predators.

The optics of LED luminaires allow much tighter control of the beam pattern and cutoff to reduce uplight while providing larger lighted areas than traditional light sources. This can mitigate the negative effects on migratory birds and sea turtles if full cutoff or cutoff less than 90° luminaires is chosen. Full cutoff luminaires can reduce the impact on insects as well by limiting the distance over which the light source can be seen.

Minimizing Impact

Modern lighting designers have many tools to control the unintended consequences of lighting. LED luminaires are now available in a wide range of spectral power distributions (SPDs), with CCTs ranging from 2100K to 6500K. For LED luminaires with continuous SPDs, lower CCT values roughly correlate with increased long wavelength content in the SPD, which can reduce the effects on taxa.

There is some evidence that 4000K LED lighting may allow humans to detect objects farther than other CCTs. Detection is the first step that needs to occur to avoid conflicts with vehicles, pedestrians, cyclists, and other hazards. Therefore, the choice of CCT has to be weighed against the safety benefits for each design.

The dimmability of LED lights when combined with wireless controls and sensors allows lighting to be reduced or removed on a curfew or when traffic volume is low. This can abate the overall consequences on a variety of flora and fauna. The National Cooperative Highway Research Program has established guidelines for adapting the lighting level to roadway type, traffic speed, median presence, intersection/interchange density, traffic volume, pedestrian traffic, and ambient lighting.³ These guidelines enable lighting to be changed as frequently as every hour.

Humans depend on flora and fauna, and we need to use the tools available with modern lighting to reduce the unintended consequences of roadway lighting while maintaining safety. LED lighting can achieve a broad range of spectral selections that minimize impacts to specific vulnerable taxa, while dimming and instant on-off capabilities minimize impacts to all taxa.

Adaptive technologies, such as modern lighting controls, sensors, and control software, can provide lighting only when needed, allowing the darkness needed for flora to mature. Spectral selection of HPS, ceramic metal halide, and LED products can produce longer wavelength content to reduce the effect on fauna or shorter wavelength content to reduce the effect on flora. Finally, limiting lighting outside of the roadway with improved beam control and house-side shielding benefits all flora and fauna.

These suggestions are not all-inclusive. Roadway lighting tools can be applied intelligently for each job, project, roadway, and ecosystem. 🌱

² Ryan Robinson, "WATCH: 'Blizzard' of mayflies swarm Route 462 bridge," *LancasterOnline*, June 14, 2015

³ Ronald Gibbons, Feng Guo, Alejandra Medina, Travis Terry, Jianhe Du, Paul Lutkevich, David Corkum, and Peter Vetere, *Guidelines for The Implementation of Reduced Lighting on Roadways*, FHWA, June 2014

Savvy? Choose Power over Ethernet for Lighting



Category cables can connect to luminaires to provide power and robust data. Photo courtesy of Leviton

Power over Ethernet (PoE) provides both power and data to devices such as Voice over IP (VoIP) telephones. Light-emitting diode (LED) luminaires are another device that may benefit by connection to a PoE network.

Recent advances have reduced the power needed to operate LED luminaires to the point where network data switches that are compliant with PoE standards (such as IEEE 802.3at) can also supply the power needed to operate them. Ethernet communications also direct the luminaires to dim, brighten, and report status such as lamp failure, sensor information, and energy consumption.

The widespread acceptance of lighting fixtures based on high-efficacy LED light sources, along with advancements in networked lighting controls, has changed the landscape of the entire lighting industry. The demand for connected lighting solutions continues to increase, as it becomes an essential requirement for high performance buildings.

Unlike many other past light sources, LEDs use direct current (DC) to produce light. Using DC can be much more efficient than the customary practice of using an alternating current line voltage converted to DC for LED power. A power system that provides DC at a voltage close to the low voltage (30-60 VDC) that most commercial LED light sources use, therefore, can also provide higher efficiency.

Ethernet uses twisted pair low-voltage communications cable (also known as category cable), which has been a core infrastructure for commercial buildings for many years. It connects computers, phones, printers, and other equipment to business information servers and the internet. It is more reliable and carries data faster than most common wireless technologies.

In 2003, a method for sending DC power over this same cable (i.e., PoE) was born. Initially, only about 15 watts of power was available. It was enough to power digital telephones, leading to the surge of VoIP phones that most businesses use today. The DC power capability was increased to 30 watts in 2009 and recent breakthroughs increased it to 60 watts. A new standard, IEEE 802.3bt, should boost capability to more than 90 watts of DC power in 2018.

Since LED power requirements are decreasing while PoE power capabilities are increasing, PoE has become a viable alternative for powering modern luminaires. Furthermore, energy efficiency is maximized by following the new ANSI C137.3 *Minimum Requirements for Installation of Energy Efficient PoE Lighting Systems*. Without the need for line voltage, a single low-voltage category cable can connect to one or more luminaires to provide both power and robust data for lighting, sensing, and control while facilitating additional advanced benefits such as light communications (Li-Fi), positioning, and other digital technologies.

There are three architecture types for PoE lighting products that use a category cable for power and data use:

- integrated into the luminaire, where the PoE electronics are part of the luminaire design;
- independent PoE LED drivers that can daisy chain with category cable to other drivers and work with a variety of luminaires; and
- remote drivers that provide direct LED drive current for several luminaires from one device.

Building owners should consider the advantages of this infrastructure for their high performance buildings, and savvy installers should consider seizing the opportunity to expand their business potential. ☺

Avoiding HID Lamp Prohibition in Connecticut

Acting on behalf of Member companies in its Light Source Section, NEMA applied for an exemption from mercury products law to ensure that critical “wide area” lighting systems can continue to operate in Connecticut. This became necessary when staff learned that state authorities interpret a section of the Connecticut General Statutes (CGS) as a ban on high-intensity discharge (HID) lamps that contain more than 100 milligrams and less than one gram of mercury.

The high-wattage HID lamps affected by this regulatory threshold fulfill a variety of general service and specialty lighting requirements. Highly valued for their long operating life and superior efficacy, HID lamps have long been preferred for large indoor and outdoor activity sites as well as sensitive industrial and medical applications.

The state Department of Energy & Environmental Protection (DEEP) contends that the mercury threshold was codified in 2006 with an effective date of July 1, 2013. At the time the amendments were enacted, NEMA’s understanding was that HID products specified in the statute were not

subject to the mercury content limitation and would not become so at any predetermined date.

The problem is the text of CGS Sec. 22a-617(a). While the first two clauses of the subsection clearly institute successively stricter mercury thresholds in 2004 and 2006, the language pertaining to 2013 is indiscernible. In NEMA’s view, it fails to impose new lower limits on HID lamps.

Moreover, during the 2006 legislative process, NEMA members made clear that nonmercury replacements for the high-wattage HID lamps affected by the threshold did not exist and would not be technologically feasible in the foreseeable future. This followed a 2003 recommendation by a mercury workgroup that HID lamps “should be exempted from the phase-out provisions of Sec. 22a-617 of the Connecticut General Statutes.”

Rather than challenge DEEP’s interpretation, NEMA Members chose to pursue a formal exemption. To learn more, contact Mark Kohorst, 703.841.3249 or mark.kohorst@nema.org.



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Unleashing the Opportunities of Solid State Lighting

Why do regulators continue to expend time and effort in the lighting sector?

First is the need to protect a market from poor quality products and opportunism. Second, solid state lighting (SSL) is ubiquitous and electronic, which increase its importance to the Internet of Things. Lastly, the affordability and connectivity of SSL afford significant opportunities for improved lighting quality, in terms of having the right light at the right place at the right time and in the correct amount.

These factors require stakeholders to defend and deliver products and guidance that allow the lighted environment to excel. NEMA’s Lighting Systems Division continues its regulatory efforts that allow SSL to continue to increase market share and provide high levels of performance both in energy efficiency and quality of light.

SSL is seeing strong entry into venues where lighting and health merge. Although recent studies

show great promise for improving light quality and human comfort, accurate health recommendations of any kind involve careful study, often taking years. While NEMA will monitor—and possibly participate in—studies examining the relationship between light and health, it is unlikely it will develop health-related standards.

During regulatory proceedings, NEMA will identify and defend opportunities to improve lighting quality in all aspects—health and comfort included—and oppose those seeking to regulate these quality metrics too soon, if at all. Scientific guidance, such as the Recommended Practices library of the Illuminating Engineering Society (IES) and similar publications, are the appropriate resource for lighting quality and quantity data.

The forecast for lighting in 2018 and beyond shows no shortage of opportunities to improve performance and applications guidance.

ANSI Lighting Committees Energized

Recognizing the need for the inclusion of updated technology in existing standards, Accredited Standards Committee (ASC) C136 Roadway and Area Lighting Equipment revised five standards and expects to revise 11 more in 2018. Six new standards are in development.

ASC C137 Lighting Systems published American National Standards Institute (ANSI) C137.0-2017 *Lighting Systems Terms and Definitions* and ANSI C137.3-2017 *Minimum Requirements for Installation of Energy Efficient Power over Ethernet (PoE) Lighting Systems*. Standards for 0-10 V dimming, cybersecurity requirements for parking lot lighting systems, and digital interface with auxiliary power are expected this year.

The American National Standards Lighting Group (ANSLG) encompasses ASC C78 Electric Lamps; ASC C81 Bases, Lampholders, and Gauges; and


ASC C82 Electric Ballasts. They cover fluorescent, high-intensity discharge (HID), and solid state technologies. It developed ANSI C78.52-2017, a new standard for LED lamps that are direct replacements for existing, ANSI-standardized, non-LED lamps. Several new projects will cover topics related to LED drivers, such as operation life estimation and dimming characteristics. A new proposed standard, ANSI C82.15, deals with LED driver robustness.

Participation in ANSI Lighting Committees is open to everyone and does not require NEMA membership; however, an annual working fee is assessed. NEMA's Lighting Systems Division is looking for industry experts in the user, producer, and general interest categories to participate in standards development activities. Contact NEMA at nemalighting@nema.org to indicate interest category and area of expertise. ☎

Code Adoption Revs Up in the South

Bryan P. Holland

South Field Representative, NEMA



The **Florida** Building Commission will begin the three-year process of updating the Florida Building Code, 7th Edition (2020), which is based on the 2018 International Code Council codes (I-Codes) and the 2017 *National Electrical Code*® (NEC).

The **Georgia** Department of Community Affairs will begin reviewing the 2015 International Building Code and 2015 International Residential Code. The updated **Louisiana** Uniform Construction Code, based on the 2015 I-Codes and 2014 NEC, goes into effect June 1.

The **North Carolina** Electrical Code, based on the 2017 NEC, goes into effect April 1. The 2018 state building code, based on the 2015 I-Codes, goes into effect on July 1. The **Oklahoma** Uniform Building Code Commission is assembling an

electrical technical committee to begin review of the 2017 NEC. The **South Carolina** Building Codes Council has issued a notice of intent to adopt the 2018 state building code based on the 2018 I-Codes and 2017 NEC.

The **Tennessee** Fire Prevention Office is expected to publish an amended rule to adopt the 2017 NEC, effective July 1. The **Virginia** Department of Housing and Community Development completed the update to the 2015 Virginia Uniform Statewide Building Code based on the 2015 I-Codes and 2014 NEC, effective March 1.

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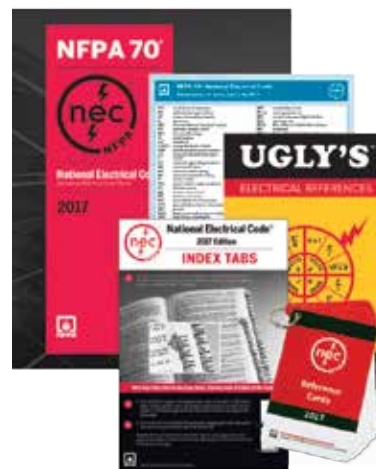
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