Workforce Development for Advanced Lighting Controls

Michael Siminovitch, Cori Jackson, Keith Graeber, Manuel Lopez

The California Lighting Technology Center at UC Davis, in collaboration with investor-owned utilities, developed and maintains the California Advanced Lighting Controls Training Program (CALCTP) for both installers and acceptance testers.

CALCTP requires that all participants be California State certified general electricians or electrical contractors. Trainings are offered at select California Joint Apprenticeship Training Committee training centers, investor-owned utility education centers, and California Community Colleges.

The CALCTP program provides a step-by-step approach to understand, apply and install commercial lighting control systems. The subjects presented in this course include:

- Lighting terminology
- Lighting control strategies
- LED light sources and drivers
- Line and low voltage controls
- Dimming systems
- Occupancy sensors
- Photosensors
- Networked lighting control systems
- Codes and standards
- Associated installation/wiring requirements

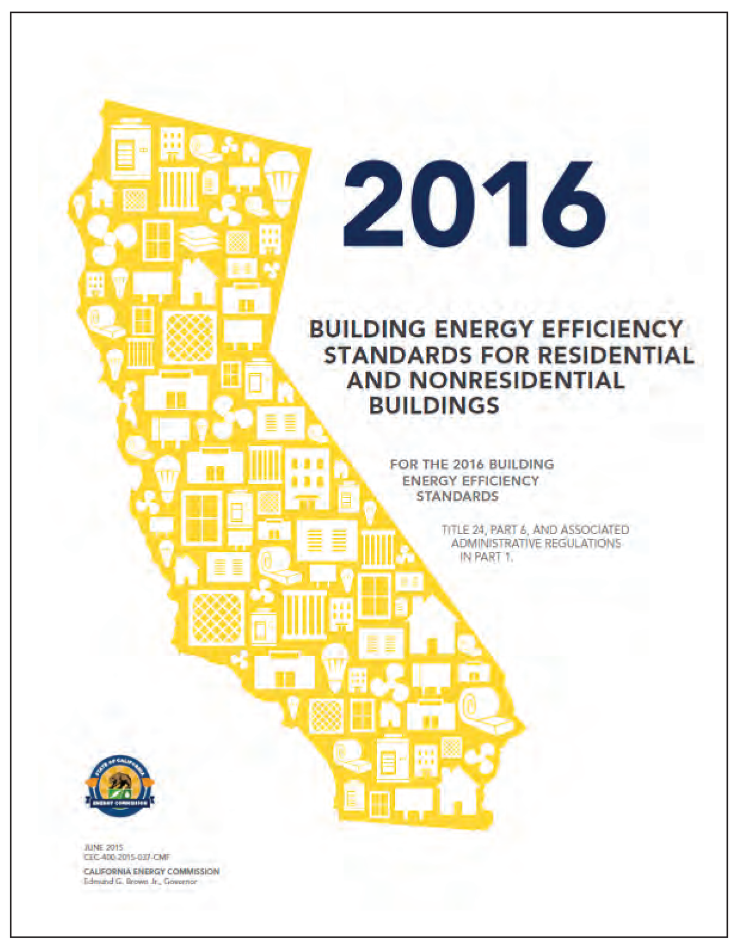

Figure 1. California's Building Energy Efficiency Standards containing requirements advanced lighting controls

Figure 2. California Advanced Lighting Controls Training Program's guide for installers

This course is divided into eight modules consisting of lecture and lab activities. The module content is organized to answer the following questions about lighting controls.

- **What are lighting controls?**
- **What do they do?**
- **Where are they used?**
- **How are they installed?**

Each "lecture" contains one or more interactive components, including group discussions, device demonstrations and/ or calculation exercises.

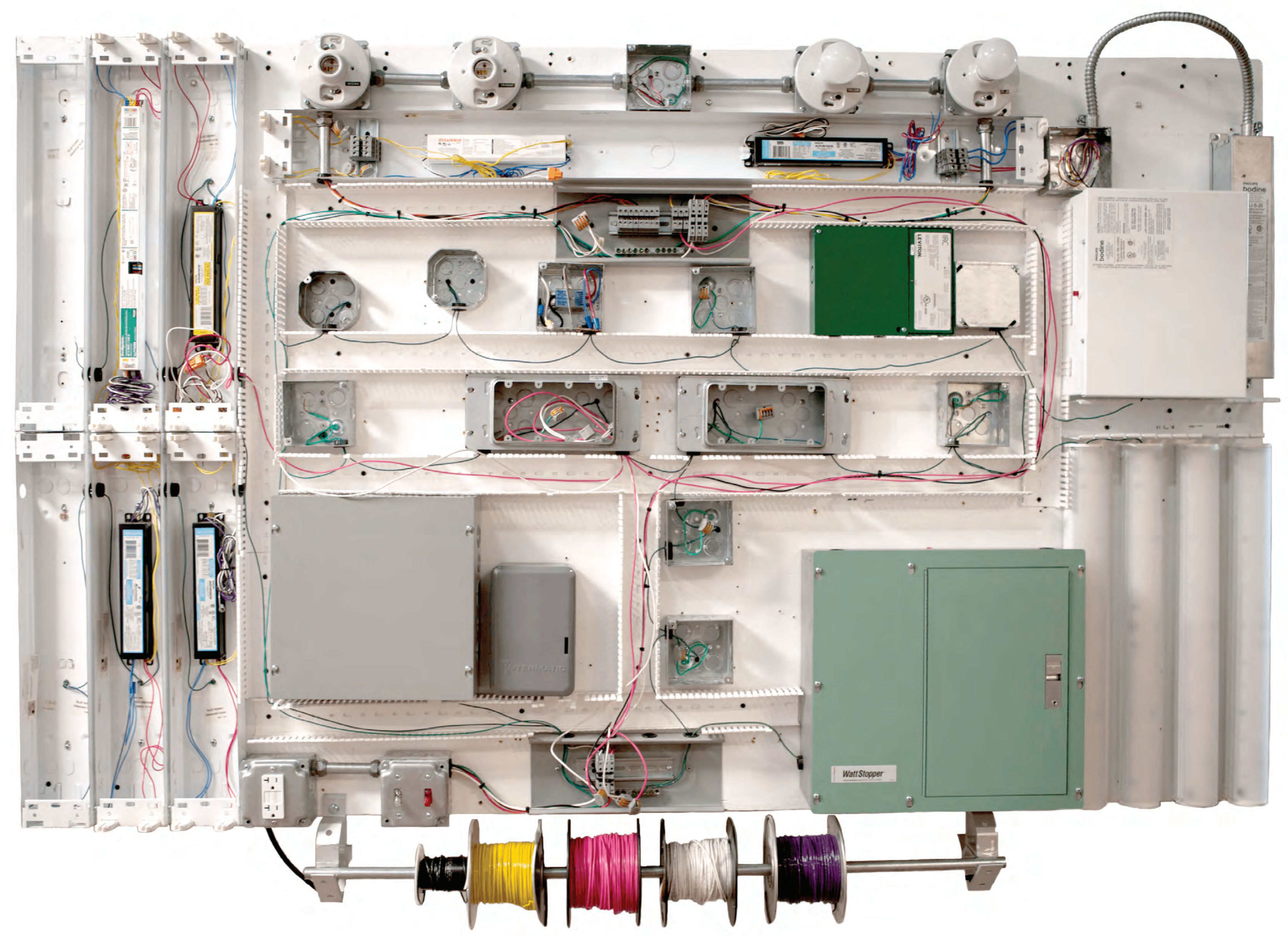

Figure 3. CALCTP Training Board used for the lab activities for each module

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Integrated Building Control Retrofit Packages for Existing Buildings

Konstantinos Papamichael, Keith Graeber, Philip von Erberich, Andrew Harper, Tristan Bond

The California Lighting Technology Center, in collaboration with California Energy Commission, is conducting research to develop and evaluate technology that integrates the control of heating, ventilating, air conditioning (HVAC), lighting, and fenestration systems. This integrated approach will increase building-wide energy efficiency, reduce peak demand and improve occupant comfort. The goal of this effort is the demonstration and evaluation of an Integrated Building Control Retrofit Package (IBCRP) in the laboratory and an existing building. A diagram of an example IBCRP is shown in Figure 1.

The laboratory testing is underway at CLTC (Figure 2) to verify the communication and performance abilities of commercially available products to be specified as the IBCRP.

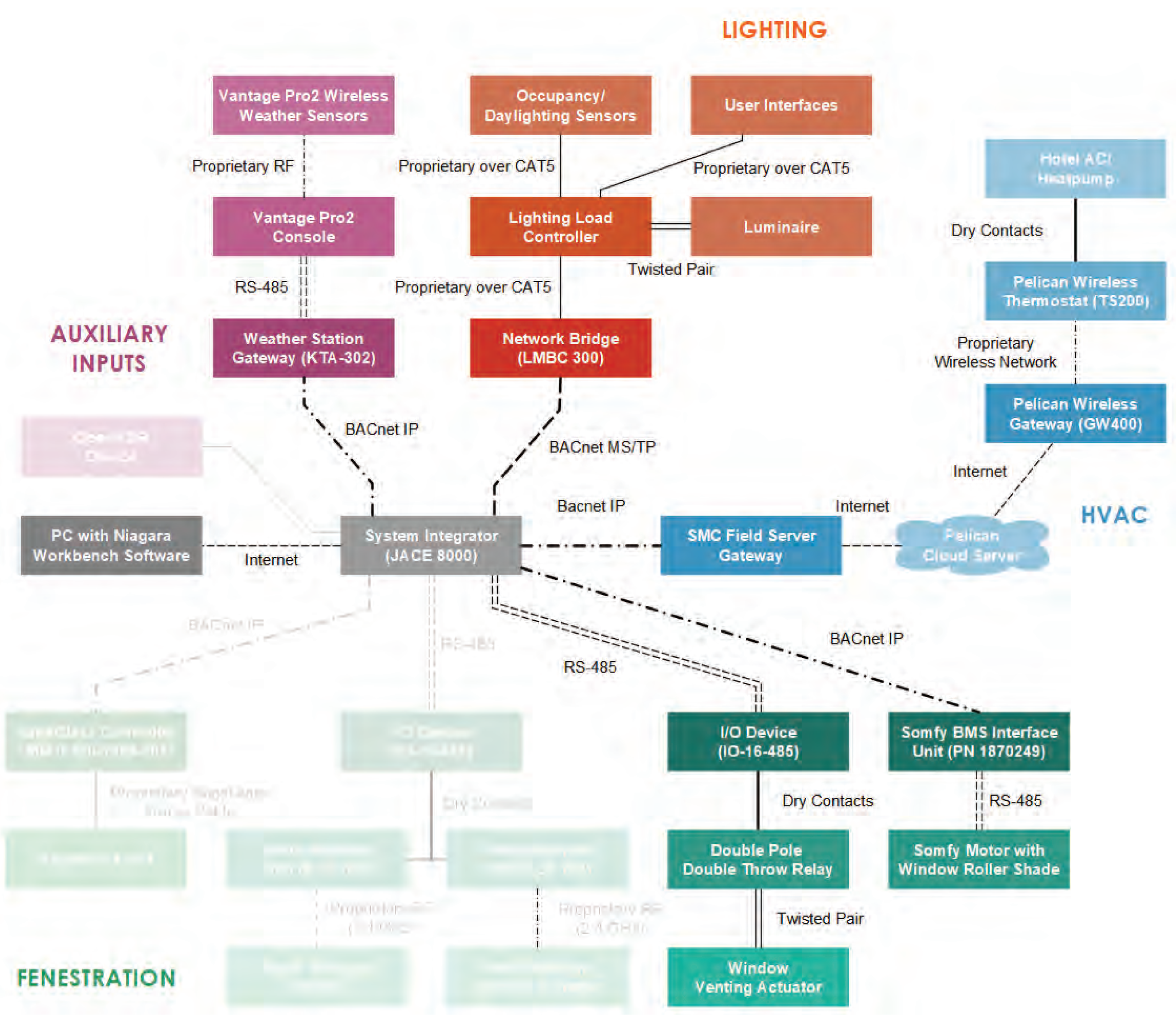

Figure 1. IBCRP system hardware to be implemented at demonstration site. Devices that are transparent in the figure have been removed from the general specification for the demonstration site implementation.

Refinement activities are in progress to optimize the performance of the products in preparation for the field demonstration in The Barn on the UC Davis campus. Installation at The Barn is scheduled for Fall 2019.

CLTC is currently developing a measurement and verification plan to evaluate the performance of the IBCRP in the field deployment. The plan includes the necessary steps to collect and analyze system performance metrics related to the lighting, HVAC, and fenestration sub-systems.

Figure 2. Integrated Building Controls Laboratory at CLTC

Figure 3. The Barn facility, UC Davis by Pete Scully

Figure 4. Electric lighting system in CLTC laboratory

Figure 5. Venting skylight with solar shade and photo sensor looking outdoors.

Figure 6. Venting window with adjustable rolling solar film

Figure 7. HVAC unit used in laboratory testing to confirm communication with integrated system components

Figure 8. Automated Controls: Central controller and system controllers for IBCRP

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The Million LED Challenge

Michael Siminovitch, Nicole Hathaway, Adrian Ang, Manuel Lopez, Ryan Allen

High quality LED light sources are an effective way for Californians to reduce their carbon foot print, reduce energy use and save money! The Million LED Challenge is set up to generate rapid transformation from fluorescent and incandescent lighting technologies to high-performance, high-quality LED technology in California.

The Million LED Challenge was formed to make high-quality, high-efficiency light bulbs available at a great price. The lamps are available for purchase to current students, staff, faculty, alumni and the facilities groups of the UC, CSU, CCC and DGS systems via the website (Figure 1).

The challenge is a two-phase effort, with the first phase focused on screw-base lamps and the second phase focused on luminaire retrofit solutions. The luminaire retrofit solution performance specification is derived from best-in-class product development work conducted in partnership with the California Energy Commission (Figure 3).

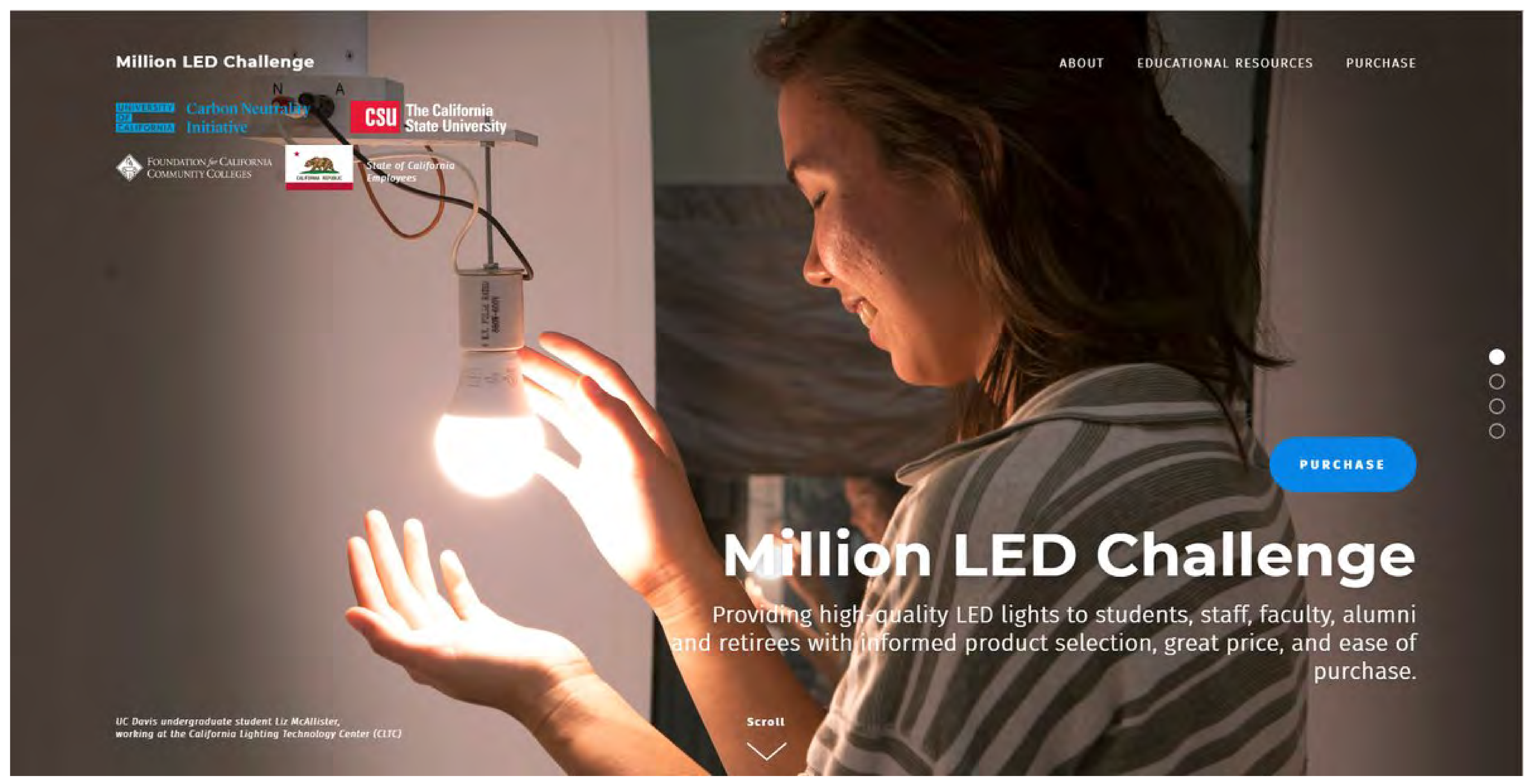

Figure 1. Million LED Challenge Website (www.millionledchallenge.org)

Figure 2. UC Davis Chancellor Gary May relighting his home with Million LED Challenge light sources.

Quality Specification for Linear LED Retrofit Solutions

Million LED Challenge

Linear fluorescent lamps can be replaced with LED alternatives, but care must be taken to ensure LED replacements provide similar or improved performance. LED retrofits should provide better efficacy and deliver equivalent light distribution. By making an informed switch to LEDs, consumers can expect lower operating costs and improved lighting quality as compared to traditional fluorescent lamps.

CLTC recommends the following criteria to help consumers successfully transition to LED retrofit solutions:

Linear LED Lamps (TLEDs)

- Electrical architecture, UL Type C
- Light output, bare single lamp light output of 2,250 lumens
- Efficacy, at least 120 lumens per Watt
- Dimming, minimum dimming level to at least 10 percent of full light output
- Controllability, be able to pair with lighting control devices **(control-ready)**
- Color, R_f value greater than 90 measured by IES TM-30-18
- Distribution, beam angle of at least 220 degrees with no less than 20 percent of total flux emitted in the 100–180 degree zone
- All else, meet **DLC minimum criteria**

LED Retrofit Kits & Fixtures

- Efficacy, at least 120 lumens per Watt
- Dimming, minimum dimming level to at least 10 percent of full light output
- Controllability, be able to pair with lighting control devices **(control-ready)**
- Color, R_f value greater than 90 measured by IES TM-30-18
- Distribution, provide photometric distribution file in IES LM-63 format
- All else, meet **DLC minimum criteria**

What is control-ready?

All LED retrofit solutions should be pairable with lighting controls that will allow for control strategies including personal tuning, occupancy sensing, daylight harvesting and automated demand response, where appropriate.

University of California Carbon Neutrality Initiative · CSU The California State University · Foundation for California Community Colleges · State of California Employees

Figure 3. Technical Performance Specifications for Luminaire Retrofit Solutions

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Consumer Preference Informs the Next Generation of LED Lighting Solutions

Michael Siminovitch, Keith Graeber, Philip von Erberich, Ryan Allen

CLTC is working to improve the adoption of LED light sources by developing optimized performance and product designs. Design criteria was determined through a series of targeted studies aimed at identifying the features and performance attributes most valued by today's consumers.

A cross-section of the general public were asked to conduct a number of tasks under varying lighting conditions. These studies evaluated the qualitative and quantitative experiences of the participants to identify consumer preferences for color related metrics. Three of the tasks are shown here:

- **Consumer perception of intentional color shift during dimming.** This study explores whether added lighting product complexity is appropriate by determining if consumers expect and want the light to behave similar to incandescent lamps (Figure 1).

- **Trade-offs between melanopic stimulus and visual performance.** Circadian rhythms (Figure 2) are predominantly driven by light intercepted by the intrinsically-photosensitive retinal ganglion cells (ipRGCs). ipRGCs respond to light based on the absorption of light by the photo-pigment called melanopsin.

  The action spectrum of melanopsin compared to the photopic sensitivity curve in provided in Figure 3. Understanding the impact that light has on both visual performance and circadian rhythms is necessary to guide the design of fixtures for use in spaces occupied at night. Tools used to gather this information are provided in Figure 4 and Figure 5. Analysis of results is provided in Figure 6.

- **LED consumer market penetration.** Specific questions aimed at understanding how many LED lights are installed in the study participant's home. Select responses are provided in Figure 7 and Figure 8.

  According to the self-reported market saturation survey performed in 2018 as part of this study, approximately 50 percent of the medium screw-base lamps used by consumers in the greater-Sacramento area are LED. Additionally, approximately 30 percent of tubular lamps and candelabra based lamps were reported as LED.

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Figure 1. CCT of table lamps in 'intentional color shift' study.

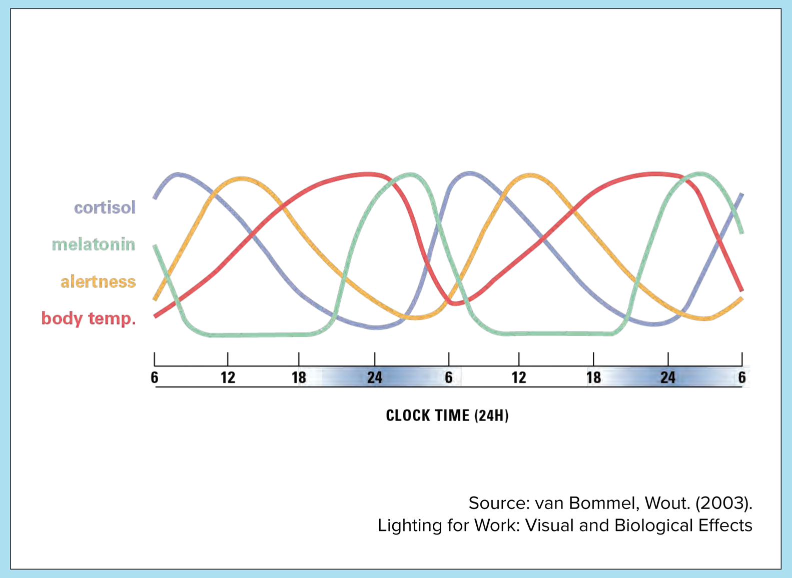

Figure 2. Circadian rhythms showing the variation of cortisol, melatonin, alertness and body temperature over two 24-hour periods

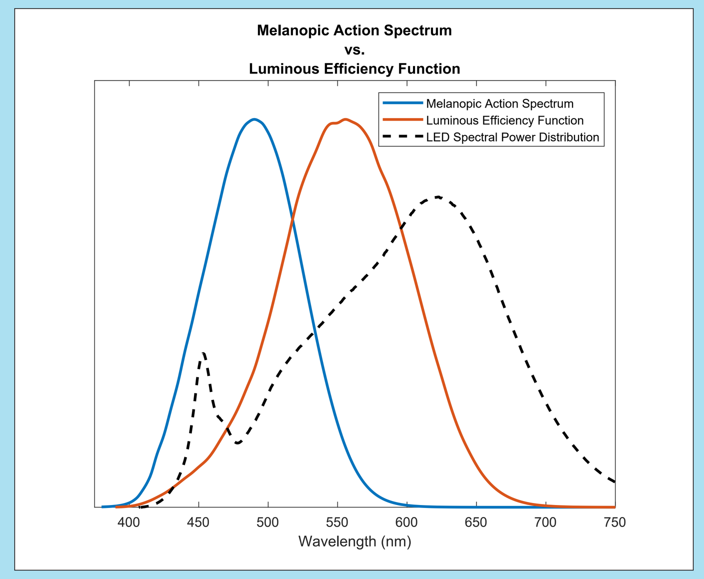

Figure 3. Melanopic vs. photopic action spectrum

Figure 4. Farnsworth-Munsell D-15 Color Test

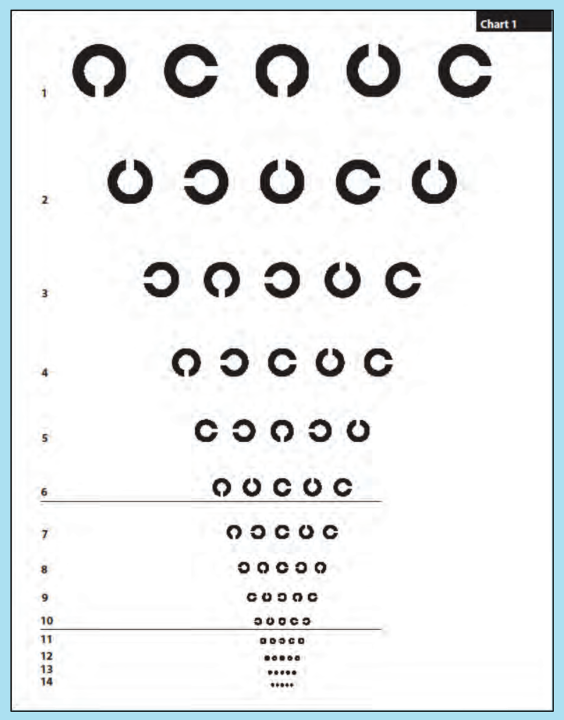

Figure 5. Example Landolt-C chart used to test participants' visual acuity in the 'Multi-Spectral Melanopic Lighting Study'

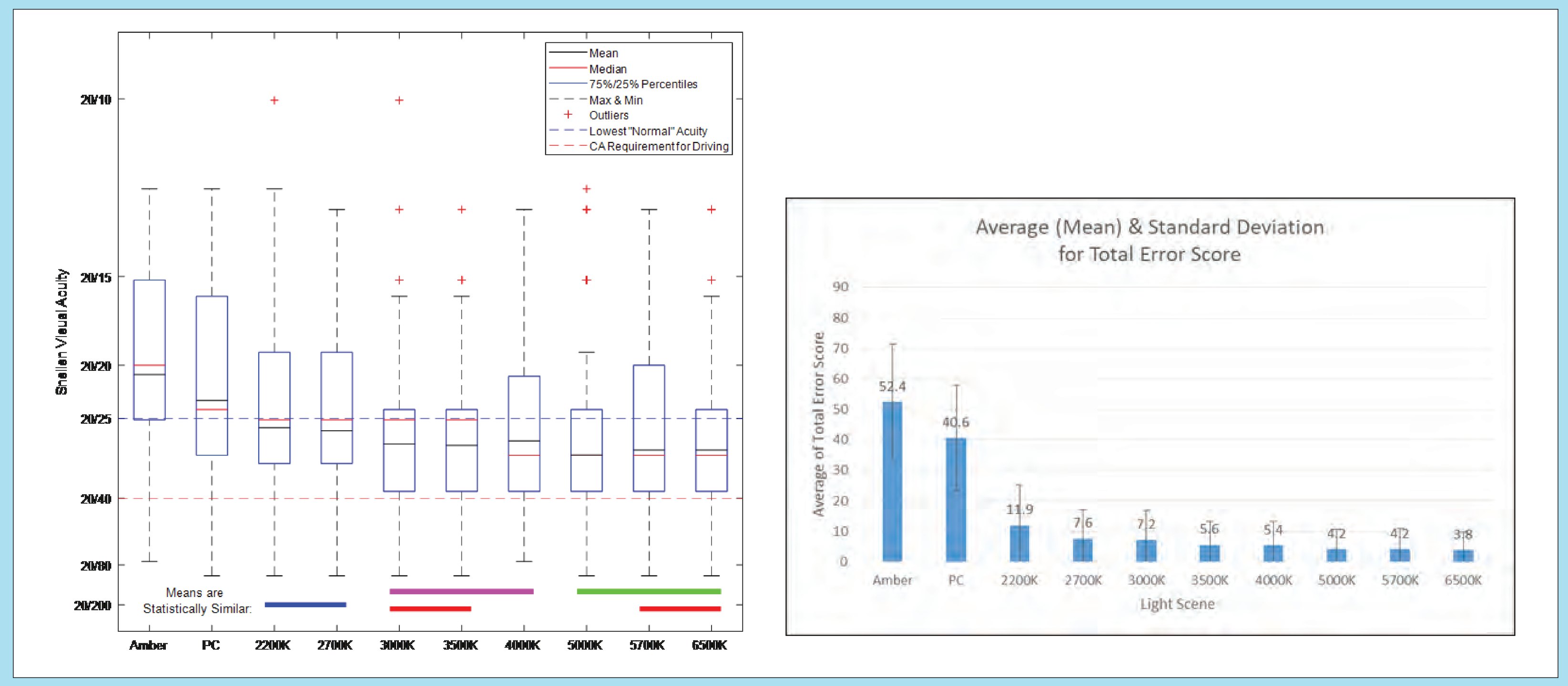

Figure 6. Visual acuity test results under the 10 CCT channels for Phase B. Blue boxes indicate 25 percent and 75 percent quartiles, red lines in blue boxes indicate median visual acuity and black lines in blue boxes indicate average visual acuity (left). Results from the 'Multi-Spectral Melanopic Lighting Study' (right).

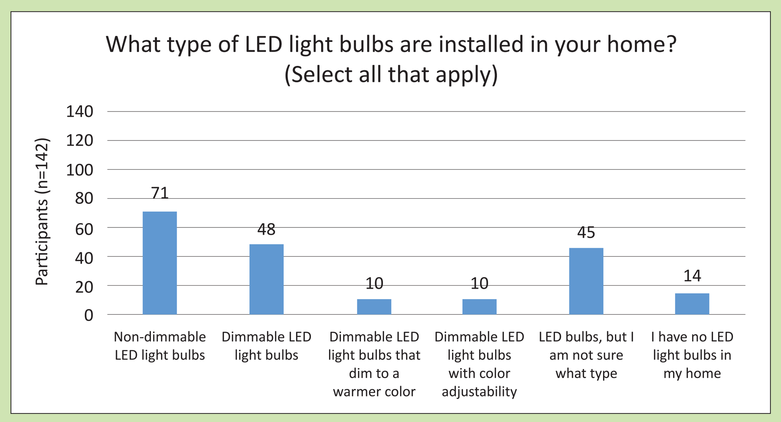

Figure 7. Number of participants who have installed LED lights in their homes

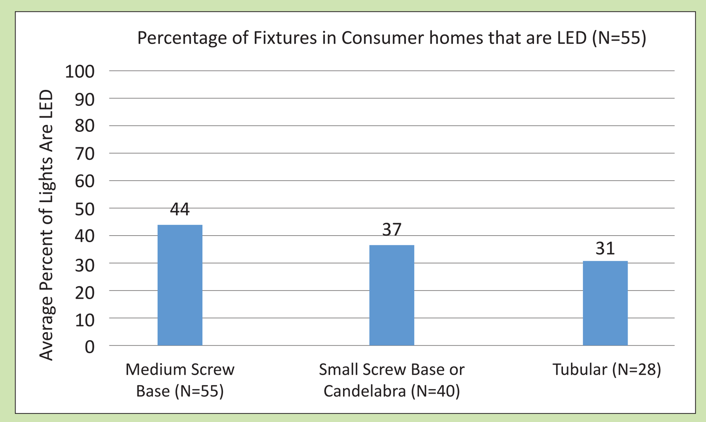

Figure 8. Percentage of Fixtures in Consumer Homes that are LED

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Adaptive, Sensor-Based Lighting for Security Applications: Exploring a New Lighting Design Paradigm

Michael Siminovitch, Nicole Hathaway, Keith Graeber, Manuel Lopez, Catherine Serou

Security lighting is traditionally achieved through static, elevated light levels, even though adaptive lighting (typically a dimmable light source and one or more environmental sensors) is considered best practice for many exterior applications. An example of a security lighting application with a perimeter fence is shown in Figure 1.

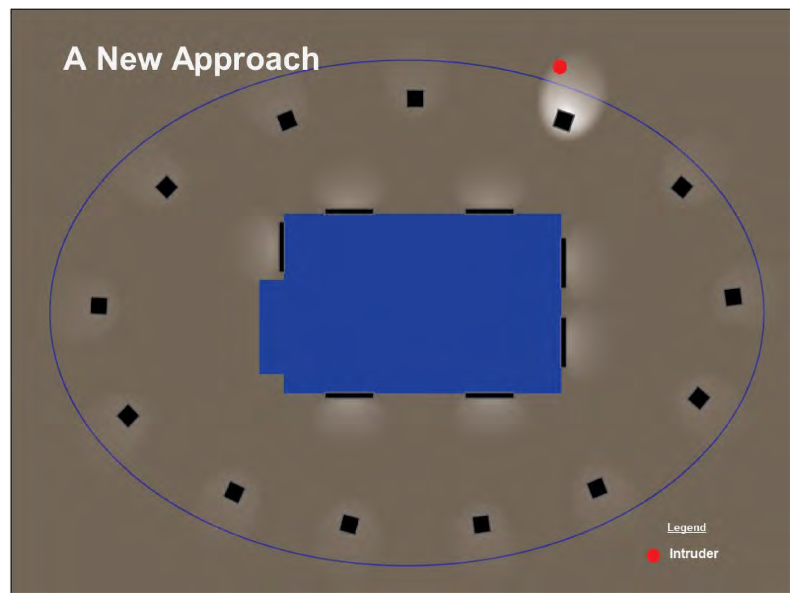

Figure 1. Example of how localized, elevated illumination can help detect intruders.

Lighting can enhance security when it helps guards and observers identify and react to potential threats. Bi-Level illumination where an intruder's presence triggers a localized elevated light level can draw guards' attention to the area of interest, potentially from much farther away than with static levels of illumination (Figure 1). Effective sensing technology will ensure accuracy and reduce false triggers.

Existing outdoor occupancy sensors targeted for lighting applications are limited in terms of detection area and in some cases, cannot provide the necessary coverage to detect occupants within a desired outdoor area. CLTC, with support from the Office of Naval Research, is evaluating existing sensing strategies targeted at other applications.

CLTC is testing outdoor occupancy sensing technologies, including dual-technology passive infrared and microwave sensors and solid state and mechanical LiDAR sensors (Figure 2). Testing will determine which sensor is most suitable for installation in the selected security applications.

Figure 2. Occupancy sensors being tested to evaluate performance in security applications. Left to right: Mechanical LiDAR, Dual-Technology PIR + Microwave, Solid State LiDAR

After testing, the selected system will be deployed in a proof-of-concept installation at the University of Hawaii Manoa campus (Figure 3). The installation will be used to 1) evaluate the solution in real-world conditions and 2) provide a demonstration of the strategy for naval personnel to experience.

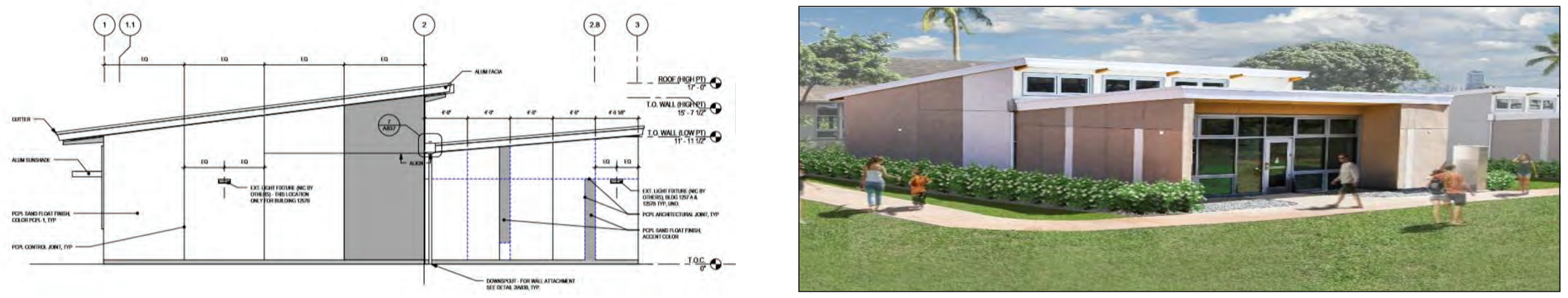

Figure 3. Proof-of-concept installation will take place at the Zero Net Energy Research Platform at the University of Hawaii, Manoa.

CLTC is currently searching for a military site to deploy the solution at for additional evaluation (Figure 4). Interested in participating? Let us know!

ADAPTIVE LIGHTING
FOR SECURITY APPLICATIONS
Seeking Outdoor Demonstration Site on a Naval Facility

The California Lighting Technology Center at UC Davis, in partnership with the Office of Naval Research's NEPTUNE program and the University of Hawaii, is developing a sensor-based adaptive lighting system that has the potential to enhance security, reduce energy use and lower maintenance costs for security applications.

The project team is currently seeking an outdoor demonstration site on a naval facility to evaluate the system in a real-world scenario. Installation of the system is anticipated to start summer 2019. Six months of measurement and verification activities will take place after the installation to evaluate the system's performance.

PROJECT BACKGROUND

Adaptive lighting consists of a dimmable light source and a suite of environmental sensors. Select building codes consider these systems best practice for exterior applications, yet security lighting is often still approached through static, uniform, high-level illumination.[1] Deep energy savings is achievable by reducing light levels in spaces during periods of vacancy. An example of this is the campus-wide exterior lighting retrofit at UC Davis, which reduced lighting energy use by 86 percent for monitored areas.[2]

Research has shown that sustained, uniform, high-level illumination typical of security lighting systems reduces alertness.[3] This project will determine if dynamically switching light levels based on occupancy has the potential to enhance guard awareness and detection ability while reducing energy use. The project team will determine optimal light levels and control strategies using a prototype system at the CLTC laboratory and a proof-of-concept installation at University of Hawaii Manoa. Then, the project team will conduct the real-world evaluation at an outdoor demonstration site on a naval facility.

DEMONSTRATION SITE CRITERIA

The project team is seeking an outdoor demonstration site on a naval facility that has one or more of the following features:

1. Perimeter fence
2. Building exterior/façade
3. Open area
4. Entry control point

Sites that include all four security lighting applications are ideal, such as a fenced building with an adjacent parking lot. The project team is currently accepting nominations of outdoor demonstration sites on a naval facility. Please email questions and nominations:

Nicole (Graeber) Hathaway, Project Manager
Phone: 530.747.3847 | negraeber@ucdavis.edu

1 Illuminating Engineering Society. IES G-1-16: Security Lighting for People, Property and Critical Infrastructure. 2016. Page 29.
2 California Lighting Technology Center. Campus-wide Networked Adaptive LED Lighting. 2014. Page 2.
3 Clanton and Associates, Inc. Seattle LED Adaptive Lighting Study. 2014. Page ii.

Figure 4. Flyer used to identify military sites for full demonstration.

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2019 Title 24 Education and Outreach for Lighting

Michael Siminovitch, Nicole Hathaway, Georgia Mckenzie, Adrian Ang

California's new Building Energy Efficiency Standards take effect on January 1, 2020. The 2019 Energy Standards focus on several key areas to improve the energy efficiency of newly constructed buildings, additions and alterations to existing buildings.

The most significant residential efficiency improvements address photovoltaic systems, walls, gas furnaces and lighting. Single-family homes built under the 2019 Energy Standards will use about 7 percent less energy due to energy efficiency measures as compared to homes built under the 2016 standards. Once rooftop solar electricity generation is factored in, homes built under the 2019 Energy Standards will use an estimated 53 percent less energy than those under the 2016 Energy Standards.

Significant changes in the nonresidential 2019 Energy Standards address ventilation, HVAC, demand response and lighting. Notably, the 2019 Energy Standards now include requirements for healthcare facilities, although there are many exceptions for this building type.

CLTC's Title 24, Part 6 resources are designed to help builders and lighting industry professionals become more familiar with California's Building Energy Efficiency Standards.

These resources are not intended to replace the Energy Commission's comprehensive Title 24 Building Energy Efficiency Standards or its compliance manuals. They are intended to help designers and building professionals become familiar with advanced lighting technologies and the latest code improvements.

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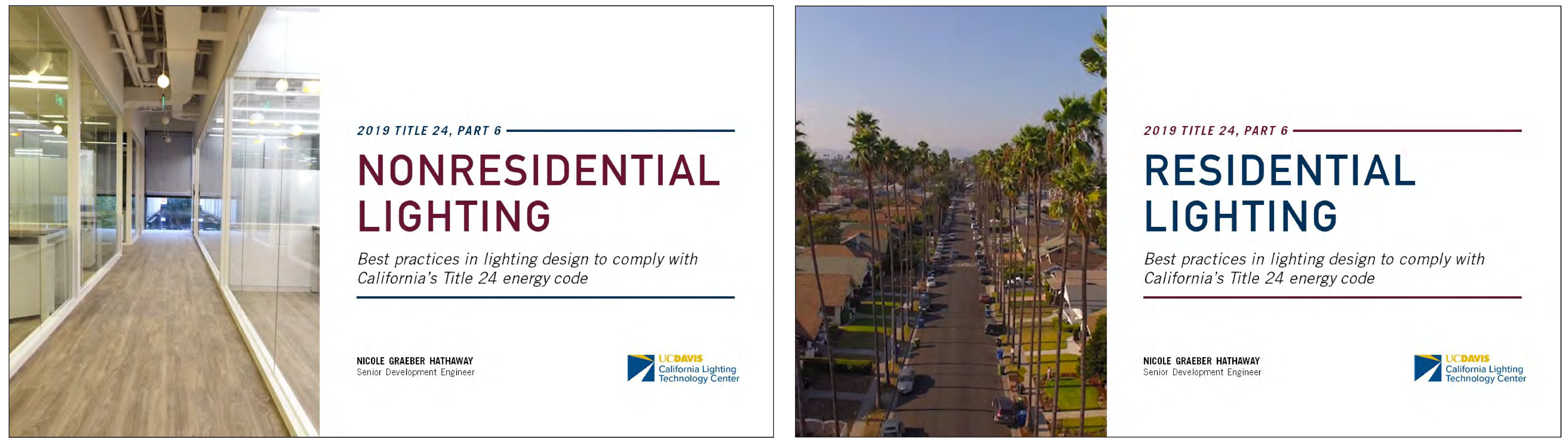

Figure 1. 2019 Title 24 Nonresidential & Residential training materials

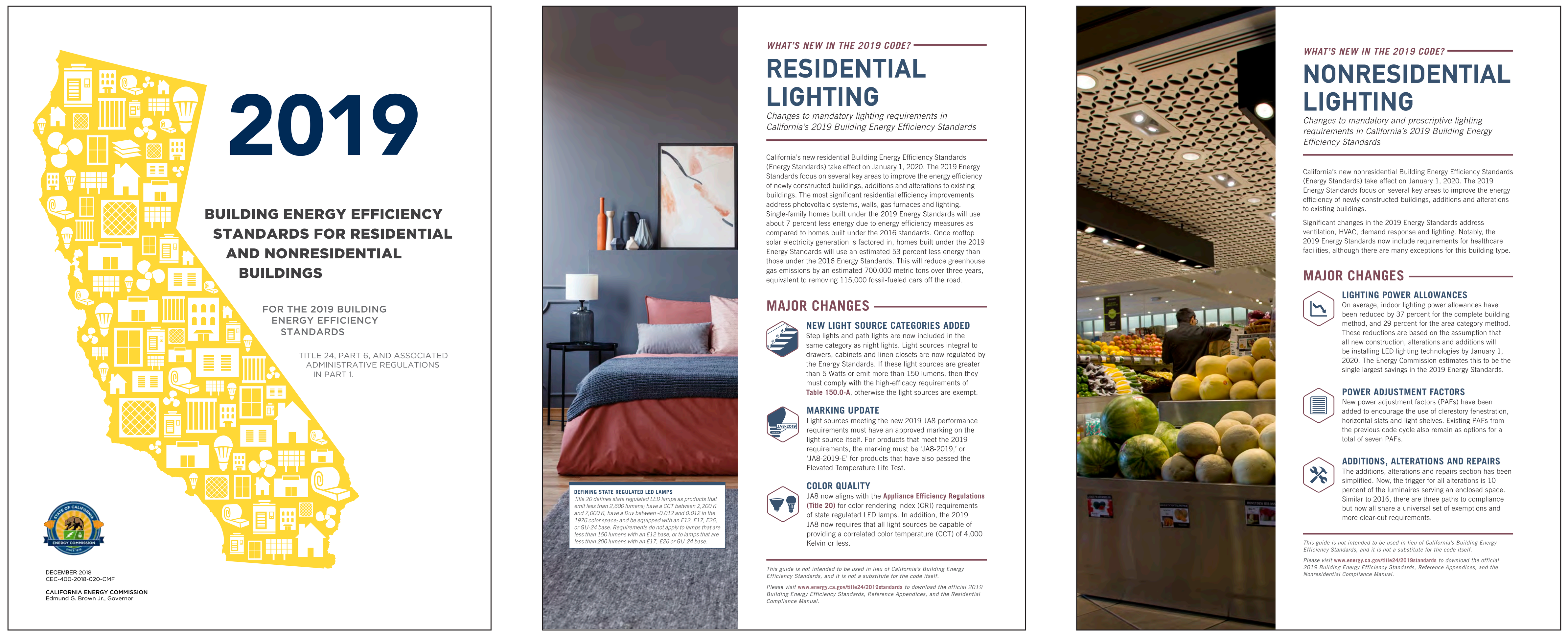

Figure 2. 2019 Title 24 Energy Standards and the What's New Residential and Nonresidential Lighting Guides

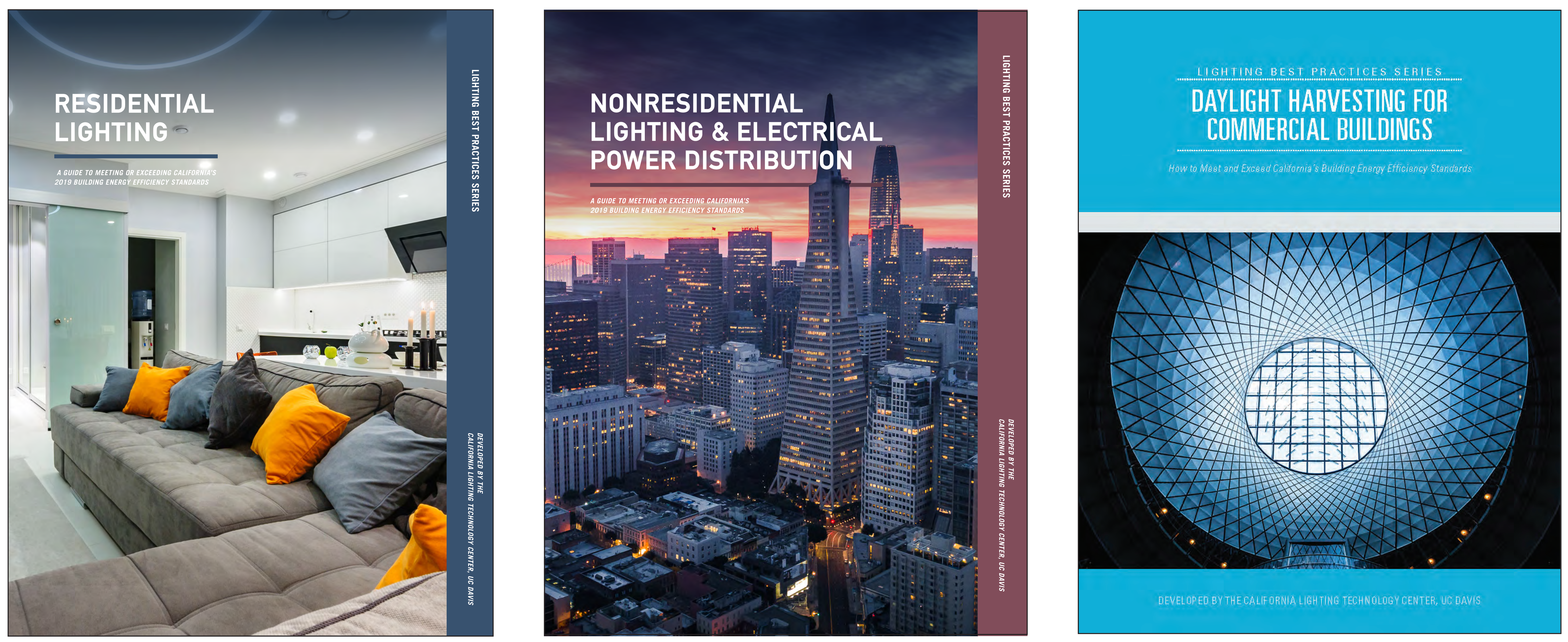

Figure 3. 2019 Title 24 Residential Lighting Guide, 2019 Nonresidential Lighting Guides, and the Daylight Harvesting Guide

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