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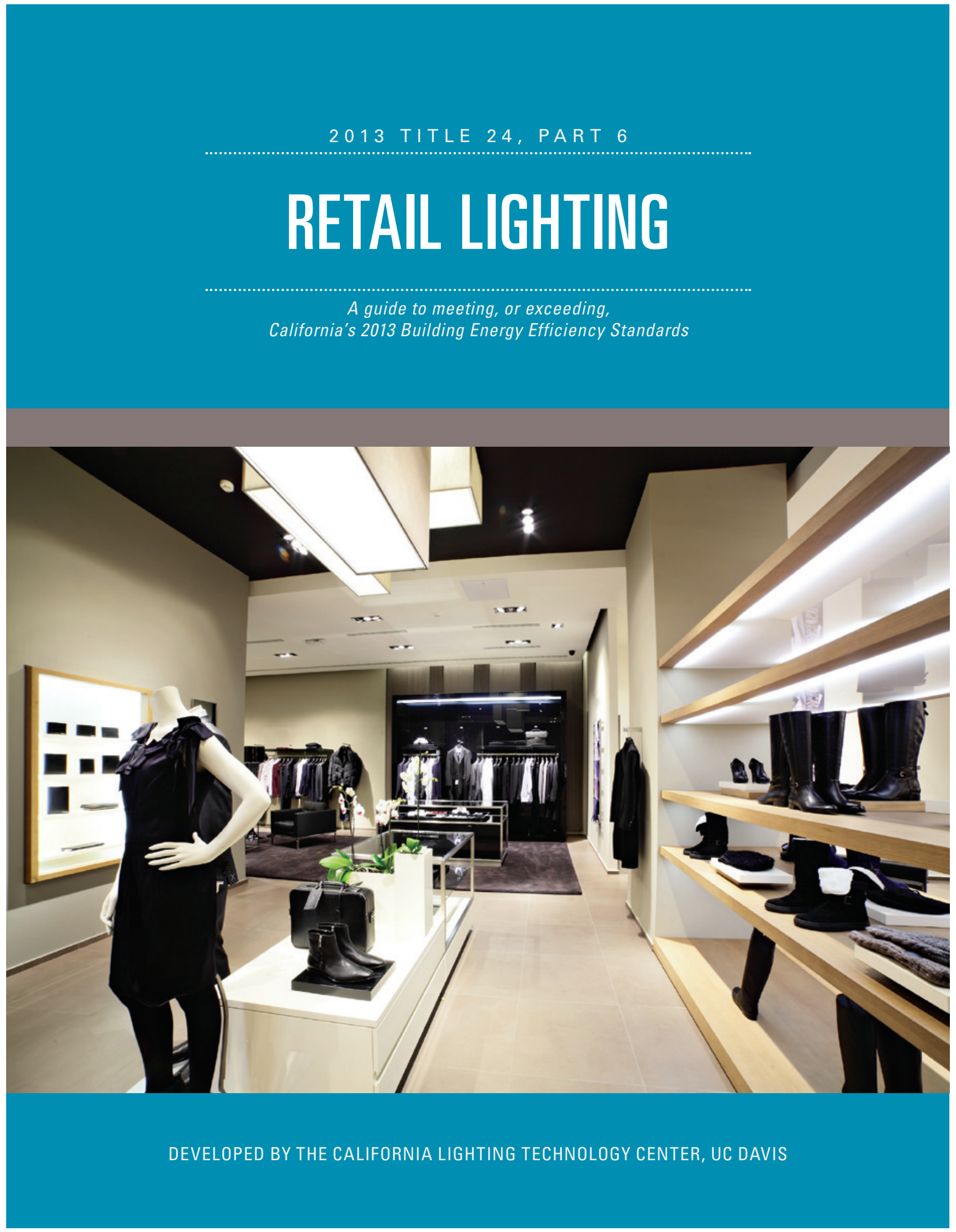
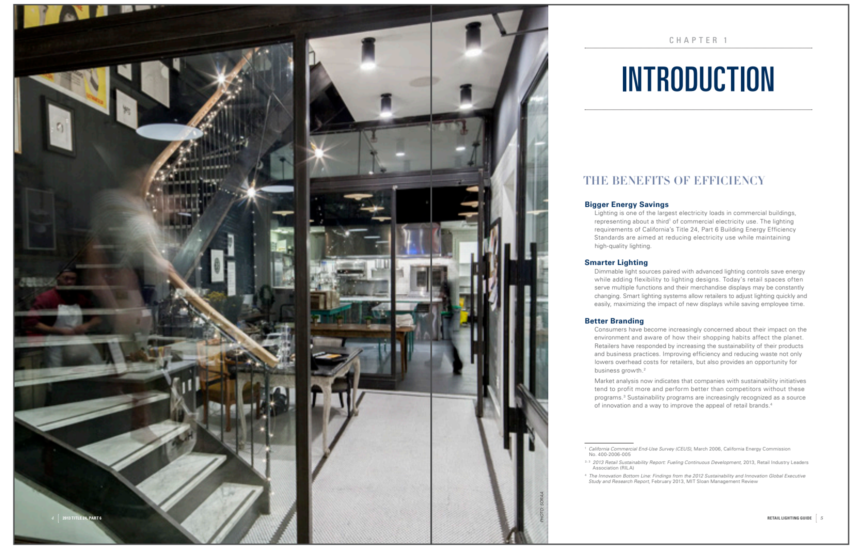
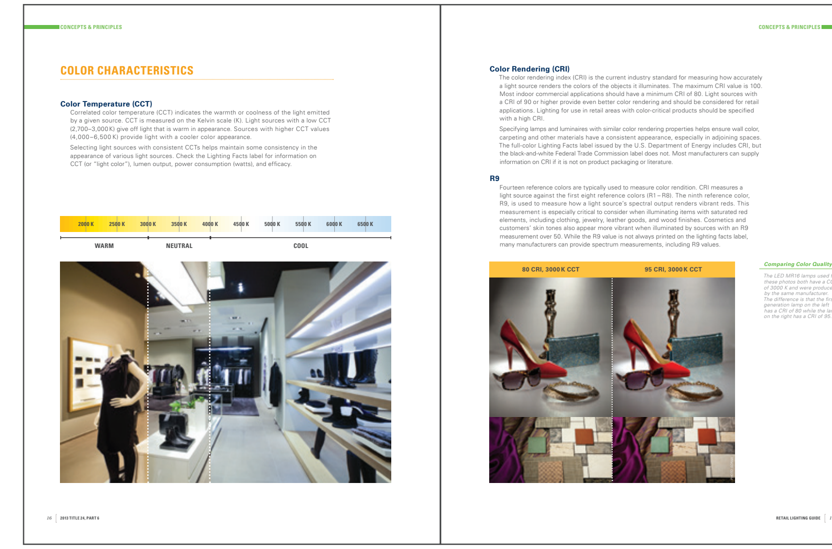
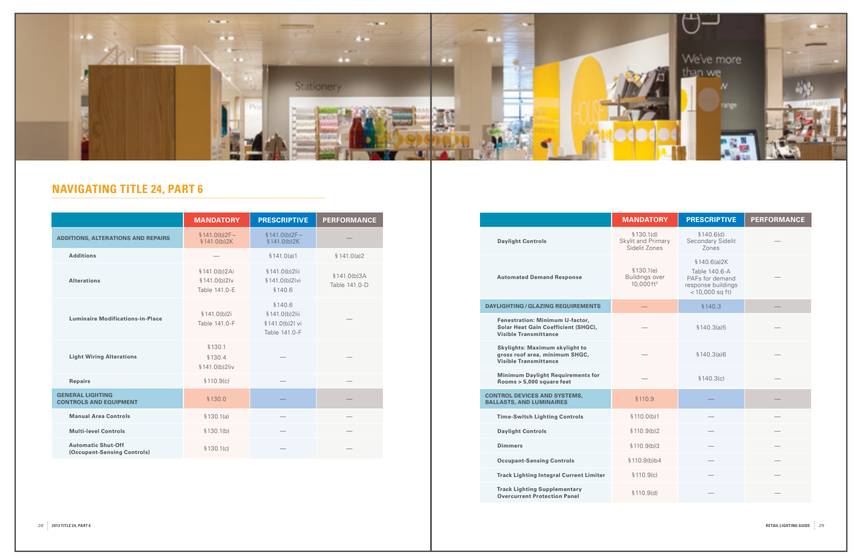
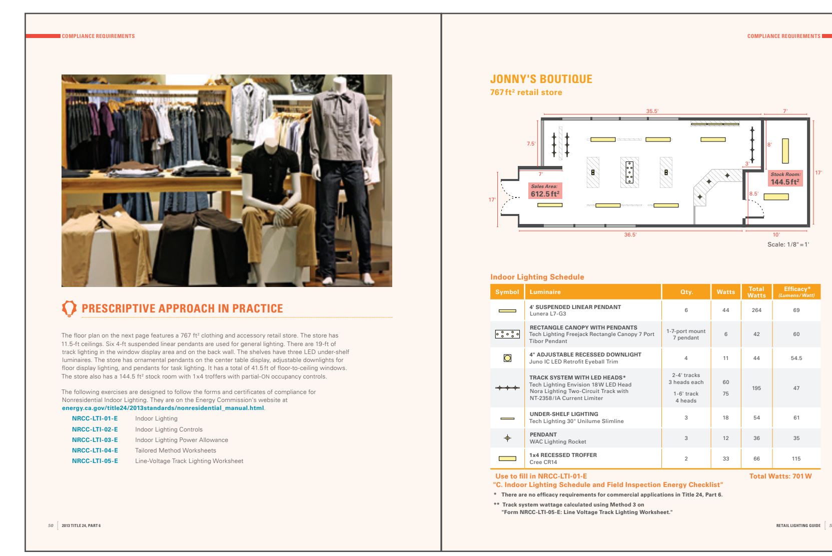






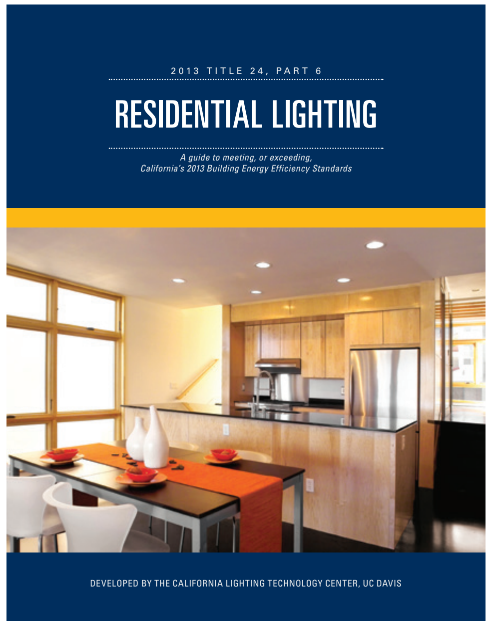


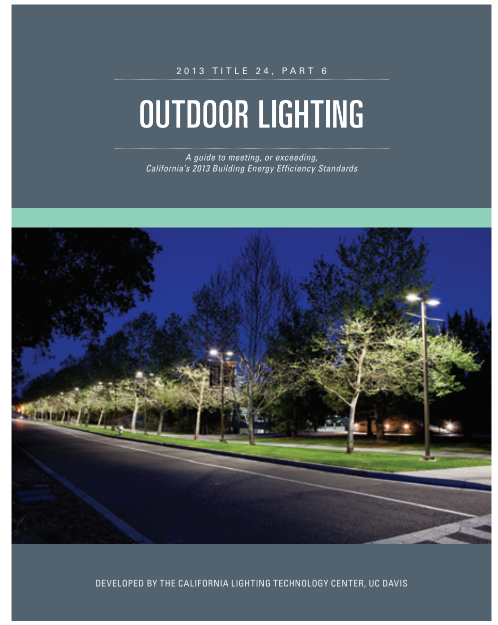


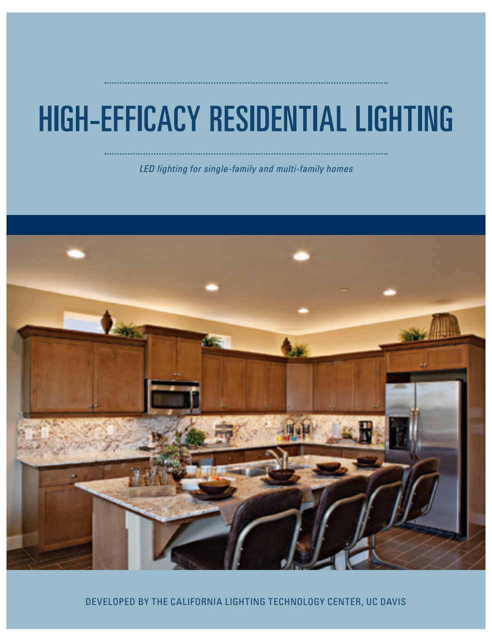
2013 Title 24, Part 6 Lighting Code Guides & Training Materials

2012–2015

Project Partner: Pacific Gas and Electric, California Energy Commission


2013 TITLE 24, PART 6
RESIDENTIAL LIGHTING
A guide to meeting, or exceeding,
California's 2013 Building Energy Efficiency Standards
DEVELOPED BY THE CALIFORNIA LIGHTING TECHNOLOGY CENTER, UC DAVIS


2013 TITLE 24, PART 6
OUTDOOR LIGHTING
A guide to meeting, or exceeding,
California's 2013 Building Energy Efficiency Standards
DEVELOPED BY THE CALIFORNIA LIGHTING TECHNOLOGY CENTER, UC DAVIS


HIGH-EFFICACY RESIDENTIAL LIGHTING
LED lighting for single-family and multi-family homes
DEVELOPED BY THE CALIFORNIA LIGHTING TECHNOLOGY CENTER, UC DAVIS


2013 TITLE 24, PART 6
LIGHTING FOR OFFICE APPLICATIONS
A guide to meeting, or exceeding,
California's 2013 Building Energy Efficiency Standards
DEVELOPED BY THE CALIFORNIA LIGHTING TECHNOLOGY CENTER, UC DAVIS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BUILDING ENERGY EFFICIENCY STANDARDS
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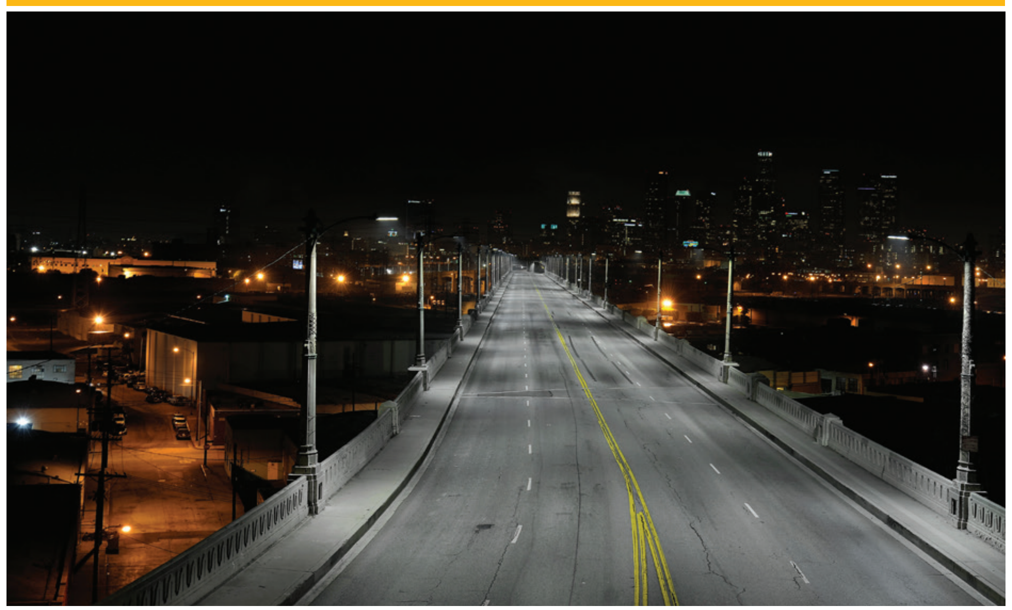
Policy, Codes & Standards
STAFF CONTACT
• Residential Lighting
• Retail Lighting
• Office Lighting
The lighting portion of the 2013 Title 24 code incorporates technologies developed through CLTC's work with the Public Interest Energy Research (PIER) program and demonstrated through the State Partnership for Energy Efficient Demonstrations (SPEED). SPEED program demonstrations provided evidence of the effectiveness, feasibility and affordability of adaptive lighting technologies added to the new state codes and standards. CLTC is also involved in outreach and education efforts aimed at helping professionals meet—or exceed—Title 24 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 simply intended to help designers and building professionals become familiar with advanced lighting technologies and the latest code improvements.

THE STATE OF STREET LIGHTING IN CALIFORNIA, 2012

A STUDY OF PUBLIC INFRASTRUCTURE & ENERGY USE IN CALIFORNIA



CALIFORNIA LIGHTING TECHNOLOGY CENTER | UNIVERSITY OF CALIFORNIA, DAVIS

THE SURVEY

Determining the state of street lighting in California

© Philips Gardco

As part of a comprehensive study of our statewide infrastructure, the California Lighting Technology Center (CLTC) at the University of California, Davis asked municipal staff across the state to help map out the current distribution of street light ownership and street light technologies in California. CLTC's research staff achieved an unusually high response rate (43 percent) for surveys of this type. Representatives from 212 California cities shared data on approximately 1.1 million municipal street lights.

The survey posed nine questions regarding cities' goals for energy efficiency, as well as the number and type of street lights within each city. Seventy-four percent of respondents rated energy efficiency as a "high" or "very high" priority, with 29 percent reporting that their city has passed a climate action plan or similar sustainability initiative. The data collected through the survey indicate that cities with climate action plans or sustainability initiatives in place are significantly more likely to have invested in street lighting retrofits aimed at increasing energy efficiency. But the data also indicate that a large portion of California's street lights have not yet been upgraded to utilize more energy-efficient street light technologies.

74%

OF RESPONDENTS RATED ENERGY EFFICIENCY AS A HIGH PRIORITY IN THEIR CITIES

HOW CURRENT ARE CALIFORNIA'S STREET LIGHTS?

The survey revealed that 76 percent (852,000) of the cities' street lights use high-pressure sodium (HPS) lamps. Until recently, HPS was the most cost-effective technology available, but now they are far from the best choice on the market. HPS lights consume about twice the energy as more advanced lighting technologies, such as LED and induction lamps. They also have a significantly shorter life span and measure poorly on the color rendering index (CRI), casting everything they illuminate in yellow light. Though more efficient alternatives exist, survey data indicate that just 2 percent of the street lights reported use LEDs and only 3 percent have induction light sources.

TOTAL NUMBER OF STREET LIGHTS REPORTED:

1.1 MILLION

76% HPS

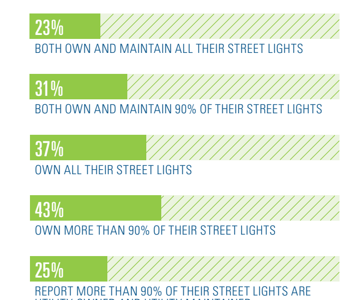
A total of 852,000 of the street lights surveyed still use high-pressure sodium lamps.

WHO OWNS CALIFORNIA'S STREET LIGHTS?

Close to 54 percent of street lights in the survey (about 605,000 of the 1.1 million street lights reported) are city-owned and city-maintained. Results also indicate that cities with a higher proportion of city-owned, city-maintained street lights are significantly more likely to have adopted more advanced street light technology (namely, LED or induction lamps).

Roughly one-third (over 353,000 street lights) are reportedly utility-owned and utility-maintained. Approximately 5 percent (58,861) were described as city-owned and third-party maintained, and close to 5 percent (48,663) are reportedly city-owned and maintained by a utility. (Street light ownership and maintenance were not reported for roughly 5 percent (50,788) of the total street lights described by survey respondents.)

Most cities report owning some, but not all, of the street lights within their city limits. Of the 212 California cities surveyed:



The State of Street Lighting in California, 2012

2012 – 2015

Project Partner: Chevron

SPEED State Partnership for Energy Efficient Demonstrations

SPEED TECHNOLOGIES

Part of California's commitment to a clean energy future

The State Partnership for Energy Efficient Demonstrations (SPEED) program drives the market adoption of energy efficient technologies. Managed through the California Institute for Energy and Environment (CIEE), SPEED has conducted more than 100 demonstrations and other technology-transfer projects across the state, showcasing the benefits of best practices and state-of-the-art solutions.

The innovations developed through the SPEED program are commercially available through a number of manufacturers. Many of these strategies will be required under California's 2013 Title 24 Energy Efficiency Standards. Details, including case studies and product information, are available at the SPEED website.

» For more information, visit ***partnershipdemonstrations.org***

CUMULATIVE ANNUAL TARGETS IN CALIFORNIA

100 million
kWh of electricity

$20 million
cost savings

7 million
thm of natural gas

100,000 tons
CO_2e reduction

Post-retrofit adaptive corridor lighting (Bainer Hall, UC Davis) with WattStopper microwave occupancy sensors and Sylvania bi-level ballasts.

ADAPTIVE CORRIDOR CONTROL SCENARIOS

The following four scenarios are specific examples of the three types of control strategies just described. These technology combinations are not the only ways to achieve deep energy savings, but they have been vetted through real-world SPEED demonstrations. All support compliance with 2013 Title 24 (Section 130.1), which requires occupant-sensing lighting controls in corridors. Other manufacturers offer similar solutions. Energy and cost savings for this business case are calculated per fixture, based on improvements to incumbent lighting. The SPEED team selected the common 2-lamp 2x4 T8 recessed fluorescent fixture to serve as the incumbent example.[1]

SCENARIO 1 – ZONAL
70% ENERGY SAVINGS

The Lutron Energi TriPak control system utilizes Lutron DALI ballasts, wired to the central PowPak relay module. The PowPak communicates with wireless, battery powered sensors to control the lights based on occupancy.

SCENARIO 2 – FIXTURE-INTEGRATED
72% ENERGY SAVINGS

This scenario uses PIR fixture-integrated occupancy sensors from WattStopper in tandem with 0–10V dimming ballasts. This strategy saves somewhat more energy than Scenario 1, but it does not offer features and benefits like Auto DR, maintenance event e-mails, or remote, dynamic monitoring and control.

SCENARIO 3 – NETWORKED
76% ENERGY SAVINGS

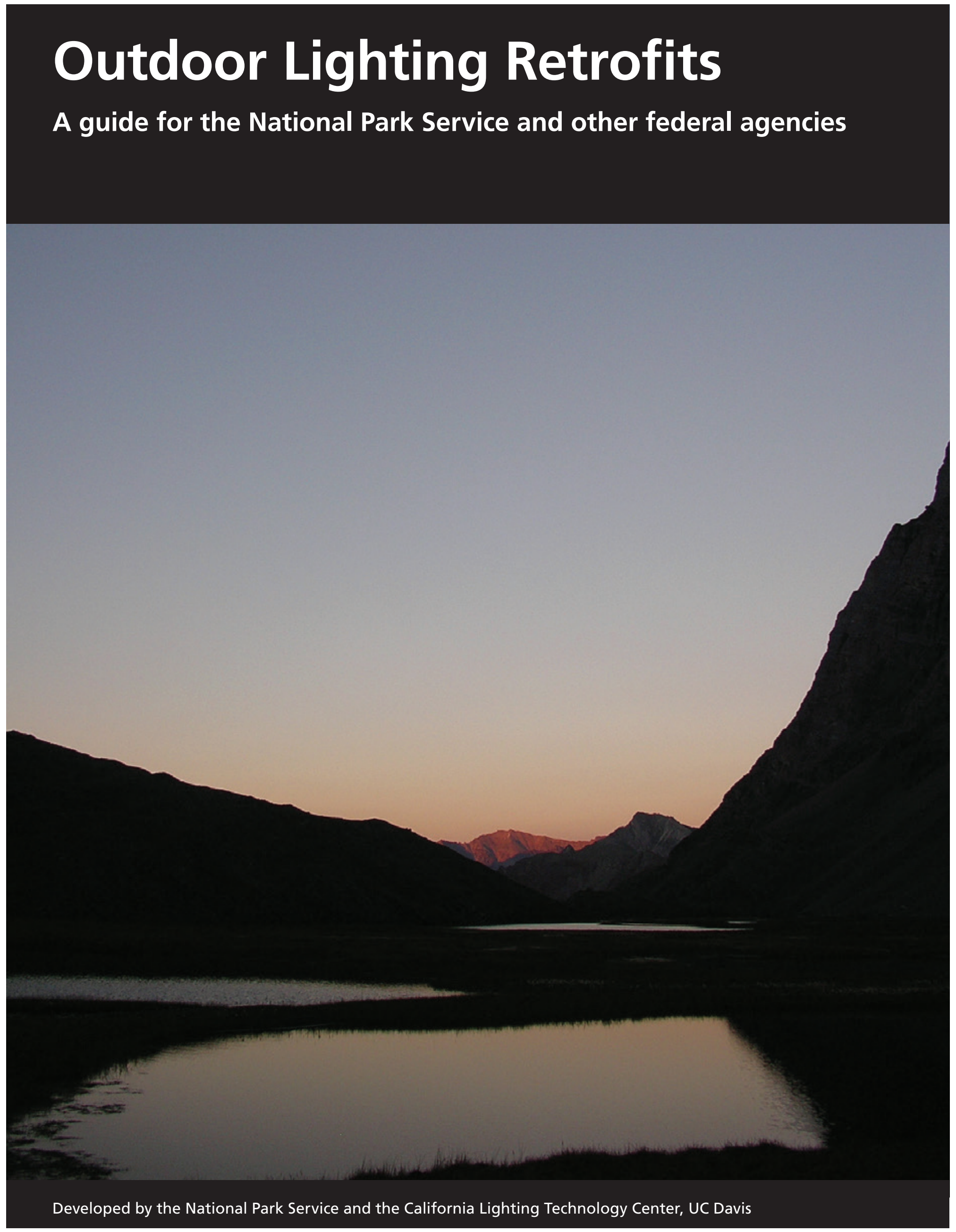
The Enlighted network control system provides occupancy sensors for every fixture, much like Scenario 2. Unlike Scenario 2, these sensors also communicate wirelessly with a gateway, which is the central node for the system. In any given installation, a number of gateways will be deployed. These gateways then communicate with an Energy Manager, which connects to the Internet. This allows a facility staff member to monitor, program and control light fixtures remotely, from any Internet connection. This system also yields deeper energy savings, thanks to options and features such as high and low-level trim, DR responsiveness, and easy connection with existing building energy management systems.

SCENARIO 4 – NETWORKED + LED
86% ENERGY SAVINGS

For maximum lighting efficiency, facilities can install LED fixtures with dimmable drivers along with the network control components described in Scenario 3. For this specific analysis, the FineLite HPR 2x4 troffer was utilized. Networked LED lighting (Scenario 4) involves higher up-front costs, but it is actually a very attractive choice for campuses planning new construction or major renovation projects. The economic reasons behind this are explored on the pages that follow.

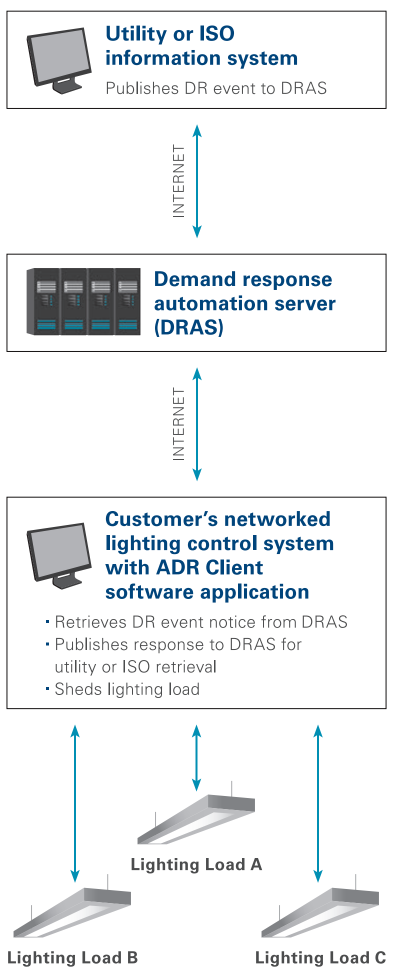
[1] Nationwide, linear fluorescent lamps constitute 80% of light sources in commercial buildings, according to the DOE's *2010 U.S. Lighting Market Characterization*, published January 2012.

State Partnership for Energy Efficient Demonstrations (SPEED) Program Print Materials
2012–2015
Project Partner: Chevron

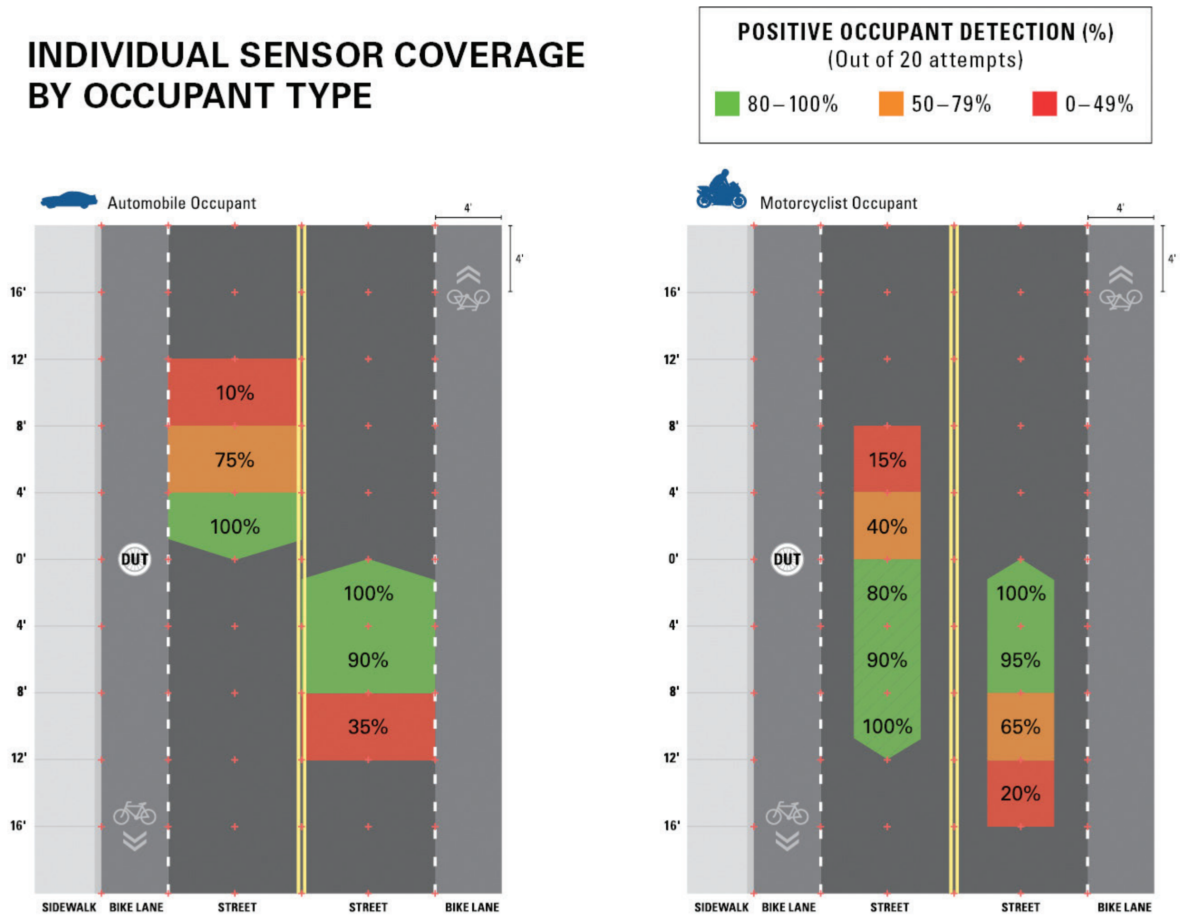


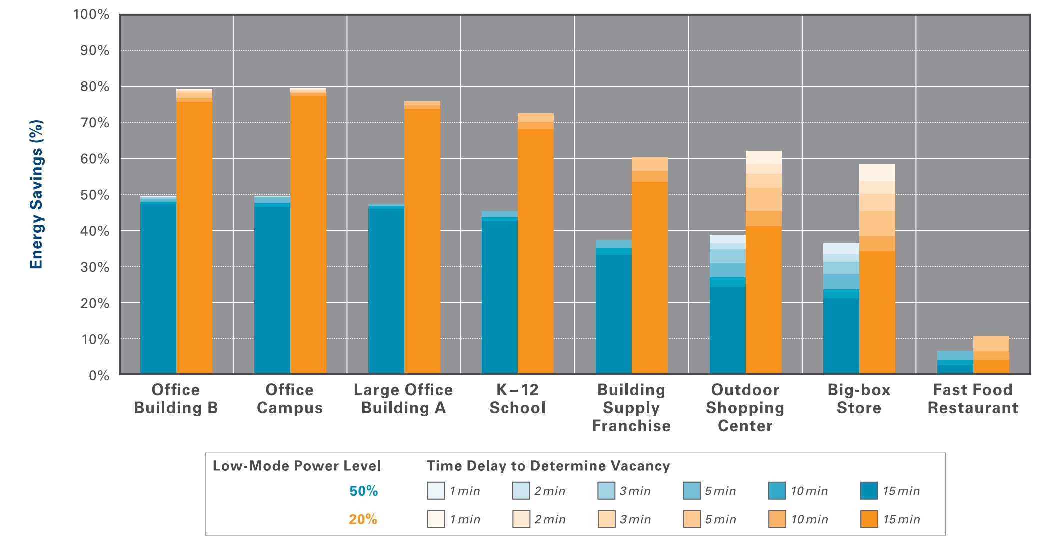
Outdoor Lighting Retrofits
2014
Project Partner: National Park Service

MODEL SERVER/CLIENT ENVIRONMENT FOR AUTOMATED DEMAND RESPONSE



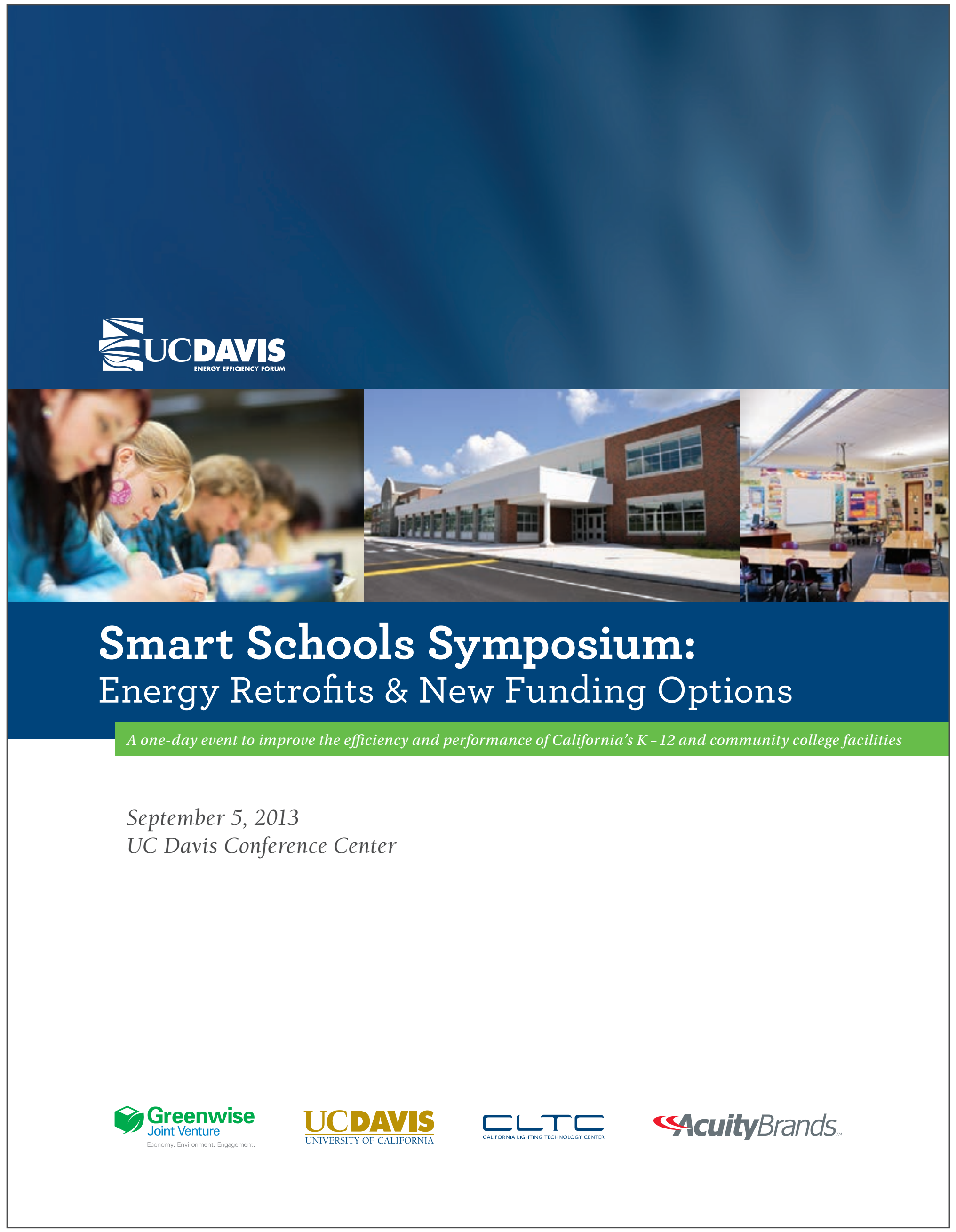
INDIVIDUAL SENSOR COVERAGE BY OCCUPANT TYPE



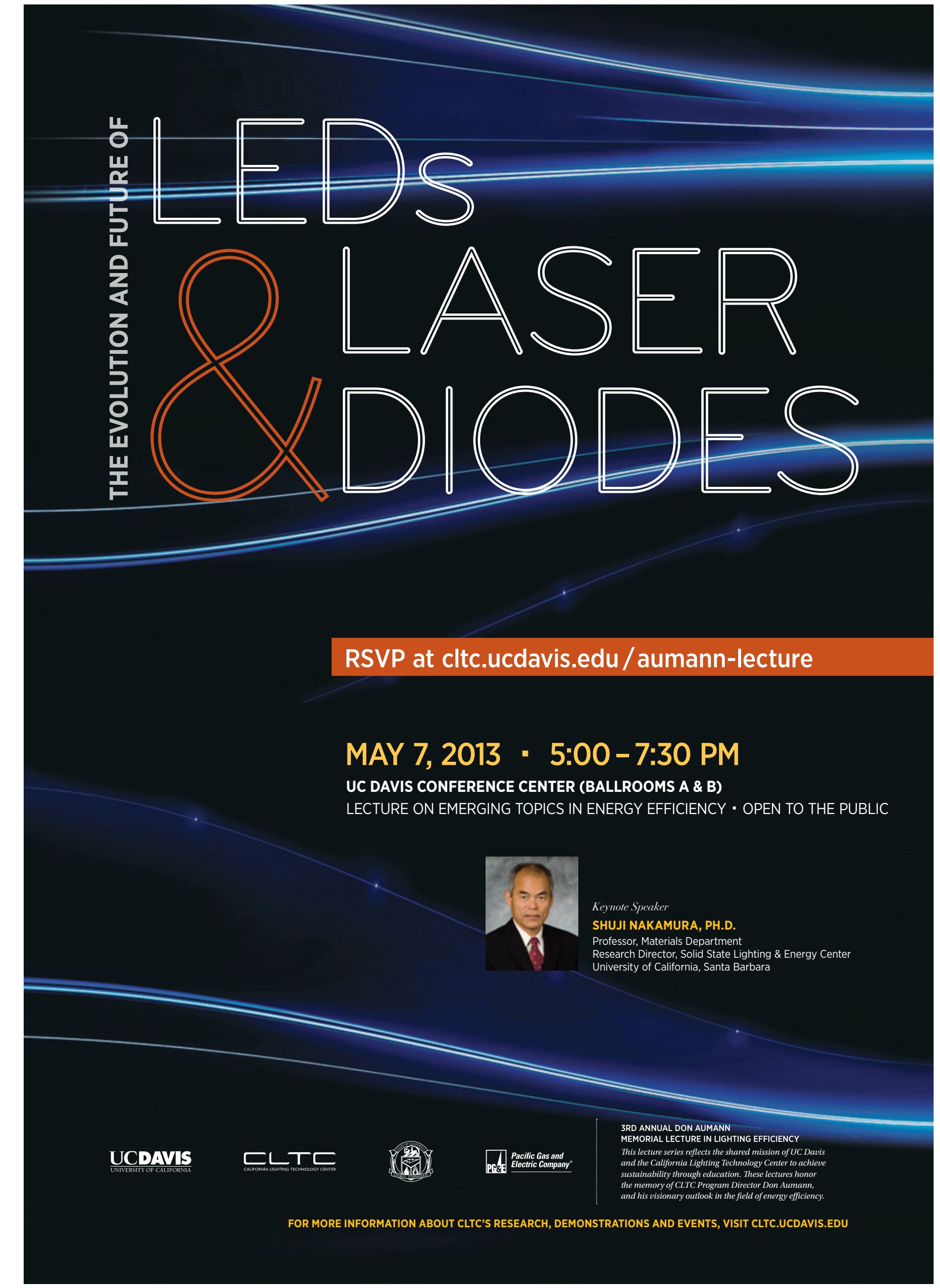


LD+A Research Column Article Graphics

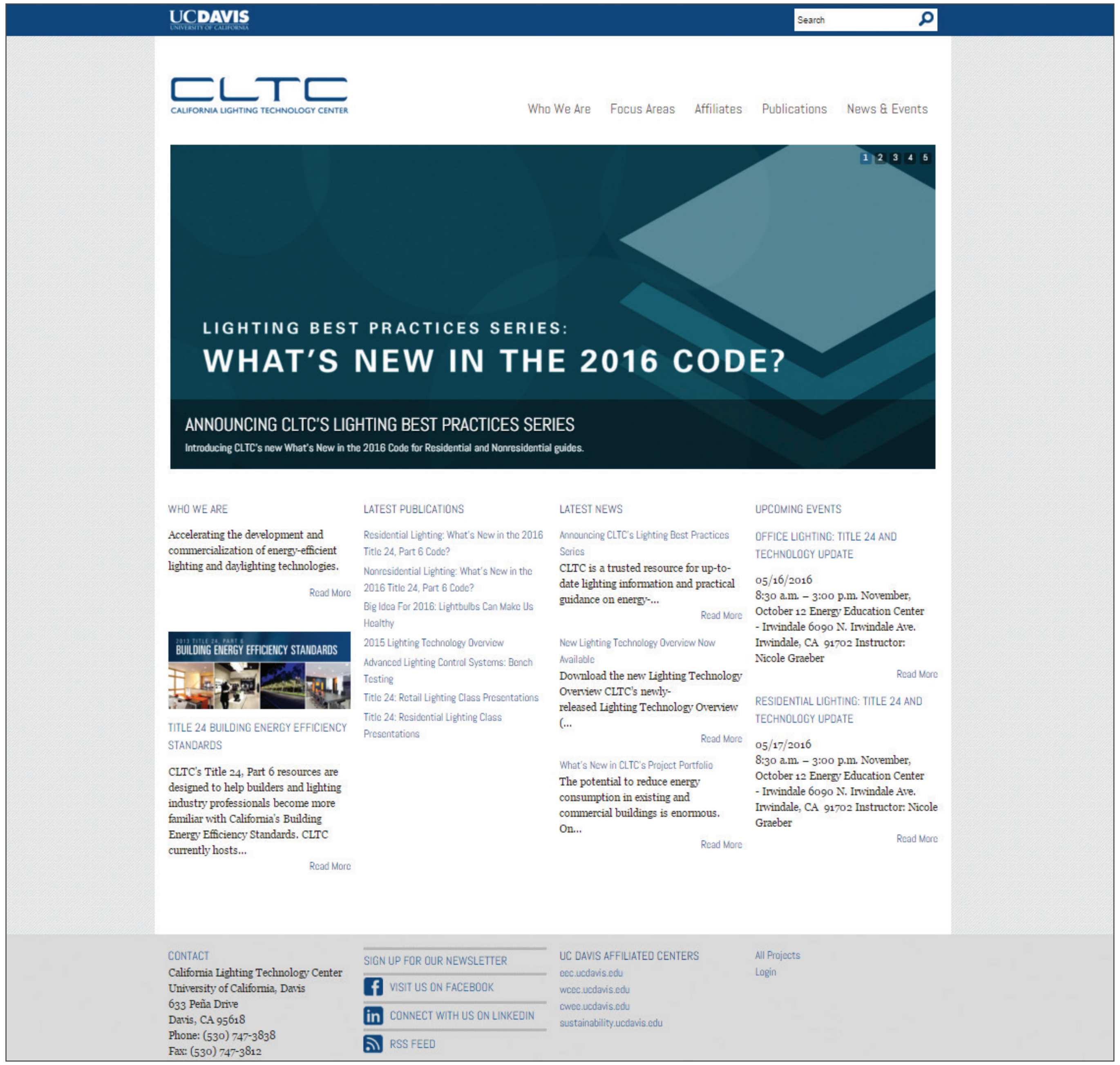
Celebrating a Decade of Innovation: CLTC 10-year Anniversary
2013

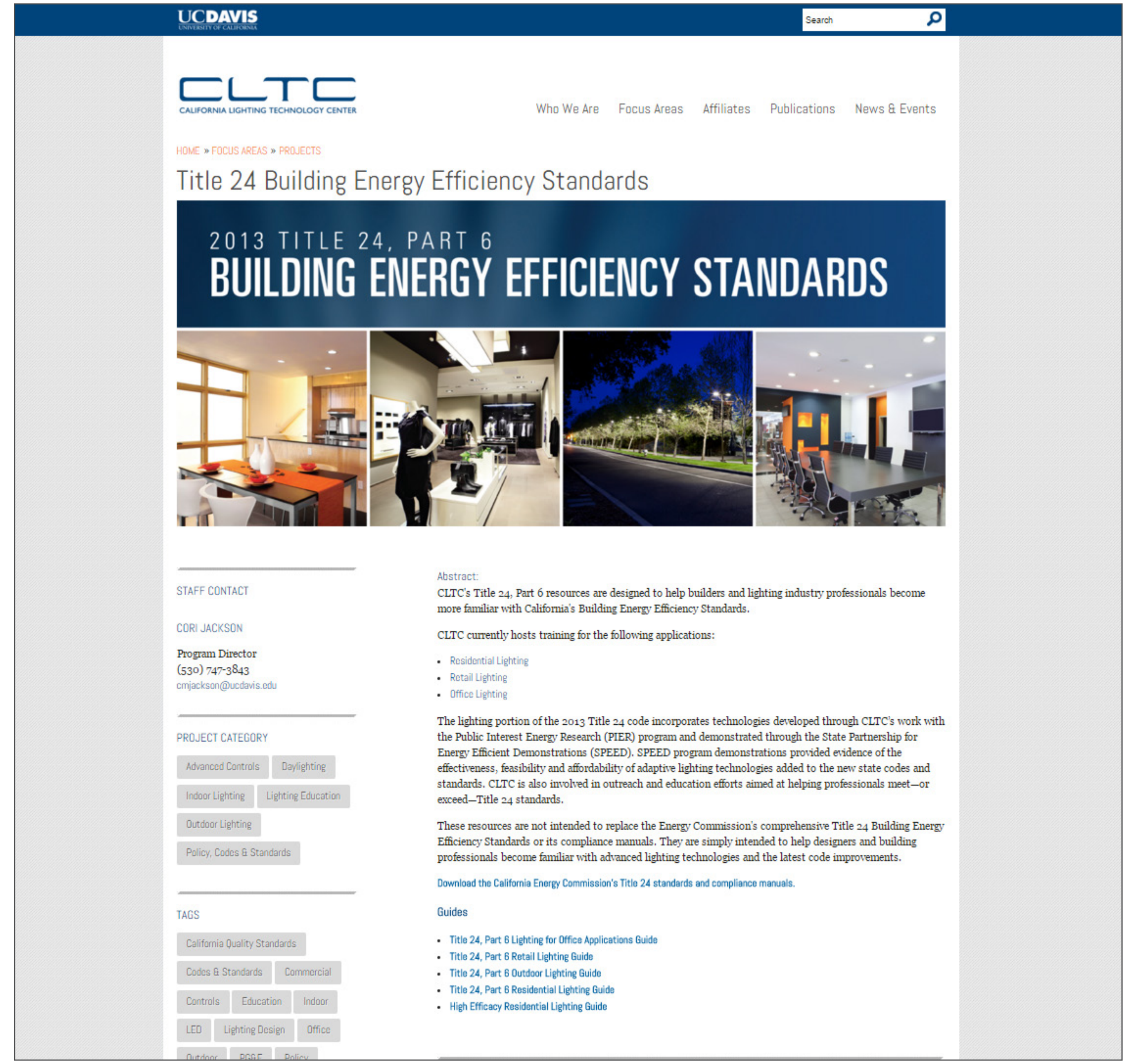


Smart Schools Symposium
2013



Don Aumann Memorial Lectures in Energy Efficiency Series
2011 – 2013





UC Davis California Lighting Technology Center Website
cltc.ucdavis.edu

Website Banners

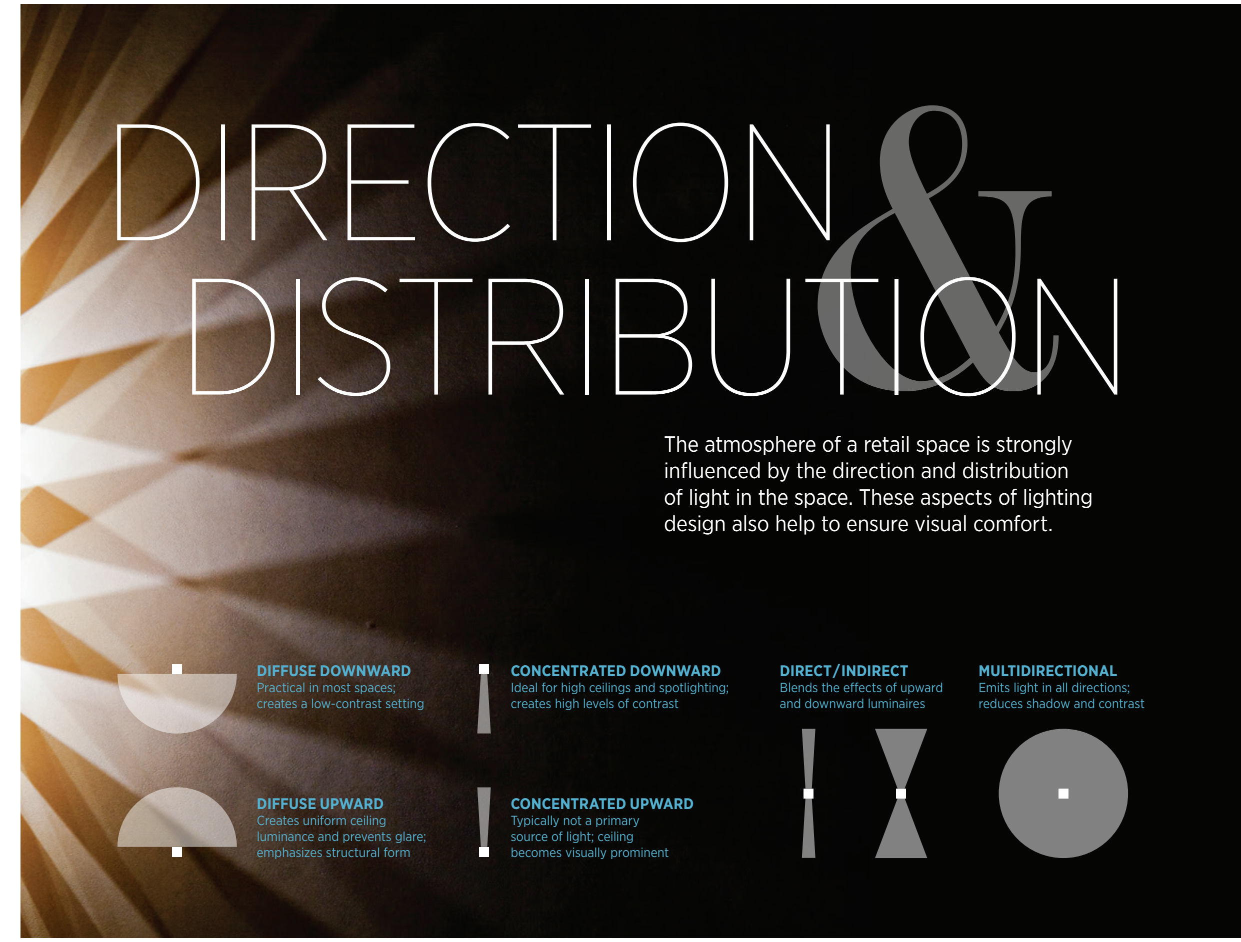
CLTC Demo Space & Signage

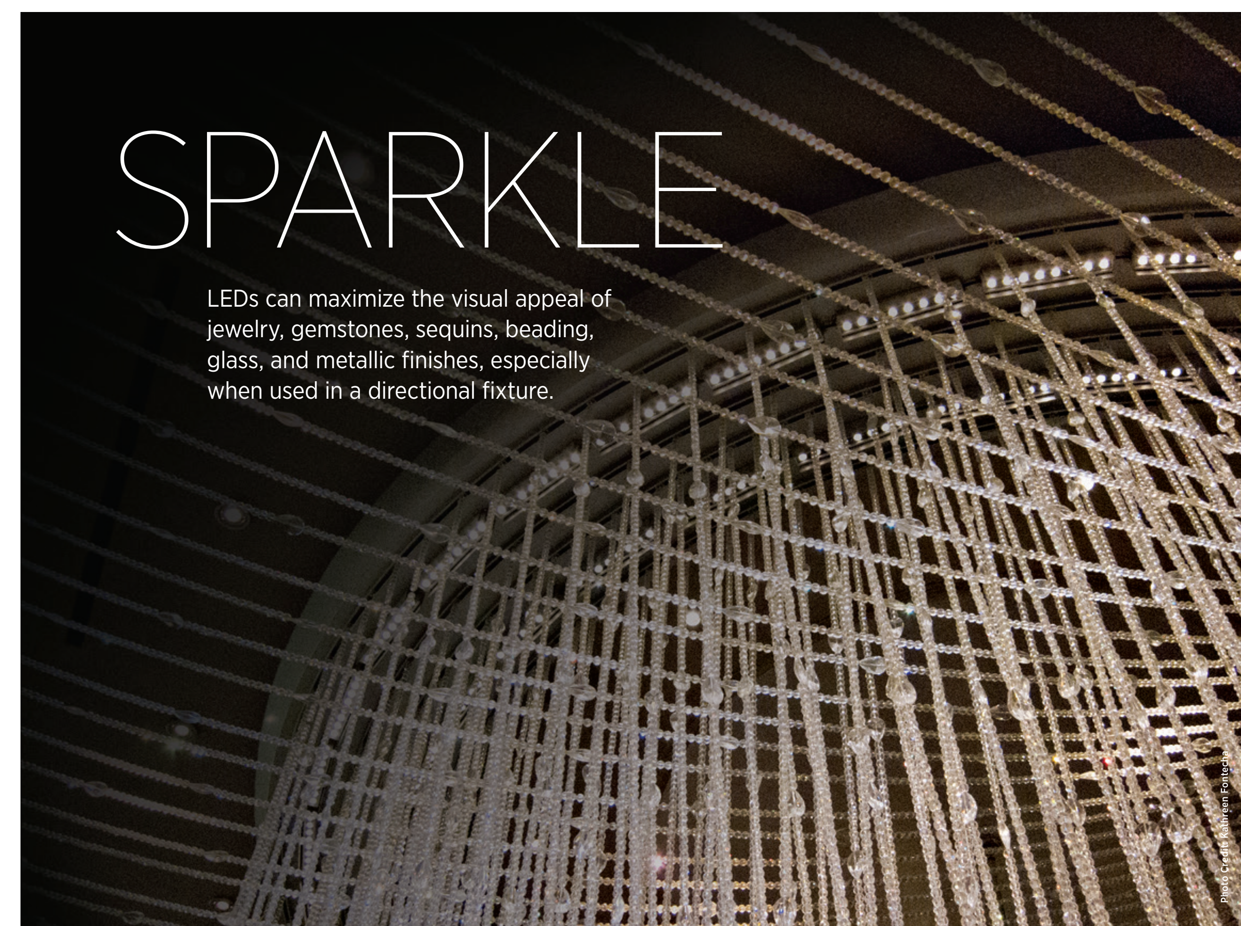
Fewer watts, more lumens, better value!

75% *off*

ENERGY USE

The PAR 38 LED lamps installed in Lux use three-quarters less energy, on average, than 75-watt incandescents, and because LED lamps last up to 50 times longer than other sources, they also reduce maintenance costs.





Both students and professionals form connections with research and industry leaders through classes, seminars, and forums that CLTC leads throughout the year. Undergraduate lighting courses are offered through the University of California, Davis, where students learn hands-on about lighting and daylighting technologies.

ONE SOURCE FOR LIGHTING EDUCATION

One UC DAVIS

Since its founding in 2003, CLTC has installed energy-efficient lighting technologies at over 100 sites on college campuses and in government buildings throughout California. These demonstrations, sponsored by the PIER Program, have saved California more than 6.1 million kWh and 6.2 million pounds of carbon emissions while reducing electricity costs by an estimated $200 million each year.

ONE DECADE ADVANCING ENERGY EFFICIENCY

One UC DAVIS

LIGHTING CONTROL USER INTERFACE STANDARDS

USER INTERFACE STANDARDIZATION FOR THE PROMOTION OF ENERGY-EFFICIENT PRACTICES

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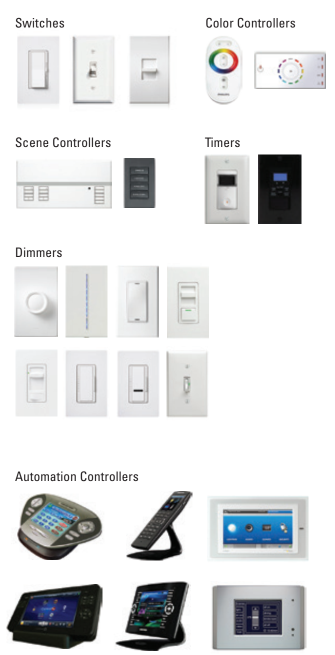
Lighting control user interface elements are governed by few standards. This may lead to products that are unnecessarily confusing for building occupants, leading to a lost opportunity for energy savings. The problem may worsen as control capabilities rise sharply with the advent of digital and networked systems.

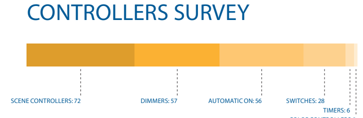
The Lighting Control User Interface Standards project documented existing and emerging user interfaces for lighting controls and collected input from industry leaders and policymakers on the need for a lighting control user interface standard on selected elements, and a process by which to design and create it.

The project team concluded that standardizing selected elements would be accepted by the lighting industry.

SURVEY CLOUD SAMPLE



CONTROLLERS SURVEY



BACKGROUND

The Lighting Control User Interface Standards project is an initial investigation. Additional phases should follow that will conduct more detailed research, draw up possible content for one or more standards on the topic, and pursue adoption of those by appropriate organizations. The project was inspired by a California Energy Commission PIER project that saw final approval of an Institute for Electrical and Electronic Engineers standard.

The underlying proposition for both projects is the same: consistent user interfaces can improve usability of products and lead to energy savings. Consistency comes from standard elements of user interfaces, and the standards work best when they have the backing of a recognized standards organization. If the user perceives the room's lighting controls as overly complex or confusing, the likelihood of energy-efficient lighting use for the space may decline.

TECHNOLOGY AND RESEARCH APPROACH

The research team conducted a Survey of Existing Controls to collect, document, and analyze the common elements found in residential and commercial controls that the average occupant regularly comes into contact with.

The survey focused on the elements of common lighting control user interfaces, including switches, dimmers, and scene controllers found in homes and office spaces. Visual, tactile, and audio elements that serve as cues or feedback also were taken into account. The survey excluded control panels and software-based systems that are specific to facility and energy managers.

DEVICE INPUT & MOBILITY

Any lighting control interface that a user does not move regularly is considered fixed, even if the controller itself is wireless or moveable under certain conditions. Any lighting control interface that the user moves on a regular basis as a part of the operation of the lighting in a space is considered mobile.

VERTICAL / HORIZONTAL MOVEMENT

	SWITCH		SLIDER		
INPUT	MECHANICAL INPUT		MECHANICAL INPUT	HYBRID INPUT	DIGITAL INPUT
INTERFACE	TOGGLE	ROCKER	DIMMER	TOUCH SLIDER	DIGITAL DIMMER CONTROLS
MOVEMENT	▸ Move toggle up & down	▸ Move rocker up & down/right & left to change states	▸ Drag node marking the current level of the system up & down/right & left to increase and decrease	▸ Drag node marking the current level of the system up & down/right & left to increase and decrease ▸ Tap different intervals to jump levels	▸ Drag node marking the current level of the system up & down/right & left to increase and decrease ▸ Tap different intervals to jump levels
APPLICATION	▸ On/off	▸ On/off	▸ Dimming, on/off	▸ Dimming, on/off	▸ Dimming, on/off
VISUAL CUES	▸ TEXT: On/Off ▸ TACTILE: Raised text	▸ TACTILE: Raised nib, usually to signify the "on" state, click for on/off	▸ TEXT: On/Off ▸ TACTILE: Click for on/off ▸ VISUAL: One button and one slider	▸ TACTILE: Raised nibs indicating different levels ▸ VISUAL: Indicator lights for level	▸ TEXT: Numbers noting different levels, text for increase/decrease ▸ SYMBOL: Increase/decrease ▸ COLOR: Brighter colored node
POSITION / STATE	▸ Two states locked at either on/off	▸ Two states locked at either on/off	▸ Slider position moveable from 0% (off) to 100%	▸ Slider position moveable from 0% (off) to 100% ▸ User can jump to different levels instead of gradually changing levels	▸ Slider position moveable from 0% (off) to 100% ▸ User can jump to different levels instead of gradually changing levels
FEEDBACK FOR STATE CHANGES	▸ TACTILE: Mechanical click, perceptible to touch ▸ AUDITORY: Soft click	▸ TACTILE: Mechanical click, perceptible to touch ▸ AUDITORY: Click	▸ TACTILE: Mechanical click, perceptible to touch	▸ VISUAL: LED indicators showing dimmer levels ▸ AUDITORY: Beep, click	▸ TACTILE: For some interfaces, there is no tactile feedback. Some systems include a vibrating feedback to show that the user input was acknowledged. ▸ VISUAL: Marker node shows what level the dimming is on. Other systems, particularly online interfaces whose response time is dependent on Internet speed, sometimes display an icon (i.e. hourglass, clock, spinning wheel) showing the passage of time, indicating that the system has registered the user input and is in the process of updating the system state to reflect the change. ▸ AUDITORY: Tone
SYSTEM INDICATION OF ACTUATION	▸ Lights turn on/off ▸ The system indication is binary in this case, since it only allows for two states.	▸ Lights turn on/off ▸ The system indication is binary in this case, since it only allows for two states.	▸ Lights turn on/off ▸ Light level increases or decreases. However, a dimmed state might not be instinctively noticed if the user does not have a reference point for a lower dimmed state to full light output. ▸ Actuation is indicated if the node is not in its off position	▸ Lights turn on/off ▸ Light level increases or decreases. However, a dimmed state might not be instinctively noticed if the user does not have a reference point for a lower dimmed state to full light output. ▸ LED indicator notes at what level the system is set.	▸ Lights turn on/off ▸ Light level increases or decreases. While looking at the lights, a dimmed state might not be instinctively noticed if the user does not have a reference point for a lower dimmed state to full light output. However, the GUI slider shows what level the system is set to.

IN / OUT PUSH MOVEMENT

	SWITCH		
INPUT	MECHANICAL INPUT	HYBRID INPUT	DIGITAL INPUT
INTERFACE	SCENE CONTROLLER	TABLETOP TOUCH PANEL CONTROLLER	WALL-MOUNTED TOUCH PANEL CONTROLLER
MOVEMENT	▸ Push button to change states or increase and decrease	▸ Push button to change states or increase and decrease	▸ Select "buttons" or links to change states, select what aspect of the system to modify, or increase and decrease
APPLICATION	▸ Change states at set intervals (scene controllers, dimming)	▸ Change states at set intervals (scene controllers, dimming)	▸ Change states at set intervals (scene controllers, dimming)
VISUAL CUES	▸ TEXT: On/Off; POWER; numbered scenes; scene names (dependent on manufacturer naming conventions) ▸ TACTILE: Raised nib to highlight special keys ▸ SYMBOL: State changes	▸ TEXT: On/Off; POWER; numbered scenes; scene names (dependent on manufacturer naming conventions) ▸ TACTILE: Raised nib to highlight special keys ▸ SYMBOL: State changes	▸ TEXT: On/Off; POWER; numbered scenes; scene names (dependent on manufacturer naming conventions) ▸ VISUAL: Buttons on digital interface often aesthetically look like a physical button (shading) to carry over metaphor. In this case, "Links" or words that are selected also can be seen as a button in its in/out movement
POSITION / STATE	▸ The physical interface of a button can only be in two states—pressed down or not pressed (no action for half-depressed button) ▸ Multiple buttons (combined with visual cues) can prompt the user to increase/decrease states at set intervals between 0% and 100%, or to change states	▸ The physical interface of a button can only be in two states—pressed down or not pressed (no action for half-depressed button) ▸ Multiple buttons (combined with visual cues) can prompt the user to increase/decrease states at set intervals between 0% and 100%, or to change states	▸ Depending on the visuals of the interface, "buttons" often have an appearance of a push movement, indicating user input was registered
FEEDBACK FOR STATE CHANGES	▸ TACTILE: Mechanical click, perceptible to touch ▸ VISUAL: Indicator lights showing power on/off (sometimes increase/decrease) ▸ AUDITORY: Tone, click	▸ TACTILE: Button pressed down, tactile feeling of state change from rest to pressed down ▸ VISUAL: Indicator lights showing user input was registered. IR light turns on for remotes that rely on IR to transmit user input. ▸ AUDITORY: Tone, click	▸ TACTILE: In some cases, vibration signifies change in state ▸ VISUAL: "Button" changing appearance (color, bolded text, highlighted, etc.), mimicking a pressed-down button. Other systems, particularly online interfaces whose response time is dependent on Internet speed, sometimes display an icon (i.e., hourglass, clock, spinning wheel) showing the passage of time, indicating that the system has registered the user input and is in the process of updating the system state to reflect the change. ▸ AUDITORY: Tone, click (reminiscent of a clicking hardware button)
SYSTEM INDICATION OF ACTUATION	▸ Lights turn on/off ▸ Lighting scenes change ▸ Some scene controllers have indicator lights showing on which scene the system is set, or the active scene button remains depressed until a different scene is chosen. However, with most interfaces, there is no indication if a state is already active, often warranting re-input of user commands to determine system activity.	▸ Lights turn on/off ▸ Lighting scenes change ▸ If the interface includes a screen, text or symbols on the screen will indicate what state the system is in. ▸ Button does not remain depressed once a scene is selected, so there is no indication if a state is already active or if the input was or was not registered, which often warrants re-input of user commands to determine system activity.	▸ Lights turn on/off ▸ Lighting scenes change ▸ The GUI of the system indicates which actions are active.

ROTATIONAL MOVEMENT

	SWITCH		
INPUT	MECHANICAL INPUT	HYBRID INPUT	DIGITAL INPUT
INTERFACE	DIMMER	CIRCULAR DIAL REMOTE	
MOVEMENT	▸ Rotate clockwise or counterclockwise to increase or decrease	▸ Rotate clockwise or counterclockwise to increase or decrease	▸ Rotate clockwise or counterclockwise to increase or decrease
APPLICATION	▸ Dimming (usually gradual change)	▸ Dimming (usually gradual change)	▸ Dimming (usually gradual change)
VISUAL CUES	▸ TEXT: On/Off; POWER; numbered scenes; scene names ▸ TACTILE: Raised nibs indicating different levels ▸ SYMBOL: Variability	▸ TEXT: On/Off; POWER; numbered scenes; scene names ▸ TACTILE: Raised nibs indicating different levels ▸ SYMBOL: Variability	▸ TEXT: On/Off; POWER; numbered scenes; scene names ▸ TACTILE: Raised nibs indicating different levels ▸ SYMBOL: Variability
POSITION / STATE	▸ Full rotation movable from 0% (off) to 100% ▸ Increase/decrease at set intervals between 0% and 100% for some dial interfaces ▸ Dimmers often have the push functionality of a button for on/off	▸ Full rotation ▸ For hybrid inputs that rely on signals from a remote to a system, there often is not a start and stop point for the rotation, so the user has a full 360-degree flexibility for movement.	▸ Full rotation movable from 0% (off) to 100% ▸ For some inputs, there often is not a start and stop point for the rotation, so the user has a full 360-degree flexibility for movement. ▸ Increase/decrease at set intervals between 0% and 100% for some dial interfaces ▸ User can sometimes jump to different levels instead of gradually moving from 0% to 100%
FEEDBACK FOR STATE CHANGES	▸ TACTILE: Kinetic click ▸ VISUAL: Indicator lights showing increase/decrease (sometimes showing power on/off) ▸ AUDITORY: Tone (sometimes increasing in volume), click	▸ TACTILE: No tactile feedback ▸ AUDITORY: Tone (sometimes increasing in volume), click	▸ TACTILE: Mostly no tactile feedback, although some systems simulate a vibrating "click" when states are changed ▸ VISUAL: Indicator lights. Unlike vertical/horizontal and in/out push movement interfaces, rotational movement ▸ AUDITORY: Tone (sometimes increasing in volume), click
SYSTEM INDICATION OF ACTUATION	▸ Lights turn on/off ▸ Light level increases or decreases. However, a dimmed state might not be instinctively noticed if the user does not have a reference point for a lower dimmed state to full light output.	▸ Lights turn on/off ▸ Light level increases or decreases. However, a dimmed state might not be instinctively noticed if the user does not have a reference point for a lower dimmed state to full light output. ▸ Color change for color-mixing systems. ▸ For systems that have a flush rotary interface that does not include mechanical parts to change the levels, there is no indication of actuation unless the user inputs commands.	▸ Lights turn on/off ▸ Light level increases or decreases. However, a dimmed state might not be instinctively noticed if the user does not have a reference point for a lower dimmed state to full light output. ▸ The GUI of the system indicates which actions are active.

LIGHTING TAXONOMY

Audit of lighting controls in today's marketplace

Product images were collected and categorized based on whether they would be encountered by an end user or a professional energy/facility manager; interface complexity; mechanical or screen input; mobility; visual cues; and dynamic feedback elements. The collection was used to develop a taxonomy that represents the most common features of lighting control interfaces that are used in residential and commercial environments; the majority of the items surveyed can be found in either environment. The residential products serve as a baseline as they are typically less complex and sold at lower prices. The products were selected from 44 companies, including 28 lighting, eight home automation, three home improvement, two electric, and three others.

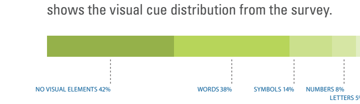
LIGHTING CONTROLS: FORMS & INTERACTIONS

Lighting controls include fixture-integrated switches/dimmers, wall-box switches, dimmers, programmable dimmers that control several scenes, and home automation systems that also control other systems (i.e., heat/air).

A controller that primarily turns a light on or off is a switch. A device used to control the intensity of light emitted by a luminaire is a dimmer. A unit capable of controlling multiple lamps, light settings, and/or lighting zones is a scene controller. A residential control system that also controls other systems is home automation. A handheld mobile lighting control device that the user moves on a regular basis is a remote.

STATIC ELEMENTS: VISUAL CUES

Visual elements assist occupants in understanding lighting control functions before touching the controller. Visual elements commonly include words, symbols, numbers, letters, and pictographs. The following graph shows the visual cue distribution from the survey.



DYNAMIC ELEMENTS: FEEDBACK & STATE CHANGES

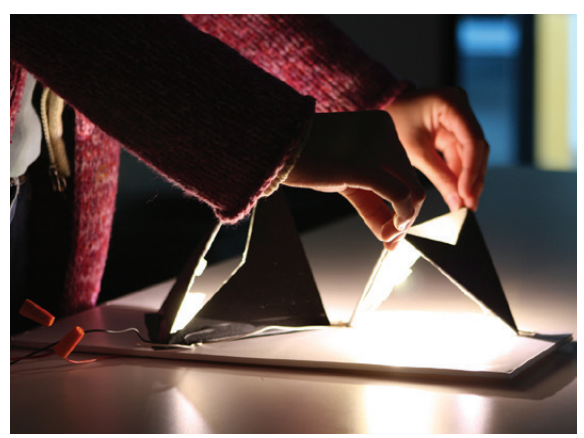
Occupants receive feedback from lighting controllers via visual, tactile/haptic, and audio methods. The surveyed lighting user interfaces used a combination of these elements, although some interfaces did not employ visual cues beyond the positioning of the control on the wall in an area where a light switch commonly would be found.

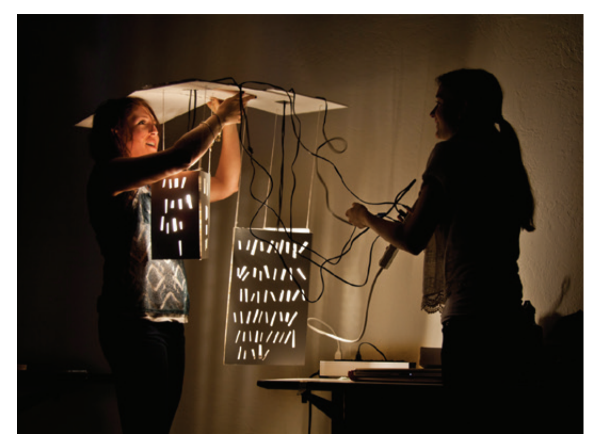
Lightfair International 2014, CLTC & Seoul Semiconductor Booths
2010

Chevron Center for Sustainable Energy Efficiency
2010

Propel Agile Networking Event
2016

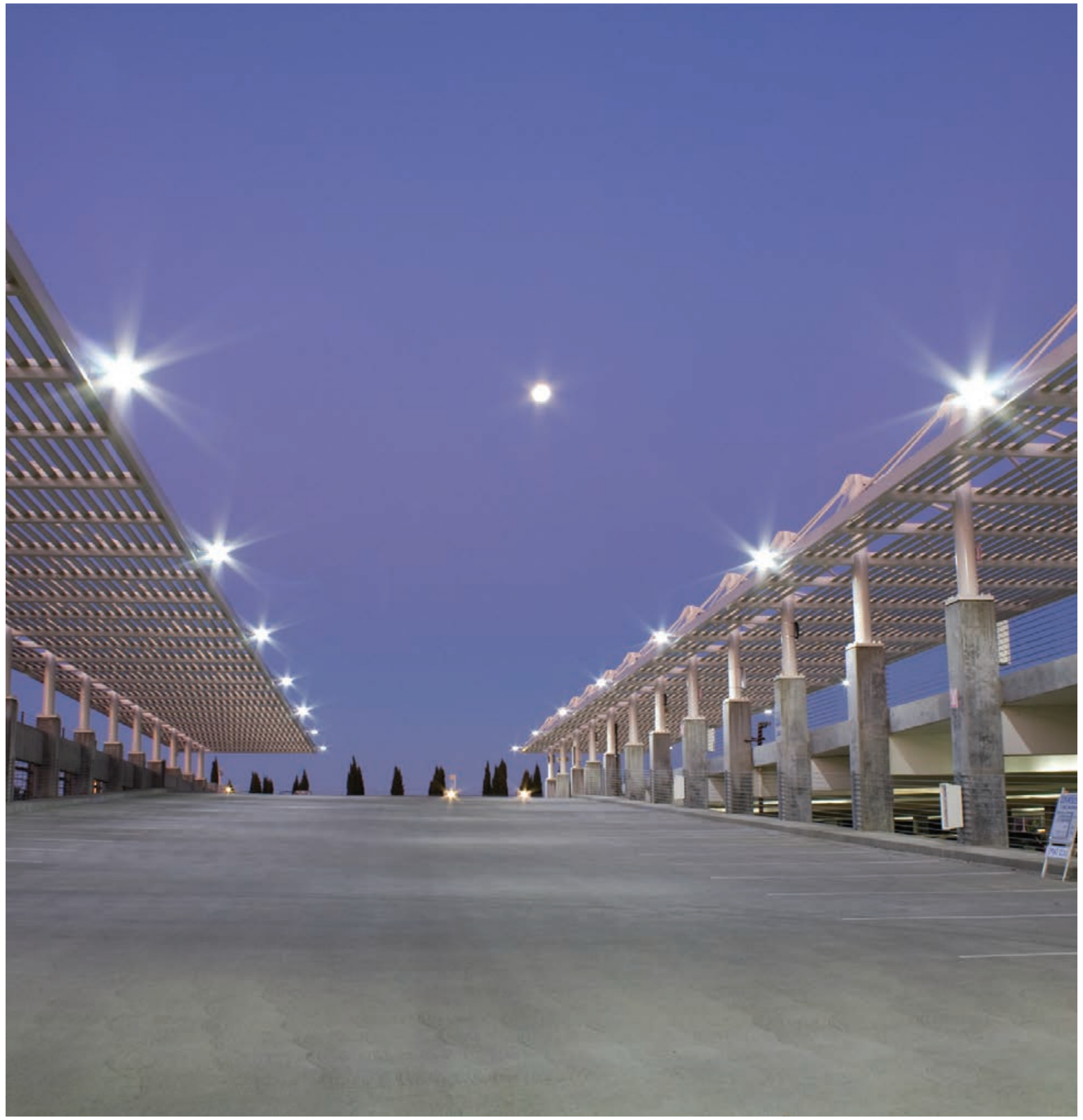
Photography





Lighting Design

Research & Demonstration



Exterior Lighting