Connected:
How Networked Control Systems *(and codes and standards!)* Will Drive LED Adoption

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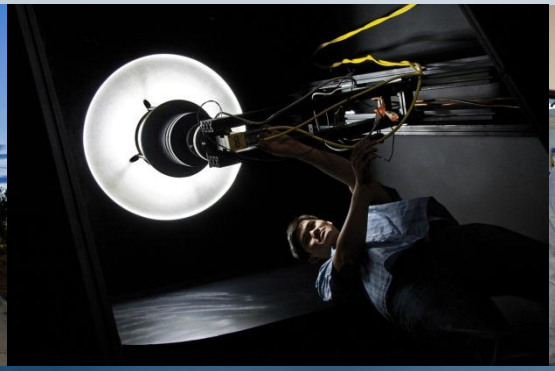
CLTC's Mission

To accelerate the development and commercialization of energy-efficient lighting and daylighting technologies in partnership with utilities, manufacturers, end users, builders, designers, researchers, academics, and governmental agencies.

MISSION-DRIVEN ACTIVITIES:

- Research & Development
- Demonstration & Outreach
- Education & Training

UC DAVIS UNIVERSITY OF CALIFORNIA

CLTC CALIFORNIA LIGHTING TECHNOLOGY CENTER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BC hydro
GE Lighting
LUXIM
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COOPER Lighting
redwoodsystems
EDL Energy Dynamics
SWITCH
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IREC
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FOUNDING ORGANIZATIONS

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PIER PUBLIC INTEREST ENERGY RESEARCH "Research Powers the Future"

NEMA

UTILITIES

Pacific Gas and Electric Company

SOUTHERN CALIFORNIA EDISON An EDISON INTERNATIONAL Company

SDGE Southern California Gas Company Sempra Energy utilities

SMUD

LA DWP Los Angeles Department of Water & Power

CITY OF ROSEVILLE CALIFORNIA Roseville Electric

Silicon Valley Power CITY OF SANTA CLARA

BC hydro

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AcuityBrands

full spectrum solutions

KENALL

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Universal Lighting Technologies

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HONDA The Power of Dreams

lumenetix

PRIDE INDUSTRIES

VELUX Skylights

enlighted

IDEAL

LUNERA

QUALCOMM

eMerge ALLIANCE

INTERMATIC Providing a brighter solution.

LUTRON

Rambus Bringing invention to market

VENTURE LIGHTING

ENTECH SOLAR

FINELITE

JADE SKY TECHNOLOGIES

LUXIM

SHARP

WattStopper

LARGE END-USERS

DGS Department of General Services BUILDING GREEN · BUYING GREEN · WORKING GREEN

THE UNIVERSITY OF CALIFORNIA 1868

CSU The California State University WORKING FOR CALIFORNIA

LACCD

NATIONAL PARK SERVICE

FOREST SERVICE US DEPARTMENT OF AGRICULTURE

Walmart Save money. Live better.

Lighting & Energy Efficiency

Luminous Efficacy

- **One time, long duration change**
- **Reduction of baseline**
  - Light Source Efficacy
  - Luminaire Efficacy
  - Application Efficacy

Lighting Controls

- **Continuous, real-time change**
- **Fluctuations from base line**
  - Occupancy / Vacancy
  - Daylighting
  - Demand Response
  - Tuning
  - Personal Control

Adaptive Lighting Systems…

automatically adjust their light output…

- Total Luminous Flux
- Spectral Power Distribution
- Candle Power Distribution

based on sensor input from the space they serve…

- Occupancy / Vacancy
- Daylight
- DR Signals

to optimize space and building performance.

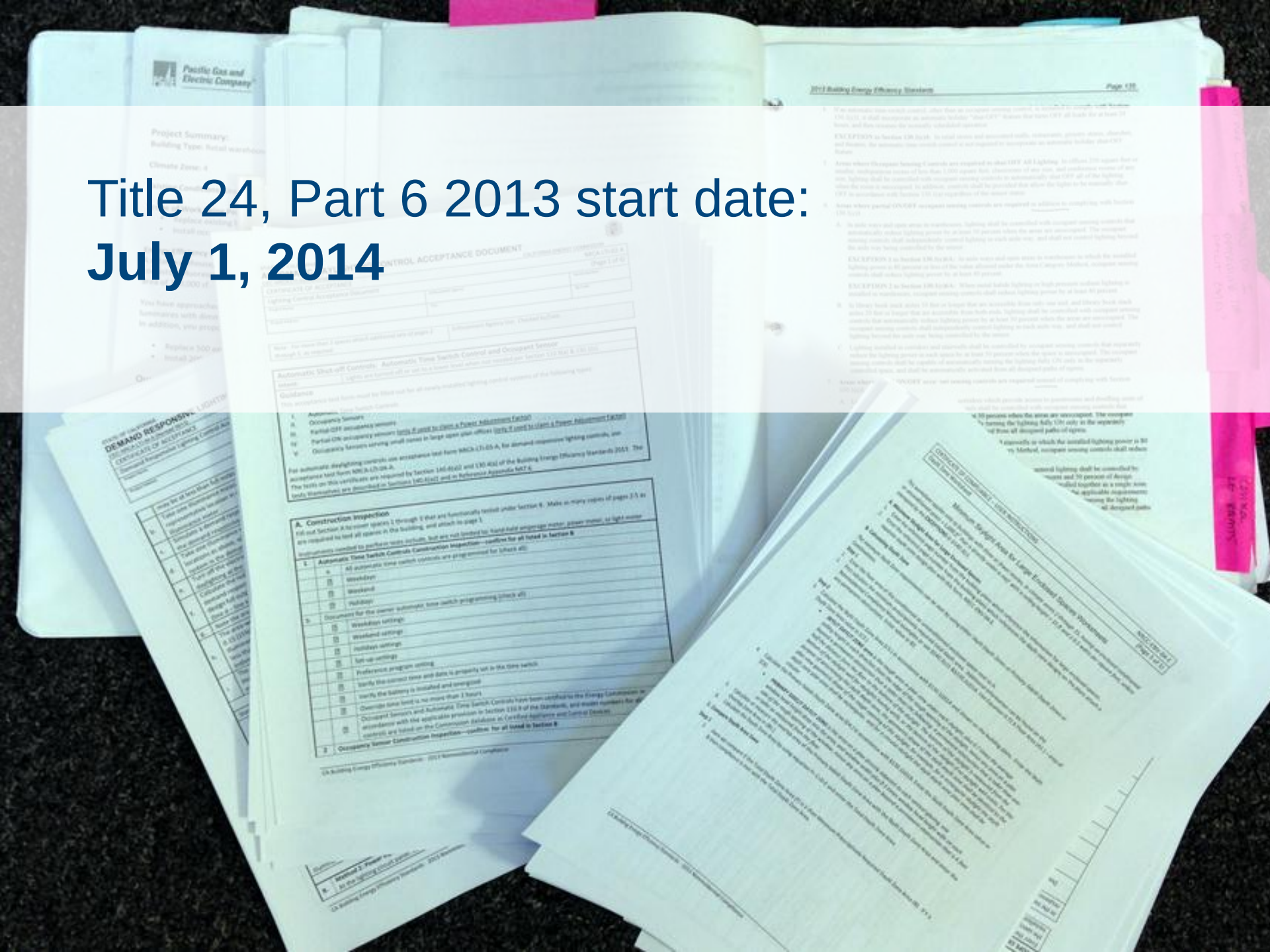
- Comfort
- Energy Savings
- Peak Demand Reduction

Select the Appropriate

Source + Luminaire + Controls (for the application)

The California Context:
2013 Building Energy Efficiency Standards

Lighting Controls Requirements



Title 24, Part 6 2013 start date:
July 1, 2014

Photo: Cree, Inc.

Luminaire alterations

TABLE 141.0-E Requirements for Luminaire Alterations

Quantity of existing affected luminaires per Enclosed Space [1]	**Resulting Lighting Power for Each Enclosed Space**	**Applicable Mandatory Control Provisions for Each Enclosed Space**	**Multi-level Lighting Control Requirements for Each Altered Luminaire**
Alterations that do not change the area of the enclosed space or the space type			
Sum total < 10% of existing luminaires	Existing lighting power is permitted	Existing provisions are permitted	Existing controls are permitted
Sum total ≥ 10% of existing luminaires	≤ 85% of allowed lighting power per Section 140.6 Area Category Method	§130.1(a), (c)	Two level lighting control [2] or §130.1(b)
	> 85% of allowed lighting power per Section 140.6 Area Category Method	§130.1(a), (c), (d) [3]	§130.1(b)
Alterations that change the area of the enclosed space or the space type or increase the lighting power in the enclosed space			
Any number	Comply with Section 140.6	§130.0(d) [3] §130.1(a), (c), (d) [3], (e)	§130.1(b)

1. Affected luminaires include any luminaire that is changed, replaced, removed, relocated; or, connected to, altered or revised wiring, except as permitted by EXCEPTIONS 1 and 2 to Section 141.0(b)**2Iii:**

2. Two level lighting control shall have at least one control step between 30 and 70% of design lighting power in a manner providing reasonably uniform illuminations

3. Daylight controls in accordance with Section 130.0(d) are required only for luminaires that are altered.

Lighting controls requirements

Indoor

130.1 (a) = area controls

130.1 (b) = ~~multi-level lighting~~ controls

130.1 (c) = ~~shut off controls~~

130.1 (d) = daylighting

130.1 (e) = demand response

Outdoor

130.2 (c)

Source Dimmability

Adaptive Controls

Multi-level lighting control: 130.1 (b)

Changes from 2008:

- Areas with LPD greater than **0.5 W/ft^2** now, *was 0.8 W/ft^2*
- Requirements based on **source type**, *was only one control step between 30% and 70% of full output*
- **Additional control strategy required**, *previously no additional requirements*
- There are some exceptions

Image Courtesy of Acuity Brands

Table 130.1-A

Any area ≥ 100 ft^2 with a connected lighting load > 0.5 W/ft^2 must meet the control and uniformity requirements in Table 130.1-A, with each luminaire controlled by at least one of the following control strategies:

- Manual dimming
- Lumen maintenance
- Tuning
- Automatic daylighting
- Demand response

MULTI-LEVEL LIGHTING CONTROLS AND UNIFORMITY REQUIREMENTS

Luminaire Type	Minimum Required Control Steps (Percent of Full Rated Power)	Uniform Level of Illuminance Shall Be Achieved by:
Line-voltage sockets except GU-24	Continuous dimming 10–100%	
Low-voltage incandescent systems		
LED luminaires and LED source systems		
GU-24 rated for LED		
GU-24 sockets rated for fluorescent >20W	Continuous dimming 20–100%	
Pin-based compact fluorescent > 20W		
GU-24 sockets rated for fluorescent ≤ 20W	Minimum one step between 30–70%	• Stepped dimming or • Continuous dimming or • Switching alternate lamps in a luminaire
Pin-based compact fluorescent ≤ 20W		
Linear fluorescent and U-bent fluorescent ≤ 13W		
Linear fluorescent and U-bent fluorescent >13W	Minimum one step in each range: 20–40% 50–70% 80–85% 100%	• Stepped dimming or • Continuous dimming or • Switching alternate lamps in each luminaire, having a minimum of 4 lamps per luminaire, illuminating the same area and in the same manner
Track lighting	Minimum one step between 30–70%	• Step dimming or • Continuous dimming or • Separately switching circuits in multi-circuit track with a minimum of two circuits
HID >20W	Minimum one step between 50–70%	• Stepped dimming or • Continuous dimming or • Switching alternate lamps in each luminaire, having a minimum of 2 lamps per luminaire, illuminating the same area and in the same manner
Induction >25W		
Other light sources		

Adaptive Lighting in Transitional Spaces

Partial ON/OFF control: 130.1 (c)

100% Power, 25 fcd

40% Power, 13 fcd

20% Power, 4.0 fcd

Partial ON/OFF control: 130.1 (c)

Specific requirements for
partial ON/OFF occupancy sensors;
none required in 2008

- Parking garages
- Other indoor parking areas
- Indoor loading and unloading zones
- Library book stacks*
- Stairwells and corridors*
- Warehouse aisle ways and open areas*

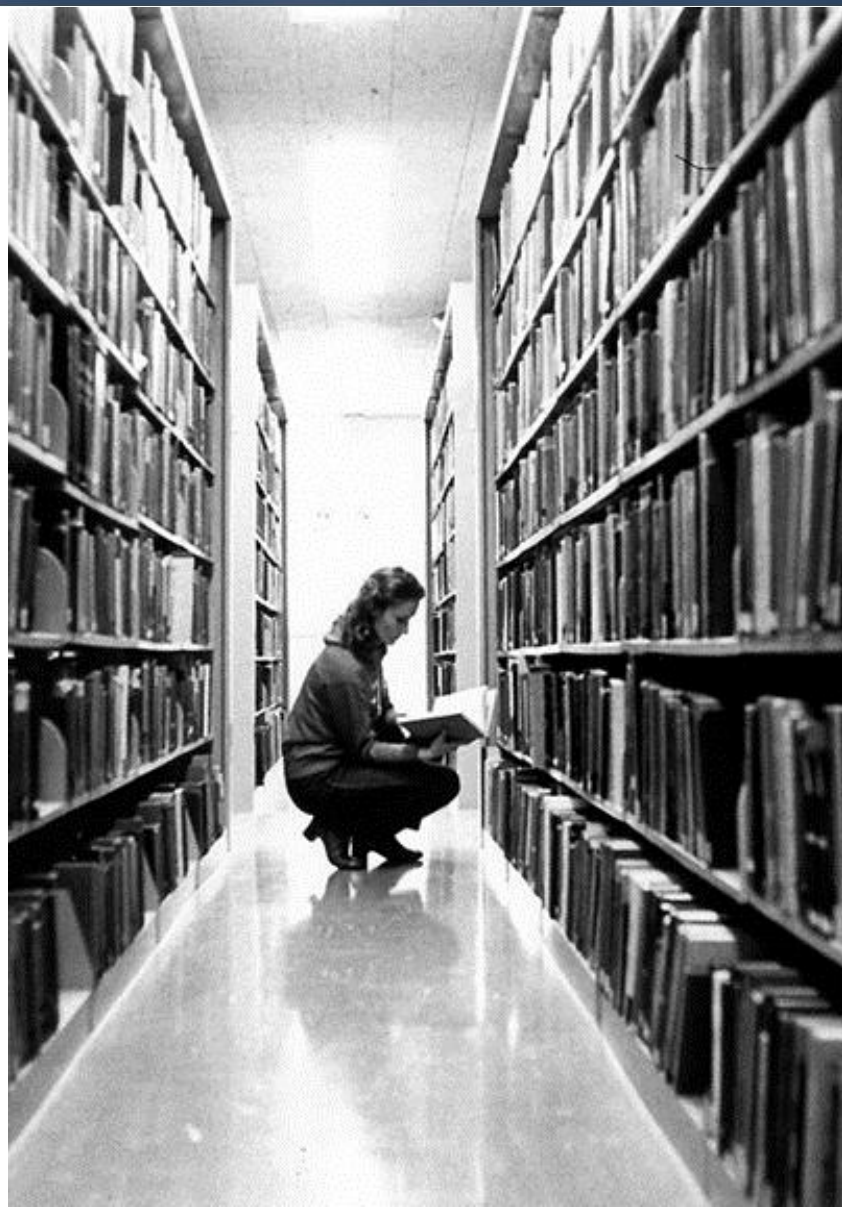
** in addition to automatic time switch controls*

Reduce on vacancy, then off at COB

Areas where partial ON/OFF occupant sensing controls are required **in addition to** full automatic shut-off at COB:

- Stairwells
- Corridors
- Aisle ways and open areas in warehouses
- Library book stack aisles, 10 feet or longer

Reduce by 50% power on vacancy, increase when occupied



Reduce on vacancy, rather than off

Areas where partial ON/OFF occupant sensing controls are required **instead of** full automatic shut-off at COB:

Stairwells and common area corridors in high-rise residential buildings and hotel/motels

– ≥ 50% reduction

Indoor parking and loading/unloading areas

– One step between 20-50%

– Control ≤ 500W per zone

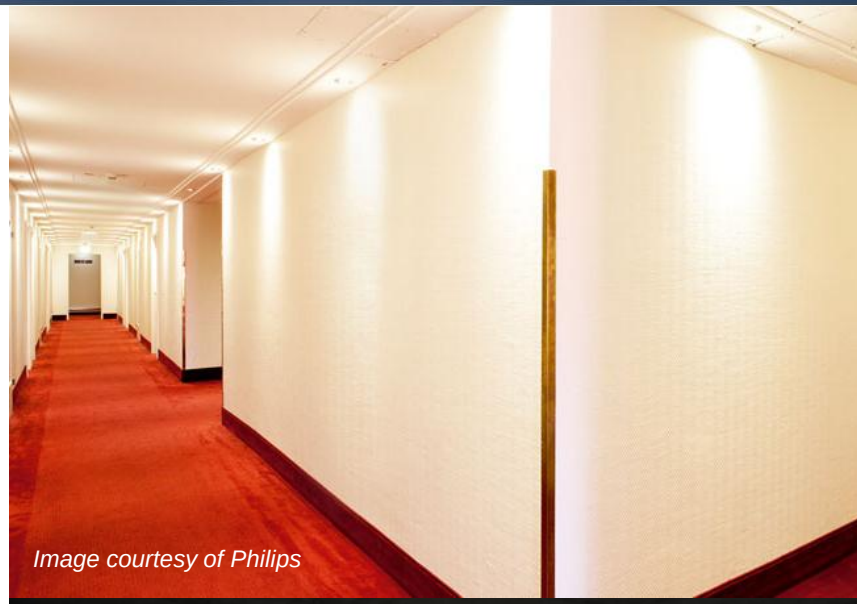


Image courtesy of Philips

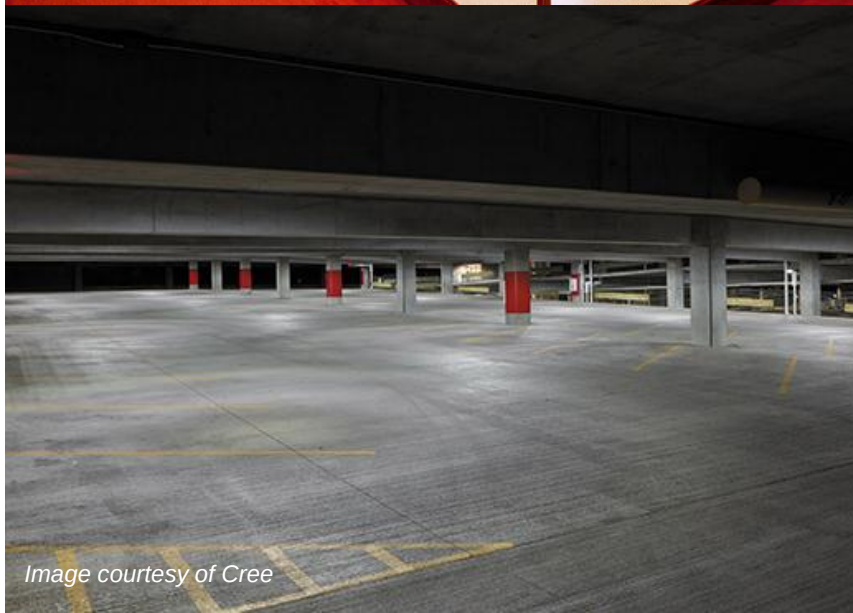


Image courtesy of Cree

Daylighting Controls: 130.1 (d)

- **Automatic controls** now required, manual option removed
- Calculation method for daylit zones = simplified!
- Area size exemptions removed
- Parking garages are now included; previously exempt

Images courtesy of WalMart

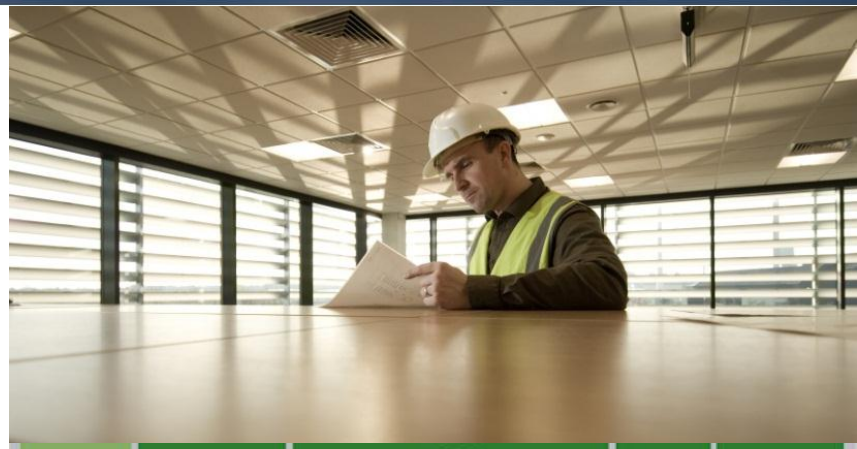
PAFs for 2013 code: Table 140.6-A

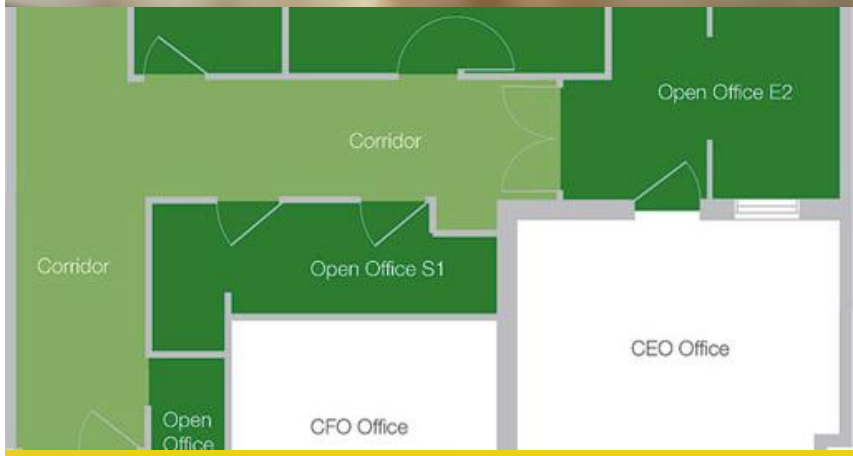
TABLE 140.6-A LIGHTING POWER DENSITY ADJUSTMENT FACTORS (PAF)

TYPE OF CONTROL		TYPE OF AREA		FACTOR
a. To qualify for any of the Power Adjustment Factors in this table, the installation shall comply with the applicable requirements in Section 140.6(a)2 b. Only one PAF may be used for each qualifying luminaire unless combined below. c. Lighting controls that are required for compliance with Part 6 shall not be eligible for a PAF				
1. Partial-ON Occupant Sensing Control		Any area ≤ 250 square feet enclosed by floor-to-ceiling partitions; any size classroom, conference or waiting room.		0.20
2. Occupant Sensing Controls in Large Open Plan Offices		In open plan offices > 250 square feet: One sensor controlling an area that is:	No larger than 125 square feet	0.40
			From 126 to 250 square feet	0.30
			From 251 to 500 square feet	0.20
3. Dimming System	Manual Dimming	Hotels/motels, restaurants, auditoriums, theaters		0.10
	Multiscene Programmable			0.20
4. Demand Responsive Control		All building types less than 10,000 square feet. Luminaires that qualify for other PAFs in this table may also qualify for this demand responsive control PAF		0.05
5. Combined Manual Dimming plus Partial-ON Occupant Sensing Control		Any area ≤ 250 square feet enclosed by floor-to-ceiling partitions; any size classroom, conference or waiting room		0.25

Certified Lighting Controls ATT

- Conducted by certified field technicians
- Verifies installation requirements are met
- Ensures installed equipment and systems operate properly
  - Automatic Daylighting Controls
  - Automatic Time Switch Controls
  - Occupancy Sensor
  - Demand Response Controls
  - Outdoor Lighting Shut-off Controls
  - Outdoor Motion Sensor





CALCTP
www.calctp.org

Outdoor controls: 130.2 (c)

Lighting mounted ≤ 24 ft above the ground, motion controls required:

- Auto-ON when the areas become occupied
- Automatic step-dimming or continuous dimming when areas are vacant
- No more than 1,500 W of lighting with a mounting height of 24 ft and under may be controlled together

Images Courtesy of Lithonia Lighting

cltc.ucdavis.edu/publication/whats-new-title24-2013-code

WHAT'S NEW IN THE 2013 CODE?

Changes to mandatory Title 24 lighting requirements

California's new Building Energy Efficiency Standards take effect in 2014. They improve the energy efficiency of homes by 25 percent and make nonresidential buildings 30 percent more efficient than the previous 2008 standards. This brief guide offers an overview of important requirements and major updates to the lighting code.

New requirements for lighting controls constitute one of the biggest changes to Title 24 standards. The latest version of the standards also includes more stringent requirements for the testing and certification of controls commissioning.

All lighting control systems with two or more components—in both residential and non-residential spaces—must meet the requirements of 2013 Title 24 standards, **Section 110.9**. Both stand-alone and luminaire-integrated lighting controls, such as vacancy sensors and photocontrols, must now comply with Title 20 regulations.

NON-RESIDENTIAL
INDOOR LIGHTING REQUIREMENTS

All interior luminaires in non-residential buildings must have manual on/off controls, and each area must be independently controlled. Dimmer switches must allow manual on/off functionality, with some exceptions such as public restrooms with two or more stalls, which do not need a publicly accessible switch.

MULTI-LEVEL LIGHTING CONTROLS

In areas larger than 100 ft², installed luminaires must:

- Incorporate multi-level lighting controls or continuous dimming, depending on the lamp type
- Meet the uniformity requirements in **Table 130.1-A**
- Have at least one of the following types of controls for each luminaire:
  - Manual continuous dimming and on/off control (**Section 130.1(a)**)
  - Lumen maintenance (**Section 100.1**)
  - Tuning (**Section 100.1**)
  - Automatic daylighting controls (**Section 130.1(d)**)
  - Demand response controls (**Section 130.1(e)**)

Classrooms are one of the rare exceptions to the multi-level requirements. Instead, if they have a connected general lighting load ≤ 0.7 W/ft², they must have at least one control step between 30% and 70% of full-rated power.

Adaptive Lighting: Case Studies

UC Davis: Bi-level Stairwells

UC Davis installed 999 LED units

Assumed 20% occupancy rate

22W high / 5W low

PIR sensor times out after 5 min

Estimated energy use reduction: **85%**

- 7,008 hours in standby mode
- 1,752 hours in active mode

Campus Corridors Case Study: UCSF

- UCSF Medical Sciences building
- Total: 50 two-lamp T8 fluorescent fixtures addressed
- 20% of full lighting power during vacancy, 70% when occupied
- 3 different systems:
  - Lutron Energi TriPak
  - WattStopper Digital Lighting Management (DLM)
  - Enlighted

Campus Corridors Case Study: UCSF

Lutron Energi TriPak: 17 fixtures

- Occupancy rate: 12%
- Reduced lighting energy use: 62%
  - 260 kWh annual savings

Photo: Lutron

WattStopper: 14 fixtures

- Occupancy rate: 16%
- Reduced energy use: 53%
  - 3,108 kWh annual savings

Photo: WattStopper

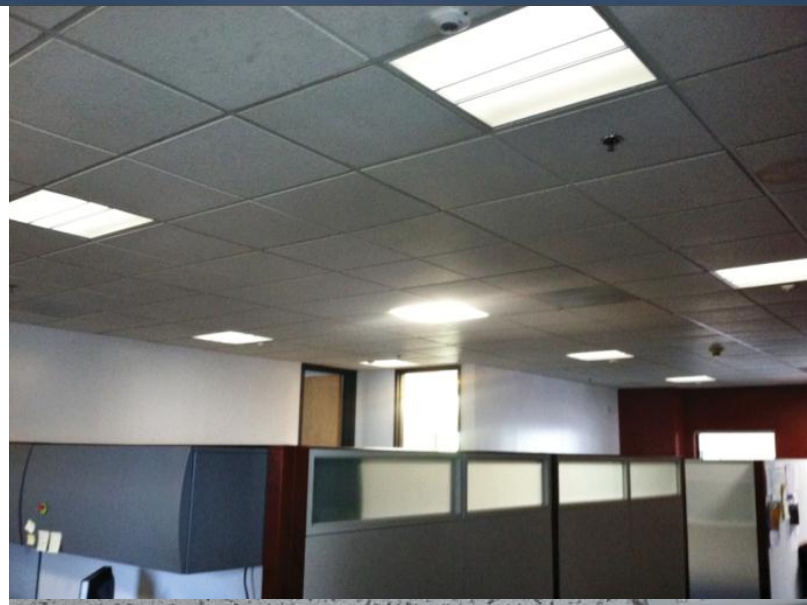
Enlighted: 19 fixtures

- Occupancy rate: 14%
- Reduced energy use: 68%
  - 5,396 kWh annual savings

Photo: Enlighted

Office Workspaces Case Study: UCSB

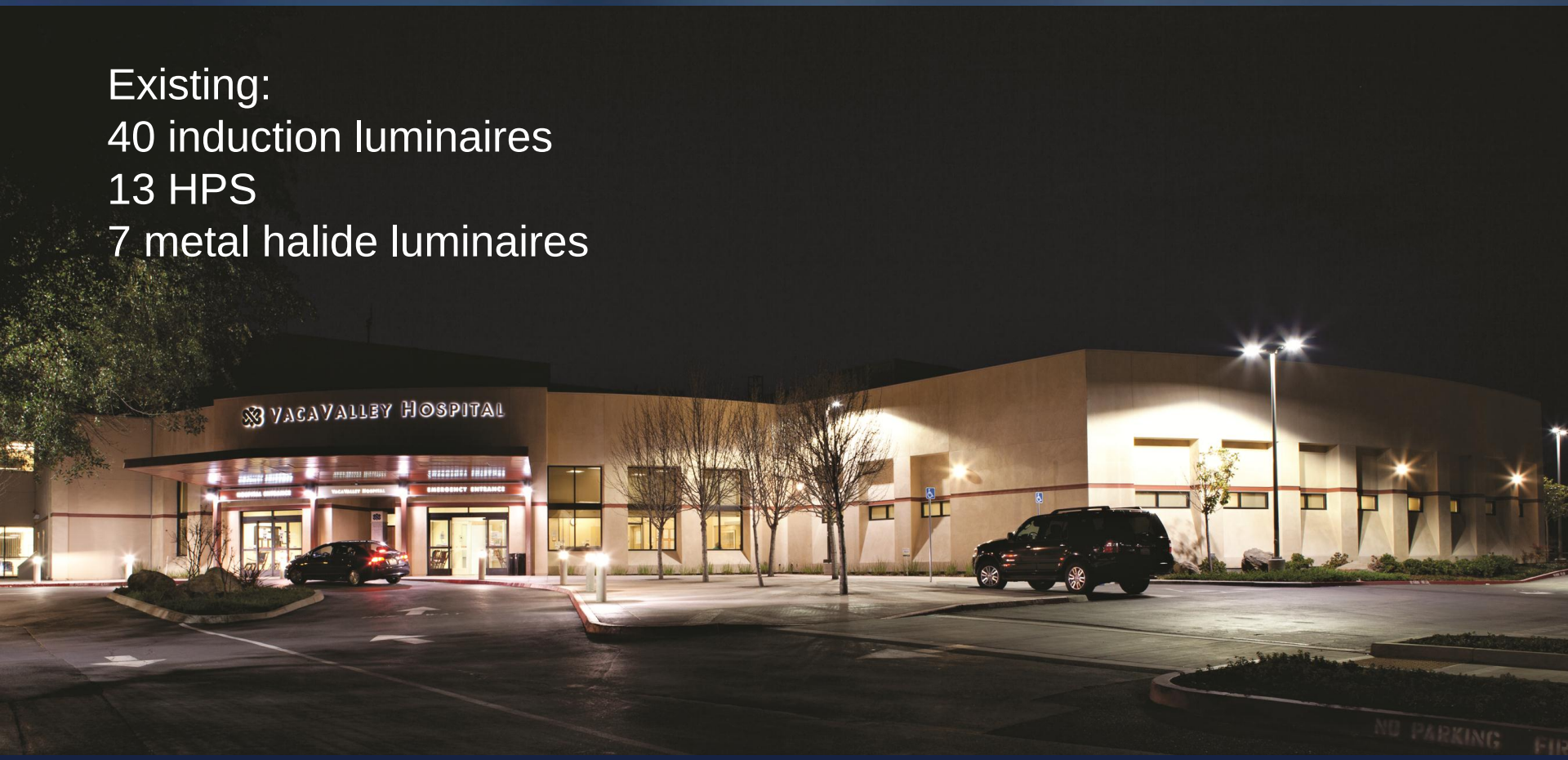
- Student Information Systems and Technology office
  - Three open office spaces with cubicles
- 58 2’x2’ 56W recessed fluorescent replaced by 58 dimmable LED
- Monitored from May to October 2013
- Occupancy rate: 28%
- Reduced energy use by 89%
  - Annual energy savings estimate: 11,500 kWh
  - Lifetime energy cost savings: $315 per fixture based on UCSB rate of $0.11/kWh



NETWORKED ADAPTIVE EXTERIOR LIGHTING

NorthBay VacaValley Hospital

Existing:
40 induction luminaires
13 HPS
7 metal halide luminaires



Project Partners:

BERKELEY LAB
LAWRENCE BERKELEY NATIONAL LABORATORY

U.S. DEPARTMENT OF ENERGY

SIEMENS

Solution

- 57 LED luminaires, passive infrared (PIR) and microwave motion sensors, and a wireless radio frequency mesh network control system
- System components meet or exceed the IES'S best-practice photometric performance recommendations and the DLC'S criteria for its Qualified Products List

MWX: Microwave Sensor

Lumewave's MWX-LVE-90U-B Outdoor Microwave Lighting Controller

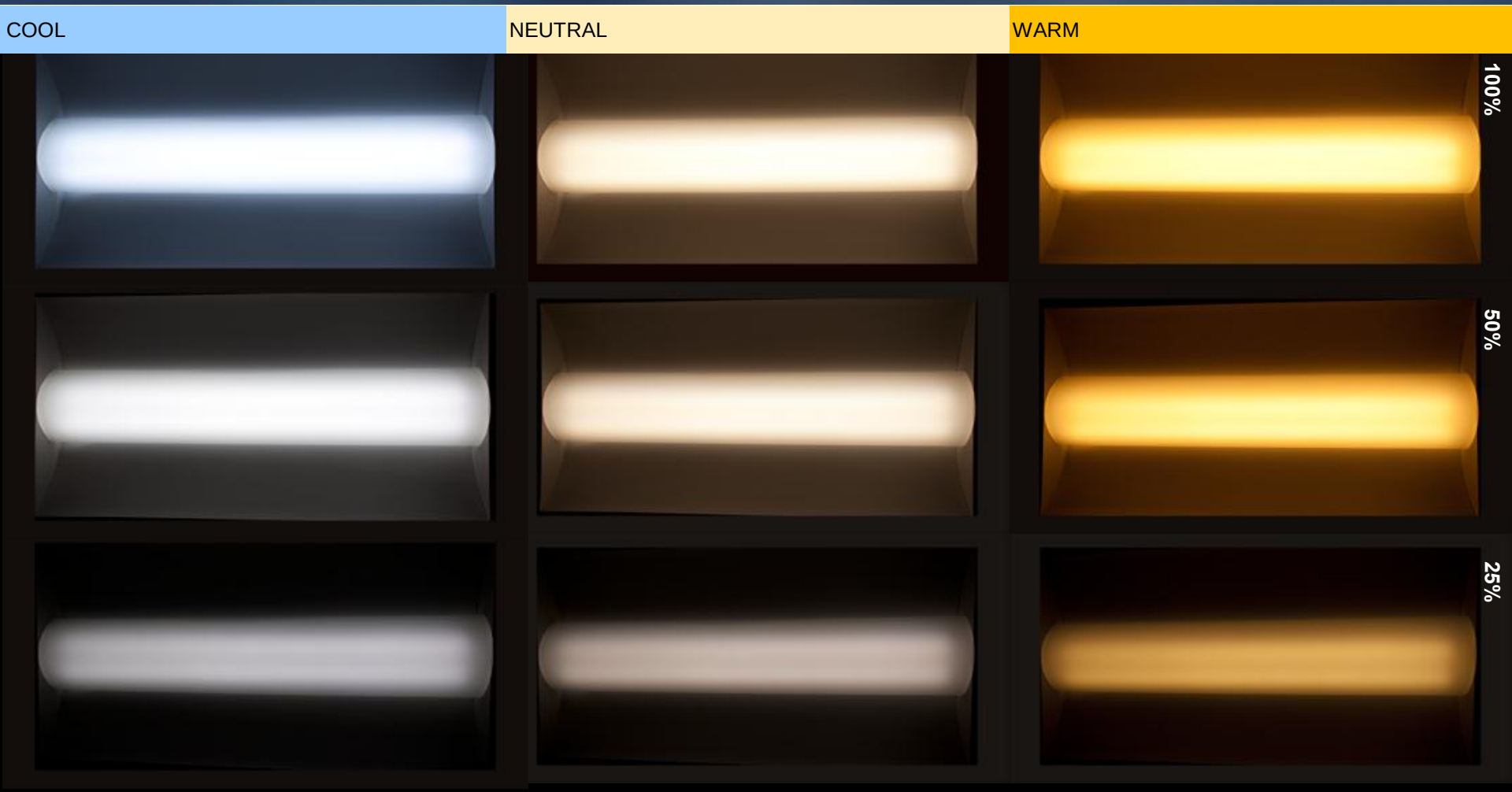
Demonstration Results

- Energy Savings: 66%
- Occupancy Rate: 35-55%
- Induction to LED luminaires reduced energy use 33.9%.
- Networked control system further reduced the energy use 49.2 %
- Total annual savings for the demonstration: 29,020 kWh
- 2014 Lighting Energy Efficiency in Parking (LEEP) Award Winner: Best Use of Lighting Controls in a Single Facility

Next: Getting to Zero Net Energy

California Department of Public Health
Richmond, CA

Next: Customizable CCT and SPD



Next: Smart Cities, Connected Streetlighting

Connected:
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