CALIFORNIA STATEWIDE
UTILITY CODES AND STANDARDS PROGRAM

2019 Title 24 Codes & Standards Enhancement (CASE) Proposal

Nonresidential Outdoor Lighting Controls

September 8th 2016

Energy Solutions

Proposed Code Change Overview

- Apply occupancy sensor requirement for outdoor luminaires mounted higher than 24 feet (new height threshold TBD)
  - Code reference: Title 24 Part 6, Section 130.2(c)3

- Develop procedure for testing detection distance of outdoor controls
  - In coordination with California Lighting Technology Center (CLTC) and NEMA/ANSI C136.54 working group

Related Code History

- Outdoor lighting control requirements were introduced in 2008 Title 24 code cycle
- Expanded in 2013 and 2016 Title 24 code cycles
- Mandatory occupancy based control requirements in the 2013 code cycle excluded luminaires mounted higher than 24 feet due to technical feasibility concerns
- Controls must be capable of reducing lighting power by 40-90%.

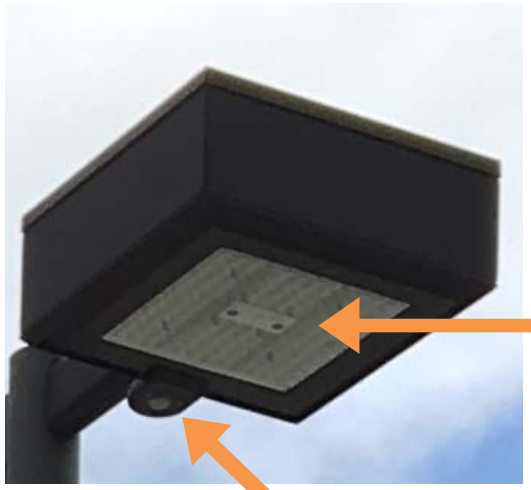
Current Code Requirements

Title 24, Section 130.2(c)

1. All installed outdoor lighting shall be controlled by a photocontrol or outdoor astronomical time-switch control, or other control capable of automatically shutting OFF the outdoor lighting when daylight is available.
2. All installed outdoor lighting shall be independently controlled from other electrical loads by an automatic scheduling control.
3. All installed outdoor lighting, where the bottom of the luminaire is mounted **24 feet or less** above the ground, shall be controlled with automatic lighting controls

Current Market

Occupancy sensors are becoming more common on LED luminaires less than 24 feet high (and they are required by code in new installations)



Current Market

30+ ft

Currently, it is less common for luminaires taller than 24 feet to employ occupancy sensors (often only photocells)

Photocell Sensor

Question: Do you agree with these assessments of the current market?

Market Overview and Analysis

Current Market

- Outdoor occupancy-based lighting controls are becoming more common (mostly parking lots and outdoor hardscape)

Market Impacts

- Statewide annual energy consumption by luminaires mounted ≥ 24 feet in new construction is estimated to be 18.6 GWh.
- Proposed measure would target a segment of these luminaires ≥ 24 feet.

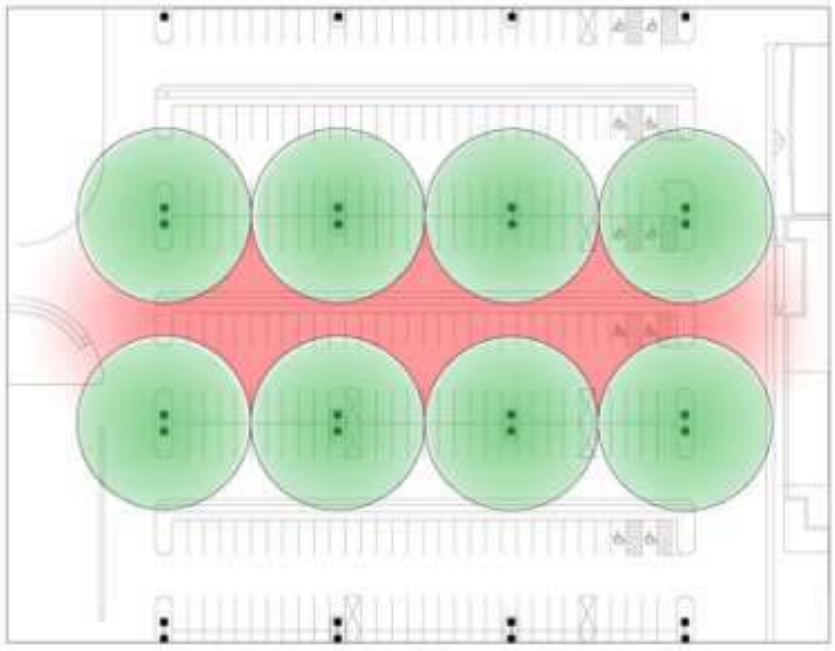
Potential Market Barriers

- Availability of enhanced PIR sensors with larger detection distances
- Cost of alternative technologies (image / camera / microwave)
- Lack of industry standard test method for sensor detection distance

Sensor Technology

Passive Infrared (PIR) Technology

- Traditional motion detection technology
- Historically, PIR sensors had a 1:1 ratio of mounting height to coverage



Illustrative example of PIR Sensor Range Limitations with Sensor Radius of 50 Feet, in an example lot with 100' x 120' pole spacing

Sensor Technology

Passive Infrared (PIR) Technology

However, enhanced PIR technology is being designed and marketed for installations of 1:2 up to 1:3, mounting height : detection distance ratios

- 10 ft. mounting height expands to between a 40 and 60 ft. detection diameter area
- For example, the Great Mall in Milpitas, CA has advanced PIR sensors installed on 60’ poles

Question

Do you have input on the state of the outdoor PIR sensor market and agree with this description?

Sensor Technologies

Microwave Motion Detection

- Common in security applications
- Uses Doppler Effect: emits microwave radiation, and analyze returned waves to detect motion
- Can be paired with PIR to create dual technology sensors

Camera based sensors

- Emergence of image/camera-based/CCD technologies can extend detection distances
- Higher precision sensing; adjustable sensitivity ranges
- However, these technologies can be expensive

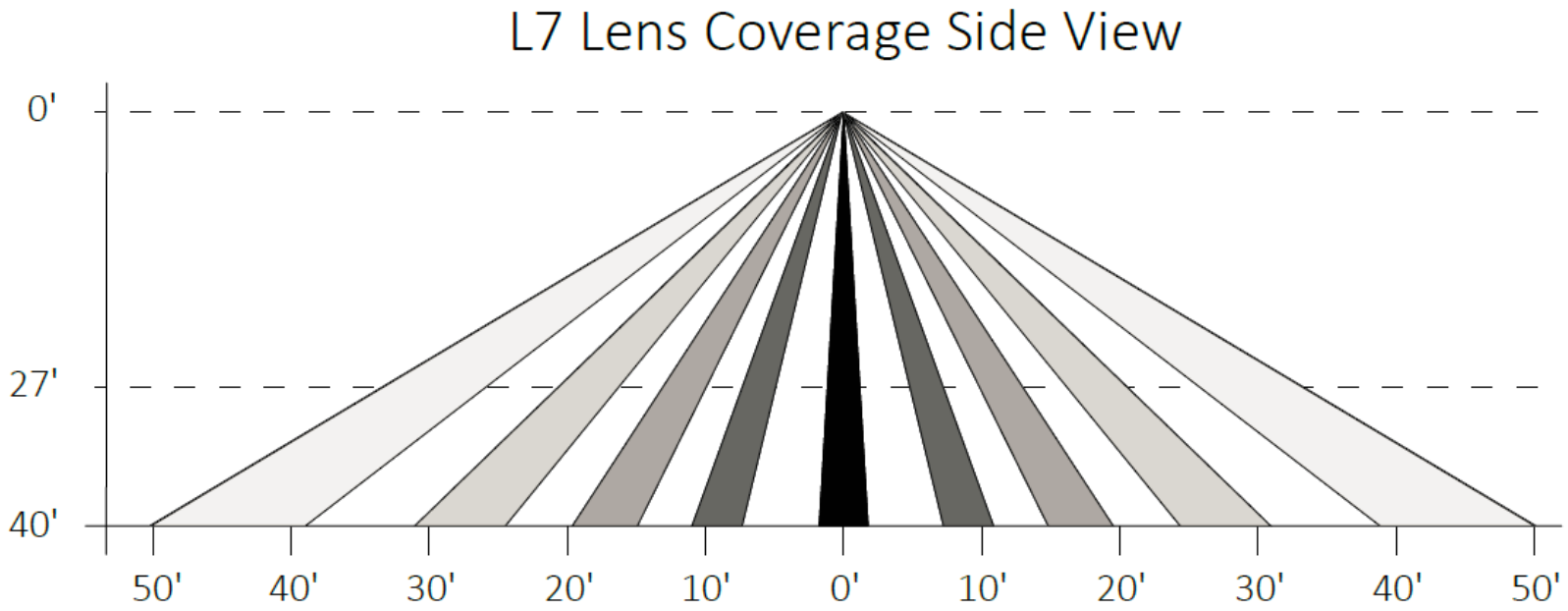
Question

Do you have input on the applicability of these sensors for use in outdoor poles and their detection distances?

Available Sensors

WattStopper

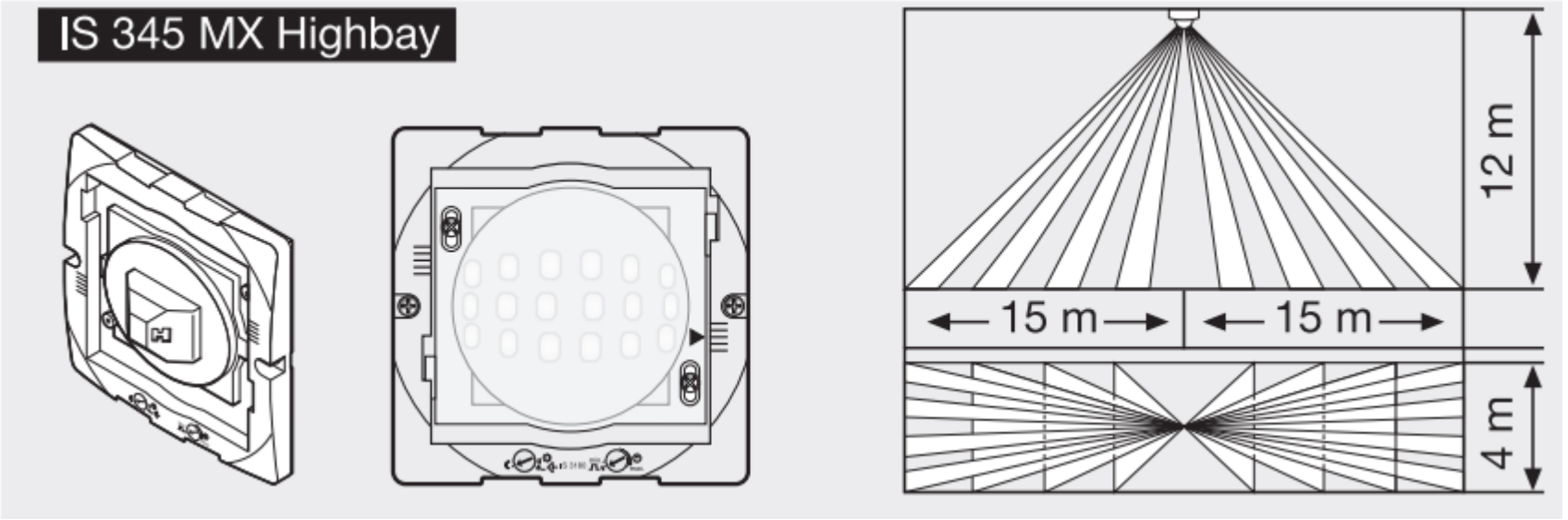
- FSP-211 Outdoor PIR Sensor with L7 Lens detects motion at 40’ height with 100’ diameter



Available Sensors

Steinel

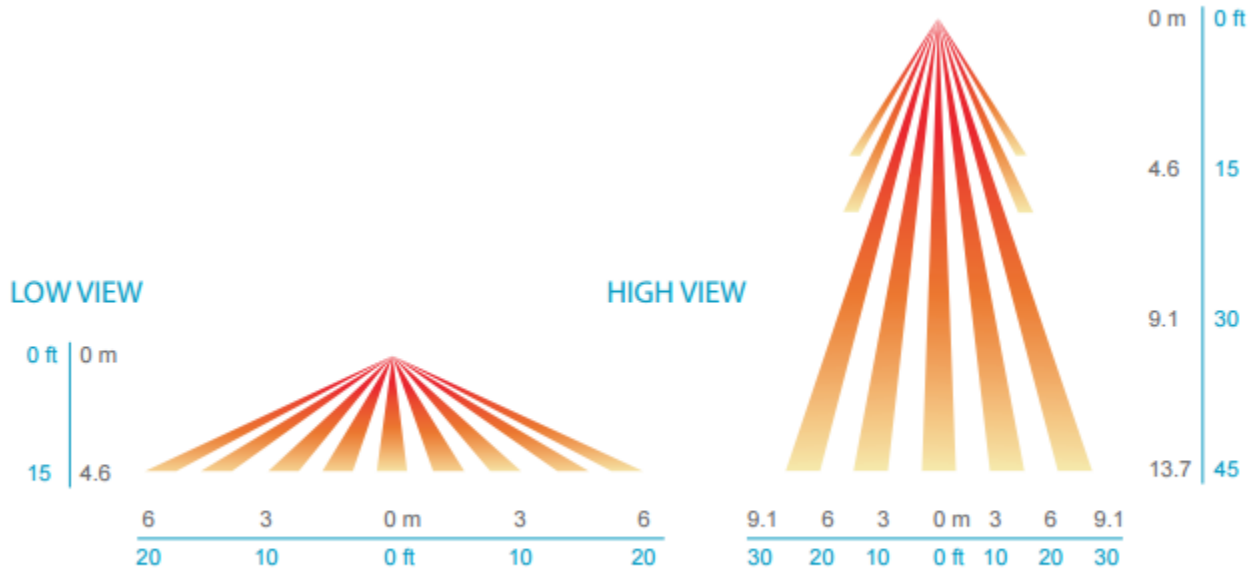
IS 345 MX is a PIR Indoor/Outdoor Motion Sensor – detects motion at 39’ height with 98’ diameter



Available Sensors

Acuity Brands

SBO 6 Indoor/Outdoor PIR Motion Sensor detects motion up to 40’ height with 60’ diameter



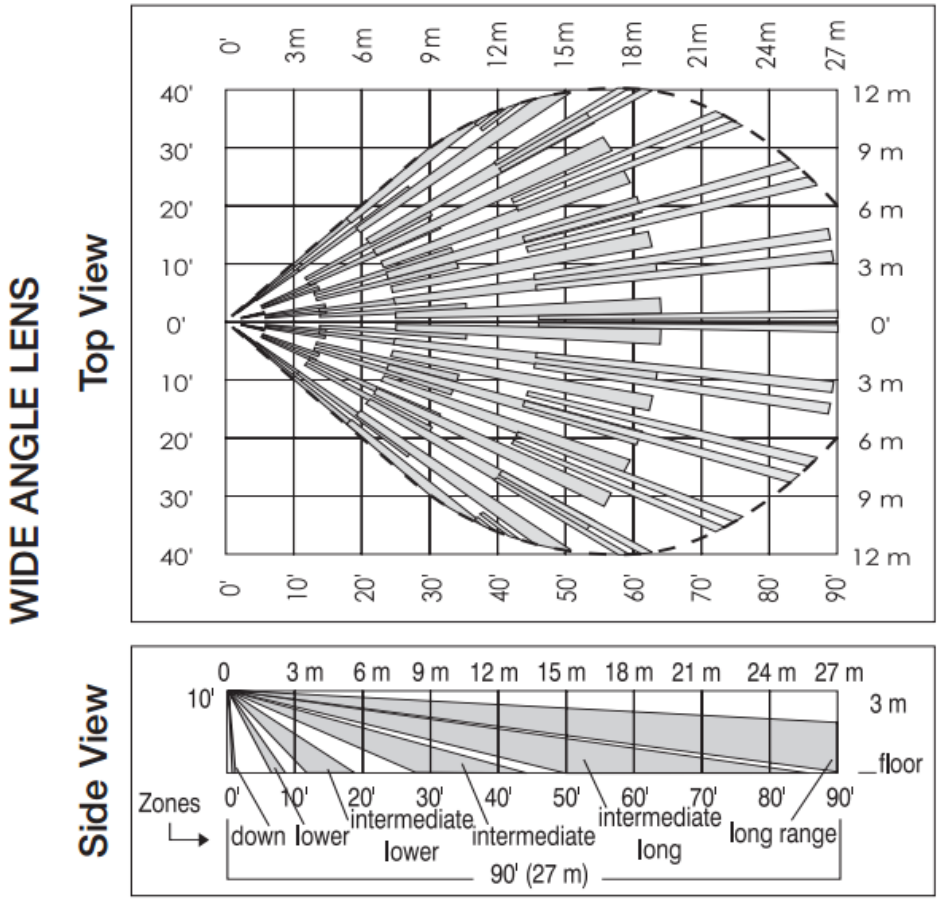
Coverage Pattern of High Mount Lens Option (SBO 6)

Available Sensors

Honeywell

– DT900 Outdoor PIR Motion Sensor detects motion at 10’ height with 90’ coverage

DT900 and DT901 set for 27m (90 ft.) range

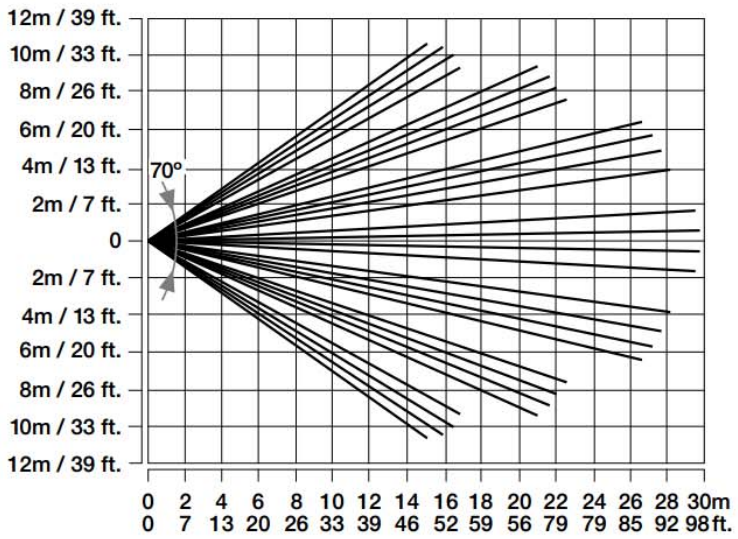


Available Sensors

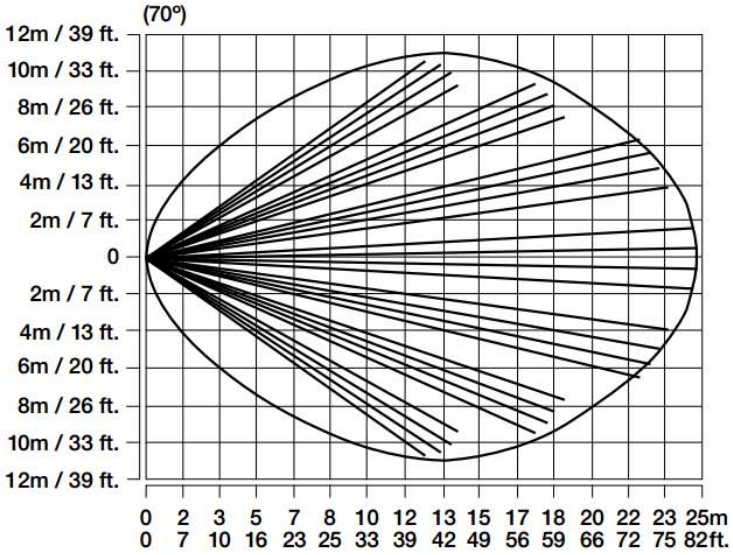
Interlogix

- DI601 (PIR) and DDI602U (PIR and Microwave Dual technology) Outdoor Motion Sensor detect motion at 10’ height with 98’ coverage

PIR pattern (DI601/TX-2810-01-4)



PIR pattern with microwave coverage (DDI602U-F1)



Example Installations >24’

- Milpitas, Great Mall
  - Sensity PIR sensors installed at Great Mall in Milpitas, CA
  - Installations as tall as 60’ Poles

- Rancho Cordova, Tri Tool Inc
  - SMUD Project with Tri Tool, Inc. in Rancho Cordova – 50’ poles, with Wattstopper PIR sensors
  - Bi-level operation from 9 PM – 4:30 AM:
    - High Mode: 50% of max output
    - Low mode: 25% of max output
  - https://www.smud.org/assets/documents/pdf/Tri-Tool-Exterior-LED-Lighting.pdf

- West Sacramento, Raley’s
  - BetaLED fixtures with integrated sensors installed at Raley’s Market
  - Installation on 29’ Poles
  - Reduced power by 65% when unoccupied (45% of the operating hours)
  - http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/gateway_raleys.pdf

Stakeholder input

Question
Are you aware of other products that have high ratios of detection distance to mounting heights?

Question
Are you aware of field installations using occupancy sensors on poles higher than 24'?

Question
Are there any outdoor area / space types where occupancy control would not be appropriate above 24'?

Sensor Detection Distance Claims and Capabilities

Sensor Assessment:

- CLTC / CASE Team proposing research initiative to test a variety of sensor types in a controlled lab environment to verify claims.
- Testing will include a variety of products such as PIR technology, camera based product, and microwave based products.
- This testing will include products from at least three manufacturers.
- Testing will measure and provide data on the trigger distance / coverage pattern of each product when mounted at various heights exceeding the 24’ threshold

Detection Distance Test Procedure

- No current industry standard test method for rating detection distance
  - CLTC / CASE Team participating in the development of an ANSI C.136 (Standards for Roadway and Area Lighting Equipment) committee dedicated to development of standards for outdoor occupancy sensors.
  - ANSI C136.54 underway to develop test protocols for outdoor sensors
  - CLTC / CASE Team may submit test data to ANSI committee process.
  - Significant progress also has been made among European manufacturers; opportunity to leverage.
  - May address issues of rain/snow/fog/visibility impacts
- Ideally, Title 24 can leverage an industry standard test method to support the requirements

Lunch

- We will resume at 1:05

Incremental Cost Estimation

2013 and 2016 Title 24 CASE Reports and ASHRAE controls proposals collected data on outdoor occupancy sensor costs:

- 2013 CASE Report (published 2011):
  - $170 per unit for hardware
  - $100 per unit for installation
- 2016 CASE Report (published 2014) :
  - **$80 & $100** measure IMC used for proposals for sales lots and sales canopies
  - Major manufacturers quoted incremental cost for fixture-integrated sensors for outdoor poles at **$50**, with 30% mark-up
- AHSRAE 90.1 (published 2015)
  - California projects have experienced an incremental cost of approximately **$50** per light point for multi-level control and motion sensing

- Additional manufacturer interviews will provide the 2019 CASE Team with more current cost information for range of products capable of being used on taller poles

Stakeholder comments? Any other cost / price data available?

Savings Opportunity

Documented savings from occupancy based bi-level controls in outdoor lighting:

- Energy Technology Assistance Program (Energy Solutions and CEC / ARRA)
  - Installed 71 bi-level lighting projects, collected monitoring data from 192 distinct fixtures in 38 different facilities.
  - Parking lot fixtures spent on average **93%** of night time hours in low-power mode.
  - Higher occupancy areas spent **40%** of night time hours in low-power mode.
  - http://www.energy.ca.gov/ab758/documents/ARRA-Programs/final_reports/Energy_Tech_Assistance_Program-Energy_Solutions-Final_Report_2012-04-30.pdf
- PIER / CLTC Case study:
  - Cal Poly parking lots unoccupied **68%** of the night time hours
  - http://cltc.ucdavis.edu/images/documents/case_studies/pier_bilevel_street_parking_area_cal_poly.pdf
- SMUD Tri Tool Lot Study
  - 48% savings from controls
  - https://www.smud.org/assets/documents/pdf/Tri-Tool-Exterior-LED-Lighting.pdf
- West Sacramento Raley's
  - 29% savings from bi level motion controls
  - http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/gateway_raleys.pdf

Methodology for Savings Analysis

Savings analysis will leverage assumptions from:

- Existing installations (previous slides)
- Leverage 2013 and 2016 CASE Reports, where appropriate
  - Luminaire height distribution
  - Energy savings assumptions
- California Outdoor Lighting Assessment data (CEC):
  - Total outdoor lighting energy in CA
- New studies identified / underway
  - California Lighting Technology Center assessing energy savings from PIR and microwave sensors, with wireless network controls

Methodology for Savings Analysis

Savings in tall-pole scenarios may be different than those observed with smaller detection distances

- Taller poles / larger detection distance may mean more motion detect per Watt of controlled lighting power.

CASE Team proposes to measure savings and document sensor performance in real-world applications in California:

- Targeting **3 – 5 demo sites** to monitor installations with occupancy controls with mounting heights ≥ 24 feet
- Sensor types would include Passive Infrared (PIR), Microwave, Image / Camera
- Monitor occupancy / detection patterns, product performance, end user experience

Question

Any input on the proposed methodology for assessing per unit savings?

Assumptions for Statewide Energy Impacts Analysis

Key assumptions:

- Operating hours: 12 hours / day or 4,380 hours / year
- Outdoor lighting energy in CA: 3,068 GWh
- Fraction of lots with luminaires mounted higher than 24': 70%
- Code triggered fraction: 5% new or retrofitted
- Energy savings fraction: TBD, at least 13% from occupancy sensors
- Relevant functional use areas (FUA):
  - Parking, general hardscape, walkways, outdoor retail, recreation, entry, landscape, outdoor patio

Question:

- Data on the percentage of outdoor light fixtures at different mounting heights?

Incremental Cost Savings

Approach

- Calculate incremental cost savings based on Time Dependent Valuation of Energy (TDV) over the entire period of analysis
- Use 2019 TDV values

Preliminary Energy Impacts

Preliminary Energy Savings Estimate				
Annual per Unit Electricity Savings (kWh/ft²)	Annual per Unit Natural Gas Savings (Therms/ft²)	First Year Statewide Electricity Savings (GWh/yr)	First Year Statewide Natural Gas Savings (Million Therms/yr)	Confidence Level (high, medium, low)
673	**0**	**2.4**	**0**	**Low**

Preliminary Cost Effectiveness Estimates

	Benefit (2020$)	Cost (2020$)
Total Per Unit Incremental Cost over Period of Analysis		$TBD
• *Incremental first cost (supplies, equipment, installation)*		*$TBD*
• *Incremental maintenance cost (replacement equipment, regular maintenance) over period of analysis*		*$0*
Per Unit TDV* Cost Savings over Period of Analysis	$720	
TOTAL	$720	$270
Benefit/Cost Ratio		**TBD**

* Using $0.20 per square foot value

Compliance and Enforcement

- CASE Team will interview stakeholders to identify potential barriers to code compliance and enforcement
- Will need to update existing compliance form (reference NRCC-LTO-02-E form)

Compliance and Enforcement, *cont*.

STATE OF CALIFORNIA
OUTDOOR LIGHTING CONTROLS
CEC-NRCC-LTO-02-E (Revised 08/15)

CALIFORNIA ENERGY COMMISSION

CERTIFICATE OF COMPLIANCE	NRCC-LTO-02-E
Outdoor Lighting Controls	(Page 1 of 3)
Project Name:	Date Prepared:

The NRCC-LTO-02-E shall be used to document all mandatory outdoor lighting controls that are applicable to the project.

A. Mandatory Outdoor Lighting Control Declaration Statements

Check all that apply:

- ☐ Lighting shall be controlled by self-contained lighting control devices which are certified to the Energy Commission according to the Title 20 Appliance Efficiency Regulations in accordance with §110.9(a).
- ☐ Lighting shall be controlled by a lighting control system or energy management control system in accordance with §110.9. An Installation Certificate shall be submitted in accordance with §130.4(b).
- ☐ All lighting controls and equipment shall comply with the applicable requirements in §110.9 and shall be installed in accordance with the manufacturer's instructions in accordance with §130.1
- ☐ Part-Night Outdoor Lighting Controls, as defined in Section 100.1(b), shall meet the requirements in Section 110.9(b)5
- ☐ All outdoor incandescent luminaires rated over 100 watts, determined in accordance with Section 130.0(c), shall be controlled by a motion sensor.
- ☐ All outdoor luminaires rated for use with lamps greater than 150 lamp watts, determined in accordance with Section 130.0(c), shall comply with Backlight, Uplight, and Glare (collectively referred to as "BUG") in accordance with Section 130.2(b)
- ☐ All installed outdoor lighting shall be controlled by a photocontrol or outdoor astronomical time-switch control in accordance with Section 130.2(c)1
- ☐ All installed outdoor lighting shall be circuited and independently controlled from other electrical loads by an automatic scheduling control in accordance with Section 130.2(c)2
- ☐ All installed outdoor lighting, where the bottom of the luminaire is mounted 24 feet or less above the ground, shall be controlled with automatic lighting controls in accordance with Section 130.2(c)3
- ☐ For Outdoor Sales Frontage, Outdoor Sales Lots, and Outdoor Sales Canopies lighting, an automatic lighting control in accordance with Section 130.2(c)4
- ☐ For Building Facade, Ornamental Hardscape and Outdoor Dining lighting, an automatic lighting control in accordance with Section 130.2(c)5
- ☐ Before an occupancy permit is granted for a newly constructed building or area, or a new lighting system serving a building, area, or site is operated for normal use, indoor lighting controls serving the building, area, or site shall be certified as meeting the Acceptance Requirements for Code Compliance in accordance with §130.4.(a). Outdoor lighting controls shall comply with the applicable requirements of Section 130.2(c) and Reference Nonresidential Appendix NA7.8

Compliance and Enforcement—Tasks

Market Actor	Task(s)	Success Criteria
Lighting Designers	- Design lighting system to meet Title 24 code - System performs to owner specifications & needs. - Compliance forms	- System meets owner needs - Do this quickly and within budget and schedule - Do this cost-effectively - System is Title 24 compliant
Contractor/Builder	- Build system exactly as designed to meet code - Purchase system from retailers/distributors - Coordinate with other market actors - Work on-site	- Do this quickly and within budget and schedule - Do this with minimal paperwork - System is Title 24 compliant

Compliance and Enforcement—Tasks

Market Actor	Task(s)	Success Criteria
Electrician	- Install lighting system - Follow lighting design - Coordinate with contractor/builder	- System is Title 24 compliant - Install to meet owner specifications - System functions properly - On schedule and within budget
Energy Consultant/Modeler	- Generate compliance documentation and fill out paperwork - Provide assistance in code interpretation - Run compliance model if necessary	- Compliance documents are properly filled out and system is compliant - Avoid redesigning related code requirements - Minimal energy code related plan check comments - Do this virtually/ remote

Compliance and Enforcement – Market Actors, Tasks, Success Criteria, Resources, and Tools

- Who would be involved in implementing this measure?
  - Lighting Designers
  - Contractor/Builder
  - Electrician
  - Energy Consultant/Modeler
  - Others?
- What Compliance and Enforcement Tasks or Success Criteria are missing?
- What resources or tools are typically used for compliance?

Strawman Code Change Language

Title 24 Part 6, Section 130.2(c)3

"All installed outdoor lighting, where the bottom of the luminaire is mounted X feet or less above the ground, shall be controlled with automatic lighting controls…"

Title 24 Part 6, Section 141.0(b)2Lii.

a. In parking lots and outdoor sales lots where the bottom of the luminaire is mounted X feet or less above the ground, the replacement luminaires shall comply with Section 130.2(c)1 AND Section 130.2(c)3;

b. For all other lighting applications and where the bottom of the luminaire is mounted greater than X feet above the ground, the replacement luminaires shall comply with Section 130.2(c)1 AND EITHER comply with Section 130.2(c)2 or be controlled by lighting control systems, including motion sensors, that automatically reduces lighting power by at least 40 percent in response to the area being vacated of occupant…

References

Possibly reference a test procedure for testing detection distance for outdoor controls

Potential Additional Measure

Wattage Exemption Reduction

Currently, an exemption from controls requirements exists for:

- Pole-mounted fixtures < 75 watts
- Non-pole-mounted fixtures < 30 watts

According to Lighting Facts database, this represents about 1/3 of outdoor fixtures

- As fixture efficacy improves, this share will grow

Depending on application and savings potential, this exemption could be reduced 15% - 25% and be cost effective.

75 Watt Pole-Mounted Exemption

Assuming the following:

- Sensor cost per fixture = $50
- Annual Hours of Operation = 4380
- Average $ / kWh = $0.08

Proposed Wattage Exemption	Savings Required to Achieve Cost Effectiveness
70	14%
65	15%
60	16%
55	17%
50	19%
45	21%
40	24%

30 Watt Non-Pole-Mounted Exemption

Assuming the following:

- Sensor cost per fixture = $50
- Annual Hours of Operation = 4380
- Average $ / kWh = $0.08

Proposed Wattage Exemption	Savings Required to Achieve Cost Effectiveness
25	38%
20	48%
15	63%

Feedback Request from Stakeholders

We would appreciate feedback and/or data on the proposed measure and testing procedure:

- Occupancy sensor requirement for lighting poles taller than 24 feet
- Procedure for testing detection distance of outdoor controls

Call or email CASE Report Lead

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Questions?