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Codes and Standards Enhancement (CASE) Initiative

2019 California Building Energy Efficiency Standards

Nonresidential Outdoor Lighting Controls – Draft Report

Measure Number: 2019-NR-LIGHT3-D

Nonresidential Lighting

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Authors:	Michael McGaraghan and Axel Pearson (Energy Solutions)
Project Management:	California Utilities Statewide Codes and Standards Team: Pacific Gas and Electric Company, Southern California Edison, SoCalGas®, San Diego Gas & Electric Company, Los Angeles Department of Water and Power, and Sacramento Municipal Utility District

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EXECUTIVE SUMMARY

This is a draft report. The Statewide CASE Team encourages readers to provide comments on the proposed code changes and the analyses presented in this version of the report. When possible, provide supporting data and justifications in addition to comments. Readers' suggested revisions will be considered when refining proposals and analyses. The final CASE Report will be submitted to the California Energy Commission in the third quarter of 2017. For this report, the Statewide CASE Team is requesting input on the following:

1. *The estimated incremental costs and if these reflect mature market trends;*
2. *The impact on product manufacturers; and*
3. *The impact on the code compliance documentation process.*

Email comments and suggestions to info@title24stakeholders.com. Comments will not be released for public review or will be anonymized if shared with stakeholders.

Introduction

The Codes and Standards Enhancement (CASE) initiative presents recommendations to support California Energy Commission's (Energy Commission) efforts to update California's Building Energy Efficiency Standards (Title 24, Part 6) to include new requirements or to upgrade existing requirements for various technologies. The four California Investor Owned Utilities (IOUs) – Pacific Gas and Electric Company (PG&E), San Diego Gas and Electric (SDG&E), Southern California Edison (SCE), and SoCalGas® – and two Publicly Owned Utilities (POUs) – Los Angeles Department of Water and Power (LADWP) and Sacramento Municipal Utility District (SMUD) – sponsored this effort. The program goal is to prepare and submit proposals that will result in cost-effective enhancements to improve energy efficiency and energy performance in California buildings. This report and the code change proposals presented herein is a part of the effort to develop technical and cost-effectiveness information for proposed requirements on building energy efficient design practices and technologies.

The Statewide CASE Team submits code change proposals to the Energy Commission, the state agency that has authority to adopt revisions to Title 24, Part 6. The Energy Commission will evaluate proposals submitted by the Statewide CASE Team and other stakeholders. The Energy Commission may accept, modify or reject proposals. See the Energy Commission's 2019 Title 24 website for information about the rulemaking schedule and how to participate in the process: http://www.energy.ca.gov/title24/2019standards/.

Measure Description

The overall goals of this CASE Report are to propose code changes that clarify and streamline requirements, update definitions, and broaden the existing mandatory outdoor lighting controls requirements.

The Statewide CASE Team is proposing to remove the exception from the occupancy-based, bi-level/dimming control requirements for pole-mounted luminaires under 75 watts and proposing 30 watts as the new threshold for exemptions for all luminaires. Additionally, the proposed changes increase the lighting savings associated with bi-level lighting controls by dropping the range of required dimming from 40 to 90 percent diming to 50 to 90 percent dimming.

The Statewide CASE Team is also proposing to revise the language for occupancy-based, bi-level controls by establishing schedules of normally occupied and normally unoccupied times. The proposed code change also requires that scheduling controls, such as time clocks and part-night controls, be capable of partial lighting power reduction.

The proposed code change maintains the savings fraction associated with motion controls by limiting the wattage of luminaires from 1,500 watts to 400 watts that can be controlled together by an occupancy sensing system.

Finally, this CASE Report proposes changes to Section 141.0(b)2L Outdoor Lighting Alterations to clarify the existing language. This clarification does not change the stringency of the intent of this section.

Scope of Code Change Proposal

Table 1 summarizes the scope of the proposed changes and which sections of the standards, References Appendices, and compliance documents will be modified as a result of the proposed change.

Table 1: Scope of Code Change Proposal

Measure Name	Type of Requirement	Modified Section(s) of Title 24, Part 6	Modified Title 24, Part 6 Appendices	Will Compliance Software Be Modified	Modified Compliance Documents(s)
Update Definitions	Mandatory	100.1	JA1	No	N/A
Part-Night Usage	Mandatory	130.2(c)1	N/A	No	N/A
Scheduling of Occupancy-Based, bi-level control	Mandatory	130.2(c)	NA7.8	No	CEC-NRCA-LTO-02-A
Change wattage exemption threshold	Mandatory	130.2(c)3	N/A	No	N/A
Decrease Wattage of Lighting Grouped Together	Mandatory	130.2(c)	N/A	No	N/A
Increase Bi-Level Controls Lighting Wattage Reduction	Mandatory	130.2(c)3	N/A	No	N/A
15 Minute Maximum Vacancy Period	Mandatory	130.2(c)3	NA7.8	No	CEC-NRCA-LTO-02-A
Tri-Level Occupancy-Based Controls	Mandatory	130.2(c)3	N/A	No	N/A
Default Schedule When Not Known	Mandatory	130.2(c)	NA7.8	No	CEC-NRCA-LTO-02-A
Code consolidation	Mandatory	130.2(c)	N/A	No	CEC-NRCC-LTO-02-E
Clarify Outdoor Lighting Alterations	Mandatory	141.0(b)2L	N/A	No	N/A

Market Analysis and Regulatory Impact Assessment

As a proposed compliance option, this measure is voluntary and does not require a cost-effectiveness assessment. The proposal offers value to California consumers by saving energy, leaving more money available for discretionary and investment purposes.

All proposed code changes are cost-effective over the period of analysis. Overall this proposal increases the wealth of the State of California. California consumers and businesses save more money on energy than they do for financing the efficiency measure.

The proposed changes to Title 24, Part 6 have a negligible impact on the complexity of the standards or the cost of enforcement. When developing this code change proposal, the Statewide CASE Team interviewed building officials, Title 24 energy analysts, and others involved in the code compliance process to simplify and streamline the compliance and enforcement of this proposal.

Cost-Effectiveness

The proposed code change was found to be cost-effective for all climate zones where it is proposed to be required. The benefit-to-cost (B/C) ratio compares the lifecycle benefits (cost savings) to the lifecycle costs. Measures that have a B/C ratio of 1.0 or greater are cost-effective. The larger the B/C ratio, the faster the measure pays for itself from energy savings. These measures have a B/C ratio ranging from 1.2 to 2.8 depending on space types and scenarios analyzed. See Section 5 for a detailed description of the cost-effectiveness analysis.

Statewide Energy Impacts

Table 2 shows the estimated energy savings over the first twelve months of implementation of the proposed code change. See Section 5 for more details.

Table 2: Estimated Statewide First-Year[1] Energy and Water Savings

First-Year Electricity Savings (GWh/yr)	First-Year Peak Electrical Demand Reduction (MW)	First-Year Water Savings (million gallons/yr)	First-Year Natural Gas Savings (million therms/yr)
8.82	0.26	N/A	N/A

1. First-year savings from all buildings completed statewide in 2020.

Compliance and Enforcement

The Statewide CASE Team worked with stakeholders to develop a recommended compliance and enforcement process and to identify the impacts this process will have on various market actors. The compliance process is described in Section 2.5. The impacts the proposed measure will have on various market actors is described in Section 3.3 and Appendix B. The Statewide CASE Team does not expect significant impacts in the compliance and enforcement process.

Although a needs analysis has been conducted with the affected market actors while developing the code change proposal, the code requirements may change between the time the draft CASE Report is submitted and the time the 2019 Standards are adopted. The recommended compliance process and compliance documentation may also evolve with the code language. To effectively implement the adopted code requirements, a plan will be developed that identifies potential barriers to compliance when rolling-out the code change and approaches that should be deployed to minimize the barriers.

1. INTRODUCTION

This is a draft report. The Statewide CASE Team encourages readers to provide comments on the proposed code changes and the analyses presented in this version of the report. When possible, provide supporting data and justifications in addition to comments. Readers' suggested revisions will be considered when refining proposals and analyses. The final CASE Report will be submitted to the California Energy Commission in the third quarter of 2017. For this report, the Statewide CASE Team is requesting input on the following:

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The Codes and Standards Enhancement (CASE) initiative presents recommendations to support California Energy Commission's (Energy Commission) efforts to update California's Building Energy Efficiency Standards (Title 24, Part 6) to include new requirements or to upgrade existing requirements for various technologies. The four California Investor Owned Utilities (IOUs) – Pacific Gas and Electric Company (PG&E), San Diego Gas and Electric (SDG&E), Southern California Edison (SCE), and SoCalGas®, – and two Publicly Owned Utilities (POUs) — Los Angeles Department of Water and Power (LADWP) and Sacramento Municipal Utility District (SMUD) sponsored this effort. The program goal is to prepare and submit proposals that will result in cost-effective enhancements to energy efficiency in buildings. This report and the code change proposal presented herein is a part of the effort to develop technical and cost-effectiveness information for proposed requirements on building energy efficient design practices and technologies.

The Statewide CASE Team submits code change proposals to the Energy Commission, the state agency that has authority to adopt revisions to Title 24, Part 6. The Energy Commission will evaluate proposals submitted by the Statewide CASE Team and other stakeholders. The Energy Commission may revise or reject proposals. See the Energy Commission's 2019 Title 24 website for information about the rulemaking schedule and how to participate in the process: http://www.energy.ca.gov/title24/2019standards/.

The overall goal of this CASE Report is to propose a code change proposal for Outdoor Lighting Controls. The report contains pertinent information supporting the code change.

When developing the code change proposal and associated technical information presented in this report, the Statewide CASE Team worked with a number of industry stakeholders including building officials, manufacturers, builders, utility incentive program managers, Title 24 energy analysts, and others involved in the code compliance process. The proposal incorporates feedback received during two public stakeholder workshops that the Statewide CASE Team held on September 8, 2016 and March 30, 2017, multiple calls with individual and small groups of stakeholders, as well as an online survey.

Section 2 of this CASE Report provides a description of the measure and its background. This section also presents a detailed description of how this change is accomplished in the various sections and documents that make up the Title 24, Part 6.

Section 3 presents the market analysis, including a review of the current market structure. Section 3.2 describes the feasibility issues associated with the code change, including whether the proposed measure

overlaps or conflict with other portions of the building standards, such as fire, seismic, and other safety standards and whether technical, compliance, or enforceability challenges exist.

Section 4 presents the per-unit energy, demand, and energy cost savings associated with the proposed code change. This section also describes the methodology that the Statewide CASE Team used to estimate energy, demand, and energy cost savings.

Section 5 presents the lifecycle cost and cost-effectiveness analysis. This includes a discussion of additional materials and labor required to implement the measure and quantification of the incremental cost. It also includes estimates of incremental maintenance costs. That is, equipment lifetime and various periodic costs associated with replacement and maintenance during the period of analysis.

Section 6 presents the statewide energy savings and environmental impacts of the proposed code change for the first year after the 2019 Standards take effect. This includes the amount of energy that will be saved by California building owners and tenants, statewide greenhouse gas (GHG) reductions associated with reduced energy consumption, and impacts (increases or reductions) on material with emphasis placed on any materials that are considered toxic. Statewide water consumption impacts are also considered.

Section 7 concludes the report with specific recommendations with ~~strikeout~~ (deletions) and <u>underlined</u> (additions) language for the standards, Appendices, Alternate Calculation Manual (ACM) Reference Manual, Compliance Manual, and compliance documents.

2. MEASURE DESCRIPTION

2.1 Measure Overview

Section 130.2(c) of Title 24, Part 6 contains controls requirements for outdoor lighting systems that apply to most outdoor lighting systems, including parking and other common outdoor hardscape areas. The standards require several different layers of controls, which are designed to accomplish different types of savings, including controls to:

1. Daylight control: ensures that lights are turned off during daylight hours using photocontrol, astronomical time-switch, or other control. (130.2(c)1).
    a. This is the first layer of control with the most energy savings
2. Automatic scheduling control: ensures that outdoor luminaires can be controlled independently and scheduled to be turned off during certain hours of the night (130.2(c) 2.).
    a. This is the second layer of control that makes sure that lights are turned off or significantly dimmed after-hours.
3. Occupancy-based, multi-level control: ensures luminaires mounted under 24-feet automatically reduce power between 40 and 90 percent in response to vacancy of the space (130.2(c)3). This control is typically provided with the use of motion sensors.
    a. This is the third layer of control for regular nighttime business hours to have occupancy-based dimming. Several exemptions exist based on space type and fixture wattage.

The intent of Section 130.2(c) has been to require layer 1 and 2 for all outdoor lighting, and all three for lighting of general hardscape, retail sales lots, and gas station canopies.

For applications where the third layer of control (motion sensing) is not mandatory (outdoor sales frontages, building facades, ornamental hardscapes, and outdoor dining lighting), *either* a part-night control *or* an occupancy-based control could be used as the third layer. However, the Statewide CASE Team believes that a part-night control is essentially a combined daylight control and automatic

scheduling control in that it turns lights off according to the availability of daylight and a pre-set schedule, so the part-night control is duplicating the functions of the first two layers/requirements. Thus, in most cases, the third layer does not save additional energy.

The first two layers of control (off during the day and a scheduling control for a portion of the night) have been requirements in Title 24, Part 6 since the 2005 version of the standards. Outdoor occupancy-based lighting controls were introduced to the 2013 Title 24 Standards for most outdoor lighting area types, but with several exceptions in place. However, the Statewide CASE Team has received feedback from stakeholders that often many new parking lot lighting systems are left on throughout the night, well after normal business hours. The rationale for leaving lights on at night could include:

- Liability associated with tripping and falling, even if the business is not open
- Safety of employees that might be leaving late at night
- Sufficient light for law enforcement personnel, building security staff or security cameras to see criminal activity
- As a perceived deterrent to criminal activity.

To clarify and streamline requirements, update definitions, and broaden the existing mandatory outdoor lighting controls requirements, the Statewide CASE Team proposes the following measures for outdoor lighting controls.

Update Definitions

Current definitions in the code for automatic controls and motions sensors were written with only on/off control in mind. However, when considering outdoor sources with dimming drivers, these definitions need to be updated to include turning lights off or dimming when light is not needed. The concept of a partial-off motion sensor is no longer valid, as the same piece of equipment that turns lights off can be used to dim lights.

Coordinating the definitions between Title 24 and Title 20 is desirable and should be revisited. From this definition, the argument is that a motion sensor is an occupancy sensor that is rated for outdoor use. Discussions with one manufacturer revealed a desire to use the same terminology and definitions as in Title 20 so there is clarity about the physical characteristics of what equipment is required.

In addition, the definitions did not make clear that a part-night outdoor lighting control was a control that can be used for scheduling lighting similar to time clocks or other scheduling controls. The basis of a part night control is a control that has a photocell and a timer circuit. The control can predict the next day's sunset and sunrise times from the prior day's sunset and sunrise times. Scheduling normally occupied and normally unoccupied times can be defined with respect to "solar midnight;" the time at night halfway between sunset and sunrise. Thus, even if there is a power outage or drift in the clock signal the part-night control resets with the rising and setting of the sun.

The definitions of outdoor lighting controls in Title 20 (**Section 1602. Definitions**. (l) "Emergency Lighting and Self-Contained Lighting Controls") include the following:

"Occupant sensing device" means a self-contained lighting control that automatically controls light, allows for complete manual operation, and includes the following devices:

> (1) "Motion sensor," which means an occupant sensing device that is used outdoors, automatically turns lights off when an area is vacated, and automatically turns the lights on when the area is occupied.
>
> (2) "Occupancy sensor," which means an occupant sensing device that is used indoors and automatically turns lights off when an area is vacated and is capable of automatically turning lights on when an area is occupied.

(3) "Partial-off," which means a motion sensor or occupancy sensor that automatically turns off part of the lighting load when an area is vacated and is capable of automatically turning on the lighting load when an area is occupied.

(4) "Partial-on," which means a motion sensor or occupancy sensor that automatically turns lights off when an area is vacated and is capable of automatically and manually turning on part of the lighting load when an area is occupied.

Part-Night Control in List of Controls That Turn Lights Off During the Day

Part-night controls use a light sensor and a timing circuit to turn lights off during the day and to turn lights off or change light levels at night according to a schedule. Thus, part-night control should be included in the list of controls that are specified in Section 130.2(c)1, alongside photocell and outdoor astronomical time-switch. This does not change the requirements in this section since a part-night control would also qualify as a control capable of automatically shutting off the outdoor lighting when daylight is available. The Statewide CASE Team believes this addition adds simplicity and clarifies that part-night controls satisfies the requirements without having to reference another document, such as the Nonresidential Compliance Manual.

Scheduling Controls with Multiple Light Output Choices

This proposal more clearly requires the capability for multiple circuits or dimming according to a time schedule. It removes the limitation of all-on or all-off control, so the building operator can control lighting power after-hours without leaving the space entirely dark when motion is detected. In most cases, this does not substantively change the requirements. Under this proposal, part-night controls would continue to comply, as would occupancy-based, bi-level controls specified by the current standard. Central time-switch controls, as long as they have at least two separately controlled channels, would also comply.

This proposal would require that a time switch must control at least half of lighting power during *normally unoccupied hours*, as confirmed by an acceptance test, whereas the current code only requires the capability to control at least half of the lighting power. Normally unoccupied hours are defined as the time when occupants are not typically present in a space. Conversely, n*ormally occupied hours* are those times when occupants are typically present. These times do not necessarily coincide with regular business hours; they can include after-hours activity, such as inventory stocking at grocery stores.

Under this proposal, the building owner or designer can define the normally occupied hours. However, if the responsible party for the building does not declare a schedule, at least 50 percent of these lights would be required to be turned off between midnight and 6:00 am.

Decrease Lighting Power Threshold for Bi-Level Motion Controlled Lighting

As outdoor light sources continue to shift to light emitting diode (LED) and improve in efficacy, it is expected that a growing number of pole-mounted fixtures will fall below the 75-watt exemption. In effect, the outdoor controls requirements will have diminishing impacts, because more and more systems will be exempt from the control requirements. Reducing the exemption of pole-mounted luminaires from 75 watts to 30 watts will account for significant additional energy savings. A detailed energy savings analysis can be seen in Section 4.

Decrease Wattage of Lighting Grouped Together on an Occupancy-Based Control

When occupancy-based, bi-level controlled lighting was proposed in 2013, the intent was to control no more than 15,000 ft^2 together, which used the 2008 area wattage allowance (AWA) for Lighting Zone (LZ) 3 of 0.092 W/ft^2. Multiplying this AWA by the desired area coverage yields: 15,000 ft^2 x 0.092 W/ft^2 = 1,380 watts (which was rounded up to 1,500 watts.)

Since that time, lighting power allowances (LPAs) have dropped to the current value of 0.025 W/ft^2 in Lighting Zone 3. Given this lower LPA, the number of watts that can serve 15,000 ft^2 is 375 watts (15,000 ft^2 x 0.025 W/ft^2). The Statewide CASE Team recommends rounding this maximum value up to 400 watts.

Align with ASHRAE 90.1 - Increase Bi-Level Controls Lighting Wattage Reduction

During the development of the 2016 version of ASHRAE 90.1, the committee agreed that the standard should be technology neutral, but not protect any technology that had a higher lifecycle cost unless there was some specific amenity provided by the technology. In the past, both ASHRAE 90.1 and Title 24 have limited the amount of dimming required to no more than 40 percent, as some high intensity discharge (HID) luminaires cannot dim below this level. Given that HID luminaires have a higher lifecycle cost, use more energy, and do not provide a specific amenity that is not matched or exceeded by LED technology, the ASHRAE 90.1 committee updated their outdoor motion control requirements to dim by at least 50 percent. This proposal would do the same and increase the minimum dimming amount from 40 to 50 percent.

Align with ASHRAE 90.1: Motion Sensors Have 15 Minute Maximum Vacancy Period Before Reducing Lighting Power

ASHRAE 90.1 has the following maximum vacancy periods before occupancy controls reduce lighting power:

- §9.4.1.1(h) Automatic full OFF: 20 minutes
- §9.4.1 Parking garage lighting control: 20 minutes
- §9.4.1.3(b)(1) Guestroom lights: 20 minutes
- §9.4.1.3(b)(2) Guestroom bathrooms: 30 minutes
- §9.4.1.4(d) Exterior lighting motion controls: 15 minutes

In the current 2016 Title 24, Part 6 Standards, interior occupancy sensor controls have the following requirements for maximum vacancy periods before occupancy controls reduce lighting:

- §110.9(b)4F "All Occupant Sensing Control types shall be programmed to turn OFF all or part of the lighting no longer than 20 minutes after the space is vacated of occupants, except as specified by Section 130.1(c)8."
- §120.1(c)5 Occupant sensor ventilation control devices: 30 minutes
- §120.6(b)3 Display case lighting sensors: 30 minutes
- §130.1(c)8 Guest room occupancy sensors: 30 minutes

The 2016 California Title 20 Appliance Efficiency Standards have the following requirements for maximum vacancy periods before occupancy controls reduce lighting:

- §1605.3(l)2G1 "All occupant sensing devices shall: a. be capable of automatically turning off controlled lights in the area no more than 30 minutes after the area has been vacated;"

As such, the Statewide CASE Team is proposing the requirement that motion sensors have 15-minute maximum vacancy period before reducing lighting power as part of Sections 130.2(c)2 and 130.2(c)3.

Add Option for Tri-Level Occupancy-Based Controls

The control requirements for general hardscape lighting mounted more than 24 feet above the ground are currently written to require a time-switch and occupancy-based, bi-level control; time clock controls are capable of turning off some of the lights and the occupancy-based, bi-level controls dim the remaining lighting when occupancy is not sensed.

However, the Statewide CASE Team believes that the time clock part of the control is sometimes not used due to liability and safety concerns described earlier. In this case, the time clock is set to 24-hour operation and the system works in normally occupied mode all the time.

Proposed Section 130.2(c)2Cii offers an alternative option where the timing signal is used to reset the dimming level when no occupancy is detected. During normally occupied hours, the lights dim to moderate levels (typically around 50 percent) when space is vacant, but during after-hours when no occupancy is detected, the lights are turned off or dimmed to very low levels (at least 90 percent). Because the lights return to full power when occupancy is detected, there are less safety and/or liability concerns.

Default Midnight to 6 am After-Hours Schedule When Schedule Not Known

The current standard is silent on how scheduling controls should be set when the occupancy schedule is not known. Frequently, at the time of certificate of occupancy the space may not be rented out yet, and thus schedules are not known. By having a default unoccupied schedule of midnight to 6 am, half of the nighttime hours are at reduced power consumption. Once there are occupants, operators can define their normal business hours and after hour times as they see fit. ASHRAE 90.1 uses a similar default time period for control of outdoor lighting.

Code Consolidation

To simplify the code, this proposal includes the recommendation to consolidate requirements for Outdoor Sales Frontage, Building Facades, Ornamental Hardscape and Outdoor Dining. All these spaces now have the same code requirements under Section 130.2(c)3.

Clarifications to Section 141.0(b)2L – Outdoor Lighting Alterations

The Statewide CASE Team has received feedback that the statements "greater of five luminaires or 10 percent" and "greater of five luminaires or 50 percent" in the existing code is unclear. The proposed changes aim to clarify the statements by recognizing that the section is exempted anytime there is less than five luminaires being added or replaced. By adding an exception for less than five luminaires, the conditional statement simplifies to the percent of luminaires being added or replaced. The intent was that the conditions applied when the installed lighting was larger than the larger of the two values– a confusing concept. Broken into a condition and an exception, this is easier to consider in a stepwise process.

The changes also reorder the requirements from least stringent to most stringent by moving Subsection i to the bottom of the list of requirements, and clarify that the newly reordered Subsection i applies to retrofits that are between 10 to 50 percent of existing luminaires. Additionally, the changes more clearly

state that items i and ii also apply to newly added luminaires in situations where a luminaire is added and others are retrofitted (or others removed), but where lighting power still does not increase.

Finally, these changes update the references to sections in Section 130.1(c), as the subsections in Section 130.1(c) have been reordered.

2.2 Measure History

The 2008 Title 24, Part 6 Standards[1] for outdoor lighting controls included the following requirements for time clocks:

> "For lighting of building facades, parking lots, garages, sales and non-sales canopies, and all outdoor sales areas, where two or more luminaires are used, an automatic time switch shall be installed that (1) turns off the lighting when not needed and (2) reduces the lighting power (in watts) by at least 50 percent but not exceeding 80 percent or provides continuous dimming through a range that includes 50 percent through 80 percent reduction. This control shall meet the requirements of Section 119 (c)."

The time clock requirement specified both the capability to turn all lighting off according to a schedule and to either turn part of the lights off or dim the lights. The second capability was added to the time switch requirement to increase the likelihood that the time switch would be used. However, this requirement was dropped during the 2013 Title 24, Part 6 revision process after the 2013 Outdoor Lighting and Controls CASE Study was written, as this proposal still included the 50 percent though 80 percent reduction for part-night control, time clock, or occupancy-based control step switching or dimming.[2]

The outdoor applications that were in the 2016 Title 24, Part 6 Section 130.2(c) items 4 and 5, (outdoor sales frontage, building facade, ornamental hardscape and outdoor dining lighting) were required to have either part-night controls, central time-switch controls, or occupancy-based, bi-level controls that reduced lighting power by at least 50 percent.

Because part-night control has individual schedules per pole, granular control is a given, and it is not necessary to define part-load controls down to the level of checker-boarding or other forms of shut off, so turning off some of the luminaires is acceptable. For centralized time clock controls, the requirement was changed to at least 50 percent power reduction (which also allows turning all the lights off). Occupancy-based controls were required to control lights between 40 percent and 90 percent.

Occupancy-based exterior lighting controls were not being installed to a significant degree prior to 2010. However, since the 2013 Standards were adopted (in 2012), accompanying the rise of light emitting diode (LED) fixtures, and multi-level, occupancy-based, outdoor lighting controls have become more common, both in California and throughout the United States. In 2016, exceptions from the controls requirements in Section 130.2(c) were removed for Outdoor Sales Lots and Outdoor Sales Canopies, and the allowed wattage reduction during dimming was lowered to 90 percent, instead of the previous 80 percent maximum reduction limit. The Statewide CASE Team is recommending revisions for the 2019 Standards, because as outdoor light sources continue to shift to LED and improve in efficacy, a growing number of fixtures can be expected to meet the current exemption, which improves the potential for savings of this measure.

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[1] Title 24, Part 6 §132(c)2.

[2] P. 44. 2013 Statewide CASE Team. Outdoor Lighting and Controls 2013 California Building Energy Efficiency Standards California Utilities Statewide Codes and Standards Team October 2011. http://www.energy.ca.gov/title24/2013standards/prerulemaking/documents/current/Reports/Nonresidential/Lighting_Controls_Bldg_Power/2013_CASE_NR_Outdoor_Lighting_and_Controls_Oct_2011.pdf

Mounting Height Threshold Increase

The Statewide CASE Team investigated increasing the mounting height threshold of 24 feet for occupancy-based control requirements, as specified in section 130.2(c)3 of the 2016 Title 24 Efficiency Standards, as a potential measure in this proposal. While there are significant potential savings associated with increasing the mounting height threshold by increasing the number of luminaires that would utilize occupancy-based controls, the Statewide CASE Team decided not to pursue this measure for the 2019 code cycle, and will continue to collect data to support a robust measure in the next code cycle.

The Statewide CASE Team has identified the following sources of data with regards to this potential measure:

- Seven installations in California that could serve as demonstration sites for technology performance data and occupant surveys
- Up to 10 years of smart meter energy interval data from the University of California at Davis parking lots that employ occupancy-based controls

The Statewide CASE Team will specifically monitor trends in outdoor sensor technology to identify products that are suitable for installations higher than 24 feet and provide adequate coverage for associated pole spacing. Further, an established test procedure for evaluating occupancy-based outdoor lighting controls would support the market in identifying adequate products for this potential measure. In addition to detection distance, the Statewide CASE Team will study the impacts of fog, snow, and ice on sensor detection distances.

2.3 Summary of Proposed Changes to Code Documents

The sections below provide a summary of how each Title 24, Part 6 documents will be modified by the proposed change. See Section 7 of this report for detailed proposed revisions to code language.

2.3.1 Standards Change Summary

This proposal would modify the following sections of the California Building Energy Efficiency Standards. See Section 7 of this report for the detailed proposed revisions to the standards language.

Title 24, Part 6 Section 130.2(c)2:

The proposed code change would require that Section 130.2(c)3 apply to all installed outdoor general hardscape lighting, outdoor sales lot lighting, vehicle service station hardscape lighting, and vehicle service station canopy lighting, rather than all installed outdoor lighting as written in the 2016 code.

The proposed code includes a new requirement for the controlled lighting to have the capability to reduce power 50 to 90 percent by dimming or by turning off a fraction of the controlled lights when more than four luminaires are controlled.

Additionally, the proposed changes include a revision to the language based on scheduling. During normally scheduled operating hours (i.e., times when occupants typically use the space), when the space is vacant, controls will dim each luminaire by 50 to 90 percent. When the area becomes occupied, controls will turn lights on. During after-hours schedule (i.e., times when occupants typically are not expected in the space), and the area is vacated, controls will either reduce half of the luminaire's lighting power by at least 90 percent (or turn lighting off) and control the other half with an occupancy-based sensor, or dim all the lights by at least 90 percent. The proposed code does not specify what

happens when the space is occupied; it is up to the building operator to use a lighting control scheme that works best for their space.

The proposed code change also requires that no more than 400 watts of lighting power shall be controlled together by occupancy-based control.

Finally, this code change proposes removing the exception from the occupancy-based, multi-level controls requirements for pole-mounted luminaires under 75 watts and proposes 30 watts as the new threshold for exemptions for all luminaires.

Title 24, Part 6 Section 130.2(c)3

The proposed code change would require that all installed outdoor lighting be independently controlled from other electrical loads by automatic scheduling controls and either:

- Be capable of reducing power of the controlled lighting at least 50 percent by dimming or by turning off a fraction of the controlled lights, or
- Use an occupancy-based sensor that reduces lighting power of each luminaire by at least 50 percent when no activity has been detected for 15 minutes

2.3.2 Reference Appendices Change Summary

This proposal will modify the following sections of the Standards Appendices as shown below. See Section 7 of this report for the detailed proposed revisions to the text of the reference appendices.

- NA 7.8 Outdoor Lighting Controls Acceptance Test

2.3.3 Alternative Calculation Method (ACM) Reference Manual Change Summary

The proposed code change will not modify the ACM Reference Manuals.

2.3.4 Compliance Manual Change Summary

The proposed code change will modify the following section of the Title 24, Part 6 Compliance Manual:

- Section 6.3.3 Controls for Outdoor Lighting
- Section 6.5 Alterations and Additions for Outdoor Lighting

2.3.5 Compliance Documents Change Summary

The proposed code change will modify the following compliance documents:

- Document CEC-NRCA-LTO-02-A
    - Add language to ensure that acceptance tests of outdoor lighting controls shall be conducted in accordance with Section 130.4(a)6. When scheduled operating hours are known, the acceptance tests shall confirm the time schedules are correctly applied. When scheduled operating hours are not known, acceptance tests shall be conducted using a default normally occupied scheduled period of 6 am to midnight and a default normally unoccupied scheduled period of midnight to 6 am.
- Document CEC-NRCC-LTO-02-E
    - Outdoor Sales Frontage, Building Facades, Ornamental Hardscape and Outdoor Dining. All these spaces now have the same code requirements under Section 130.2(c)3.
    - Remove options 130.2(c)4 and 130.2(c)5 from Section B Mandatory Outdoor Lighting Control Schedule and Field Inspection Checklist.

2.4 Regulatory Context

2.4.1 Existing Title 24, Part 6 Standards

Existing standards require all installed outdoor lighting, where the bottom of the luminaire is mounted 24 feet or less above the ground, to be controlled with automatic lighting controls that are capable of reducing lighting power between 40 percent and 90 percent when the area is vacated of occupants. Certain exceptions apply based on area type and wattage,

2.4.2 Relationship to Other Title 24 Requirements

There is no direct relationship between the existing or proposed standard to other Title 24 requirements.

2.4.3 Relationship to Federal Laws

There are no federal standards related to outdoor lighting controls.

2.4.4 Relationship to Industry Standards

ASHRAE 90.1, Section 9.4.1.4-2016 specifies that lighting for exterior applications that is not building façade, landscape lighting, or exempted (emergency lighting, lighting required by health or safety statute, or decorative gas lighting systems), shall be controlled by a device that automatically reduces the connected lighting power by at least 50 percent during any period when no activity has been detected for a time of no longer than 15 minutes. ASHRAE 90.1-2106 specifies that outdoor parking area luminaires greater than 78 watts and a mounting height of 24 feet or less above the ground shall be controlled to automatically reduce the power of each luminaire by a minimum of 50 percent when no activity has been detected in the area illuminated by the controlled luminaires for a time of no longer than 15 minutes.

2.5 Compliance and Enforcement

The Statewide CASE Team collected input on what compliance and enforcement issues may be associated with this measure during the stakeholder outreach process. This section summarizes how the proposed code change will modify the code compliance process. Appendix B presents a detailed description of how the proposed code changes could impact various market actors. When developing this proposal, the Statewide CASE Team considered methods to streamline the compliance and enforcement process and how negative impacts on market actors who are involved in the process could be mitigated or reduced.

Considering that occupancy-based control requirements already exist for outdoor lighting, the proposed reduction of wattage threshold should have little effect on compliance and enforcement. However, including schedules of occupancy-based controls requires a new acceptance testing procedure. When scheduled operating hours are known for a space, the acceptance tests shall confirm the time schedules are correctly applied. When scheduled operating hours are not known, acceptance tests shall be conducted using a default normally occupied scheduled period of 6 am to midnight and a default normally unoccupied scheduled period of midnight to 6 am. By using this default unoccupied schedule of midnight to 6 am, half of the nighttime hours are at reduced power consumption. Once there are occupants, operators can define their normal business hours and after hour times as is best appropriate for their space.

3. MARKET ANALYSIS

The Statewide CASE Team performed a market analysis with the goals of identifying current technology availability, current product availability, and market trends. The Statewide CASE Team considered how the proposed standard may impact the market in general and individual market actors. The Statewide CASE Team gathered information about the incremental cost of complying with the proposed measure. Estimates of market size and measure applicability were identified through research and outreach with stakeholders including utility program staff, Energy Commission staff, and a wide range of industry players who were invited to participate in Utility-Sponsored Stakeholder Meetings held on September 8, 2016 and March 30, 2017.

3.1 Market Structure

The market for motion sensor controls for electric lighting is well established with multiple manufacturers that offer products designed for outdoor use with various technologies, such as passive infrared (PIR) and microwave. Motion sensor controls can be integrated into the luminaire or mounted remotely away from the light source. Because motion sensors are already required on pole-mounted luminaires greater than 75 watts, the market will be able to provide for the additional sensors required by the proposed code.

As outdoor light sources continue to shift to LED and improve in efficacy, it is expected that a growing number of fixtures will meet the 75-watt exemption. In effect, the outdoor controls requirements will have diminishing impacts, because more and more systems will be exempt from the control requirements.

The Statewide CASE Team assumed the maximum lumen output that would be installed on a 24-foot pole to be 15,000 lumens.[3] Searching the DesignLights Consortium qualified products list (QPL) for outdoor luminaires less than or equal to 15,000 lumens revealed that 48 percent of pole-mounted products at this light output level or lower are rated at 75 watts or less. This indicates that many products that are currently available are exempt from the Title 24, Part 6 outdoor controls requirement, because they fall below the 75-watt exemption threshold. Reducing the exemption of pole-mounted luminaires from 75 watts to 30 watts covers an additional 42 percent of luminaires designed for mounting 24 feet or less above the ground.

If the wattage threshold is revised, as recommended, a larger portion of lighting systems will be required to meet the lighting control requirements. See Table 3 for a summary of products in the DLC QPL that are rated at 75 watts or below and 30 watts and below.

[3] Based on Statewide CASE Team experience.

Table 3: Number of Products Found on the DLC QPL That are Above and Below the Current Wattage Exemption for Occupancy-Based Controls.

Pole Mounted LED Luminaires ≤15,000 Lumens on DLC QPL		
Watts	**# of Products on DLC QPL[1]**	**Percentage**
≤75	20,514	48%
>75	21,856	52%
Total	42,370	100%

1. DLC QPL query made on March 8, 2017.

3.2 Technical Feasibility, Market Availability, and Current Practices

Occupancy sensors are becoming more common on LED luminaires mounted 24 feet or less as they are required by code in new installations. Because occupancy sensors are already required on luminaires mounted 24 feet or less and greater than 75 watts, it is technically feasible to control luminaires greater than 30 watts.

There are products on the market that offer multiple levels of occupancy-based dimming by schedule, but are often offered as part of a wireless network control system. The Statewide CASE Team considered requiring the tri-level controls as described in Section 130.2(c)2Cii, but feedback from stakeholders recommended making this an option for those operators that would like to be code compliant with a stand-alone system.

3.3 Market Impacts and Economic Assessments

3.3.1 Impact on Builders

It is expected that builders will not be impacted significantly by any one proposed code change or the collective effect of all the proposed changes to Title 24, Part 6. Builders could be impacted for change in demand for new buildings and by construction costs, but demand for new buildings is driven more by factors such as the overall health of the economy and population growth than the cost of construction. The cost of complying with Title 24, Part 6 requirements represents a very small portion of the total building value. Increasing the building cost by a fraction of a percent is not expected to have a significant impact on demand for new buildings or the builders' profits.

Market actors will need to invest in training and education to ensure the workforce, including designers and those working in construction trades, know how to comply with the proposed requirements. Workforce training is not unique to the building industry, and is common in many fields associated with the production of goods and services. Costs associated with workforce training are typically accounted for in long-term financial planning and spread out across the unit price of many units as to avoid price spikes when changes in designs and/or processes are implemented.

The proposed code change is not expected to have a significant impact on builders. Controls systems commonly installed in other outdoor lighting projects will now also be required for additional luminaires.

3.3.2 Impact on Building Designers and Energy Consultants

Adjusting design practices to comply with changing building codes practices is within the normal practices of building designers. Building codes (including the California Building code and model national building codes published by the International Code Council, the International Association of

Plumbing and Mechanical Officials and ASHRAE 90.) are typically updated on a three-year revision cycle. As discussed in Section 3.3.1 all market actors, including building designers and energy consultants, should (and do) plan for training and education that may be required to adjust design practices to accommodate compliance with new building codes. As a whole, the measures the Statewide CASE Team is proposing for the 2019 code cycle aim to provide designers and energy consultants with opportunities to comply with code requirements in multiple ways, thereby providing flexibility in requirements can be met.

Building designers will need to incorporate control design into the construction of a larger subset of outdoor lighting applications. However, this is not expected to be overly cumbersome from a design standpoint – particularly the integrated-fixture approach, which will require very little additional expertise for building designers.

3.3.3 Impact on Occupational Safety and Health

The proposed code change does not alter any existing federal, state, or local regulations pertaining to safety and health, including rules enforced by the California Department of Occupational Safety and Health (Cal/OSHA). All existing health and safety rules will remain in place. Complying with the proposed code change is not anticipated to have adverse impacts on the safety or health of occupants, or those involved with the construction, commissioning, and maintenance of the building.

There has been some discussion with stakeholders about the potential implications for safety at the sites covered by this proposal. Stakeholders and manufacturer contacts have suggested that because light levels will instantly increase whenever motion is detected on the premises, the measure may increase safety and awareness of occupants and workers in these facilities. The controls will dim lights with the ability to ramp up should motion be detected, which can be a valuable safety feature, where increased light levels can draw attention to the presence of other occupants in the area.

3.3.4 Impact on Building Owners and Occupants

Building owners and occupants will benefit from lower energy bills. As discussed in Section 3.4.1, when building occupants save on energy bills, they tend to spend it elsewhere in the economy thereby creating jobs and economic growth for the California economy. Energy cost savings can be particularly beneficial to low income homeowners who typically spend a higher portion of their income on energy bills, often have trouble paying energy bills, and sometimes go without food or medical care to save money for energy bills (Association, National Energy Assistance Directors 2011).

Because this proposed measure has been found to be cost-effective, the building owners are reducing their energy costs more than their mortgage costs are increased because of this measure (i.e. they experience net cost savings). For building occupants that are paying for their energy bills, since the measure saves more energy cost on a monthly basis than the measure costs on the mortgage as experienced by the building owner, the pass-through of added mortgage costs into rents is less than the energy cost savings experienced by occupants.

3.3.5 Impact on Building Component Retailers (Including Manufacturers and Distributors)

Building component retailers will need to consider the increased demand for control systems due to this measure.

3.3.6 Impact on Building Inspectors

Because this measure proposes a reduced wattage threshold and no change in technology, building inspectors will be inspecting the same equipment as previously existed in code. As compared to the overall code enforcement effort, this measure has negligible impact on the effort required to enforce the building codes.

3.3.7 Impact on Statewide Employment

Section 3.4.1 discusses statewide job creation from the energy efficiency sector in general, including updates to Title 24, Part 6. The proposed code change is expected to have a small positive impact on statewide employment.

3.4 Economic Impacts

3.4.1 Creation or Elimination of Jobs

In 2015, California's building energy efficiency industry employed more than 321,000 workers who worked at least part time or a fraction of their time on activities related to building efficiency. Employment in the building energy efficiency industry grew six percent between 2014 and 2015 while the overall statewide employment grew three percent (BW Research Partnership, 2016). Lawrence Berkeley National Laboratory's 2010 *Characterizing the Energy Efficiency Services Sector* report provides a detail on the types of jobs in the energy efficiency sector that are likely to be supported by revisions to building codes.

Building codes that reduce energy consumption provide jobs through *direct employment, indirect employment,* and *induced employment.*[4] Title 24, Part 6 creates jobs in all three categories with a significant amount created from induced employment, which accounts for the expenditure-induced effects in the general economy due to the economic activity and spending of direct and indirect employees (e.g., non-industry jobs created such as teachers, grocery store clerks, and postal workers). A large portion of the induced jobs from energy efficiency are the jobs created by the energy cost savings due to the energy efficiency measures. Wei et al. (2010) estimates that energy efficiency creates 0.17 to 0.59 net job-years[5] per GWh saved (Wei, Patadia, & Kammen, 2010). By comparison, they estimate that the coal and natural gas industries create 0.11 net job-years per GWh produced. Using the mid-point for the energy efficiency range (0.38 net job-years per GWh saved) and estimates that this proposed code change will result in a statewide first-year savings of 10.5 GWh, this measure will result in approximately 4 jobs created per first year. See Section 6 for statewide savings estimates.

3.4.2 Creation or Elimination of Businesses within California

There are approximately 43,000 businesses that play a role in California's advanced energy economy (BW Research Partnership, 2016). California's clean economy grew 10 times more than the total state economy between 2002 and 2012 (20 percent compared to 2 percent). The energy efficiency industry, which is driven in part by recurrent updates to the building code, is the largest component of the core clean economy (Ettenson & Heavey, 2015). Adopting cost-effective code changes for the 2019 Title 24, Part 6 code cycle will help maintain the energy efficiency industry.

Table 4 lists industries that will likely benefit from the proposed code change classified by their North American Industry Classification System (NAICS) Code.

[4] The definitions of direct, indirect, and induced jobs vary widely by study. Wei et al (2010) describes the definitions and usage of these categories as follows: "Direct employment includes those jobs created in the design, manufacturing, delivery, construction/installation, project management and operation and maintenance of the different components of the technology, or power plant, under consideration. Indirect employment refers to the ''supplier effect'' of upstream and downstream suppliers. For example, the task of installing wind turbines is a direct job, whereas manufacturing the steel that is used to build the wind turbine is an indirect job. Induced employment accounts for the expenditure-induced effects in the general economy due to the economic activity and spending of direct and indirect employees, e.g. non industry jobs created such as teachers, grocery store clerks, and postal workers."

[5] One job-year (or ''full-time equivalent'' FTE job) is full time employment for one person for a duration of one year.

Table 4: Industries Receiving Energy Efficiency Related Investment, by North American Industry Classification System (NAICS) Code

Industry	NAICS Code
Nonresidential Building Construction	2362
Electrical Contractors	23821
Manufacturing	32412
Other Nonmetallic Mineral Product Manufacturing	3279
Electric Lighting Equipment Manufacturing	3351
Engineering Services	541330
Building Inspection Services	541350
Environmental Consulting Services	541620
Other Scientific and Technical Consulting Services	541690

3.4.3 Competitive Advantages or Disadvantages for Businesses Within California

In 2014, California's electricity statewide costs were 1.7 percent of the state's gross domestic product (GPD) while electricity costs in the rest of the United States were 2.4 percent of GDP (Thornberg, Chong, & Fowler, 2016). As a result of spending a smaller portion of overall GDP on electricity relative to other states, Californians and California businesses save billions of dollars in energy costs per year relative to businesses located elsewhere. Money saved on energy costs can otherwise be invested, which provides California businesses with an advantage that will only be strengthened by the adoption of the proposed codes changes that impact nonresidential buildings.

3.4.4 Increase or Decrease of Investments in the State of California

The proposed changes to the building code are not expected to impact investments in California on a macroeconomic scale, nor are they expected to affect investments by individual firms. The allocation of resources for the production of goods in California is not expected to change as a result of this code change proposal.

3.4.5 Effects on Innovation in Products, Materials, or Processes

The proposed code changes are not expected to have a significant impact on the California's General Fund, any state special funds, or local government funds. Revenue to these funds comes from taxes levied. The most relevant taxes to consider for this proposed code change are: personal income taxes, corporation taxes, sales and use taxes, and property taxes. The proposed changes for the 2019 Title 24, Part 6 Standards are not expected to result in noteworthy changes to personal or corporate income, so the revenue from personal income taxes or corporate taxes is not expected to change. As discussed, reductions in energy expenditures are expected to increase discretionary income. State and local sales tax revenues may increase if building occupants spend their additional discretionary income on taxable items. Although logic indicates there may be changes to sales tax revenue, the impacts that are directly related to revisions to Title 24, Part 6 have not been quantified. Finally, revenue generated from property taxes is directly linked to the value of the property, which is usually linked to the purchase price of the property. The proposed changes will increase construction costs. As discussed in Section 3.3.1, however, there is no statistical evidence that Title 24, Part 6 drives construction costs or that construction costs have a significant impact on home price. Since compliance with Title 24, Part 6 does not have a clear impact on purchase price, it can follow that Title 24, Part 6 cannot be shown to impact revenues from property taxes.

This proposal has the net effect of increasing the wealth of the State of California as the increased cost of construction is offset by reduced electricity consumption of lighting systems. This proposal has an average B/C ratio of 2.2:1 across space various space types. As a result, two times more energy cost savings are returned to California than was expended, including the cost of capital. Thus, everything

else being equal, companies are more profitable, which results in more taxes being paid to state and local government.

3.4.6 Effects on the State General Fund, State Special Funds, and Local Governments

The Statewide CASE Team expects positive overall impacts on state and local government revenues due to higher GSP and commercial enterprise profit margins resulting in higher tax revenues, as noted earlier. Higher property valuations due to energy efficiency enhancements may also result in positive local property tax revenues. The Statewide CASE Team has not obtained specific data to quantify potential revenue benefits for this measure.

3.4.6.1 Cost of Enforcement

Cost to the State

State government already has budget for code development, education, and compliance enforcement. While state government will be allocating resources to update the Title 24, Part 6 Standards, including updating education and compliance materials and responding to questions about the revised requirements, these activities are already covered by existing state budgets. The costs to state government are small when compared to the overall costs savings and policy benefits associated with the code change proposals. While the proposed code changes may impact state buildings, the measures are cost-effective and will reduce energy costs over the life of the project.

Cost to Local Governments

All revisions to Title 24, Part 6 will result in changes to compliance determinations. Local governments will need to train building department staff on the revised Title 24, Part 6 Standards. While this re-training is an expense to local governments, it is not a new cost associated with the 2019 code change cycle. The building code is updated on a triennial basis, and local governments plan and budget for retraining every time the code is updated. There are numerous resources available to local governments to support compliance training that can help mitigate the cost of retraining, including tools, training, and resources provided by the IOU codes and standards program (such as, Energy Code Ace). As noted in Section 2.5 and Appendix B, the Statewide CASE Team considered how the proposed code change might impact various market actors involved in the compliance and enforcement process and aimed to minimize negative impacts on local governments.

3.4.6.2 Impacts on Specific Persons

The proposed changes to Title 24, Part 6 are not expected to have a differential impact on any groups relative to the state population as a whole, including migrant workers, commuters or persons by age, race or religion. Given construction costs are not well correlated with building prices, the proposed code changes are not expected to have an impact on financing costs for business or home-buyers.

Renters will typically benefit from lower energy bills if they pay energy bills directly. These savings should more than offset any capital costs passed-through from landlords. Renters who do not pay directly for energy costs may see some of the net savings depending on if and how landlords account for energy cost when determining rent prices.

4. ENERGY SAVINGS

4.1 Key Assumptions for Energy Savings Analysis

4.1.1 Scheduling Controls with Multiple Light Output Choices

This proposal requires the capability for multiple circuits or dimming according to a time schedule, and removes the limitation of all-on or all-off control, so the building operator can control lighting power after-hours without leaving the space entirely dark. In most cases, this does not substantively change the requirements. Under this proposal, part-night controls would continue to comply, as would the occupancy-based, bi-level controls specified by the current standard. Central time-switch controls, if they had at least two separately controlled channels, would also comply.

This proposal would require that a time-clock control at least half of lighting power after-hours as confirmed by an acceptance test, whereas the current code only requires the capability to control at least half of the lighting power. Under this proposal, the building owner can define their normally occupied hours as being all night. However, if the responsible party for the building does not declare a schedule, at least 50 percent of these lights would be required to be turned off between midnight and 6:00 am.

Scheduling controls with multiple light output choices applies to both §130.2(c) 2 and §130.2(c) 3, thus it applies to all outdoor lighting.

Section §130.2(c) 3 applies to all the luminaires that are not covered by Section 130.2(c)2. This includes hardscape lighting mounted at heights greater than 24 feet, or less than 30 watts, and all the various types of application specific lighting. Two choices are available: scheduling controls capable of reducing power between 50 and 90 percent or a motion control that reduces lighting power between 50 and 90 percent. However, in many cases the motion control is not a feasible option:

- On tall poles, the detection range is not wide enough to provide sufficient coverage
- For façade or outdoor dining lighting, one does not want to lights to be modulating depending upon activity

The 2016 Title 24 outdoor lighting controls standard only requires a central time clock that can reduce lighting power by at least 50 percent. From conversations with designers, utility representatives, and others, the consensus is that lights are left on at night unless one can turn off some of the lights. For this analysis, the Statewide CASE Team assumes that if a facility has only one scheduling circuit, there is a 50 percent chance they will not turn off their lights in the middle of the night. If they already have more than one circuit, conservatively, they do not have additional costs or savings. The Statewide CASE Team assumes for those building operators that turn off all their lights with one circuit, that they will also turn off all the lights with two circuits.

A similar logic model applies to operators of outdoor lighting with a time-clock and motion controls. The operator has even less incentive to turn off some of the lights if they have only one time clock circuit. The energy penalty of leaving the lights on at night is much reduced if the lights will be dimmed when there is no occupancy. From discussion with manufacturers, the most common default dimmed level is 50 percent. Again, it is more likely that some of the lights might be turned off after-hours if the scheduling control has more than one control channel, and more than one controlled power wire to the luminaires.

4.1.2 Decrease Lighting Power Threshold for Bi-Level Motion Controlled Lighting

The energy savings potential from a schedule and occupancy-based control measure is dependent on the following key assumptions:

- The base case.
- Occupancy patterns of the space types in question, in terms of frequency and duration of occupancy.
- Bi-level scheduling: amount of time luminaires are scheduled for normal operating hours, and after-hours schedule.
- Level of dimming.
- Total installed wattage in California.
- Number of outdoor luminaires installed in California mounted 24 feet or less.

The Base Case

The energy savings analysis for the reduction of the wattage based exemption is performed against a base case that assumes that all pole-mounted luminaires between 30 and 75 watts mounted 24 feet or less above the ground are effectively controlled only by a photocell that turns the lights on 30 minutes before sunrise and turns the lights off 30 minutes after sunset. This means that all lighting in the base case are on at 100 percent light levels and power throughout the night.

The Statewide CASE Team used 31 watts as a baseline for the per unit savings calculations as this is the most conservative savings assumption (i.e., controlling 31 watt luminaires with bi-level controls will result in less energy savings than 75 watt luminaires). Luminaires 30 watts and less are exempted from the proposed code requirements.

Additionally, the energy consumption of both the base case and the standards case are calculated from unweighted averages of the length of night in each of the different 16 climate zones in California. The length of nighttime was calculated using the latitude and longitude of the reference cities found in Appendix C.

Occupancy Patterns

The Statewide CASE Team relied on three primary sources of occupancy data as inputs to the model to calculate savings from occupancy-based controls. The Western Exterior Occupancy Survey (WEOS) for Exterior Adaptive Lighting Applications (phase 2 performed by the California Lighting Technology Center (CLTC) for Pacific Gas & Electric, Southern California Edison, and Bonneville Power Administration in 2014), the Energy Technology Assistance Program (ETAP) performed by Energy Solutions for the Energy Commission from 2010 to 2012, and the 2016 CASE Report statistically modeled data for auto sales lots and gas stations.

The WEOS study surveyed eight sites that employ outdoor lighting to establish occupancy profiles to represent pedestrian and vehicular traffic. Occupancy data was collected with Passive Infrared (PIR) motion sensors strategically placed throughout each site to capture representative occupancy patterns. Each time the PIR motion sensors detected motion, they communicated with a receiver, which would tally the number of times motion was detected. Receivers collected data from one to three sensors.

Output data was compiled to report results in five minute intervals indicating the number of times each sensor detected motion. Each 5-minute interval that recorded no motion was deemed a period of vacancy. By dividing the time stamps into day and night, occupancy patterns could be established to assume the amount of time a bi-level luminaire would spend in high (occupied) and low (vacant) mode.

The Statewide CASE Team analyzed the raw WEOS data and split the time-stamped logs into two time periods: 6:00pm to midnight, and midnight to 6:00am. Table 5 reports the average amount of time each receiver went without being triggered by occupancy. This is assumed to be the amount of time a luminaire would be in low mode. The alternative calculation method used in the WEOS study, termed absolute method, overestimates occupancy and underestimates motion sensing savings by grouping sensors. In other words, occupancy for the entire site was recorded when any single sensor would detect motion. In a real-life setting, only the luminaire that sensed occupancy would be triggered to enter high output mode.

Similarly, ETAP was an emerging technology program implemented from 2010-2012 that installed and monitored bi-level, occupancy-based controls on outdoor lighting. Three of the parking lot ETAP projects performed verification studies on the pole-mounted installations by installing light loggers on representative luminaires and monitoring light levels. This CASE Report uses occupancy data from those three ETAP Projects: Walnut Creek Recreational Parks, Placerville Government Center, and the Pittsburg Health Center. A summary of the ETAP space types, descriptions, and occupancy data can be seen in Table 6.

Finally, the Statewide CASE Team included the statistically modeled occupancy data developed for the 2016 CASE Report for auto sales lots and gas stations. Again, the Statewide CASE Team split the time-stamped data into two time periods: 6:00pm to midnight, and midnight to 6:00am, and reported the modeled occupancy in Table 7.

Table 5: Assumed Occupancy Rates at Night by Space Type in the WEOS Study

Space Type	Site Description	Average Proportion of Five Minute Increments When No Motion Was Detected	
		6:00pm to Midnight	Midnight to 6:00am
Retail Building Supply Franchise	9-acre typical retail location of a building supply franchise in a suburb of a city of 30,000 people.	61%	96%
Big Box Retail (24hr)	20-acre premises include a single building housing retail operations, large parking lot, small auxiliary parking lots, loading docks, roadways around the building perimeter and pedestrian pathways.	55%	80%
Outdoor Shopping Center	Site consists of 164 stores and service providers, parking garage, roadway, and central pedestrian walkway between storefronts.	33%	76%
Fast Food Restaurant (24hr)	1-acre premises including restaurant structure, drive-through window, and a small parking lot.	43%[1]	43%[1]
K-12 School	40-acre site includes several building structures, sports fields, and parking lot.	81%	99%
Large Office Building	15-acre municipal facility with one larger complex, a second smaller complex, and two large parking lots.	93%	96%
Office Campus	60-acre premises including office buildings and parking lots.	91%	96%
Medium Office Building	6-acre site includes office building and parking lots.	85%	97%

1. Raw data was not available, so the Statewide CASE Team used the WEOS published average nighttime data for the Fast Food space type in both time periods.

Table 6: Assumed Occupancy Rates at Night by Space Type in the Three ETAP Projects

Space Type	Site Description	Average Amount of Time Monitored Luminaires Were in Low Mode	
		6:00pm to Midnight	Midnight to 6:00am
Recreational Parks	Walnut Creek's recreational parks include San Miguel Park, Heather Farms Park, and Civic Park.	95%	99%
Government Center	The Placerville Government center is comprised of El Dorado county facilities, which include 70 pole-mounted LEDs with bi-level controls.	93%	96%
Health Center	Pittsburg Health Center's 120,000 square foot parking lot in Contra Costa County includes approximately 180 parking spaces illuminated by 57 pole-mounted fixtures.	84%	89%

Table 7: Assumed Occupancy Rates at Night by Space Type in the 2016 CASE Report

Space Type	Prototype Site Description	Average Amount of Time Luminaires Were Modeled to be in Low Mode	
		6:00pm to Midnight	Midnight to 6:00am
Auto Sales Lot	An uncovered paved area used exclusively for the display of vehicles, equipment or other merchandise for sale.	55%	84%
Gas Station	A canopied, paved area used for servicing motor vehicles especially with gasoline and oil.	29%	55%

Bi-Level Scheduling

Scheduling exterior lighting and occupancy-based controls by normally occupied hours and after-hour periods can influence savings over a single scheduling period; the normally unoccupied time of midnight to 6:00am consistently has lower occupancy rates than the normally occupied time of 6:00pm to midnight. Normally occupied hours are not necessarily the same as business hours, but include times of day that occupants are regularly present. The after-hours schedule includes times when the space is expected to have very few regular occupants. As proposed, the individual building owner/operator has the ability to set the schedule for the site's unique needs. Controls must be capable of providing this feature (two different operating schedules and lighting strategies), but scheduling this way is not required. Because the site designer or building operator can schedule the lighting system to run on the "normally occupied hours" schedule for the entire night, the same was done for the savings analysis, as it is the most energy consumptive (and therefore most conservative) scenario. The Statewide CASE Team assumed the normally occupied schedule to be 6:00pm to 6:00am for each space type and used the higher occupancy rates in the analysis.

Level of Dimming

The level of dimming was assumed to be the highest (most energy consumptive) allowed by the proposed code change, as shown in Table 8. This level is full light output when motion is detected with a time delay of five minutes, and 50 percent dimming when no motion is detected.

Table 8: Savings Analysis Assumes the Highest Level of Dimming Allowed by Proposed Code

Automatic Scheduling Control	Occupancy-Based Controls	
	Occupied	Vacant
Normally Occupied	ON; 0% dimming	50% dimming

4.2 Energy Savings Methodology

To assess the energy, demand, and energy cost impacts, the Statewide CASE Team compared current design practices to design practices that would comply with the proposed requirements.

The proposed conditions are defined as the design conditions that will comply with the proposed code change. Specifically, for this analysis, the proposed condition assumes that fixture-integrated occupancy-based control systems are installed on outdoor luminaires greater than 30 watts. The proposed conditions assume that during normally scheduled operating hours, the controls ramp up lights to full power when occupants are present, and then ramp down fixture power to 50 percent after vacancy is detected.

Using estimates of the distribution of luminaire wattages, the Statewide CASE Team can calculate the energy savings from each wattage bin that will experience savings from occupancy-based controls. Since this measure is not climate sensitive, it is not necessary to model savings in every climate zone and statewide average time dependent valuation (TDV) factors were used in the energy and cost analysis. Energy savings, energy cost savings, and peak demand reductions were calculated using a TDV methodology.

4.3 Per-Unit Energy Impacts Results

The energy savings are calculated for the smallest amount of controlled lighting power to illustrate wattage or number of luminaire thresholds. Thus, the energy savings calculated here are for the following proposed minimum thresholds:

- Lighting systems with more than 4 luminaires shall be capable of reducing lighting power by least 50 percent, but not exceeding 90 percent
- Luminaires greater than 30 Watts and mounted less than 24 feet above grade shall be controlled by motion sensors that reduce power of each luminaire by at least 50 percent but not exceeding 90 percent when no activity is sensed during normally occupied hours and further reduce lighting power during unoccupied hours by turning some of the lights off or the motion sensor turns the lights off or dims them further when no activity is sensed.

Per luminaire energy and demand impacts of the proposed measures are presented in Table 12. Per square foot energy and demand impacts are presented in which is calculated by averaging the total savings in each space type and dividing by the square footage impacted by code.

4.3.1 Per-Unit Energy Savings from Multi-Level Scheduling Controls: Wall-mounted luminaire scenario

The Statewide CASE Team has prepared a scenario to describe the savings associated with adding multi-level control capability to time clock controlled luminaires. A summary of assumptions for this scenario can be seen in Table 9.

Table 9: Costs and Inputs for Wall-mounted Luminaires Scheduling Controls Savings and Cost-effectiveness Calculation

Assumption	Value[6]
#12 THHN[7] wire (Installed cost)	$0.53 per linear foot
4-channel time-clock	$160
Cost per time-clock channel	$40
Number of luminaires	4
Typical wall mounted luminaire power	35 watts
Distance from time-clock to first luminaire	20 feet
Distance between luminaires	35 feet
Probability lights are not controlled	50%
Reduced full load hours per year	2,130

The geometry of this scenario was developed from an interview with a lighting designer and electrical engineer at Clanton & Associates. A typical scenario for wall mounted luminaires is that they are positioned 35 feet apart with the first luminaire located approximately 30 feet from the timeclock. The additional control channel would be added to the timeclock and an additional controlled hot lead would be by-passing half of the luminaires so it could be controlled at different times. This had no added expense for conduit, neutrals or grounds, or wiring of luminaires. If an extra conductor (wire) was required to by-pass the first two luminaires, the total length of the extra conductor would be 30 + 35 + 35 = 90 lineal feet. From the 2015 RS Means pricing catalogue, the installed cost of #12 conductors is $0.53/lineal ft. This is a conservative value given this wire is being pulled with other conductors and from a review of on-line costs for wire, we found that #12-gauge wire was selling for $0.18/lineal ft. so this RS Means estimate has a $0.35/lineal ft. adder for labor and mark-up. From this, the additional installed cost for 90 feet of 12-gauge wire would be $47.70. The cost for a 4-channel timeclock is $160, so the cost per channel is $40. Thus, the total incremental cost is $87.70 for the extra channel and wiring. In many cases the default timeclock is a 4-channel version that already has a couple circuits filled for signage, parking lot lighting and building exterior lighting. Assuming four 35 watt luminaires combined with a 50 percent chance that the lights are not already controls produces 70 watts of lighting being controlled between midnight and 6 am that would result in a reduction of 2,130 full load hours. This scenario includes the assumed operation of the daylight control, that lights are turned on 30 minutes before sunset and 30 minutes after sunrise.

Considering these four luminaires are 35 Watts each, we are assuming there is a 50% chance of having half of the luminaires or 70 Watts being controlled between midnight and 6 am. This 50% probability assumes that the other 50 percent of the time occupants are either willing to turn all their lights off after hours without the additional control channel or for some building operators when an additional control channel is available, they may still not take advantage of the energy savings opportunity. This multi-level scheduling control would result in a reduction in 2,130 full load hours. This includes the assumed operation of the daylight control that lights are turned on 30 minutes before sunset and 30 minutes after sunrise. Sometimes the sun has already risen before 6 am; and explains why reduced hours of operation for half the luminaires are not 6 x 365 = 2,190 hr/yr. The estimated savings, ES are:

ES = Controlled Watts x Probability of Control x Full Load Hour Reduction x Conversion [kW/W].

[6] Costs gathered from 2015 RS Means pricing catalogue

[7] Thermoplastic High Heat-resistant Nylon-coated (THHN) Wire

ES = (70 W) x (0.5) x (2,130 h/yr) x (0.001 kW/W) = **75 kWh/yr**.

After conducting a calculation for each hour of the year and multiplying by the Time Dependent Valuation (TDV) Factors, the present valued savings for the change in schedule for each watt of connected load is PV$2.14 or PV$1.99/kWh or a first year's effective energy rate of $0.18/kWh.

The present valued energy cost savings (ECS) are:

ECS = *(ES) x (PV$/kWh)*

ECS = (75 kWh/yr) x (PV$2.14/kWh) = **$160**

The benefit/cost (B/C) ratio is the energy cost savings divided by the incremental cost:

B/C ratio = $251 / $87.70 = **1.82**

Thus, the extra wire and control channel is cost-effective for this situation. With more luminaires energy benefit of the control increases faster than the incremental cost and thus the measure is more cost-effective for larger systems.

4.3.2 Per-Unit Energy Savings from Multi-Level Scheduling Controls: Pole-mounted luminaire scenario

A more stringent cost-effectiveness comparison is one where short pole-mounted luminaires are being controlled by occupancy-based controls in addition to the time clock control as is required by Section 130.2(c)2. The Statewide CASE Team has prepared another scenario to describe the savings associated with the proposed code change for luminaires mounted less than 24 feet in a parking lot. A summary of assumptions for this scenario can be seen in Table 10.

Table 10: Short Parking Lot Poles Scheduling Controls Savings Scenario Assumptions

Assumption	**Value[6]**
#10 THHN wire (Installed cost)	$0.65 per linear ft[6]
4-channel time-clock	$160[6]
Cost per time-clock channel	$40[6]
Number of luminaires	4
Typical pole-mounted luminaire power	55 watts
Distance from time-clock to first luminaire	50 ft.
Probability lights are not controlled	50%
Full load hours per year	4,745

The savings associated with the time clock in this scenario are reduced due to interaction effects with the motion control: the full load hours of savings due to the scheduling control are reduced because the motion control reduces energy consumption, especially late at night when the space is vacant. This scenario assumes that the lights are at full power when occupancy is sensed and declines to 50 percent when no activity is detected. During the normally occupied hours from 6 am to midnight, on average 70 percent of the time activity is sensed. From midnight to 6 am, there is approximately 10 percent of the time activity is sensed. If higher levels of nighttime occupancy are assumed, the savings and the cost-effectiveness would be higher.

For these short (24 feet and less) pole mounted parking lot luminaires, the Statewide CASE Team is projecting a 2 x 2 grid of four luminaires on a 60-foot by 60-foot spacing. The first luminaire is 50 feet from the time clock. This scenario assumes a typical fixture power of 55-watt luminaires on poles less than 24 feet (resulting in lighting power density of 0.02 W/sf or around 80 percent of the area wattage allowance for Lighting Zone 3).

To conservatively price this scenario high, 10-gauge wire was specified, even though the total power draw for this scenario is only 220 watts. This scenario only needs to account for extra wire to the first luminaire, as the first and second control channels can go in separate directions after the first luminaire, the added conductor is not required after the first luminaire for a 2 x 2 grid layout. The additional installed cost for 50 feet of 10-gauge wire would be $32.50 plus the extra $40 for the time clock channel, which results in a total incremental cost of $72.50. For half of the four luminaires that 55 watts each, a total of 110 Watts has a 50 percent chance that these luminaires are not already controlled or won't be controlled with the added control channel. After accounting for the presence of motion controls, the scenario results in an additional reduction of 1,172 full load hours for these two luminaires that could be turned off. This includes the assumed operation of the daylight control, that lights are turned on 30 minutes before sunset and 30 minutes after sunrise.

Additional calculations can be seen in Appendix C, Table 39.

The estimated savings (ES) from the pole-mounted scenario described in section 4.1.2 are:

ES = Controlled Watts x Probability of Control x Full Load Hour Reduction x Conversion [kW/W].

ES = (110) x (0.5) x (1,172) x (0.001) = **64 kWh/yr**

After conducting a calculation for each hour of the year and multiplying by the Time Dependent Valuation Factors, the present valued savings kWh/yr saved is PV$2.14/kWh.

The present valued energy cost savings (ECS) are:

ECS = (*ES) x (PV$/kWh)*

ECS = 64 kWh/yr x PV$2.14/kWh = **$138**

The benefit/cost (B/C) ratio is the energy cost savings divided by the incremental cost:

B/C ratio = $138 / $72.50 = **2.76**

If the luminaires were not in a grid pattern but were in a linear pattern spaced 60 feet apart (worst case), this would add another 60 feet of wire, so the total cost would be $110, and the B/C ratio would be 1.25.

Table 11: Additional Energy Savings from Multi-level Scheduling Controls with

Scenario	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (W)	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)
Four 35 Watt Wall-mounted Luminaires	75	0	-	1,794
Four 55 Watt Pole-mounted Luminaires	64	0	-	1,550

There is no demand savings associated with this measure as the savings occurs during the midnight to 6 am time period which is not coincident with peak demand.

Given that most parking lot luminaires have a dimming driver at no incremental cost, it will be increasingly cost-effective to replace relay control of power wiring with low voltage control cable to the luminaires and change the dimming levels for different scheduled periods. This proposal will allow changing the dimming level when no occupancy is detected, as an alternate approach towards compliance with timeclock plus bi-level motion controlled lighting.

4.3.3 Decrease Lighting Power Threshold for Bi-Level Motion Controlled Lighting

Per unit savings for decreasing the lighting power threshold for bi-level motion controlled lighting in the first year are expected to range from 31 to 71 kilowatt-hours per year (kWh/yr), depending on space type and occupancy rate. It is estimated that the per luminaire TDV electricity savings over the first year of the analysis will range from 793 kBtu to 1,880 kBtu. The TDV methodology allows peak electricity savings to be valued more than electricity savings during non-peak periods. Because this measure saves energy primarily at night (off peak), there are low peak savings attributed to this code change. Using the TDV method resulted in relatively low energy cost savings when compared to a measure that saves peak energy, based on the higher value given to peak energy in the TDV method.

Table 12: First-Year Energy Impacts Per 31 Watt Luminaire Resulting from of Decreasing Lighting Power Threshold for Bi-Level Motion Controlled Lighting

Space Type	Full load hour reductions	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (W)	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)
Retail Building Supply Franchise	1,871	58	2.7	-	1,494
Big Box Retail (24hr)	1,613	50	2.4	-	1,289
Outdoor Shopping Center	1,290	40	1.4	-	1,021
Fast Food Restaurant (24hr)	1,032	32	1.9	-	835
K-12 School	2,129	66	3.5	-	1,732
Large Office Building	2,226	69	4	-	1,833
Office Campus	2,226	69	4	-	1,812
Medium Office Building	2,161	67	3.7	-	1,757
Recreational Parks	2,290	71	4.1	-	1,880
Government Center	2,226	69	4	-	1,833
Health Center	2,065	64	3.7	-	1,676
Auto Sales Lot	1,645	51	2.4	-	1,324
Gas Station	1,000	31	1.3	-	793

Table 13: First-Year Energy Impacts Per Square Foot of Decreasing Lighting Power Threshold for Bi-Level Motion Controlled Lighting

Electricity Savings (kWh/yr) per ft^2	Peak Electricity Demand Reductions (W) per ft^2	Natural Gas Savings (therms/yr) per ft^2	TDV Energy Savings (TDV kBtu/yr) per ft^2
0.01	0.0005	-	0.24

5. LIFECYCLE COST AND COST-EFFECTIVENESS

5.1 Energy Cost Savings Methodology

TDV energy is a normalized format for comparing electricity and natural gas cost savings that takes into account the cost of electricity and natural gas consumed during each hour of the year. The TDV values are based on long term discounted costs (30 years for all residential measures and nonresidential envelope measures and 15 years for all other nonresidential measures). In this case, the period of analysis used is 15 years. The TDV cost impacts are presented in 2020 present valued dollars. The TDV energy estimates are based on present-valued cost savings but are normalized in terms of "TDV kBtu." Peak demand reductions are presented in peak power reductions (kW). The Energy Commission derived the 2020 TDV values that were used in the analyses for this report (Energy + Environmental Economics, 2016).

5.2 Energy Cost Savings Results

The TDV methodology allows peak electricity savings to be valued more than electricity savings during non-peak periods. Because outdoor lighting controls will reduce electricity consumption at night, the Statewide CASE Team expects less peak electricity savings to be experienced over traditional lighting measures. Peak electricity savings are calculated by multiplying the energy saved each hour of the year by the corresponding 15-year demand factor found in the 2019 TDV factors.

Table 14: Per Unit TDV Energy Cost Savings Over 15-Year Analysis Period of Scheduling Controls with Multiple Light Output Choices

Scenario	15-Year TDV Electricity Cost Savings (2020 PV $)	15-Year TDV Natural Gas Cost Savings (2020 PV $)	Total 15-Year TDV Energy Cost Savings (2020 PV $)
Four 35 Watt Wall-mounted Luminaires	$160	-	$160
Four 55 Watt Pole-mounted Luminaires	$138	-	$138

Table 15: TDV Energy Cost Savings per 31 Watt Luminaire Over 15-Year Analysis Period of Decreasing Lighting Power Threshold for Bi-Level Motion Controlled Lighting

Space Type	15-Year TDV Electricity Cost Savings (2020 PV $)	15-Year TDV Natural Gas Cost Savings (2020PV $)	Total 15-Year TDV Energy Cost Savings (2020PV $)
Retail Building Supply Franchise	$130	-	$130
Big Box Retail (24hr)	$113	-	$113
Outdoor Shopping Center	$87	-	$87
Fast Food Restaurant (24hr)	$74	-	$74
K-12 School	$153	-	$153
Large Office Building	$163	-	$163
Office Campus	$161	-	$161
Office Building B	$155	-	$155
Recreational Parks	$167	-	$167
Government Center	$163	-	$163
Health Center	$149	-	$149
Auto Sales Lot	$116	-	$116
Gas Station	$69	-	$69

5.3 Incremental First Cost

5.3.1 Multi-level Scheduling Controls

This proposal demonstrates, based on example scenarios, that when more than four luminaires are controlled it is cost-effective to have at least two control channels. The additional control channel would be added to the time clock, and an additional controlled hot lead would be bypassing half of the luminaires, so it could be controlled at different times. There is no added expense for conduit, neutrals or grounds or wiring of luminaires as this expense is the same in the base case without the additional control channel. From the 2015 RS Means pricing catalogue, the installed cost of #12 conductors is $0.53 per linear foot and the installed cost of #10 conductors is $0.65 per linear foot. This is a conservative value given these wires are being pulled with other conductors. Similarly, from a review of on-line costs for wire, it was found that #12 was selling for $0.18 per linear foot and #10 selling for $0.27 per linear foot. A cost for a 4-channel time clock is $160, so the cost per channel is $40.

5.3.2 Decrease Lighting Power Threshold for Occupancy Based, Bi-Level Lighting Controls

The Statewide CASE Team conducted outreach to manufacturers and distributors to obtain estimated incremental costs for compliance with this measure and arrived at an incremental cost of $50 per (on/off) sensor used with a high/low driver LED fixture from the original equipment manufacturer. The Statewide CASE Team was also advised by stakeholders to include distributor mark-ups (5 percent to 8 percent of OEM price) and contractor mark-ups (5 percent to 10 percent of OEM) in the cost to the end user. Accounting for the high estimates of these markups (8 percent for distributor mark-ups and 10 percent for contractor mark-ups), the final incremental cost of the sensor is $59.

The current incremental construction cost represents the incremental cost of the measure if a building just meeting the proposed standard if it were built today. The Post-Adoption Incremental Construction Cost represents the anticipated cost assuming full market penetration of the measure as a result of the new Standards, resulting in a possible reduction in unit costs as manufacturing practices improve over time and with increased production volume of qualifying products the year the Standard becomes effective. The Statewide CASE Team estimated the difference between the Current Incremental Construction Costs and Post-Adoption Incremental Construction Costs to be negligible.

Per the Energy Commission's guidance, design costs are not included in the incremental first cost.

5.4 Lifetime Incremental Maintenance Costs

Incremental maintenance cost is the incremental cost of replacing the equipment or parts of the equipment, as well as periodic maintenance required to keep the equipment operating relative to current practices over the period of analysis. The present value of equipment and maintenance costs (savings) was calculated using a three percent discount rate (d), which is consistent with the discount rate used when developing the 2019 TDV. The present value of maintenance costs that occurs in the nth year is calculated as follows (where d is the discount rate of three percent):

$$\text{Present Value of Maintenance Cost} = \text{Maintenance Cost} \times \left[\frac{1}{1+\text{d}}\right]^{\text{n}}$$

The Statewide CASE Team does not expect any incremental maintenance costs associated with this code change. If anything, dimming LED fixtures extends product life, so there is some chance the consumer will see longer fixture life (and therefore lower maintenance costs) as a result of this measure.

5.5 Lifecycle Cost-Effectiveness

This measure proposes a mandatory requirement. As such, a lifecycle cost analysis is required to demonstrate that the measure is cost-effective over the 15-year period of analysis.

The Energy Commission establishes the procedures for calculating lifecycle cost-effectiveness. The Statewide CASE Team collaborated with Energy Commission staff to confirm that the methodology described in this report is consistent with their guidelines, including which costs were included in the analysis. In this case, incremental first cost and incremental maintenance costs over the 15-year period of analysis were included. The TDV energy cost savings from electricity savings were also included in the evaluation.

Design costs were not included nor was the incremental cost of code compliance verification.

According to the Energy Commission's definitions, a measure is cost-effective if the B/C ratio is greater than 1.0. The B/C ratio is calculated by dividing the total present lifecycle cost benefits by the present value of the total incremental costs.

Results per unit lifecycle cost-effectiveness analyses are presented in Table 16 and Table 17.

Table 16: Lifecycle Cost-Effectiveness Summary by Scenario

Scenario	Benefits TDV Energy Cost Savings + Other PV Savings[1] (2020 PV $)	Costs Total Incremental Present Valued (PV) Costs[2] (2020 PV $)	Benefit-to-Cost Ratio
Four 35 Watt Wall-mounted Luminaires	$160	$88	1.8
Four 55 Watt Pole-mounted Luminaires	$138	$73	2.8

Table 17: Lifecycle Cost-Effectiveness Summary by Space Type

Space Type	Benefits TDV Energy Cost Savings + Other PV Savings[1] (2020 PV $)	Costs Total Incremental Present Valued (PV) Costs[2] (2020 PV $)	Benefit-to-Cost Ratio
Retail Building Supply Franchise	$133	$59	2.3
Big Box Retail (24hr)	$115	$59	1.9
Outdoor Shopping Center	$91	$59	1.5
Fast Food Restaurant (24hr)	$74	$59	1.3
K-12 School	$154	$59	2.6
Large Office Building	$163	$59	2.8
Office Campus	$161	$59	2.7
Medium Office Building	$156	$59	2.6
Recreational Parks	$167	$59	2.8
Government Center	$163	$59	2.8
Health Center	$149	$59	2.5
Auto Sales Lot	$118	$59	2.0
Gas Station	$71	$59	1.2

1. **Benefits: TDV Energy Cost Savings + Other PV Savings:** Benefits include TDV energy cost savings over the period of analysis (Energy Commission 2016, Chapter 5 p.51-53). Other savings are discounted at a real (nominal – inflation) three percent rate. Other PV savings include incremental first cost savings if proposed first cost is less than current first cost. Includes present value maintenance cost savings if PV of proposed maintenance costs is less than the PV of current maintenance costs.

2. **Costs: Total Incremental Present Valued Costs:** Costs include incremental equipment, replacement and maintenance costs over the period of analysis. Costs are discounted at a real (inflation adjusted) three percent rate. Includes incremental first cost if proposed first cost is greater than current first cost. Includes present value of maintenance incremental cost if PV of proposed maintenance costs is greater than the PV of current maintenance costs. If incremental maintenance cost is negative, it is treated as a positive benefit. If there are no total incremental present valued costs, the B/C ratio is infinite.

6. First-Year Statewide Impacts

6.1 Key Assumptions for Statewide Energy Savings Analysis

The Statewide CASE Team assumes the large majority of savings will come from new and retrofitted general hardscape parking lots. As such, sections 6.1.1 and 6.2.2 describe the assumptions and calculations used to estimate statewide savings from requiring scheduling controls with multiple light output choices, and decreasing lighting power threshold for bi-level motion controlled lighting.

Area of Hardscape in California the Year 2020

Using the ratios of parking lot area to building areas from the 2016 Outdoor Lighting Power Allowance CASE Report[8] (seen in Table 18), the total new parking lot area in California associated with new buildings is estimated at 133.5 million square feet (ft^2). Additionally, the Statewide CASE Team assumes that three percent of all existing parking lots are retrofitted each year, which account for an additional 176.4 million square feet. Combining these two figures results in a total of 310 million ft^2 of parking area that will trigger code in 2020, as seen in Table 19. New Construction forecasts can found in Appendix A.

Table 18: Assumptions for Statewide Impacts Estimate Calculations for General Hardscape as Used in the 2016 Outdoor LPA CASE Report

Assumptions for Statewide Estimates - General Hardscape		
General Hardscape	**Assumptions**	**Area Multipliers for Construction Area**
Large Office, Small Office, Food, Restaurant, College	1 parking space per 250 ft^2 of gross building area	1.0
Hotel, Retail, School, Other	1 parking space per 360 ft^2 of gross building area	0.7
Nonrefrigerated Warehouse, Refrigerated Warehouse	1 parking space per 830 ft^2 of gross building area	0.3

8 http://www.energy.ca.gov/title24/2016standards/rulemaking/documents/dru_title24_parts_01_06/2016%20T24%20CASE%20Report%20-%20Outdoor%20LPA%20-%20Dec%202014-V3.pdf

Table 19: New Construction and Altered General Hardscape Area Forecast for 2020

Construction Forecast Building Type	New Construction (Million ft^2)	Altered / Retrofitted (Million ft^2)	Total Hardscape in 2020 Subject to Code (Million ft^2)
Small Office	10.86	14.53	25.39
Restaurant	5.71	7.23	12.93
Retail	25.12	32.17	57.29
Food	9.52	12.19	21.71
Non-Refrigerated Warehouse	8.73	12.34	21.07
Refrigerated Warehouse	0.49	0.65	1.14
Schools	10.70	15.56	26.26
College	6.97	11.46	18.43
Hospital	6.39	10.12	16.51
Hotel/motel	6.67	9.31	15.98
Large offices	42.36	50.85	93.21
Total	133.51	176.40	309.91

Installed Wattage in California

Using the proposed 2019 Outdoor LPAs, along with the assumed share of lighting zones in California collected from an interview with an outdoor lighting designer, and seen in Table 20, the Statewide CASE Team was able to estimate the statewide savings associated with these measures.

Table 20: Assumed Share of Construction Activity by Lighting Zone (LZ)

Construction by Lighting Zone Area	
Lighting Zone	**Percent of Construction Activity (Estimate)**
LZ0	0.0%
LZ1	0.1%
LZ2	9.9%
LZ3	90.0%
LZ4	0.0%

To calculate installed wattage, the area of total hardscape by building type was subdivided into lighting zones, shown in Table 21. This was done by multiplying the area of new construction and altered general hardscape forecast for 2020 seen in Table 19 and weighting each area by the estimated percent of construction activity in Table 20.

Table 21: New Construction (NC) and Alteration Forecast of General Hardscape Area in Million Square Feet (ft^2) Impacted by Proposed Code Measure

Lighting Zone	Large Office, Small Office, Food, Restaurant, College (Million ft^2)		Hotel, Retail, School, Other (Million ft^2)		Non-Refrigerated Warehouse, Refrigerated Warehouse (Million ft^2)		Total (Million ft^2)
	NC in 2020	Altered in 2020	NC in 2020	Altered in 2020	NC in 2020	Altered in 2020	
LZ1	0.08	0.08	0.05	0.05	0.01	0.01	0.27
LZ2	7.47	7.47	4.84	4.84	0.91	0.91	26.43
LZ3	67.87	67.87	43.99	43.99	8.30	8.30	240.31
LZ4	-	-	-	-	-	-	-
All LZs	**75.41**	**96.26**	**48.88**	**67.15**	**9.22**	**12.99**	**309.91**

Multiplying the lighting zone weighted area of new construction and alterations forecasted in 2020 by the average Light Power Allowance assumed in the 2019 CASE Report on Outdoor Sources (seen in Appendix D) produces the installed wattage in CA seen in Table 22.

Table 22: Megawatts of Outdoor Lighting Installed in New Construction and Altered General Hardscapes in 2020

Lighting Zone	Large Office, Small Office, Food, Restaurant, College (MW)	Hotel, Retail, School, Other (MW)	Nonresidential Warehouse, Refrigerated Warehouse (MW)	Total Installed Power (MW)
LZ1	0.01	0.00	0.00	0.01
LZ2	0.75	0.34	0.07	1.16
LZ3	8.05	3.12	0.60	11.77
LZ4	0.00	0.00	0.00	0.00
All LZs	8.80	3.47	0.66	12.93

However, the proposed code change of decreasing lighting power threshold for bi-level motion controlled lighting only affects luminaires mounted 24 feet or less above the ground, while the proposed code change of scheduling controls with multiple light output choices affects all general hardscape lighting. Table 23 shows the estimates of luminaire mounted 24 feet or less by lighting zone, calculated from the 2019 LPA Lighting Layouts, based on Statewide CASE Team experience. The assumed distribution of luminaire wattages, shown in Table 26, was developed by reviewing products available for parking lot lighting and by conducting interviews with lighting professionals. Multiplying the total wattage installed in California by the estimate of poles with luminaires under 24 feet yields the total wattage of exterior lighting installed in California that is affected by the proposed code change, seen in Table 24.

Table 23: Assumed Share of Luminaires Mounted Below 24' by Lighting Zone (LZ)

Lighting Zone	Percent of Luminaires Mounted Under 24 Feet[9]
LZ0	N/A
LZ1	25%
LZ2	25%
LZ3	22%
LZ4	N/A

Table 24: Total Wattage of Installed Outdoor Hardscape Luminaires Mounted Less than 24 feet

Lighting Zone	MW Installed on Poles Mounted 24 Feet or less
LZ1	0.00
LZ2	0.29
LZ3	2.58
LZ4	0.00
Total	**2.87**

Table 25 shows the remaining installed wattage of luminaires mounted higher than 24 feet.

Table 25: Installed Wattage of Hardscape Luminaires Mounted higher than 24 feet

Lighting Zone	MW Installed on poles greater than 24 ft.
LZ1	0.01
LZ2	0.87
LZ3	9.19
LZ4	0.00
Total	**10.07**

6.1.1 Assumptions for Statewide Savings of Multi-level Scheduling Controls

Statewide savings for two-channel time-clocks when time-clocks are only required (Section 130.2(c)3A) applies to all outdoor lighting, except for general hardscape lighting, outdoor sales lot lighting, vehicle service station hardscape lighting, or vehicle service station canopy lighting where the bottom of the luminaire is mounted 24 feet or less above the ground, which includes all non-roadway lighting mounted greater than 24 feet above the ground, and where motion controls are used for compliance (Section 130.2(c)3B). The Statewide CASE Team assumes that only 10 percent of these installations use motion controls to comply, as in many cases, motion control is not a feasible option:

- On tall poles, the detection range is not wide enough to provide sufficient coverage

[9] Calculated from the 2019 LPA Lighting Layouts, based on Statewide CASE Team experience.

- For façade or outdoor dining lighting, one does not want to lights to be modulating depending upon activity

The statewide savings calculation assumes half of the outdoor lighting systems already have multiple channels. For small systems, this will not be the case but for large applications, multiple circuits would be required to distribute power; this is less an issue as outdoor lighting efficacy increases.

Annual Energy Savings (AES) associated with hardscape lighting are calculated by the following method:

AES = *(total installed watts) x (fraction currently without multi-level) x (fraction controlled) x (probability of control) x (percent without motion controls) x (full load hours savings) x (conversion [kWh/yr])*

AES = (10,070 kW) x (0.50) x (0.5) x (0.5) x (0.9) x (2,130 hrs.) x (.000001 GWh/kWh) = **2.41GWh**

Annual Energy Savings (AES) associated with specific application lighting (entrances, canopies, ornamental, façade, sales lots) are calculated by the following method:

AES = (4,929 kW) x (0.50) x (0.5) x (0.5) x (0.9) x (2,130 hrs.) x (.000001 GWh/kWh) = **1.18 GWh**

Statewide savings for two-channel time-clocks when time-clocks are required with motion sensors (Section 130.2(c)2) are required for general hardscape lighting, outdoor sales lot lighting, vehicle service station hardscape lighting, or vehicle service station canopy lighting where the bottom of the luminaire is mounted 24 feet or less above the ground. Annual Energy Savings (AES) are calculated by the following method:

AES = *(total installed watts) x (fraction currently without multi-level) x (fraction controlled) x (probability of control) x (full load hours savings) x (conversion factor)*

AES = (2,550 kW) x (0.50) x (0.5) x (0.5) x (1,172 hrs.) x (.000001 GWh/kWh) = **0.33 GWh**

6.1.2 Assumptions for Statewide Savings of Decreasing Lighting Power Threshold for Bi-Level Motion Controlled Lighting

The Statewide CASE Team calculated the first-year statewide savings by multiplying the per unit savings, which are presented in Section 4.3, by the statewide new construction forecast for 2020, which is presented in more detail in Appendix A. To arrive at the Statewide savings estimates of reducing the exemption from the control requirements to 30 watts or less, the Statewide CASE Team made the assumptions described in this section.

Applying this distribution to the total installed wattage from Table 24, and assuming an average wattage of luminaires listed in Table 27, produces an estimate number of luminaires affected by code. This produces savings from typical fixture wattages, rather than the most conservative fixture wattage (31W) used in the per unit savings analysis.

Table 26: Installed Wattage by Assumed Luminaire Range

Luminaire Wattage Range	Distribution (Percent of Outdoor Luminaires Designed for Poles <24')	Installed Megawatts
≤ 30 watts	0.7%	0.02
31 - 40 watts	2.8%	0.08
40 - 50 watts	12.0%	0.34
50 - 60 watts	63.5%	1.82
60 - 70 watts	3.6%	0.10
70 - 75 watts	7.0%	0.20
> 75 watts	10.4%	0.30
Total	**100%**	**2.87**

Summing only those luminaire wattages that would be affected by the proposed code change (31W to 75W) yields a total installed power affected by code of 2.55 MW.

Table 27: Assumed Luminaire Wattage and Resulting Number of Luminaires Affected by Proposed Code Changes

Assumed Luminaire Wattage	Number of Luminaires
35 watts	2295
45 watts	7650
55 watts	33119
65 watts	1589
75 watts	2677
Total	**47330**

Finally, the Statewide CASE Team assumed a weighted average occupancy across all space types listed in Section 4.1: 26.2 percent occupancy from 6:00 pm to midnight, and 12.3 percent occupancy from midnight to 6:00 am. This assumption was found from the occupancy patterns of each space type weighted by the corresponding statewide construction forecast building types. More information on the weighting can be seen in Appendix C, Table 40.

6.2 Statewide Energy Savings and Lifecycle Energy Cost Savings

The first-year energy impacts in Table 28 represent the first-year annual savings from all buildings that are estimated to be completed in 2020. The lifecycle energy cost savings represents the energy cost savings over the entire 15-year analysis period.

Given data regarding the new construction forecast for 2020, the Statewide CASE Team estimates that the proposed code change will reduce annual statewide electricity use by 8.82 GWh with an associated demand reduction of 0.23 MW. The energy savings for buildings constructed in 2020 are associated with a present valued energy cost savings of approximately $20 million in (discounted) energy costs over the 15-year period of analysis.

Table 28: Statewide Energy and Energy Cost Impacts

Measure	Statewide Construction in 2020 (million ft^2)	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First-Year Natural Gas Savings (million therms)	Lifecycle[2] Present Valued Energy Cost Savings (PV$ million)
Decreasing Lighting Power Threshold for Bi-Level Motion Controlled Lighting	68.8	4.89	0.26	N/A	$11.4
Scheduling Controls with Multiple Light Output Choices	309.9	3.93	0.0	N/A	$8.4
Total		**8.82**	**0.26**	**N/A**	**$19.8**

1. First-year savings from all buildings completed statewide in 2020.
2. Energy cost savings from all buildings completed statewide in 2020 accrued during 15-year period of analysis.

6.3 Statewide Water Use Impacts

The proposed code change will not result in water savings.

6.4 Statewide Material Impacts

Material impact assumptions used for occupancy sensors are those used in the 2013 CASE Report. This impact analysis assumes that each new luminaire will have an integrated sensor. This is a conservative assumption, because some outdoor lighting installations will employ remote sensors that have the ability to control groups of luminaires, which will result in lower material impacts.

Table 29: Impacts of Material Use

	Impact on Material Use (lbs./yr)					
	Mercury	**Lead**	**Copper**	**Steel**	**Plastic**	**Others (Identify)**
Impact (I or NC)[1]	I	I	I	NC	I	NC
Per Unit Impacts	0.0005	.0025	0.15	0	0.25	0
First-Year[2] Statewide Impacts	1.51	7.53	451.81	0	753.02	0

1. Material Increase (I) or No Change (NC) compared to base case (lbs./year).
2. First-year savings from all buildings completed statewide in 2020.

6.5 Other Non-Energy Impacts

Stakeholders have stated that occupancy-based outdoor lighting controls improve safety and security of an area as it provides an additional indicator of occupancy and will reduce the chances of undetected presence. The controls will dim lights with the ability to ramp up should motion be detected, which can be a valuable safety feature, where increased light levels can draw attention to the presence of other occupants in the area. Additionally, feedback from law enforcement has indicated that in a nighttime setting, the dimmed state of outdoor lighting was not as noticeable until the lights ramp up to full output.

7. PROPOSED REVISIONS TO CODE LANGUAGE

The proposed changes to the Standards, Reference Appendices, and the ACM Reference Manuals are provided below. Changes to the 2016 documents are marked with underlining (new language) and ~~strikethroughs~~ (deletions).

7.1 Standards

SECTION 100.1 – DEFINITIONS AND RULES OF CONSTRUCTION

…

(b) **Definitions.** Terms, phrases, words and their derivatives in Part 6 shall be defined as specified in Section 100.1. Terms, phrases, words and their derivatives not found in Section 100.1 shall be defined as specified in the "Definitions" chapters of Title 24, Parts 1 through 5 of the California Code of Regulations. Where terms, phrases, words and their derivatives are not defined in any of the references above, they shall be defined as specified in *Webster's Third New International Dictionary of the English Language, Unabridged* (1961 edition, through the 2002 addenda), unless the context requires otherwise.

LIGHTING CONTROLS consist of the following:

ASTRONOMICAL TIME-SWITCH CONTROL is an Automatic Time Switch Control that controls lighting based on the time of day and astronomical events such as sunset and sunrise, accounting for geographic location and calendar date.

AUTOMATIC SCHEDULING CONTROL is a time-based lighting control device or system that is capable of being programmed to reduce or turn off outdoor luminaire power for a portion of the night and the day.

AUTOMATIC TIME SWITCH CONTROL is an *automatic scheduling control* that controls lighting based on the time of day.

OCCUPANT SENSING CONTROLS automatically control levels of illumination, allow for manual operation, and consist of the following types:

MOTION SENSOR is used outdoors, automatically turns lights OFF or reduces lighting power after an area is vacated of occupants, and automatically turns the lights ON or increases light output when the area is occupied.

OCCUPANT SENSOR is used indoors and automatically turns lights OFF after an area is vacated of occupants and is capable of automatically turning the lighting load ON when an area is occupied.

PARTIAL-ON OCCUPANT/~~MOTION~~ SENSOR automatically turns lights OFF after an area is vacated of occupants and is capable of automatically or manually turning ON part of the lighting load when an area is occupied.

PARTIAL-OFF OCCUPANT/~~MOTION~~ SENSOR automatically turns OFF part of the lighting load after an area is vacated of occupants and is capable of automatically turning ON the lighting load when an area is occupied.

VACANCY SENSOR automatically turns lights OFF after an area is vacated of occupants but requires lights to be turned ON manually.

PART-NIGHT OUTDOOR LIGHTING CONTROL is a light sensing and time-based ~~lighting~~ *automatic scheduling control* device or system that is programmed to reduce or turn off the lighting power to an outdoor luminaire for a portion of the night.

PHOTO CONTROL automatically turns lights ON and OFF, or automatically adjusts lighting levels, in response to the amount of daylight that is available. A Photo Control may also be one component of a field assembled lighting system, the component having the capability to provide a signal proportional to the amount of daylight to a Lighting Control System to dim or brighten the electric lights in response.

SECTION 110.9 – MANDATORY REQUIREMENTS FOR LIGHTING CONTROL DEVICES AND SYSTEMS, BALLASTS, AND LUMINAIRES

(b) **All Installed Lighting Control Systems** listed in Section 110.9(b) shall comply with the requirements listed below; and all components of the system considered together as installed shall meet all applicable requirements for the application for which they are installed as required in Sections 130.0 through 130.5, Sections 140.6 through 140.8, Section 141.0, and Section 150.0(k).

5. Part-Night Outdoor Lighting Controls, as defined in Section 100.1, shall meet all of the following requirements:

A. Have sunrise and sunset prediction accuracy within +/- 15 minutes, using both light sensing and time measurement ~~and timekeeping accuracy within five minutes per year~~; and

B. Have the ability to reduce lighting power ~~setback~~ or turn off lighting ~~at night~~ during selected periods as required in Section 130.2(c), ~~by means of a programmable timeclock or motion sensing device~~; and

C. ~~When controlled with a timeclock~~, Shall be capable of being programmed to ~~allow the setback~~ reduce lighting power or ~~turning~~ turn off ~~of the~~ lighting ~~to occur~~ ~~from~~ at any time ~~at night until any time in the morning~~, as determined by the user. Tine-based scheduling control is allowed to be relative to sunset and sunrise times including relative to the midpoint between sunset and sunrise times.

SECTION 130.2 – OUTDOOR LIGHTING CONTROLS AND EQUIPMENT

Nonresidential, high-rise residential and hotel/motel buildings shall comply with the applicable requirements of Sections 130.2(a) through 130.2(c).

(a) Outdoor Incandescent Lighting. All outdoor incandescent luminaires rated over 100 watts, determined in accordance with Section 130.0(c)2, shall be controlled by a motion sensor.

(b) Luminaire Cutoff Requirements. 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 IES TM-15-11, Addendum A) requirements as follows:

1. There are no Backlight requirements in Section 130.2 of Part 6; and

2. Maximum zonal lumens for Uplight shall be in accordance with TABLE 130.2-A; and

3. Maximum zonal lumens for Glare shall be in accordance with TABLE 130.2-B.

NOTE: Title 24, Part 11, Section 5.106.8 includes additional restrictions on backlight, uplight and glare that may apply.

EXCEPTION 1 to Section 130.2(b): Signs.

EXCEPTION 2 to Section 130.2(b): ~~Lighting for~~ Luminaires where more than 50 percent of the light leaving each luminaire is illuminating building facades, public monuments, statues, and vertical surfaces of bridges.

EXCEPTION 3 to Section 130.2(b): Lighting not permitted by a health or life safety statute, ordinance, or regulation to be a cutoff luminaire.

EXCEPTION 4 to Section 130.2(b): Temporary outdoor lighting.

EXCEPTION 5 to Section 130.2(b): Replacement of existing pole mounted luminaires in hardscape areas meeting all of the following conditions:

A. Where the existing luminaire does not meet the luminaire BUG requirements in Section 130.2(b); and

B. Spacing between existing poles is greater than six times the mounting height of the existing luminaires; and

C. Where no additional poles are being added to the site; and

D. Where new wiring to the luminaires is not being installed; and

E. Provided that the connected lighting power wattage is not increased.

EXCEPTION 6 to Section 130.2(b): Luminaires that illuminate the public right of way on publicly maintained roadways, sidewalks, and bikeways.

(c) **Controls for Outdoor Lighting.** Outdoor lighting controls shall be installed that meet all the following requirements as applicable:

EXCEPTION 1 to Section 130.2(c): Outdoor lighting not permitted by a health or life safety statute, ordinance, or regulation to be turned OFF.

EXCEPTION 2 to Section 130.2(c): Lighting in tunnels required to be illuminated 24 hours per day and 365 days per year.

1. All installed outdoor lighting shall be controlled by a photocontrol, ~~or~~ outdoor astronomical time switch control, part-night outdoor lighting control, or other control capable of automatically shutting OFF the outdoor lighting when daylight is available.

~~3~~2. All ~~installed outdoor~~ luminaires that are primarily providing general hardscape lighting, outdoor sales lot lighting, vehicle service station hardscape lighting, or vehicle service station canopy lighting where the bottom of the luminaire is mounted 24 feet or less above the ground, shall be controlled ~~with automatic lighting controls that meet all of the following requirements~~ by combined automatic

scheduling controls and motion sensors or other automatic controls responding to both schedule and activity. The controls shall comply with items A through D:

A. Where more than four luminaires are controlled, automatic scheduling controls capable of reducing power of the controlled lighting at least 50 percent, but not exceeding 90 percent by dimming or by turning off a fraction of the controlled lights.

B. During normally occupied scheduled periods (normal operating hours), when no activity has been detected in the area illuminated by the controlled luminaires for a time no longer than 15 minutes, lighting power of each luminaire shall be reduced by at least 50 percent but not exceeding 90 percent.

C. During normally unoccupied scheduled periods (after-hours), controls shall operate in accordance with either i or ii:

i. At least 50 percent of controlled luminaires are turned OFF or power reduced by at least 90 percent by automatic scheduling controls, and the remainder of luminaires are controlled by a motion sensor or other controls in accordance with Section 130.2(c)3B; or

ii. When no activity has been detected in the area illuminated by the controlled luminaires for a time no longer than 15 minutes, controls shall automatically reduce the lighting power of each luminaire by at least 80 percent or turn lights completely OFF.

D. No more than 400 watts of lighting power shall be controlled together by a motion sensing control or other control responding to activity,

~~A. Shall be motion sensors or other lighting control systems that automatically controls lighting in accordance with item B in response to the area being vacated of occupants; and~~

~~B. Shall be capable of automatically reducing the lighting power of each luminaire by at least 40 percent but not exceeding 90 percent, or provide continuous dimming through a range that includes 40 percent through 90 percent, and~~

~~C. Shall employ auto-ON functionality when the area becomes occupied; and~~

~~D. No more than 1,500 watts of lighting power shall be controlled together~~.

~~EXCEPTION 1 to Section 130.2(c)3:~~ ~~Lighting for Outdoor Sales Frontage complying with Section 130.2(c)4.~~

~~EXCEPTION 2 to Section 130.2(c)3:~~ ~~Lighting for Building Facades, Ornamental Hardscape and Outdoor Dining complying with Section 130.2(c)5.~~

EXCEPTION ~~3~~ 1 to Section 130.2(c)~~3~~2: Outdoor lighting, in compliance with Sections 130.2(c)1 and 130.2(c)3, where luminaire rated wattage, ~~is~~ determined in accordance with Section 130.0(c), is 30 watts or less. ~~and which meet one of the following conditions:~~

~~A. Pole-mounted luminaires with a maximum rated wattage of 75 watts; or~~

~~B. Non-pole mounted luminaires with a maximum rated wattage of 30 watts each; or~~

~~C. Linear lighting with a maximum wattage of 4 watts per linear foot of luminaire.~~

EXCEPTION 2 to Section 130.2(c)~~3~~2: Applications listed as Exceptions to Section 140.7(a) shall not be required to meet the requirements of Section 130.2(c)3.

~~2~~3. All installed outdoor lighting, except lighting complying with the requirements of Section 130.2(c)2 without the use of any exceptions shall be independently controlled from other electrical loads by an automatic scheduling control and by at least one of the following:

A. Where more than four luminaires are controlled, automatic scheduling controls are capable of reducing power of the controlled lighting at least 50 percent but not exceeding 90 percent by dimming or by turning off a fraction of the controlled lights. *Automatic scheduling controls* shall reduce lighting power of controlled luminaires by at least 50 percent during normally unoccupied scheduled periods (after-hours); or

B. *Motion sensor* or other control that reduces lighting power of each luminaire by at least 50 percent but not exceeding 90 percent when no activity has been detected in the area illuminated by the controlled luminaires for a time no longer than 15 minutes. No more than 400 watts of lighting power shall be controlled together.

~~**EXCEPTION to Section 130.2(c)2:** Outdoor lighting controls complying with the requirements of Section 130.2(c)2 without the use of any exceptions.~~

4. Acceptance tests of outdoor lighting controls shall be conducted in accordance with Section 130.4(a)6. When scheduled operating hours are known, the acceptance tests shall confirm the time schedules are correctly applied. When scheduled operating hours are not known, acceptance tests shall be conducted using a default normally occupied scheduled period of 6 am to midnight and a default normally unoccupied scheduled period of midnight to 6 am.

~~4. For Outdoor Sales Frontage lighting, an automatic lighting control shall be installed that meets the following requirements:~~

~~A. A part-night outdoor lighting control as defined in Section 100.1; or~~

~~B. Motion sensors capable of automatically reducing lighting power by at least 40 percent but not exceeding 90 percent, and which have auto-ON functionality.~~

~~5. For Building Facade, Ornamental Hardscape and Outdoor Dining lighting, an automatic lighting control shall be installed that meets one or more of the following requirements:~~

~~A. A part-night outdoor lighting control as defined in Section 100.1; or~~

~~B. Motion sensors capable of automatically reducing lighting power by at least 40 percent but not exceeding 90 percent, and which have auto-ON functionality; or~~

~~C. A centralized time-based zone lighting control capable of automatically reducing lighting power by at least 50 percent.~~

~~D. Outdoor wall-mounted luminaires having a bilaterally symmetric distribution as described in the IES Handbook (typically referred to as "wall packs") where the bottom of the luminaire is mounted 24 feet or less above the ground shall comply with the applicable requirements in Section 130.2(c)3.~~

SECTION 141.0 – ADDITIONS, ALTERATIONS, AND REPAIRS TO EXISTING NONRESIDENTIAL, HIGH-RISE RESIDENTIAL, AND HOTEL/MOTEL BUILDINGS, TO EXISTING OUTDOOR LIGHTING, AND TO INTERNALLY AND EXTERNALLY ILLUMINATED SIGNS

…

(b) Alterations. Alterations to existing nonresidential, high-rise residential, or hotel/motel buildings, relocatable public school buildings or alterations in conjunction with a change in building occupancy to a nonresidential, high-rise residential, or hotel/motel occupancy are not subject to Subsection (a) and shall meet item 1, and either item 2 or 3 below:

…

2. Prescriptive approach. The altered components of the envelope, or space conditioning, lighting, electrical power distribution and water heating systems, and any newly installed equipment serving the alteration, shall meet the applicable requirements of Sections 110.0 through 110.9, Sections 120.0 through 120.6, and Sections 120.9 through 130.5.

…

L. Alterations to existing outdoor lighting systems in a lighting application listed in TABLE 140.7-A or 140.7-B shall meet the applicable requirements of Sections 130.0, 130.2(a), 130.2(b), and 130.4, and:

~~ii~~.i In alterations that do not increase the connected lighting load, where the number of luminaires added or replaced in general hardscape or a specific application, exceed ~~the greater of 5 luminaires or~~ 10 percent and are no greater than 50 percent of the existing luminaires ~~are replaced~~ in a general hardscape or a specific lighting application, the alterations shall meet the following applicable control requirements:

a. In parking lots and outdoor sales lots where the bottom of the luminaire is mounted 24 feet or less above the ground, ~~the~~ added or replacement luminaires shall comply with Section 130.2(c)1 AND Section 130.2(c)~~3~~ 2 or;

b. For all other lighting applications ~~and~~ or where the bottom of the luminaire is mounted greater than 24 feet above the ground, the added or replacement luminaires shall comply with Section 130.2(c)1 AND EITHER comply with Section 130.2(c)~~2~~ 3 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 occupants;

~~iii~~.ii. In alterations that do not increase the connected lighting load, where the number of luminaires added or replaced in general hardscape or a specific application, exceed ~~greater of 5 luminaires or~~ 50 percent of the existing luminaires ~~are replaced~~ in general hardscape or a specific application, the added or replacement luminaires shall meet the control requirements of subsections ia and ib ~~ii~~ above and the requirements of Section 140.7 for general hardscape lighting or specific lighting applications containing the alterations.

EXCEPTION to Section 141.0(b)2L~~iii~~.ii Alterations where the replacement luminaires have at least 40 percent lower power consumption compared to the original luminaires are not required to comply with the lighting power allowances of Section 140.7.

EXCEPTION to Section 141.0(b)2L i and ii . Alterations which do not increase connected lighting load and where less than five (5) luminaires are added or replaced in a general hardscape or a specific application.

~~i.~~ iii. In alterations that increase the connected lighting load, the added or altered luminaires shall meet the applicable requirements of Section 130.2(c) and the requirements of Section 140.7 for general hardscape lighting or for the specific lighting applications containing the alterations.

EXCEPTION to Section 141.0(b)2L. Acceptance testing requirements of Section 130.4 are not required for alterations where controls are added to 20 or fewer luminaires.

7.2 Reference Appendices

This proposal will modify Section JA1 of the Standards Reference Appendices as shown below.

Joint Appendix JA1

Appendix JA1 – Glossary

…

LIGHTING CONTROLS consist of the following:

…

Part Night Outdoor Lighting Control is a light sensing and time-based or ~~occupancy-based lighting~~ automatic scheduling control device or system that is programmed to reduce or turn off the lighting power to an outdoor luminaire for a portion of the night

This proposal will modify Section NA7.8 of the Standards Reference Appendices as shown below.

NA7.8 Outdoor Lighting Controls Acceptance Test

Verify that outdoor lighting controls qualify as one of the required control types, are installed, and are fully functional in accordance with each applicable requirement in Section 130.2(c), or that the application meets one of the exceptions. List each specific exception claimed, from Section 130.2(c).

NA7.8.1 Motion Sensor Construction Inspection

Prior to Functional testing, verify and document the following:

(a) Sensor has been located to minimize false signals.

(b) Sensor is not triggered by motion outside of adjacent area.

(c) Desired sensor coverage is not blocked by obstructions that could adversely affect performance.

NA7.8.2 Motion Sensor Functional testing

For buildings with up to seven (7) outdoor motion sensors, all outdoor motion sensors shall be tested. For buildings with more than seven (7) outdoor motion sensors for outdoor lighting system, sampling may be done on outdoor areas with similar sensors that cover similar unobstructed areas; sampling shall include a minimum of 1 outdoor motion sensor for each group of up to 7 additional outdoor motion sensors. If the first sensor in the sample group passes the acceptance test, the remaining outdoor areas in the sample group also pass. If the first sensor in the sample group fails the acceptance test, the rest of the sensors in that group shall be tested and any failed sensor in the sample group shall be repaired or replaced and retested until the sensor passes the test.

Step 1: Simulate motion in area under lights controlled by the sensor. Verify and document the following:

(a) Status indicator operates correctly.

(b) Lights controlled by sensors turn on immediately upon entry into the area lit by the controlled lights near the motion sensor.

(c) Signal sensitivity is adequate to achieve desired control.

Step 2: Simulate no motion in area with lighting controlled by the sensor. Verify and document the following:

(a) Lights controlled by the sensor reduces light output within a maximum of ~~30~~ 15 minutes from the start of an unoccupied condition.

(b) The sensor does not trigger a false "on" from movement outside of the controlled area. (c) Signal sensitivity is adequate to achieve desired control.

NA7.8.3 Photocontrol Construction Inspection

Verify and document the following: The photocontrol is installed.

NA7.8.4 Photocontrol Functional Testing

Verify and document the following:

(a) During daytime simulation, all controlled outdoor lights are turned off.

(b) During nighttime simulation, all controlled outdoor lights are turned on.

NA7.8.5 Astronomical Time-Switch Control Construction Inspection

Prior to Functional Testing, confirm and document the following:

(a) Verify the astronomical time-switch control is installed.

(b) If more than 4 luminaires are controlled confirm that there are at two control channels controlling the luminaires.

(~~b~~c) Verify the astronomical time switch control is programmed with ~~acceptable~~ ON schedule and OFF Schedule that matches the schedules in the construction documents. If the schedule is unknown, verify that programmed schedules match the default schedule where the OFF schedule is from midnight to 6 am and the ON schedule are all other night time hours, 7 days per week.

(~~c~~d) Demonstrate and document for the time switch programming including ON schedule and OFF schedule, for weekday, weekend, and holidays (if applicable).

(~~d~~e) Verify the correct time and date is properly set in the control.

NA7.8.6 Astronomical Time-Switch Control Functional Testing

Verify and document the following:

(a) During daytime simulation, all controlled outdoor lights are turned off.

(b) During nighttime simulation, all controlled outdoor lights are turned on in accordance with the astronomical schedule.

(c) During nighttime simulation, ~~all~~ power of controlled outdoor lights ~~are~~ is reduced by at least 50% (including turned off) in accordance with the programmed schedule.

NA7.8.7 Part-Night Outdoor Lighting Control Construction Inspection

Prior to Functional Testing for time based control type, confirm and document the following:

(a) Verify the part-night outdoor lighting control is installed.

(b) Verify the control is programmed with ~~acceptable~~ schedules that match the schedules in the construction documents. If the schedule is unknown, verify that programmed schedules match the default schedule where the OFF schedule is from midnight to 6 am and the ON schedule are all other night time hours, 7 days per week. It is acceptable for schedules to be relative to sunrise and sunset times. The midnight to 6 am schedule can be approximated by "solar midnight" (halfway between sunset and sunrise at night) to 6 hours afterwards.

(c) Demonstrate and document for the lighting control programming including both ON schedule and OFF schedule, for weekday, weekend, and holidays (if applicable).

(d) Verify the correct time and date is properly set in the control.

Prior to Functional Testing for occupancy-based control type, verify and document the following:

(a) Sensor has been located to minimize false signals.

(b) Sensor is not triggered by motion outside of adjacent area.

(c) Desired sensor coverage is not blocked by obstructions that could adversely affect performance.

NA7.8.8 Part-Night Outdoor Lighting Control Functional Testing

For time-based control type, verify and document the following:

(a) During daytime simulation, all controlled outdoor lights are turned off.

(b) During nighttime simulation, all controlled outdoor lights are turned on in accordance with the ON schedule.

(c) During nighttime simulation, all controlled outdoor lights are turned off or reduced in light level in accordance with the OFF schedule. Lighting power is reduced by at least 50% during the OFF schedule.

For part-night control used in conjunction with ~~occupancy-based~~ motion sensing control ~~type~~, verify and document the following:

Step 1: During daytime simulation, all controlled outdoor lights are turned off.

Step ~~1~~2: Simulate motion in area under lights controlled by the sensor. Verify and document the following:

(a) Status indicator operates correctly.

(b) Lights controlled by sensors turn on immediately upon entry into the area lit by the controlled lights near the motion sensor.

(c) Signal sensitivity is adequate to achieve desired control.

Step ~~2~~3: During simulation of normally occupied schedule, ~~Simulate~~ simulate no occupancy in area with lighting controlled by the sensor. Verify and document the following:

(a) ~~Lights~~ Lighting power of each luminaire controlled by the sensor are ~~off or reduces light output~~ reduced by at least 50 percent but not exceeding 90 percent within a maximum of ~~30~~ 15 minutes from the start of an unoccupied condition. Fraction of light output reduction is an acceptable proxy for reduction in lighting power.

(b) The sensor does not trigger a false "on" from movement outside of the controlled area.

(c) Signal sensitivity is adequate to achieve desired control.

Step ~~4~~: During simulation of normally unoccupied schedule, simulate no occupancy in area with lighting controlled by the sensor. Verify and document the following:

(a) Each luminaire controlled by the sensor are off or lighting power is reduced by at least 80 percent within a maximum of-15 minutes from the start of an unoccupied condition.

(b) The sensor does not trigger a false "on" from movement outside of the controlled area.

(c) Signal sensitivity is adequate to achieve desired control.

NA7.8.9 Automatic Scheduling Control Construction Inspection

Prior to functional testing, confirm and document the following:

(a) Verify the automatic scheduling control is installed.

(b) If more than 4 luminaires are controlled confirm that there are at two control channels controlling the luminaires.

(~~b~~c) Verify the control is programmed with ~~acceptable~~ schedules that matches the schedules in the construction documents. If the schedule is unknown, verify that programmed schedules match the default schedule where the OFF schedule is from midnight to 6 am and the ON schedule are all other night time hours, 7 days per week.

(~~c~~d) Demonstrate and document for the lighting control programming including both ON schedule and OFF schedule, for weekday, weekend, and holidays (if applicable).

(~~d~~e) Verify the correct time and date is properly set in the control.

NA7.8.10 Automatic Scheduling Control Functional Testing

Verify and document the following:

(a) During daytime simulation, all controlled outdoor lights are turned off.

(b) During nighttime simulation, all controlled outdoor lights are turned on in accordance with the ON schedule.

(c) During nighttime simulation, ~~all~~ power of controlled outdoor lights ~~are~~ is reduced by at least 50% (including turned off) in accordance with the OFF schedule.

7.3 ACM Reference Manual

There are no proposed changes to the ACM Reference Manual.

7.4 Compliance Manuals

The proposed code change will modify the following compliance documents:

- Document CEC-NRCA-LTO-02-A
  - Add language to ensure that acceptance tests of outdoor lighting controls shall be conducted in accordance with Section 130.4(a)6. When scheduled operating hours are known, the acceptance tests shall confirm the time schedules are correctly applied. When scheduled operating hours are not known, acceptance tests shall be conducted using a default normally occupied scheduled period of 6 am to midnight and a default normally unoccupied scheduled period of midnight to 6 am.
- Document CEC-NRCC-LTO-02-E

- Outdoor Sales Frontage, Building Facades, Ornamental Hardscape and Outdoor Dining. All these spaces now have the same code requirements under Section 130.2(c)3.
- Remove options 130.2(c)4 and 130.2(c)5 from Section B Mandatory Outdoor Lighting Control Schedule and Field Inspection Checklist.

8. REFERENCES

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Appendix A: Statewide Savings Methodology

The projected nonresidential new construction forecast that will be impacted by the proposed code change in 2020 is presented in Table 30. The projected nonresidential existing statewide building stock that will be impacted by the propose code change as a result of additions and alterations in 2020 is presented in Table 31.

The Energy Commission Demand Analysis Office provided the Statewide CASE Team with the nonresidential new construction forecast for 2020, broken out by building type and forecast climate zones (FCZ). The raw data from the Energy Commission is not provided in this report, but can be available upon request.

The Statewide CASE Team completed the following steps to refine the data and develop estimates of statewide floorspace that will be impacted by the proposed code changes:

1. Translated data from FCZ data into building climate zones (BCZ). This was completed using the FCZ to BCZ conversion factors provided by the Energy Commission (see Table 32).
2. Redistributed square footage allocated to the "Miscellaneous" building type. The Energy Commission's forecast allocated 18.5 percent of the total square footage from nonresidential new construction in 2020 and the nonresidential existing building stock in 2020 to the miscellaneous building type, which is a category for all space types that do not fit well into another building category. It is likely that the Title 24, Part 6 requirements apply to the miscellaneous building types, and savings will be realized from this floorspace. The new construction forecast does not provide sufficient information to distribute the miscellaneous square footage into the most likely building type, so the Statewide CASE Team redistributed the miscellaneous square footage into the remaining building types in such a way that the percentage of building floorspace in each climate zone, net of the miscellaneous square footage, will remain constant. See Table 34 for an example calculation.
3. Made assumptions about the percentage of nonresidential new construction in 2020 that will be impacted by proposed code change by building type and climate zone. The Statewide CASE Team's assumptions are presented in Table 35 and Table 36.
4. Made assumptions about the percentage of the total nonresidential building stock in 2020 that will be impacted by the proposed code change (additions and alterations) by building type and climate zone. The Statewide CASE Team's assumptions are presented in Table 35 and Table 36.
5. Calculated nonresidential floorspace that will be impacted by the proposed code change in 2020 by building type and climate zone for both new construction and alterations. Results are presented in Table 30 and Table 31.

Table 30: Estimated New Nonresidential Construction Impacted by Proposed Code Change in 2020, by Climate Zone and Building Type (Million ft^2)

Climate Zone	New Construction in 2020 (Million ft^2)											
	OFF-SMALL	REST	RETAIL	FOOD	NWHSE	RWHSE	SCHOOL	COLLEGE	HOSP	HOTEL	OFF-LRG	TOTAL
1	0.0624	0.0206	0.1078	0.0363	0.0465	0.0030	0.0829	0.0353	0.0387	0.0318	0.0690	**0.5344**
2	0.2634	0.1159	0.8896	0.2335	0.5955	0.0477	0.4123	0.2049	0.2650	0.2961	1.0438	**4.3678**
3	0.8593	0.4853	3.9510	0.9175	3.5733	0.2309	1.5130	0.9134	1.0474	1.6641	6.9282	**22.0835**
4	0.5865	0.2639	2.1380	0.5551	1.3529	0.1190	0.9313	0.4608	0.6360	0.6610	2.3426	**10.0470**
5	0.1139	0.0512	0.4151	0.1078	0.2627	0.0231	0.1808	0.0895	0.1235	0.1283	0.4549	**1.9508**
6	0.7882	0.5772	3.3114	0.8283	2.7167	0.1184	0.9998	0.5722	0.6318	0.7713	4.3662	**15.6814**
7	1.0552	0.3173	2.0421	0.6279	1.1428	0.0112	1.0756	0.4709	0.6677	0.6743	2.2004	**10.2854**
8	1.0965	0.8296	4.7789	1.1887	3.8598	0.1642	1.4590	0.8024	0.9627	1.1082	6.3919	**22.6420**
9	1.0763	0.9179	5.0481	1.2250	4.1325	0.1377	1.4796	0.9431	1.3686	1.2751	8.6231	**26.2269**
10	1.2326	0.8023	3.8314	1.0753	3.2834	0.0746	2.0664	0.6893	0.8147	0.7384	2.1700	**16.7786**
11	0.3489	0.1079	0.8068	0.2750	0.8004	0.0947	0.5383	0.1734	0.2602	0.1786	0.4119	**3.9962**
12	1.8705	0.5377	4.3939	1.1580	3.7594	0.2787	2.1966	0.8447	1.2374	1.1038	4.5040	**21.8846**
13	0.7571	0.2495	1.7891	0.6025	1.5334	0.2459	1.1913	0.3456	0.5637	0.4021	0.7897	**8.4700**
14	0.2010	0.1534	0.7569	0.2039	0.6413	0.0235	0.3759	0.1218	0.1609	0.1386	0.5436	**3.3207**
15	0.2704	0.1062	0.6649	0.2263	0.7179	0.0208	0.3797	0.0918	0.1127	0.1667	0.2721	**3.0295**
16	0.2779	0.1700	0.9567	0.2578	0.6697	0.0416	0.4056	0.2086	0.2369	0.1890	1.2472	**4.6611**
TOTAL	**10.8602**	**5.7059**	**35.8816**	**9.5191**	**29.0882**	**1.6350**	**15.2881**	**6.9678**	**9.1279**	**9.5274**	**42.3586**	**175.96**

Table 31: Estimated Existing Nonresidential Floorspace Impacted by Proposed Code Change in 2020 (Alterations), by Climate Zone and Building Type (Million ft^2)

Climate Zone	Alterations in 2020 (Million ft^2)											
	OFF-SMALL	REST	RETAIL	FOOD	NWHSE	RWHSE	SCHOOL	COLLEGE	HOSP	HOTEL	OFF-LRG	TOTAL
1	0.0818	0.0264	0.1433	0.0486	0.0714	0.0040	0.1058	0.0545	0.0622	0.0501	0.0852	**0.7333**
2	0.3651	0.1361	1.0890	0.2879	0.7618	0.0603	0.5933	0.3233	0.4047	0.3833	1.2659	**5.6706**
3	1.1589	0.5451	4.5311	1.0540	3.9584	0.2737	2.3035	1.3551	1.5948	1.8179	7.6122	**26.2047**
4	0.8305	0.3065	2.6322	0.6845	1.7958	0.1525	1.3592	0.7437	0.9614	0.8832	2.9605	**13.3101**
5	0.1613	0.0595	0.5111	0.1329	0.3487	0.0296	0.2639	0.1444	0.1867	0.1715	0.5748	**2.5843**
6	1.1568	0.7699	4.5452	1.1379	4.2300	0.1715	2.0118	1.1275	1.1991	1.2627	5.5711	**23.1837**
7	1.3627	0.3956	2.7502	0.8341	1.8392	0.0169	1.3210	0.7196	0.9860	1.1707	3.0238	**14.4198**
8	1.5997	1.1004	6.4930	1.6188	5.9524	0.2373	2.8300	1.5520	1.7686	1.7913	8.0928	**33.0365**
9	1.4447	1.1588	6.2659	1.5329	5.6289	0.1914	2.5104	1.6528	2.1336	1.7609	9.7613	**34.0416**
10	1.7149	1.1060	5.4400	1.5104	5.8176	0.1115	2.5974	1.0696	1.2723	1.2387	2.9186	**24.7968**
11	0.4414	0.1279	0.9681	0.3307	1.0503	0.1221	0.6518	0.2673	0.3889	0.2173	0.4665	**5.0325**
12	2.2472	0.6424	5.3606	1.4155	4.7939	0.3701	2.7740	1.2640	1.8821	1.3971	5.2760	**27.4230**
13	0.9596	0.2887	2.0838	0.7012	1.7823	0.3041	1.4724	0.5453	0.8212	0.4546	0.8359	**10.2491**
14	0.2827	0.2093	1.0435	0.2803	1.0855	0.0329	0.4890	0.1914	0.2531	0.2173	0.6788	**4.7638**
15	0.3578	0.1394	0.8512	0.2829	1.0490	0.0274	0.4147	0.1219	0.1690	0.2133	0.3246	**3.9512**
16	0.3688	0.2148	1.2475	0.3354	0.9801	0.0544	0.5318	0.3260	0.3699	0.2646	1.4017	**6.0949**
TOTAL	**14.5340**	**7.2269**	**45.9556**	**12.1882**	**41.1453**	**2.1596**	**22.2301**	**11.4583**	**14.4536**	**13.2946**	**50.8498**	**235.4959**

Table 32: Translation from Forecast Climate Zone (FCZ) to Building Standards Climate Zone (BCZ)

		Building Climate Zone (BCZ)																
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**Total**
Forecast Climate Zone (FCZ)	**1**	22.5%	20.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	9.8%	33.1%	0.2%	0.0%	0.0%	13.8%	100%
	2	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	22.0%	75.7%	0.0%	0.0%	0.0%	2.3%	100%
	3	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	20.9%	22.8%	54.5%	0.0%	0.0%	1.8%	100%
	4	0.1%	13.7%	8.4%	46.0%	8.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	22.8%	0.0%	0.0%	0.0%	0.0%	100%
	5	0.0%	4.2%	89.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	6.6%	0.0%	0.0%	0.0%	0.0%	100%
	6	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	100%
	7	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	75.8%	7.1%	0.0%	17.1%	100%
	8	0.0%	0.0%	0.0%	0.0%	0.0%	40.1%	0.0%	50.8%	8.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.5%	100%
	9	0.0%	0.0%	0.0%	0.0%	0.0%	6.4%	0.0%	26.9%	54.8%	0.0%	0.0%	0.0%	0.0%	6.1%	0.0%	5.8%	100%
	10	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	74.9%	0.0%	0.0%	0.0%	12.3%	7.9%	4.9%	100%
	11	0.0%	0.0%	0.0%	0.0%	0.0%	27.0%	0.0%	30.6%	42.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100%
	12	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	4.2%	95.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	100%
	13	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	69.6%	0.0%	0.0%	28.8%	0.0%	0.0%	0.0%	1.6%	0.1%	0.0%	100%
	14	2.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	97.1%	100%
	15	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	99.9%	0.0%	100%
	16	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100%

Table 33: Description of Building Types and Sub-Types (Prototypes) in Statewide Construction Forecast

Energy Commission Building Type ID	Energy Commission Description	Prototype Description			
		Prototype ID	Floor Area (Ft^2)	Stories	Notes
OFF-SMALL	Offices less than 30,000 square feet	Small Office	5,502	1	Five zone office model with unconditioned attic and pitched roof.
REST	Any facility that serves food	Small Restaurant	2,501	1	Similar to a fast food joint with a small kitchen and dining areas.
RETAIL	Retail stores and shopping centers	Stand-Alone Retail	24,563	1	Stand Alone store similar to Walgreens or Banana Republic.
		Large Retail	240,000	1	Big box retail building, similar to a Target or Best Buy store.
		Strip Mall	9,375	1	Four-unit strip mall retail building. West end unit is twice as large as other three.
		Mixed-Use Retail	9,375	1	Four-unit retail representing the ground floor units in a mixed-use building. Same as the strip mall with adiabatic ceilings.
FOOD	Any service facility that sells food and or liquor	N/A	N/A	N/A	N/A
NWHSE	Non-refrigerated warehouses	Warehouse	49,495	1	High ceiling warehouse space with small office area.
RWHSE	Refrigerated Warehouses	N/A	N/A	N/A	N/A
SCHOOL	Schools K-12, not including colleges	Small School	24,413	1	Similar to an elementary school with classrooms, support spaces and small dining area.
		Large School	210,886	2	Similar to high school with classrooms, commercial kitchen, auditorium, gymnasium and support spaces.
COLLEGE	Colleges, universities, community colleges	Small Office	5,502	1	Five zone office model with unconditioned attic and pitched roof.
		Medium Office	53,628	3	Five zones per floor office building with plenums on each floor.
		Medium Office/Lab		3	Five zones per floor building with a combination of office and lab spaces.
		Public Assembly		2	TBD
		Large School	210,886	2	Similar to high school with classrooms, commercial kitchen, auditorium, gymnasium and support spaces.
		High Rise Apartment	93,632	10	75 residential units along with common spaces and a penthouse. Multipliers are used to represent typical floors.
HOSP	Hospitals and other health-related facilities	N/A	N/A	N/A	N/A
HOTEL	Hotels and motels	Hotel	42,554	4	Hotel building with common spaces and 77 guest rooms.
MISC	All other space types that do not fit another category	N/A	N/A	N/A	N/A
OFF-LRG	Offices larger than 30,000 square feet	Medium Office	53,628	3	Five zones per floor office building with plenums on each floor.
		Large Office	498,589	12	Five zones per floor office building with plenums on each floor. Middle floors represented using multipliers.

Table 34: Example of Redistribution of Miscellaneous Category - 2020 New Construction in Climate Zone 1

Building Type	**2020 Forecast** (Million ft^2) **[A]**	**Distribution Excluding Miscellaneous Category** **[B]**	**Redistribution of Miscellaneous Category** (Million Square Feet) **[C] = B × 0.11**	**Revised 2020 Forecast** (Million Square Feet) **[D] = A + C**
Small Office	0.049	12%	0.013	0.062
Restaurant	0.016	4%	0.004	0.021
Retail	0.085	20%	0.022	0.108
Food	0.029	7%	0.008	0.036
Non-Refrigerated Warehouse	0.037	9%	0.010	0.046
Refrigerated Warehouse	0.002	1%	0.001	0.003
Schools	0.066	16%	0.017	0.083
College	0.028	7%	0.007	0.035
Hospital	0.031	7%	0.008	0.039
Hotel/Motel	0.025	6%	0.007	0.032
Miscellaneous	**0.111**	---	-	---
Large Offices	0.055	13%	0.014	0.069
Total	0.534	100%	**0.111**	0.534

Table 35: Percent of Floorspace Impacted by Proposed Measure, by Building Type

Building Type *Building Sub-Type*	Composition of Building Type by Sub-Types [1]	Percent of Area Impacted [2]	
		New Construction	Existing Building Stock (Alterations) [3]
Small Office		100%	3%
Restaurant		100%	3%
Retail		100%	3%
Stand-Alone Retail	*10%*	*100%*	*3%*
Large Retail	*75%*	*100%*	*3%*
Strip Mall	*5%*	*100%*	*3%*
Mixed-Use Retail	*10%*	*100%*	*3%*
Food		100%	3%
Non-Refrigerated Warehouse		100%	3%
Refrigerated Warehouse		100%	3%
Schools		100%	3%
Small School	*60%*	*100%*	*3%*
Large School	*40%*	*100%*	*3%*
College		100%	3%
Small Office	*5%*	*100%*	*3%*
Medium Office	*15%*	*100%*	*3%*
Medium Office/Lab	*20%*	*100%*	*3%*
Public Assembly	*5%*	*100%*	*3%*
Large School	*30%*	*100%*	*3%*
High Rise Apartment	*25%*	*100%*	*3%*
Hospital		100%	3%
Hotel/Motel		100%	3%
Large Offices		100%	3%
Medium Office	*50%*	*100%*	*3%*
Large Office	*50%*	*100%*	*3%*

1. Presents the assumed composition of the main building type category by the building sub-types. All 2019 CASE Reports assumed the same percentages of building sub-types.
2. When the building type is comprised of multiple sub-types, the overall percentage for the main building category was calculated by weighing the contribution of each sub-type.
3. Percent of existing floorspace that will be altered during the first year the 2019 Standards are in effect.

Table 36: Percent of Floorspace Impacted by Proposed Measure, by Climate Zone

Climate Zone	Percent of Area Impacted	
	New Construction	Existing Building Stock (Alterations) [1]
1	100%	100%
2	100%	100%
3	100%	100%
4	100%	100%
5	100%	100%
6	100%	100%
7	100%	100%
8	100%	100%
9	100%	100%
10	100%	100%
11	100%	100%
12	100%	100%
13	100%	100%
14	100%	100%
15	100%	100%
16	100%	100%

1. Percent of existing floorspace that will be altered during the first year the 2019 Standards are in effect.

Appendix B: DISCUSSION OF IMPACTS OF COMPLIANCE PROCESS ON MARKET ACTORS

This section discusses how the recommended compliance process, which is described in Section 2.5, could impact various market actors. The Statewide CASE Team asked stakeholders for feedback on how the measure will impact various market actors during public stakeholder meetings that were held on September 8, 2016, and March 30, 2017 (Statewide Utility Codes and Standards Team, 2016). The Statewide CASE Team also held several meetings with NEMA and conducted an online survey. The key results from feedback received during stakeholder meetings and other target outreach efforts are detailed below.

Table 37 identifies the market actors who will play a role in complying with the proposed change, the tasks for which they will be responsible, their objectives in completing the tasks, how the proposed code change could impact their existing work flow, and ways negative impacts could be mitigated.

The proposed code change increases current code stringency. The Statewide CASE Team expects little to no compliance issues since no new requirements are being introduced. Market actors will continue to use the same compliance processes as before. Market actors will need to understand the newer, more strict requirements, but otherwise little is expected to change.

Table 37: Roles of Market Actors in the Proposed Compliance Process

Market Actor	Task(s) In Compliance Process	Objective(s) in Completing Compliance Tasks	How Proposed Code Change Could Impact Work Flow	Opportunities to Minimize Negative Impacts of Compliance Requirement
Lighting Designer	• Identify relevant requirements and/ or compliance path and ensure their design complies and meets building owner's needs. • Perform required calculations by space to confirm compliance. • Coordinate design with other team members (HVAC & modeler). • Complete compliance documents for permit application. • Review submittals during construction. • Coordinate with commissioning agent/ ATT as necessary.	• Quickly and easily determine requirements based on scope. • Demonstrate compliance with calculations required for other design tasks. • Streamlined coordination with other team members. • Clearly communicate system requirements to constructors. • Quickly complete compliance documents. • Easily identify non-compliant substitutions. • Coordinate with manufacturers/dealers to know what products are available and meet compliance. • Coordinate with building owner to determine what their needs/wants are early in design phase. • Interaction with contractors is around submittal reviews, so not much coordination (RFI or submittal reviews). Subcontractors sends specs through submittal process to designer to make sure compliant with codes. Lighting designer is supposed to catch if lights don't meet code. • Coordinate with the building department for a plan check by the Plans Examiner.	• Will need to learn new, more stringent controls requirements. • Will need to apply new schedules as described in 130.2(c)4.	• Revise compliance form to automate compliance calculations. • Existing conditions could be documented via as-builts or photographs. Some market actors supportive of ATT verification. • Modeling software will need to be updated to include proposed values. Software training updates. • Clear code requirements that apply to the project. • Designation on products about whether or not they meet code requirements. How to/direction on how to specify the products that meet the code (lighting designer is not purchasing the lighting fixtures, the contractor purchases). • Examples showing systems that are Title 24 compliant. • Examples showing systems that are not Title 24 compliant with explanations of why they aren't. • Documents showing exactly what their role in Title 24 compliance is/how to complete compliance tasks. • Documents explaining who they can speak with for help on code compliance.

Market Actor	Task(s) In Compliance Process	Objective(s) in Completing Compliance Tasks	How Proposed Code Change Could Impact Work Flow	Opportunities to Minimize Negative Impacts of Compliance Requirement
Contractor/Builder	• Follow the lighting design and specifications provided by the lighting designer. • They should only need to follow the design, but it's helpful for them to understand the code in case they need to make substitutions in products.	• They are responsible for following what's in the design – if they don't, the system can end up being out of compliance. They complete installation compliance documents. • Coordinate with lighting designer in case issues with installation arise. • They purchase/install products specified by design. It's helpful for them to know what products meet compliance in case they need to substitute products.	• Will need to know wattage products due to lowered exemption threshold for controls.	• Clear documentation of Title 24, Part 6 compliant products. • Clear documentation illustrating difference between old standards and new one. • Clear documentation explaining who they can speak with for help on code compliance. • Examples showing systems that are Title 24 compliant. • Examples showing systems that are not Title 24 compliant with explanations of why they aren't.
Electrician	• Need to understand the code as they might be responsible for designing lighting systems. • They might play a similar role to contractor/builder and follow lighting design/install lighting equipment.	• If designing the system, they are responsible for ensuring it follows the code. They would also be responsible for filling out design compliance documents. • If building the system, they are responsible for following what's in the design – if they don't, the system can end out of compliance. They would complete installation compliance documents. • Coordinate with lighting designer in case issues with installation arise. • Purchase/install products specified by design that are compliant.	• If remote sensors are used, electricians ensure proper installation. Otherwise, sensor integrated luminaires will not need additional effort from electricians.	• Clear documentation of Title 24, Part 6 compliant products. • Clear documentation illustrating difference between old standards and new one. • Clear documentation explaining who they can speak with for help on code compliance. • Examples showing systems that are Title 24 compliant. • Examples showing systems that are not Title 24 compliant with explanations of why they aren't.

Market Actor	Task(s) In Compliance Process	Objective(s) in Completing Compliance Tasks	How Proposed Code Change Could Impact Work Flow	Opportunities to Minimize Negative Impacts of Compliance Requirement
Title 24 Consultant	• Experts on Title 24, Part 6 and compliance/compliance documents/compliance steps. • They are hired by designers/building owners to help interpret the code/ensure compliance/fill out paperwork.	• Coordinate with designers, installers, building owners, and compliance agencies. • They generate compliance documentation as well as provide assistance in code interpretation.	• Will need to know the new, more stringent standards.	• Document explaining Title 24 process and where documents go/who needs to sign what. • Modeling software will need to be updated to include proposed values. Software training updates. • Clear code requirements that apply to the project. • Designation on products about whether or not they meet code requirements. How to/direction on how to specify the products that meet the code (lighting designer is not purchasing the lighting fixtures, the contractor purchases). • Examples showing systems that are Title 24 compliant. • Examples showing systems that are not Title 24 compliant with explanations of why they aren't. • Documents explaining who they can speak with for help on code compliance.

Market Actor	Task(s) In Compliance Process	Objective(s) in Completing Compliance Tasks	How Proposed Code Change Could Impact Work Flow	Opportunities to Minimize Negative Impacts of Compliance Requirement
Building Owner	• Coordinate with designers/contractors and fill out appropriate paperwork. They must also ensure proper compliance paperwork is filled out/signed/submitted to appropriate entities.	• Need to ensure paperwork is sent to proper places and their system is up to code. • Coordinate with contractors, designers, and compliance enforcement agencies.	• Will need to know the standards have changed and what the changes are.	• Clear documentation of code requirements. • Clear documentation of everything that needs to be completed for code requirements. • Clear documentation of what compliance paperwork goes where, and the steps of the process. • Documents explaining who they can speak with for help on code compliance.

Market Actor	Task(s) In Compliance Process	Objective(s) in Completing Compliance Tasks	How Proposed Code Change Could Impact Work Flow	Opportunities to Minimize Negative Impacts of Compliance Requirement
Plan Checker	• Identify relevant requirements. • Confirm data on documents is compliant. • Confirm plans/ specifications match data on documents. • Provide correction comments if necessary.	• Quickly and easily determine requirements based on scope. • Quickly and easily determine if data in documents meets requirements. • Quickly and easily determine if plans/ specs match documents. • Quickly and easily provide correction comments that will resolve issue. • Coordinate with building owners/designers/inspectors.	• Will need to verify plans are compliant with new standards.	• Clear code language that's easily understandable. Clear instructions on where to find everything in the plans. • Clear documentation of what paperwork they need to receive and/or other tasks they need to perform. • Clear documentation of how the new code differs from the old. • Compliance documents could auto-verify data is compliant with Standards. • Existing conditions documented via as-builts or photos or ATT. Do not require additional field visit by Authority Having Jurisdiction. • Document compliance on documents in a way easily compared to plans. • Examples of plans that are in compliance. • Examples of plans that aren't in compliance and reasons why they aren't.

Market Actor	Task(s) In Compliance Process	Objective(s) in Completing Compliance Tasks	How Proposed Code Change Could Impact Work Flow	Opportunities to Minimize Negative Impacts of Compliance Requirement
Building Inspector	• Identify relevant requirements. • Confirm installed equipment matches documents/plans. • Provide correction comments if necessary.	• Quickly and easily determine requirements based on scope. • Quickly and easily determine if installation meets requirements and matches documents/plans. • Quickly and easily provide correction comments that will resolve issue. • Coordinate with building owners/designers/plan checkers.	• Will need to verify installations are compliant with new standards.	• Clear documentation of code requirements, although they probably rely more on the plan checker to make sure everything in the plan is up to code. • Clear documentation of how the new code differs from the old. • Clear documentation of the different types of technologies that might be used/installed and equivalences – if something installed is different from the plans, then the inspector needs to know whether or not it is still in code compliance. • Clear documentation of what paperwork they need to receive and/or other tasks they need to perform.

Appendix C: Energy Savings Calculation Assumptions

Reference cities and respective latitudes and longitudes used in energy savings calculation assumptions can be seen in Table 38.

Table 38: Reference Cities Used to Calculate Length of Nighttime in Each Climate Zone.

Reference City	**Climate Zone** (1 through 16)	**Latitude** (Degrees)	**Latitude** (Radians)	**Longitude** (Degrees)	**Longitude** (Radians)	**Elevation** (ft)	**Time Offset Due to Long** (Hr)
Arcata	1	40.97	0.72	-124.08	-2.17	200	-0.27
Santa Rosa	2	38.52	0.67	-122.82	-2.14	125	-0.19
Oakland	3	37.72	0.66	-122.22	-2.13	3	-0.15
San Jose	4	37.32	0.65	-121.82	-2.13	135	-0.12
Santa Maria	5	34.92	0.61	-120.47	-2.10	253	-0.03
Torrance	6	33.78	0.59	-118.32	-2.07	89	0.11
San Diego	7	32.72	0.57	-117.17	-2.05	13	0.19
Fullerton	8	33.87	0.59	-117.97	-2.06	95	0.14
Burbank-Glendale	9	34.2	0.60	-118.33	-2.07	738	0.11
Riverside	10	33.95	0.59	-117.42	-2.05	840	0.17
Red Bluff	11	40.13	0.70	-122.25	-2.13	348	-0.15
Sacramento	12	38.5	0.67	-121.50	-2.12	13	-0.10
Fresno	13	36.77	0.64	-119.72	-2.09	331	0.02
Palmdale	14	34.62	0.60	-118.07	-2.06	2523	0.13
Palm Springs	15	33.82	0.59	-116.50	-2.03	476	0.23
Blue Canyon	16	39.28	0.69	-120.72	-2.11	5279	-0.05

Table 39: Per watt savings from Scheduling Controls with Multiple Light Output Choices

	Photocontrols + Timeclock Control				PC + TC + Bi-level Motion Control			
	kWh/W or thousand Full load hours	Peak W/ W	TDV kBtu/W	PV$/W	kWh/W or thousand Full load hours	Peak W/ W	TDV kBtu/W	PV$/W
Timeclock Disabled	4.745	0.280	125.302	$ 11.15	3.394	0.238	91.130	$ 8.11
Timeclock Enabled	2.615	0.280	74.046	$ 6.59	2.223	0.238	62.939	$ 5.60
Savings from Timeclock	**2.130**	**0.000**	**51.255**	**$ 4.56**	**1.172**	**0.000**	**28.190**	**$ 2.51**
			PV$/kWh	**$ 2.14**			**PV$/kWh**	**$ 2.14**
			$/kWh	$ 0.18			$/kWh	$ 0.18

Table 40: Weighted Vacancy Values of Construction Forecast Building Types

Construction Forecast Building Type	New Construction in 2020 (million ft)	Altered / Retrofitted in 2020 (million ft)	Total Impacted by Code (million ft)	% of total	Average Vacancy based on WEOS, ETAP, and 2016 CASE Report[1]		Weighted Vacancy	
					6:00pm to midnight	Midnight to 6:00am	6:00pm to midnight	Midnight to 6:00am
Small Office	10.860	14.534	25.394	8%	91%	96%	7.42%	7.89%
Restaurant	5.706	7.227	12.933	4%	43%	43%	1.79%	1.79%
Retail	25.117	32.169	57.286	18%	47%	78%	8.61%	14.46%
Food	9.519	12.188	21.707	7%	69%	85%	4.84%	5.96%
Non-refrigerated warehouse	8.726	12.344	21.070	7%	69%	85%	4.70%	5.78%
Refrigerated warehouse	0.490	0.648	1.138	0%	69%	85%	0.25%	0.31%
Schools	10.702	15.561	26.263	8%	81%	99%	6.86%	8.39%
College	6.968	11.458	18.426	6%	69%	85%	4.11%	5.06%
Hospital	6.390	10.118	16.507	5%	84%	89%	4.47%	4.74%
Hotel/motel	6.669	9.306	15.975	5%	69%	85%	3.56%	4.39%
Large offices	42.359	50.850	93.208	30%	91%	96%	27.22%	28.95%
Total	133.506	176.402	309.908	100%			**73.84%**	**87.71%**

[1] Where the space type found in the Construction Forecast Building Type was not represented by occupancy data in WEOS, ETAP, or the 2016 CASE report, an average vacancy of 69% from 6pm to midnight and 85% from midnight to 6am was used.

Appendix D: Assumed Lighting Power Allowances

Table 41 and Table 42 were used to calculate the installed wattage of outdoor lighting in California seen in Table 22. The weighted lighting zone area of new construction and alterations forecasted in 2020 was multiplied by the average Light Power Allowance assumed in the 2019 CASE Report on Outdoor Sources.

Table 41: Proposed 2019 LED Prototype Site Calculations, LZ1 and LZ2

Site Description			A- Long Skinny, Big Building	B-Square, Odd Building	C- Odd, Campus Buildings	D- Long Skinny, Small Square Building	E- Square, Small Building	F- Odd, Long Square Building	G- Long Skinny, Odd Building	H- Square, Large Square Building	J- Odd, Large Odd Building	K- Perfect Square Site, No Building	
Area, [sf]			501,626	471,726	42,828	28,500	21,000	61,798	21,797	11,040	34,735	250,000	
Perimeter, [sf]			6,794	5,131	3,052	960	760	1,940	1,408	1,042	2,593	2,000	
Perimeter to Area Ratio			1.4%	1.1%	7.1%	3.4%	3.6%	3.1%	6.5%	9.4%	7.5%	0.8%	
Title 24 - 2019: With IWA													
LZ1	AWA	W/sf	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	
		W	9,029	8,491	771	513	378	1,112	392	199	625	4,500	
	LWA	W/lf	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	
		W	1,019	770	458	144	114	291	211	156	389	300	
	IWA	W	180	180	180	180	180	180	180	180	180	180	
	TOTAL	W	10,228	9,441	1,409	837	672	1,583	784	535	1,194	4,980	Mean
	LPD	W/sf	0.020	0.020	0.033	0.029	0.032	0.026	0.036	0.048	0.034	0.020	0.030
	%W from AWA		88.3%	89.9%	54.7%	61.3%	56.3%	70.3%	50.1%	37.1%	52.4%	90.4%	65.1%
	%W from LWA		10.0%	8.2%	32.5%	17.2%	17.0%	18.4%	27.0%	29.2%	32.6%	6.0%	19.8%
	%W from IWA		1.8%	1.9%	12.8%	21.5%	26.8%	11.4%	23.0%	33.6%	15.1%	3.6%	15.1%
LZ2 Asphalt	AWA	W/sf	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	
		W	11,537	10,850	985	656	483	1,421	501	254	799	5,750	
	LWA	W/lf	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	
		W	1,155	872	519	163	129	330	239	177	441	340	
	IWA	W	250	250	250	250	250	250	250	250	250	250	
	TOTAL	W	12,942	11,972	1,754	1,069	862	2,001	991	681	1,490	6,340	Mean
	LPD	W/sf	0.026	0.025	0.041	0.037	0.041	0.032	0.045	0.062	0.043	0.025	0.038
	%W from AWA		89.1%	90.6%	56.2%	61.3%	56.0%	71.0%	50.6%	37.3%	53.6%	90.7%	65.7%
	%W from LWA		8.9%	7.3%	29.6%	15.3%	15.0%	16.5%	24.2%	26.0%	29.6%	5.4%	17.8%
	%W from IWA		1.9%	2.1%	14.3%	23.4%	29.0%	12.5%	25.2%	36.7%	16.8%	3.9%	16.6%
LZ2 Concrete	AWA	W/sf	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	
		W	12,541	11,793	1,071	713	525	1,545	545	276	868	6,250	
	LWA	W/lf	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	
		W	2,718	2,052	1,221	384	304	776	563	417	1,037	800	
	IWA	W	250	250	250	250	250	250	250	250	250	250	
	TOTAL	W	15,508	14,096	2,542	1,347	1,079	2,571	1,358	943	2,156	7,300	Mean
	LPD	W/sf	0.031	0.030	0.059	0.047	0.051	0.042	0.062	0.085	0.062	0.029	0.050
	%W from AWA		80.9%	83.7%	42.1%	52.9%	48.7%	60.1%	40.1%	29.3%	40.3%	85.6%	56.4%
	%W from LWA		17.5%	14.6%	48.0%	28.5%	28.2%	30.2%	41.5%	44.2%	48.1%	11.0%	31.2%
	%W from IWA		1.6%	1.8%	9.8%	18.6%	23.2%	9.7%	18.4%	26.5%	11.6%	3.4%	12.5%

Table 42: Proposed 2019 LED Prototype Site Calculations, LZ3 and LZ4

Site Description			A- Long Skinny, Big Building	B-Square, Odd Building	C- Odd, Campus Buildings	D- Long Skinny, Small Square Building	E- Square, Small Building	F- Odd, Long Square Building	G- Long Skinny, Odd Building	H- Square, Large Square Building	J- Odd, Large Odd Building	K- Perfect Square Site, No Building	
Area, [sf]			501,626	471,726	42,828	28,500	21,000	61,798	21,797	11,040	34,735	250,000	
Perimeter, [sf]			6,794	5,131	3,052	960	760	1,940	1,408	1,042	2,593	2,000	
Perimeter to Area Ratio			1.4%	1.1%	7.1%	3.4%	3.6%	3.1%	6.5%	9.4%	7.5%	0.8%	
Title 24 - 2019: With IWA													
LZ3 Asphalt	AWA	W/sf	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	
		W	12,541	11,793	1,071	713	525	1,545	545	276	868	6,250	
	LWA	W/lf	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	
		W	1,699	1,283	763	240	190	485	352	261	648	500	
	IWA	W	350	350	350	350	350	350	350	350	350	350	
	TOTAL	W	14,589	13,426	2,184	1,303	1,065	2,380	1,247	887	1,867	7,100	Mean
	LPD	W/sf	0.029	0.028	0.051	0.046	0.051	0.039	0.057	0.080	0.054	0.028	0.046
	%W from AWA		86.0%	87.8%	49.0%	54.7%	49.3%	64.9%	43.7%	31.1%	46.5%	88.0%	60.1%
	%W from LWA		11.6%	9.6%	34.9%	18.4%	17.8%	20.4%	28.2%	29.4%	34.7%	7.0%	21.2%
	%W from IWA		2.4%	2.6%	16.0%	26.9%	32.9%	14.7%	28.1%	39.5%	18.8%	4.9%	18.7%
LZ3 Concrete	AWA	W/sf	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	
		W	15,049	14,152	1,285	855	630	1,854	654	331	1,042	7,500	
	LWA	W/lf	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	
		W	2,718	2,052	1,221	384	304	776	563	417	1,037	800	
	IWA	W	350	350	350	350	350	350	350	350	350	350	
	TOTAL	W	18,116	16,554	2,856	1,589	1,284	2,980	1,567	1,098	2,429	8,650	Mean
	LPD	W/sf	0.036	0.035	0.067	0.056	0.061	0.048	0.072	0.099	0.070	0.035	0.058
	%W from AWA		83.1%	85.5%	45.0%	53.8%	49.1%	62.2%	41.7%	30.2%	42.9%	86.7%	58.0%
	%W from LWA		15.0%	12.4%	42.8%	24.2%	23.7%	26.0%	35.9%	38.0%	42.7%	9.2%	27.0%
	%W from IWA		1.9%	2.1%	12.3%	22.0%	27.3%	11.7%	22.3%	31.9%	14.4%	4.0%	15.0%
LZ4	AWA	W/sf	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	
		W	15,049	14,152	1,285	855	630	1,854	654	331	1,042	7,500	
	LWA	W/lf	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	
		W	2,378	1,796	1,068	336	266	679	493	365	908	700	
	IWA	W	400	400	400	400	400	400	400	400	400	400	
	TOTAL	W	17,827	16,348	2,753	1,591	1,296	2,933	1,547	1,096	2,350	8,600	Mean
	LPD	W/sf	0.036	0.035	0.064	0.056	0.062	0.047	0.071	0.099	0.068	0.034	0.057
	%W from AWA		84.4%	86.6%	46.7%	53.7%	48.6%	63.2%	42.3%	30.2%	44.4%	87.2%	58.7%
	%W from LWA		13.3%	11.0%	38.8%	21.1%	20.5%	23.2%	31.9%	33.3%	38.6%	8.1%	24.0%
	%W from IWA		2.2%	2.4%	14.5%	25.1%	30.9%	13.6%	25.9%	36.5%	17.0%	4.7%	17.3%