Codes and Standards Enhancement (CASE) Initiative

2019 California Building Energy Efficiency Standards

Nonresidential Indoor Controls (Alignment with ASHRAE 90.1) – Draft Report

Measure Number: 2019-NR-LIGHT4-D

Nonresidential Lighting

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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, San Diego Gas and Electric, Southern California Edison, 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 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/.

Measure Description

This CASE Report proposes three mandatory measures related to nonresidential lighting indoor controls as well as code language cleanup:

- Automatic Daylight Dimming Plus OFF Controls (referred to as "Daylight Dimming Plus OFF" for short throughout the report),
- Mandatory Occupant Sensing Full OFF Controls in Nonresidential Restrooms (referred to as "Occupant Sensing Controls in Restrooms"),
- Manual ON Commissioning for Automatic Time-Switch Controls (referred to as "Manual ON Time-Switch"), and
- Nonresidential Indoor Lighting Code Language Cleanup and Alignment with ASHRAE 90.1-2016.

The "Daylight Dimming Plus OFF" measure proposes to require nonresidential automatic daylight dimming controls to include the OFF step to align with ASHRAE 90.1-2016. The proposed daylighting dimming plus OFF control step will be mandatory and apply to the luminaires in the Primary Sidelit Daylit Zone and Skylit Daylit Zone. The prescriptive approach for new construction and nonresidential lighting alteration projects would require luminaires in the Secondary Sidelit Daylit Zone, in addition to the Primary Sidelit Daylit Zone and Skylit Daylit Zone, to have daylight dimming plus OFF control step. This measure also proposes to update the existing Title 24, Part 6 Power Adjustment Factor (PAF) for daylight dimming plus OFF controls to only be applicable to areas that are proposed to be exempt in Section 130.1(d)2C.

The "Occupant Sensing Controls in Restrooms" measure proposes mandatory occupant sensing full OFF controls in nonresidential restrooms to be more aligned with ASHRAE 90.1-2016.

The "Manual ON Time-Switch" measure proposes that automatic time-switch controls, should they be used to comply with Section 130.1(c), be commissioned as manual ON. This proposal would exempt automatic time-switch controls used in the following function spaces: industrial, single tenant retail, malls, auditoriums, concourses, lobbies and other areas open to the general public. This measure will reduce the amount of time that nonresidential indoor lighting is turned ON when there are no occupants present in the space.

1.1 Scope of Code Change Proposal

Table 1 summarizes the scope of the proposed changes, by listing sections of the Standards, references appendices, and compliance documents that 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 Document(s)
Daylight Dimming Plus OFF Controls in Primary and Skylit Zones	Mandatory	Section 130.1(d) Section 140.6(d)	NA7.6.1 Automatic Daylighting Control Acceptance	Yes	2016-NRCA-LTI-03-A Automatic Daylighting Control Acceptance Document
Daylight Dimming Plus OFF Controls in Secondary Zones	Prescriptive	Section 140.6(d)	N/A	Yes	N/A
Occupant Sensing Controls in Restrooms	Mandatory	Section 130.1(c)	NA7.6.2	No	NRCC-LTI-02-E "Mandatory Declaration Statements"
Manual ON Time-Switch Controls	Mandatory	Section 130.1	N/A	No	N/A
Nonresidential Indoor Lighting Code Language Cleanup and Alignment with ASHRAE 90.1-2016	Mandatory	Section 100.1 Section 130.1 Section 140.1	NA 7.6.1.2.1	No	N/A

Market Analysis and Regulatory Impact Assessment

The market of occupancy and daylighting controls is well established.

This proposal is 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 Standards have a negligible impact on the complexity of the standards and 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 changes were found to be cost-effective for all climate zones where they are 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.

The "Daylight Dimming Plus OFF" measure provides energy costs savings without the incremental costs. The proposed measure saves money over the 15-year period of analysis relative to the existing conditions. The proposed code change is cost-effective for new construction and alterations.

The B/C ratio for the "Occupant Sensing Controls in Restrooms" measure is 1.97 for new construction and 1.78 for alterations.

The "Manual ON Time-Switch" measure does not incur any incremental costs, while yielding significant savings. The proposed code change is thus cost-effective for both new construction and alterations

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 6 for more details.

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

Measure	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)
Daylight Dimming Plus OFF Controls	15.5	0.8	N/A	N/A
Occupant Sensing Controls in Restrooms	13.3	2.4×10^{-3}	N/A	N/A
Manual ON Time-Switch Controls	2.1	0	N/A	N/A

1. First-year savings from all buildings completed statewide in 2020.
2. The grid peak is moving to later in the day when daylighting is not major source of illumination.

Compliance and Enforcement

The Statewide CASE Team worked with stakeholders to develop a recommended a 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 2.5 and Appendix B. The key issues related to compliance and enforcement are summarized below:

- Existing Automatic Daylighting Control Acceptance Test requirements need revision. Detailed information can be found in Section 2.5 and 7.3.
- Existing Occupancy Sensor Control Acceptance Test requirements and the Compliance Manual will need revision to recommend the appropriate occupancy sensor technology as it applies to different bathroom configurations and bathroom stalls.

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 final 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 should 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:

1. *The estimated incremental costs and if these reflect mature market trends;*
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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, San Diego Gas and Electric, Southern California Edison and SoCalGas® and two Publicly Owned Utilities (POUs) — Los Angeles Department of Water and Power and Sacramento Municipal Utility District 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 information for a proposed compliance option on building energy efficient design practices and technologies. This proposed code change does not require a cost-effectiveness analysis.

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 for three indoor controls measures. The report contains pertinent information supporting cost-effectiveness, market readiness, and technical feasibility of the code change.

When developing the code change proposal and associated technical information presented in this report, the Statewide CASE Team worked with several 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 public stakeholder workshops that the Statewide CASE Team held on September 8, 2016 and March 22, 2017.

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 conflicts 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 a 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. The statewide energy savings are calculated for new construction and alterations.

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

This CASE Report proposes three mandatory measures and code language cleanup related to nonresidential lighting indoor controls:

- Mandatory Automatic Daylight Dimming Plus OFF Controls (referred to as "Daylight Dimming Plus OFF"),
- Mandatory Occupant Sensing Full OFF Controls in Nonresidential Restrooms (referred to as "Occupant Sensing Controls in Restrooms"),
- Manual ON Commissioning for Automatic Time-Switch Controls (referred to as "Manual ON Time-Switch"), and
- Nonresidential Indoor Lighting Code Language Cleanup and Alignment with ASHRAE 90.1-2016.

<u>Mandatory Automatic Daylight Dimming Plus OFF Controls</u>

The "Daylight Dimming Plus OFF" measure proposes nonresidential automatic daylight dimming controls requirements to include the OFF step to align with requirements in ASHRAE 90.1-2016. The proposed daylighting dimming plus OFF control step will be mandatory and apply to luminaires in Primary Sidelit Daylit Zones and Skylit Daylit Zones. The proposed measure includes an exemption for classroom areas and Primary and Secondary Sidelit retail spaces. For new construction and alterations projects that use the prescriptive approach (versus performance approach), the proposed daylight dimming plus OFF control step would be required for luminaires in Secondary Sidelit Daylit Zones. The existing exemption for Secondary Sidelit Daylit Zones where lighting power in total Secondary Sidelit Daylit Zones is less than 120 watts would remain.

This measure also proposes to update the existing Power Adjustment Factor (PAF) for daylight dimming plus OFF controls so it would only be applicable to areas that are exempt in Section 130.1(d)2C.

This proposal recommends *not* aligning the following existing 2016 Title 24, Part 6 exceptions for automatic daylight dimming controls with ASHRAE 90.1-2016:

- Lighting power wattage exception: Title 24, Part 6 currently exempts spaces in which the combined total installed general lighting power in the Skylight and Primary Sidelit Zone is less than 120 watts. ASHRAE 90.1-2016 exempts rooms if the lighting power is less than 150 watts. The Statewide CASE Team recommends leaving the Title 24, Part 6 lighting power exemption in place as opposed to harmonizing with ASHRAE 90.1-2016. The cost of energy is more expensive in California and Title 24, Part 6 uses a lower discount rate than ASHRAE-90.1, which allows for a lighting power wattage to be cost-effective.
- Total glazing area exception: Title 24, Part 6 currently exempts rooms with a total glazing area of less than 24 square feet. ASHRAE 90.1-2016 exempts sidelit areas where the total glazing area is less than 20 square feet. For code simplicity, the Statewide CASE Team recommends leaving the Title 24, Part 6 glazing exemption in place as opposed to harmonizing with ASHRAE 90.1-2016.

The current 2016 Title 24, Part 6 definitions for Daylit Zones are provided below for reference; however, this proposal also recommends modifications to the Daylit Zones definitions. See Section 7 for proposed revisions to the definitions provided below:

> **Skylit Daylit Zone** is the rough area in plan view under each skylight, plus 0.7 times the average ceiling height in each direction from the edge of the rough opening of the skylight, minus any area on a plan beyond a permanent obstruction that is taller than the following: A permanent obstruction that is taller than one-half the distance from the floor to the bottom of the skylight. The bottom of the skylight is measured from the bottom of the skylight well for skylights having wells, or the bottom of the skylight if no skylight well exists.
>
> For the purpose of determining the skylit daylit zone, the geometric shape of the skylit daylit zone shall be identical to the plan view geometric shape of the rough opening of the skylight; for example, for a rectangular skylight the skylit daylit zone plan area shall be rectangular, and for a circular skylight the skylit daylit zone plan area shall be circular.
>
> **Primary Sidelit Daylit Zone** is the area in plan view and is directly adjacent to each vertical glazing, one window head height deep into the area, and window width plus 0.5 times window head height wide on each side of the rough opening of the window, minus any area on a plan beyond a permanent obstruction that is 6 feet or taller as measured from the floor.
>
> **Secondary Sidelit Daylit Zone** is the area in plan view and is directly adjacent to each vertical glazing, two window head heights deep into the area, and window width plus 0.5 times window head height wide on each side of the rough opening of the window, minus any area on a plan beyond a permanent obstruction that is 6 feet or taller as measured from the floor.[1]

The 2016 Nonresidential Compliance Manual, Chapter 5 includes diagrams for each type of daylit area.

[1] 2016 Building Energy Efficiency Standards for Residential and Nonresidential Buildings, California Energy Commission. § 130.1(d)1 (2016).

Mandatory Occupant Sensing Full OFF Controls in Nonresidential Restrooms

The "Occupant Sensing Controls in Restrooms" measure proposes mandatory occupant sensing full OFF controls in nonresidential restrooms to be aligned with ASHRAE 90.1-2016. This measure would apply to all nonresidential restrooms.

The Statewide CASE Team recommends that Chapter 5 in the 2019 Nonresidential Compliance Manual include guidance on the appropriate occupancy sensor technology based on the size and configuration of the nonresidential restroom.

Manual ON Commissioning for Automatic Time-Switch Controls

The "Manual ON Time-Switch" measure proposes that automatic time-switch controls, should they be used to comply with Section 130.1(c), be commissioned as manual ON. This proposal would exempt automatic time-switch controls used in the following function spaces: industrial, single tenant retail, malls, auditoriums, concourses, lobbies, and other areas open to the general public. This measure will reduce the amount of time that nonresidential indoor lighting is turned ON when there are no occupants present in the space.

This measure does not prevent automatic time-switches from being reprogrammed to use automatic ON setting after acceptance testing and commissioning are completed.

Nonresidential Indoor Lighting Code Language Cleanup and Alignment with ASHRAE 90.1-2016

The Statewide CASE Team proposes general code cleanup to clarify Title 24, Part 6 requirements.

The following changes are also proposed to harmonize with ASHRAE 90.1:

- Increase minimum diming level in classrooms

2.2 Measure History

Mandatory Automatic Daylight Dimming Plus OFF Controls

Requirements for mandatory automatic daylighting controls were first introduced in the 2005 Title 24, Part 6 Standards.

In the 2013 Title 24, Part 6 code cycle, the requirements for automatic daylighting controls were significantly simplified. Specifically, the 2013 CASE Report on Nonresidential Daylighting proposed a Watt Calculation Method that provides a simpler way to calculate the savings from daylighting controls (California Utilities Statewide Codes and Standards Team 2011). In addition, the 2013 CASE Report addressed the threshold for requiring photocontrols, which simplified the method of compliance.

In the 2016 Title 24, Part 6 code cycle, the requirements for automatic daylighting were updated further. The 2016 CASE Report on Nonresidential Lighting Controls clarified Section 130.1(d)2D, which states the requirements for the access to the calibration adjustment control(s) for photocontrol systems (California Utilities Statewide Codes and Standards Team 2014). The primary purpose of this requirement is to prevent tampering with the photosensor and to have the calibration controls readily accessible so that adjustments to daylighting controls can be easily performed by authorized personnel in response to changes in geometry or reflectance of the interior, changes in occupancy or tasks, and in response to requests for more or less light from occupants.

In addition, the 2016 Title 24, Part 6 code cycle added a PAF for daylighting controls that includes the OFF step (i.e., controls that turn OFF lights when enough daylight is available). The 2016 CASE Report on Nonresidential Lighting Controls stated the goal of the PAF was to prepare the market for this control strategy as a mandatory measure in the 2019 code cycle (California Utilities Statewide Codes and Standards Team 2014).

A simulation study conducted by Pacific Northwest National Laboratory[2] (PNNL) found that energy savings from automatic daylighting controls are increased by approximately 30 percent when an OFF step is added to either dimming or stepped switching controls in medium office buildings. The OFF step turns lights completely OFF when daylight exceeds the design illuminance in the daylit zone. The full dimmed lighting consumes approximately 25 percent of rated lighting power and the three-step stepped switching consumes 33 percent of full power at lowest stepped dimmed level without being turned off (Pacific Northwest National Laboratory 2013). Daylight dimming plus OFF controls has been in ASHRAE 90.1 since the 2013 code cycle.

Mandatory Occupant Sensing Full OFF Controls in Nonresidential Restrooms

The 2016 Title 24, Part 6, Section 130.1 – Mandatory Indoor Lighting Controls, Section (c) – Shut-OFF Controls, part 1 (130.1(c)1) states that all indoor lighting is required to be "controlled with an occupant sensing control, automatic time-switch control, or other control capable of automatically shutting OFF all of the lighting when the space is typically unoccupied." Section 130.1(c)2 states "Countdown timer switches shall not be used to comply with the automatic shut-OFF control requirements in Section 130.1(c)1." An exception to Section 130.1(c)2 was introduced in the 2013 Title 24 code, in which "single-stall bathrooms less than 70 square feet…may use countdown timer switches with a maximum setting capability of ten minutes to comply with the automatic shut-OFF requirements." In addition, Section (b) requires the general lighting in rooms 100 square feet or larger, with a Lighting Power Density (LPD) greater than 0.5 watts per square feet, to have multi-level controls. This essentially requires a dimming driver or ballast. However, EXCEPTION 1 to Section 130.1(b) includes: "and public restrooms shall have at least one control step between 30-70 percent of full rated power." Thus, per Title 24, Part 6, public restrooms can use bi-level switching.

Notably, the 2016 Title 24, Part 6, Section 130.1(c)5 "Areas where Occupant Sensing Controls are required to shut OFF all lighting" does not list nonresidential restrooms: "In offices 250 square feet or smaller, multipurpose rooms of less than 1,000 square feet, classrooms of any size, and conference rooms of any size, lighting shall be controlled with occupant sensing controls to automatically shut OFF all of the lighting when the room is unoccupied."

Thus, the 2016 Title 24, Part 6 controls allowable for restrooms are as follows:

1. Section 130.1(a) Area Controls: Required, but for restrooms with two or more stalls, manual control not accessible to unauthorized personnel allowed.
2. Section 130.1(b) Multi-Level Lighting Controls: Provide multi-level lighting control which shall have at least one control step between 30-70 percent of full rated power if:
    a. Restroom is 100 square feet or larger;
    b. Restrooms with a connected lighting load that exceeds 0.5 watts per square foot (W/ft^2);
    c. Restrooms with only one luminaire with no more than two lamps are exempt.
3. Section 130.1(c) Shut-OFF Controls:
    a. A countdown timer when the restroom is 70 square feet or smaller; or
    b. An occupancy sensor; or
    c. Automatic timeclock based control with a timed override switch (if bathroom has two or more stalls, this override has can be inaccessible to unauthorized personnel).

Manual ON Commissioning for Automatic Time-Switch Controls

As stated above, Section 130.1(c) has allowed the use of automatic time-switch controls to comply with Title 24, Part 6 Shut-OFF requirements going back to the 2008 code cycle. In the utility-sponsored stakeholder meeting held on September 8, 2016, the Statewide CASE Team received feedback from

[2] With assistance from Mudit Saxena.

several manufacturers who suggested that automatic time-switch controls should be commissioned as ON, since the typical automatic ON feature often results in wasted energy due to the switches turning ON when no occupants are present within the area. Stakeholders expressed that commissioning with manual ON will lead to significant energy savings by reducing the number of inadvertent occurrences. Stakeholders felt certain public function spaces should be exempt and the code should include the option to reprogram the switch to automatic ON after acceptance testing.

2.3 Summary of Proposed Changes to Code Documents

The sections below provide a summary of how each Title 24, Part 6 document 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 will modify the following sections of the Building Energy Efficiency Standards as shown below. See Section 7.1 of this report for the detailed proposed revisions to the code language pertaining to standards change.

Section 130.1 (c), Mandatory Indoor Lighting Controls, Shut-OFF Controls: add a mandatory requirement for occupant sensing full OFF controls in nonresidential restrooms to capture energy savings when restrooms are unoccupied. An exception to Section 130.1(c)5A & B is proposed whereby, in areas not required by Section 130.1(b) to have multi-level lighting controls, lighting is permitted to be controlled by an occupancy sensor that automatically turns ON all lighting when the room is occupied. In addition, the Statewide CASE Team proposes that automatic time-switches, should they be used to comply with this section, be commissioned as manual ON, with the exception of several function spaces that are open to the general public.

Section 130.1(d), Mandatory Indoor Lighting Controls, Automatic Daylighting Controls: add a mandatory requirement including OFF step in automatic daylight dimming controls to maximize savings from daylight harvesting and to be more aligned with ASHRAE 90.1-2016. The proposed measure includes an exemption for classroom areas and Primary and Secondary Sidelit retail spaces, based on stakeholder feedback. This mandatory requirement would apply to Skylit Daylit Zone and Primary Sidelit Daylit Zone. This requirement would also apply to Secondary Sidelit Daylit Zone for projects in which the prescriptive approach (verses performance approach) is elected to comply with other provisions of the Title 24, Part 6 code. The Statewide CASE Team proposes to reduce the daylight illuminance level in the daylit zone at which lights are dimmed at 35 percent of rated power to 125 percent of design illuminance. The proposed change would require lights being turned off when daylight illuminance exceeds 150 percent of design illuminance.

Section 140.6(d), Table 140.6-A Lighting Power Adjustment Factors (PAF): Revise PAF for daylight dimming plus OFF control to only be applicable to areas that are proposed to be exempt in Section 130.1(d)2C.

Section 130.1. The Statewide CASE Team proposes general cleanup of code related to indoor controls for clarity and to align with ASHRAE 90.1-2016.

2.3.1.1 Rationale for Changes to Lighting Controls Requirements

Section 100.1 Definitions. The Statewide CASE Team proposes to add the term "vertical fenestration" so Title 24, Part 6 defines the Sidelit Daylight Zones in a manner similar to ASHRAE 90.1. In addition, the definition will clearly demonstrate that areas by glazed doors are also considered Sidelit Daylit Zones if the term "window" is replaced with "vertical fenestration."

Section 130.1(a)3 Other Lighting Controls. The current language causes confusion, because there are certain times when area controls can be overridden by automatic lighting controls. The Statewide CASE

Team received feedback from stakeholders to propose clearer language. The exhaustive list of the four applications where this occurs is contained in the newly proposed **Section 130.1(f) Controls Coordination.**

Section 130.1(b) Multi-Level Controls.

- The Statewide CASE Team proposes to replace "enclosed area," which is not a defined term, with "enclosed space," which is a defined term in **Section 100.1 Definitions**.
- The Statewide CASE Team proposes to delete **EXCEPTION 1 to Section 130.1(b).** Classroom lighting is proposed to be no longer exempted at the higher 0.7 W/ft^2 with simple multi-level controls.
    - Classrooms commonly have a sidelit zone, so this requirement creates a conflict as in Section130.1(d)2Cii: *"Automatic daylighting controls shall provide functional multilevel lighting having at least the number of control steps specified in TABLE 130.1-A."* TABLE 130.1-A contains the control steps required by Section 130.1(b).
    - During the development of the 2013 CASE Report on Requirements for Controllable Lighting, classrooms were exempted from the dimming requirements (California Utilities Statewide Codes and Standards Team 2011). At the time, the default technology was linear fluorescent and the addition of dimming ballasts to fluorescent luminaires was relatively expensive. Classrooms were singled out as being exempt, because of fewer full load hours than other space types. This report assumed that energy savings from dimming lighting is approximately 15 percent due to institutional tuning of dimmable lighting to better match design illuminance. Without institutional tuning, spaces are over lighted due to discrete spacing choices (i.e., lining up with the two or four-foot grid spacing of suspended ceilings) and discrete light output from luminaires.
    - The Statewide CASE Team replicated the analysis in the 2013 CASE Report on Requirements for Controllable Lighting, and concluded that the current market default technology is continuous diming LED troffers, which have a negligible difference between static and dimmable troffers. The analysis found that LEDs are cost-effective, which is described in more detail in Section 5.5.
    - The 2019 LPD for classrooms is 0.72 W/ft^2, which is the maximum allowable wattage.
    - The Statewide CASE Team proposes striking the exception for classrooms since the dimming control has a B/C ratio of 5 to 1, using the same rationale as was used in the 2013 CASE Report on Requirements for Controllable Lighting (California Utilities Statewide Codes and Standards Team 2011).
- **EXCEPTION 2 to Section 130.1(b):** The Statewide CASE Team proposes adding applications complying with Section 130.1(c)7 and Section 130.1(c)8 to the exception for continuous dimming controls. The current exception only includes applications complying with Section 130.1(c)6.
- The Statewide CASE Team proposes adding a new exception to **Section 130.1(b)** for restrooms.
    - **EXCEPTION 3 to Section 130.1(b):** Restrooms should be an exception based on the control strategy that lights are usually only turned ON or OFF in restrooms and that there is no added benefit of having a dimmer. See also **Section 130.1(c)5.**

Section 130.1(c)1C Separate Shut-off Controls

- The Statewide CASE Team recommends clarifying the intent of the square footage limits per control. The 2016 Title 24, Part 6 requirement states: *"Separate controls for a space enclosed by ceiling height partitions; not exceeding 5,000 square feet."* The Statewide CASE Team received feedback from stakeholders that there are varying interpretations. For example, one interpretation of the intent could be that separate controls were only required for spaces that were less than 5,000 square feet. The direct intent of this section is, *"Separate controls [are*

required] for each space enclosed by ceiling height partitions; and no greater than 5,000 square feet of lighting is controlled by each control."

- In addition to clarifying the intent of the code, the Statewide CASE Team finds that the enforcement of this requirement would be easier if the criteria were based on wattage instead of square footage. Stakeholders find that calculating the square footage of irregularly shaped spaces is significantly more difficult than finding the total wattage of luminaires controlled by a single control. The proposed code change would not add any additional work as calculating the total connected wattage per control must be completed to avoid violating the ampacity of conductors serving luminaires and for overcurrent protection of the circuits serving the control. The maximum wattage that was to be the proxy for 5,000 square feet was selected to be 3,000 watts. This was selected based on average 0.65 W/square foot whole building LPDs for the spaces served which yields 3,250 watts, and this was rounded down to the closes increment of 1,000 watts yielding a 3,000-watt maximum power per control.
- **EXCEPTION to Section 130.1(c)1C:** The code language was modified to indicate the original intent of the code, which requires there to be a separate control per enclosed space and the space per control is relaxed to 20,000 square feet. The 2016 Title 24, Part 6 requirement states: *" In the following function areas the area controlled may not exceed 20,000 square feet: Malls, auditoriums, single tenant retail, industrial, convention centers, and arenas."* This could be interpreted as a separate control per enclosed space is not required in these areas. The Statewide CASE Team's understanding is that in addition to a separate control per enclosed space, each control cannot control more than 20,000 square feet of lighting. The Statewide CASE Team's proposes clarifying the exemption to read as follows: *"In Malls, auditoriums, single tenant retail, industrial, convention centers, and arenas, <u>with separate controls for each space and no greater than 20,000 square feet of lighting is controlled by each control</u>."*
- **EXCEPTION to Section 130.1(c)1C:** The Statewide CASE Team proposes to convert the maximum controlled area from 20,000 square feet to 15,000 watts of controlled power. A majority of the exempted spaces have low lighting power densities that are around 0.65 W/square foot. One exception is single tenant retail which has a whole building lighting power density of 0.85 W/ft^2 The Statewide CASE Team proposes the 15,000 watts of controlled power because a 20,000 square foot building with 0.65 W/ft^2 has a total of 13,000 watts and with 0.85 W/ft^2 has a total of 17,000 watts.
    - Furthermore, the California Electrical Code considers lighting a continuous duty load and the ampacity of wiring conductors must be derated to 80 percent of their nominal load. The most common conductor size used for commercial lighting is 12-gauge wire with a nominal ampacity of 20 amps or a continuous duty rating of 16 amps. For a 277 Volt circuit with 12 gauge conductors, the maximum wattage is 4,432 watts (277 Volts x 0.8 x 20 Amps = 4,432W). For a three-phase lighting contactor with 12-gauge wire, the controlled wattage is three times as much or 13,296 watts. Thus, the 15,000 watt limit would allow a three-phase 20 amp lighting contactor per separate control.

Section 130.1(c)3 Manual ON Time Switch Controls

- The Statewide CASE Team recommends removing the language in strikethrough format in the following sentence: "time switch control, ~~other than an occupant sensing control~~…" The language causes confusion as it implies there is a time switch control that is an occupancy control.
- **Item A:** The Statewide CASE Team proposes language to clarify that the area control in each room is capable of manually turning lights OFF.
- **Item B:** The Statewide CASE Team proposes language to clarify the timed override of the time clock control by the area control.

- **Item C:** The Statewide CASE Team proposes a new requirement in which time-switch controls are manual ON for most occupancies. This proposed change is in response to The Association of Electrical Equipment and Medical Imaging Manufacturers (NEMA) Indoor Controls Subcommittee members who indicated that the manual ON control would save energy and add no cost to their controls. In addition to the energy savings associated with delaying the ON time until people show up, this control saves energy when holidays are not programmed into the lighting control or when a portion of a building is not occupied due to the space not being leased, a new division of a company has not moved in, etc.
- **Section 130.1(c)4:** The Statewide CASE Team proposes renumbering Section 130.1(c)3D as it is another requirement of time-switch controls. The draft code change language in Section 7.1 has Section 130.1(c)4 temporarily "reserved." Renumbering the remainder of Section 130.1 should occur if this proposal is accepted as well as correct references made to Section 130.1 from Section 141.0(b)2I, J, and K (lighting and wiring alterations).

Section 130.1(c)5 Areas where Occupant Sensing Controls are required to shut OFF All Lighting

- The Statewide CASE Team proposes to require restrooms to be controlled by occupancy controls. The rationale, energy savings, and cost-effectiveness analysis are provided in detail in the CASE Report.
- The Statewide CASE Team proposes to remove the term "room," since a defined term for a room is an "enclosed space." The term “space” is an abbreviated term for enclosed space.
- The Statewide CASE Team proposes language to clarify that areas control shall be capable of turn OFF lights even when occupancy is detected. The Statewide CASE Team proposes to move this feature, which is not subject to exceptions, from the bottom of the requirements to earlier in this section.
- The Statewide CASE Team proposes to simplify the area control (manual ON or partial ON) requirements by including an exception for controls that are exempted from Section 130.1(b).
- In response to comments from NEMA members, the Statewide CASE Team added the term "manual ON" to better reflect the terms used by industry practitioners. NEMA would also like to see the term “vacancy sensor” removed as they would like to be able to sell occupancy sensors with field adjustable settings depending upon the occupancy. The Title 20 definition of a vacantly sensor does not allow field adjustment from a vacancy sensor (manual ON mode) to occupancy sensor (automatic ON).

Section 130.1(c)6 Areas where full or partial OFF occupant sensing controls are required

- The Statewide CASE Team proposes to remove **Exceptions to Section 130.1(c)6A** for controls that reduce power by 40 percent if they are less than 80 percent of area category LPD or if they are HID lighting. These exceptions are an artifact from the 2013 Title 24, Part 6 Standards when HID lighting was still the lowest lifecycle cost method for lighting certain applications, such as warehouses. The Statewide CASE Team concludes this is no longer the case. As is shown in the Interior Lighting Sources CASE Report for the 2019 Standards, LED light sources have higher lighting quality as measured by CRI (color rendering index), are more controllable, save energy, and have a lower lifecycle cost. In ASHRAE 90.1-2016, the carve outs that were designed to protect metal halide lighting from functional requirements that would otherwise apply were removed. Removing this exception is aligning with the ASHRAE 90.1-2016 controls requirements.
- Section 130.1(c)6 controls requirements were adopted at the same time as the controllable lighting proposal. In items A through D, the Statewide CASE Team proposes adding clarifying language to the phrase "reduce lighting power <u>of each luminaire,</u>" which is applied with the assumption that the Energy Commission’s intent was to have a uniform reduction of lighting when the area is vacant. This addition is recommended if uniform lighting reduction is desired.

- **In items C and D**, the Statewide CASE Team proposes adding language to provide the flexibility to reduce lighting power when the space is vacant but other portions of the path of egress are occupied. This is captured by the added words "when entered" in the phrase *"... controls shall be capable of automatically turning the lighting fully ON only in the separately controlled space, and shall be automatically activated <u>when entered</u> from all designed paths of egress."*
- The Statewide CASE Team added item D in order for retrofits to be able to call out stairwells (controls retrofit when altering luminaires) as separate from corridors (controls not required to be retrofitted when altering luminaire).

Section 130.1(c)7 Areas where partial OFF occupant sensing controls are required

- **Item A. Lighting in common area corridors that provide access to guestrooms.** The Statewide CASE Team proposes similar changes as 130.1(c)6.
    - The Statewide CASE Team proposes to remove **Exceptions to Section 130.1(c)7A** for controls that reduce power by 40 percent if they are less than 80 percent of area category LPD. An additional 10 percent savings is obtained by not having a carve out for HID luminaires and reducing power to between 50 percent and 80 percent. This technology has a higher energy consumption and a higher lifecycle cost. ASHRAE 90.1-2016, Section 9.4.1.1(g) requires all corridors to have, at a minimum, partial OFF controls that require that power is reduced by at least 50 percent when no activity is detected in a corridor for longer than 20 minutes.
    - The Statewide CASE Team proposes to include the phrase "reduce lighting power <u>of each luminaire</u>" based on the assumption that the Energy Commission's intent was to have a uniform reduction of lighting when the area is vacant.
    - The Statewide CASE Team proposes adding language to provide the flexibility to reduce lighting power when the space is vacant but other portions of the path of egress are occupied. This is captured by the added words "when entered" in the phrase *"... controls shall be capable of automatically turning the lighting fully ON only in the separately controlled space, and shall be automatically activated <u>when entered</u> from all designed paths of egress*" This does not require lights to be ON when any part of the path of egress is occupied.
- **Item B. Lighting in stairwells.** The Statewide CASE Team proposes to separate stairwells from corridors so stairwell controls can be called out as part of lighting retrofits. Corridors are more difficult to retrofit motion controls, due to hard ceilings, small wattage luminaires and aesthetic considerations.
- **Item C. Parking garages, parking areas and loading and unloading areas.** The Statewide CASE Team proposes similar changes as to Section 130.1(c)6.
    - Similar to ASHRAE 90.1-2016, the Statewide CASE Team proposes to remove the carve outs that were designed to protect metal halide lighting from functional requirements that would otherwise apply. The proposed change would align with the ASHRAE 90.1-2016 controls requirements to control to lighting power between 20 percent and 50 percent of rated power. It should be noted that Section 9.4.1.2 in ASHRAE 90.1-2016 still only requires a reduction of 30 percent of power for parking garages. However, an ASHRAE proposal is underway to change the requirements to be in line with the 50 percent power reduction requirements for outdoor lighting (Section 9.4.1.4(d)) and Automatic partial OFF controls (Section 9.4.1.1(g)).
    - Section 130.1(c)7 controls requirements were adopted at the same time as the controllable lighting proposal. In items A through D, the Statewide CASE Team proposes adding clarifying language to the phrase "reduce lighting power <u>of each luminaire</u>," which is applied with the assumption that the Energy Commission's intent

was to have a uniform reduction of lighting when the area is vacant. This addition is recommended if uniform lighting reduction is desired.

- **Section 130.1(d) Automatic Daylighting Controls.**

Section 130.1(d)1A. Skylit Daylit Zone Definition

- The Statewide CASE Team recommends removing the introductory language, which was intended for a list of items but there is only one item.
- The Statewide CASE Team recommends adding a definition of daylit zone for atria. This recommendation is from the Washington State Energy Code and is based on analysis in the 2019 Title 24, Part 6 Advanced Daylighting Design CASE Report.
- The Statewide CASE Team recommends exempting areas under skylights that are shaded half of the time (1,500 hours) during the timeframe of 8 a.m. to 4 p.m. This is aligned with ASHRAE 90.1-2016 Section 9.4.1.1(f) "automatic daylight responsive controls for toplighting" which has a similar exemption.

Section 130.1(d)1B. Primary Sidelit Daylit Zone Definition

- The Statewide CASE Team proposes clarifying that the term “glazing” is only located in an exterior wall and does not define sidelit zones near interior windows.
- The Statewide CASE Team proposes replacing the term "window" with "vertical fenestration" which includes glass doors.
- The Statewide CASE Team proposes adding the term “vertical” to clarify that this zone does not include areas that are obstructed by vertical obstructions. This clarifies that horizontal obstructions (like light shelves) do not reduce the areas of the sidelit zone.
- The Statewide CASE Team proposes that any area in a Skylit Daylit Zone is subtracked from the Primary Sidelit Daylit Zone to avoid double counting of areas and to provide clarity on how lights are grouped together for separate control of lighting by daylighting controls. The proposed definition eliminates any overlapping Skylit and Primary Sidelit Zones.

Section 130.1(d)1C. Secondary Sidelit Daylit Zone Definition

- The Statewide CASE Team proposes similar edits to Secondary Sidelit Zones definition as those listed above for Primary Sidelit Zone. This includes clarifying the terms vertical fenestration and vertical obstructions.
- The Statewide CASE Team proposes that any lights in a Skylit Zone or Primary Sidelit zone are subtracted from the Secondary Sidelit Daylit Zone to avoid double counting of areas and to provide clarity on how lights are grouped together for separate control of lighting by daylighting controls. The proposed definition eliminates any overlapping skylit and primary sidelit zones.

EXCEPTION to 130.1(d)1B & C

- The Statewide CASE Team proposes an exemption for areas near windows from being considered as primary or secondary sidelit zone when the horizontal projection of overhang distance is equal to the window head height. The Statewide CASE Team justifies this exception because energy savings are reduced by around 50 percent when the ratio of the overhang projection to the window head height is 1.0 or greater.
- The Statewide CASE Team proposes to specifically call out that exception does not apply if there is glazing above the overhang (e.g., a clerestory above an exterior lightshelf).

Section 130.1(d)2 Daylighting Controls

- The Statewide CASE Team is looking for feedback on moving the prescriptive daylighting control requirements from Section 140.6(d) to Section 130.1(d)2. This could simplify enforcement and reflects current compliance. Controlling lights in secondary zones was found

to be cost-effective in the 2013 CASE Report on Daylighting, which was required for this measure to be prescriptively required (California Utilities Statewide Codes and Standards Team 2011). A project must install controls in Secondary Sidelit Zone if using the prescriptive approach or using the 2-D (two dimensional) performance approach software. A project can only conduct a trade-off between controls for the Secondary Sidelit Zone when using a 3-D performance approach software. Thus, the Statewide CASE Team believes the proposal under consideration would not alter the typical design practice and would result in a simpler, more enforceable standard.

- The Statewide CASE Team proposes removing **Section 130.1(d)2C.** The proposed definition ensures there are no longer any overlapping areas (see Section 130.1(d)1B & C).
- The Statewide CASE Team recommends removing **Section 130.1(d)2D** and renumbering the following item **(Section 130.1(d)2C (old Section 130.1(d)2D).** The Statewide CASE Team recommends adding the term "general lighting," in response to reports that designers and acceptance testing agents are not cognizant of fact that the requirements only apply to general lighting despite the introductory language in Section 130.1(d)2. This is further reiterated in **EXCEPTION 4 to Section 130.1(d)2,** which clarifies that the controls are not required for "*Luminaires providing display, ornamental, and display case lighting*."
- **130.1(d)2Ciii**. The Statewide CASE Team recommends referring to "daylit zone" rather than "space," as the space is a larger area and is not representing the intent of the requirement.
- **130.1(d)2Civ**. The Statewide CASE Team proposes to drop the daylight illuminance in the daylit zone at which lights are dimmed to 35 percent of rated power to 125 percent of design illuminance. The proposed change would require lights to be turned OFF when daylight illuminance exceeds 150 percent of design illuminance. Since LEDs are required by Section 130(b) and Table 130.1-A to be dimmed to 10 percent of power, this does not result in a difficult criterion to achieve during acceptance testing while still allowing for some adaptation compensation. If the 35 percent power target is achieved exactly at 125 percent of design illuminance, a space could comply because there would still be 160 percent of the design illuminance in the rear of the daylit zone.
- **130.1(d)2Cv.** This section adds the "plus-OFF" portion of the daylighting controls and allows a daylight "gap" of 25 percent of design illuminance between the minimum dimming level and turning lights completely OFF. The energy savings methodology is described in Section 4.
- **EXCEPTION 2 to Section 130.1(d)2.** The Statewide CASE Team proposes this change in response to reports that acceptance testing training is teaching people if a space does not have lights in the Secondary Sidelit Zone, no daylight controls are required in the Secondary Sidelit Zone. This more clearly defines when controls are exempted in the Secondary Sidelit Zone. The exemption from the Secondary Sidelit Zone controls requirement in Section 140.6(d) is currently unclear.

Section 130.1 (e) Demand Responsive Controls.

The Statewide CASE Team proposes to strike the following sentence: “Lighting shall be reduced in a manner consistent with uniform level of illumination requirements in TABLE 130.1-A.” This requirement can be advantageous in applications, such as ornamental display, or displays in retail or restaurants. However, the Statewide CASE Team feels the language “uniform manner’ over specifies how projects choose to reduce their lighting power.

Section 130.1 (f) Controls Coordination.

This new section was motivated by an ambiguity in the code with respect to the sequence of operation when multiple controls are controlling the same lighting system. This section is also in response to questions about whether a designer can install controls that override the automatic controls.

Background. Prior to the 2008 Title 24, Part 6 Standards, the standards only specified the equipment characteristics and the control capabilities. Since the 2008 code cycle, acceptance tests were added. which specified how devices are required to behave at time of occupancy as verified by the acceptance tests. Section 130.1(c)6 in the 2016 Standards states, "lighting *shall be controlled* with occupant sensing controls that *automatically reduce lighting power* of each luminaire by at least 50 percent when the areas are unoccupied." Prior to the 2008 Standards, the controls would be "*capable* of reducing power…" stakeholders have expressed confusion about whether the code mandates that the occupants cannot change the functioning of controls during building operation. Contrary to this misinterpretation, occupants can change the functioning of the controls during building operations. However, the design of the building according to code is that the building operates in accordance with the intent of the code, and the building is not designed with any overrides except those that are explicitly defined by the code. Section 130.1(a)3A was intended to ban override switches; however, the scope of the section, as currently written, is too narrow. In addition, this section does not describe which automatic controls could increase lighting power.

Proposal. The Statewide CASE Team's proposal is to clarify that no control is allowed to increase the energy consumption of the lighting system, except for the three applications where either manual controls or automatic controls are allowed to override the functioning of other controls and increase energy consumption. These three applications are narrow and are either timed or respond to occupancy so that the override is temporary. The Statewide CASE Team proposes the introductory phrase, "<u>No control shall override any of the required lighting controls in Section 130.1 that results in an increase in the energy consumption…</u>" The phrase indicates that additional controls can be included that reduces energy consumption. For example, a project can include a light switch that turns lights OFF, but does not override the occupancy sensor or the daylight dimming controls. The three defined exceptions where an override <u>temporarily</u> increases energy consumption are:

- **Exception 1.** The required area switch, which temporarily overrides a time-switch control to keep the lights ON for two hours, when the space is typically unoccupied. The override can keep the lights on in certain occupancies indefinitely, if they have a captive key switch.
- **Exception 2.** There are only certain time-switch controls that can turn lights ON after someone has manually turned the lights OFF. This is currently the case for all time-switches; however, the Statewide CASE Team's proposes that this capability is only allowed for the occupancies called out in Exception to Section 130.1(c)3C, *"<u>industrial, single tenant retail, malls, auditoriums, concourses, lobbies and other areas open to the general public</u>."*
- **Exception 3.** This exception applies to occupancy sensors that are not required to be manual ON. The proposed exception clarifies that occupancy sensor can only override the manual switch after *<u>"the space has been vacated and re-occupied regardless of prior operation of area controls.</u>*" Thus, the occupancy sensor would have to time out and then sense re-occupancy of the space before the control could turn the lights back ON. The following spaces do not require occupancy sensors to be manual ON: Section 130.1(c)1, Section 130.1(c)5A, Exception to 130.1(c)5A & B, Section 130.1(c)6, Section 130.1(c)7, and Section 130.1(c)8.

2.3.2 Reference Appendices Change Summary

This proposal will modify the following sections of the Standards Appendices as shown below. See Section 7.2 of this report for the detailed proposed revisions to the text of the reference appendices.

- NA7.6.1 Automatic Daylighting Control Acceptance
- NA7.6.2 Shut-off Controls Acceptance
- NA7.7.6.1 Construction Inspection for all PAFs except institutional Tuning

2.3.3 Alternative Calculation Method (ACM) Reference Manual Change Summary

The proposed code change will modify the required daylighting controls and illuminance set points necessary in software modeling.

2.3.4 Compliance Manual Change Summary

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

- Chapter 5.2 General Requirements for Mandatory Measures
- Chapter 5.4.3.4 Areas where Occupant Sensing Controls are required to shut OFF all Lighting
    - Based on stakeholder feedback and review of the available technology, the Statewide CASE Team recommends that larger, multi-stall restrooms consider zoning and install more than one dual-technology occupancy sensor to avoid false OFFs. Occupancy sensing technology and the layout of the space should be discussed in the compliance manual.
- Chapter 5.4.1 Area Lighting Controls
- Chapter 5.4.3.1 General Exceptions to Section 130.1(c)1
- Chapter 5.4.4.4 Automatic Daylighting Control Installation and Operation
- Chapter 5.4.8 Summary of Mandatory Controls
- Chapter 5.5 Prescriptive Daylighting Requirements
- Chapter 13.1 New or Modified Acceptance Test Requirements for 2019
- Chapter 13.24 NA7.6.1 Automatic Daylighting Control Acceptance

2.3.5 Compliance Forms Change Summary

The proposed code change will modify the compliance forms listed below:

- 2016-NRCA-LTI-02-A Lighting Control Acceptance Document Form
- 2016-NRCA-LTI-03-A Automatic Daylighting Control Acceptance Document Form
- 2016-NRCC-LTI-01-E Certificate of Compliance
- 2016-NRCC-LTI-02-E Certificate of Compliance
- Equivalent Performance Forms generated on per project basis

2.4 Regulatory Context

2.4.1 Existing Title 24, Part 6 Standards

Title 24, Part 6, Section 130.1, Mandatory Indoor Lighting Controls, Section (d) covers automatic daylighting controls. The mandatory requirement specifies that general lighting luminaries "that are in or are partially in Skylit Daylit Zones or the Primary Sidelit Daylit Zones shall be controlled independently by fully functional automatic daylighting controls that meet the applicable requirements of Section 110.9…".[3] In addition, the total lighting power must be reduced by at least 65 percent when the total area illuminance is 150 percent or higher. Title 24, Part 6, Section 140.6 Prescriptive Requirements for Indoor Lighting requires automatic daylighting controls in Secondary Sidelit Daylit Zones, in addition to the requirements in Section 130.1(d).

Title 24, Part 6, Section 130.1, Mandatory Indoor Lighting Controls, Section (c) covers time-switch controls. The mandatory requirement specified that all installed lighting in addition to meeting requirements in Section 130.1(a) and (b) which specify that "All luminaires shall be functionally

[3] 2016 Building Energy Efficiency Standards for Residential and Nonresidential Buildings, California Energy Commission. § 130.1(d)1 (2017).

controlled with manual ON and OFF lighting controls." Automatic time-switch control is considered a compliant method of control if it is not a countdown timer.

2.4.2 Relationship to Other Title 24 Requirements

For nonresidential voluntary measures related to automatic daylighting controls, 2013 Title 24, Part 11 California Green Building Standards Code (also known as CALGreen) included the following provisions:

> A5.209.1.6 Automatic daylighting control devices. Automatic daylighting control devices used to control lights in daylit zones shall:
>
> > 1. Be capable of reducing the power consumption of the general lighting in the controlled area by at least two thirds in response to the availability of daylight
> >
> > …
> >
> > 3. If the devices reduce lighting in control steps, incorporate time-delay circuits to prevent cycling of light level changes of less than 3 minutes and have a manual or automatic means of adjusting the deadband to provide separation of on and off points for each control step.[4]

2013 CALGreen has provisions for nonresidential voluntary measures relevant to automatic time-switch control devices:

> A5.209.1.3 Automatic time-switch control devices. Automatic-time switch control devices or system shall:
>
> > 1. Be capable of programming different schedules for weekdays and weekends; and
> >
> > 2. Have program backup capabilities that prevent the loss of the device's schedules for at least 7 days and the device's time and date setting for at least 72 hours if power is interrupted.

However, 2016 CALGreen, which went into effect on January 1, 2017, simply requires compliance with Title 24, Part 6.

2016 CALGreen does not have specific requirements pertaining to occupant sensing controls in restrooms.

This CASE Report affects the analysis presented in Title 24, Part 6 Nonresidential Indoor Lighting Alterations code change proposal for the 2019 cycle.

2.4.3 Relationship to State or Federal Laws

There are no federal regulatory requirements that address the same topic as the proposed change.

2.4.4 Relationship to Industry Standards

2.4.4.1 ASHRAE 90.1

Mandatory Automatic Daylight Dimming Plus OFF Controls

ASHRAE 90.1-2013 (addendum 90.1-10ay) expanded the daylighting control requirements introduced in 90.1-2010 in three areas. First, it requires independent control of lights in the Secondary Sidelit Zone. Second, controls are required to turn the general lighting completely OFF when sufficient daylight is available. Lastly, ASHRAE updated the threshold for mandatory daylighting controls to be required if the total luminaire wattage in all daylit zones in a given room is more than 150 W. This change results

[4] 2016 California Green Building Standards Code, Part 11, California Energy Commission. Appendix A5 (2017).

in some smaller daylit areas in a room being included for daylight control in the ASHRAE 90.1-2013 building prototype models.

Automatic daylighting requirements are listed in Section 9.4.1.1 and Table 9.6.1 in ASHRAE 90.1-2016. Per ASHRAE 90.1-2016, automatic daylight dimming plus OFF controls are required for all space types except guestrooms, interior parking areas, storage rooms less than 50 square feet, living quarters in dormitories, sleeping quarters in fire stations, facilities for the visually impaired, and imaging and operating rooms at healthcare facilities. Note that, for the sales area space type, automatic daylight dimming plus OFF controls are required for toplighting, but not sidelighting.

Mandatory Occupant Sensing Full OFF Controls in Nonresidential Restrooms

Occupancy sensor controls in nonresidential restrooms were introduced in ASHRAE 90.1-2010 through addendum 90.1-07x, and addendum 90.1-07aw. The ASHRAE 90.1-2016 Standards increased the energy savings potential for restrooms by requiring restrooms space types to have automatic full OFF controls.

More specifically, ASHRAE 90.1-2016 Section 9.4.1.1[h] defines the automatic full OFF controls requirement as "all lighting, including lighting connected to emergency circuits, shall be automatically shut off within 20 minutes of all occupants leaving the space. A control device meeting this requirement shall control no more than 5,000 square feet."[5] Table 3 shows the minimum control requirements for restrooms required in ASHRAE 90.1-2016.

Table 3: Excerpt from ASHRAE 90.1-2016 Table 9.6.1, Minimum Control Requirements

			The control functions below shall be implemented in accordance with the descriptions found in the referenced paragraphs within Section 9.4.1.1. For each space type: (1) All REQs shall be implemented. (2) At least one ADD1 (when present) shall be implemented. (3) At least one ADD2 (when present) shall be implemented.				
			Automatic Daylight Responsive Controls for Sidelighting (See Section 9.4.1.1[e][6])	Automatic Daylight Responsive Controls for Toplighting (See Section 9.4.1.1[f][6])	Automatic Partial OFF (See Section 9.4.1.1[g] [Full Off complies])	Automatic Full OFF (See Section 9.4.1.1[h])	Scheduled Shutoff (See Section 9.4.1.1[i])
Common *Space* Type	*LPD*, W/ft^2	*RCR* Threshold	e	f	g	h	i
Restroom							
Facility for the visually impaired (and not used primarily by the staff)	0.96	8	REQ	REQ		REQ	
All other restrooms	0.85	8	REQ	REQ		REQ	
[6] Automatic daylight responsive controls are mandatory only if the requirements of the specified sections are present.							

Source: ANSI/ASHRAE/IES Standard 90.1-2016 – Energy Standard for Buildings Except Low-Rise Residential Buildings, Section 9.4.1.1[i] (2016).

2.4.4.2 International Energy Conservation Code (IECC) 2015

[5] ANSI/ASHRAE/IES Standard 90.1-2016 – Energy Standard for Buildings Except Low-Rise Residential Buildings, Section 9.4.1.1[i] (2016).

IECC 2015 requires dimming to a minimum of 15 percent of light output for certain area categories, while requiring the capability of automatic daylighting controls to completely turn OFF lighting:

"C405.2.3.1 Daylight-responsive control function.

Where required, daylight-responsive controls shall be provided within each space for control of lights in that space and shall comply with all of the following:

…

5. Where located in offices, classrooms, laboratories and library reading rooms, daylight responsive controls shall dim lights continuously from full light output to 15 percent of full light output or lower.

6. Daylight responsive controls shall be capable of a complete shutoff of all controlled lights."

IECC requires the use of a 50 percent ON occupancy sensor or manual ON vacancy sensor in all restrooms [Section C405.2.1 item 7].

Manual ON Commissioning for Automatic Time-Switch Controls

Per 2016 ASHRAE 90.1, Table 9.6.1, all space types are required to have the control of lighting to be restricted either to Manual ON (Section 9.4.1.1(b)), or to Partial Automatic ON (Section 9.4.1.1(c).

For reference, 2016 ASHRAE 90.1 Section 9.4.1.1(b) states: "Restricted to Manual ON: None of the lighting shall be automatically turned on. Exception to 9.4.1.1(b): Manual ON is not required where manual ON operation of the general lighting would endanger the safety or security of the room or building occupants."

For reference, 2016 ASHRAE 90.1, Section 9.4.1.1(c) states: "Restricted to partial automatic ON: No more than 50% of the lighting power for the general lighting hall be allowed to be automatically turned on, and none of the remaining lighting shall be automatically turned on. Exception to 9.4.1.1(c): Lighting in open-plan office spaces shall be allowed to turn on automatically to more than 50%, provided the control zone is no larger than 600 ft^2."

2.5 Compliance and Enforcement

The Statewide CASE Team collected input on this measure with which compliance and enforcement issues may be associated 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.

This code change proposal will primarily affect buildings that use the prescriptive or performance approach to compliance. The key step changes to the compliance process are summarized below:

- **Design Phase**: The proposed code changes would have minimal impact on the existing design phase process. Certificate of Compliance Forms, NRCC forms, would need to minimal changes for the proposed measure. In general, as more lighting controls are required in the code, additional documentation and understanding of the code requirements is required by the designers.
- **Permit Application Phase**: The proposed code changes would have minimal impact to the existing permit application phase process. Additional time will be required to make sure design documents include these requirements properly

- **Construction Phase**: The proposed code changes would have minimal impact to the existing permit construction phase process. Coordination and understanding of the controls (and the exceptions) that will affect the time and cost associated with the job. The Statewide CASE Team recommends the Compliance Manual include recommendations regarding the appropriate occupancy sensing technology for installation in multiple occupant restrooms.
- **Inspection Phase**: The proposed code changes would have minimal impact to the existing inspection application phase process. The Statewide CASE Team conducted interviews with stakeholders, such as Acceptance Test Technicians, to determine if the inspection time would increase for the proposed measures, especially in regards to requiring automatic daylight dimming plus OFF controls. The Statewide CASE Team identified current lighting inspection forms and tables which will need to be updated in Section 7. Building inspectors and acceptance testers will need to be trained on the new control requirements as well as the field verified process through acceptance testing.
- **Commissioning Phase:** The Statewide CASE Team recommends this phase includes educating the building occupants about the daylight dimming controls to minimize issues and call backs. In addition, an effort should be made to educate future occupants of the space who are not present during the initial education. Stakeholders have recommended that a simple instruction sheet or label near the lighting controls that describes the intent and function of the daylight dimming controls would minimize user frustration and minimize contractor call backs. The Statewide CASE Team also recognizes the importance of educating building occupants about Manual ON time-switch controls for the occupants to be comfortable with the Manual ON setting. Therefore, the Statewide CASE Team recommends covering the logistics of using automatic time-switch with Manual ON setting in the new occupant orientation communications.

The CASE Team and Statewide Utility Compliance Improvement Team interviewed stakeholders to identify potential barriers to code compliance and enforcement. The outreach strategy included collecting stakeholder feedback with an online survey, as well as during one-on-one meetings with stakeholder groups, such as manufacturers, distributors, lighting designers, lighting contractors, and building owners. The results from the survey are included in Appendix C.

If this code change proposal is adopted, the Statewide CASE Team recommends that information presented in this section, Section 3 and Appendix B be used to develop a plan that identifies a process to develop compliance documentation and how to minimize barriers to compliance.

Mandatory Automatic Daylight Dimming Plus OFF Controls

There are two approaches to achieve Title 24, Part 6 compliance—the performance approach and the prescriptive approach. The performance approach requires a building's energy performance to be modeled with the ACM through compliance software. For example, CBECC-Com is one of the allowed compliance energy modeling software programs. The performance method allows energy trade-offs between measures if the overall building energy usage is kept within the maximum allowable values of kBtu per square foot and demonstrated in an approved computer program. The prescriptive approach for indoor lighting requires individual components to meet minimum energy requirements in Title 24, Part 6, Section 140.6 and does not require the use of compliance software. The prescriptive approach is less flexible than the performance approach since trade-offs are not allowed. The actual indoor lighting power of all proposed building areas must be no greater than requirements specified in section 140.6(d). Additionally, the calculation of allowed indoor lighting power must follow one of three methods: Complete Building, Area Category, or Tailored Method.

Staff at three lighting controls manufacturers indicated that daylight dimming plus OFF controls would be the most difficult to adopt in office buildings and other areas where users expect to have more control over their electric lighting. One Certified Lighting Controls Acceptance Provider noted, however, that it

could be appropriate to deploy daylight dimming plus OFF controls in offices, if deployment is accompanied with proper outreach to building owners and building end-users. It is essential to have comprehensive end-user training to achieve maximum energy savings from daylight dimming plus OFF controls.

Several stakeholders suggested to lower the required dimming level further, but not all the way to OFF as an alternative to daylighting plus OFF controls that would have comparable savings, but greater user acceptance. This approach may be hindered by some sources having a noticeably high flicker when dimmed to very low levels.

Several interviewed stakeholders expressed frustration about existing Automatic Daylighting Control Acceptance Test requirements. The CASE Team will work with the Utility Compliance Improvement Team to incorporate stakeholder feedback when updating the Acceptance Test requirements.

The Statewide CASE Team conducted a survey to determine the current practices and end-user acceptance of daylight dimming controls. In response to the question about end-user acceptance, two of the five respondents felt that most or all end-users appeared to be in favor of having the OFF step, one respondent said that more than half of end-users appeared to be in favor of having the OFF step, and two respondents felt just about half of end-users appeared to be in favor of having the OFF step. For more details on stakeholder outreach, please refer to Appendix C.

Mandatory Occupant Sensing Full OFF Controls in Nonresidential Restrooms

The Statewide CASE Team does not foresee any challenges with the feasibility of compliance and enforcement with the proposed changes. The Statewide CASE Team has mitigated any potential compliance and enforcement challenges by aligning the proposed changes, to the extent feasible, with ASHRAE 90.1-2016. Based on stakeholder feedback and review of the available technology, the Statewide CASE Team recommends that larger, multi-stall restrooms consider zoning and install more than one dual-technology occupancy sensor to avoid false OFFs. Occupancy sensing technology and the layout of the space should be discussed in the compliance manual.

Manual ON Commissioning for Automatic Time-Switch Controls

The Statewide CASE Team does not foresee any challenges with the feasibility of compliance and enforcement with the proposed changes. Based on stakeholder feedback and a review of available products, the Statewide CASE Team determined that most automatic time-switch controls already offer or employ technologies that could easily implement manual ON functionality.

3. MARKET ANALYSIS

The Statewide CASE Team performed a market analysis with the goal 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 22, 2017.

The Statewide CASE Team distributed a survey and interviewed stakeholders to collect information about effects of the proposed measures on market. The survey results can be found in Appendix C.

3.1 Market Structure

The market of wired and wireless photocontrols, occupancy controls, and automatic time-switches is well established in the United States (U.S.). Table 4 summarizes the market actors in the commercial lighting distribution chain.

Table 4: Lighting Distribution Chain

Market Actor	Core Function
Manufacturers	Production
Wholesale Distributors	Distribution of Product, Logistics, Financing
Manufacturer Representatives	Sales Generation
Electrical Contractors	Installation and Sales
Commercial End Users	Decision Maker

A recent study that was conducted by Bonneville Power Administration characterized four distribution channels used by manufacturers to sell lighting products to end users. The four channels include wholesale distribution, retail, online only, and direct. Furthermore, manufacturer representatives, either independent or in-house, act as brokers for deals, thus playing an important role in the distribution chain (Bonneville Power Authority 2015). Table 5 summarizes the key points about each distribution channel.

Table 5: Market Channels

Distribution Channel	Description
Wholesale Distribution	• Dominant channel • Not all inventory is physically stored at distributor site, some manufactures "drop-ship" directly from factory to project site
Retail	• Selling products through traditional brick and mortar storefronts
Online Only	• Selling only at sites, such as 1000bulbs.com; shipping directly from a central warehouse • Offering minimum customer service
Direct	• Smallest channel used by large customers "because they can" or by new manufacturers "because they have to"

Fixture manufacturers have been adding lighting controls to their product lines as the demand for lighting controls increases. With the advancement of solid-state lighting technology that enables easier integration of lighting controls and opportunities to provide non-lighting related features as part of a lighting system, the manufacturers have been shifting the focus from stand-alone products, such as lamps and ballasts to full-system offerings.

Some of the major manufacturers that offer lighting controls include: Acuity Controls, Cree, Douglas Lighting Controls, Eaton Corporation, Echelon Corporation, Finelite, GE Lighting, Hubbell Control Solutions, Leviton, Legrand/WattStopper, Lutron, Organic Response, OSRAM Encelium, Philips Lighting Controls, PLC-Multipoint, Inc., Schneider Electric, and Sensor Switch, Inc.

Many these large companies along with smaller companies, such as Daintree Networks, Digital Lumens, and Enlighted, offer photocontrols and occupancy controls as part of whole-building energy management solutions.

In a recent study conducted by the National Lighting Product Information Program (NLPIP), it was noted that wireless lighting controls are available from more than 40 companies in the U.S. (National Lighting Product Information Program 2015). According to NLPIP's outreach to 152 lighting specifiers not associated with a particular manufacturer, the most frequently selected brands of wireless lighting controls include: Leviton, Lutron, and Legrand/WattStopper.

The U.S. Energy Information Administration (EIA) conducted the 2012 Commercial Buildings Energy Consumption Survey (CBECS). According to the survey, the estimated adoption of occupancy and daylighting controls in U.S. is as follows:

- Daylighting controls are in two percent of the U.S. buildings, which account for seven percent of total floor area (larger buildings are more likely to have daylighting controls), and
- Occupancy controls are in 15 percent of the U.S. buildings, which account for 41 percent of total floor area (U.S. Energy Information Administration 2016).

In the U.S. Department of Energy (DOE) study released in 2016, 140 sources of published literature were reviewed to assess market penetration of lighting controls as well as energy savings from lighting controls. According to the study, the 2015 installed lighting stock[6] penetration of lighting controls in commercial sector is estimated as follows:

- Daylighting controls are in less than one percent of the U.S. commercial lighting stock and
- Occupancy controls are six percent of the U.S. commercial lighting stock (DOE 2016).

Although the 2012 CBECS and 2016 DOE studies found different levels of adoption of occupancy and daylighting controls, both studies demonstrate that occupancy sensors and daylighting controls have a low penetration rate across the U.S and there is an opportunity for energy savings.

3.2 Technical Feasibility, Market Availability and Current Practices

Mandatory Automatic Daylight Dimming Plus OFF Controls

There are several strategies for daylight dimming controls using dimmable fixtures and controls. Wireless and wired, stand-alone and luminaire level daylighting controls are widely available from the distribution channels. According to staff interviewed at Acuity Brands, Lutron, CJS Lighting, Performance Lighting Systems and one Certified Lighting Controls Acceptance Test Provider, the majority of daylight controls and integrated fixtures with daylight controls have the option to be configured to dim to OFF.

The technology is not proprietary so the market is able to increase production to meet increased demand. The proposed measure does not impact the manufacturing or specification market in a substantial manner, thus no impacts are expected based on the requirement for automatic daylight dimming plus OFF sensor approach.

Photocontrol products could be categorized in three types as summarized in Table 6. Table 7 summarizes common dimming strategies.

Table 6: Types of Photocontrol Products

Type of Photocontrol	Description
Wireless Systems	Photosensor sends a wireless signal to a controller that turns off or dims lights at the pre-determined setpoint(s)
Wired Stand-Alone Products	Photosensor sends a wired signal (line- or low-voltage) directly to the lighting to be turned OFF or dimmed
Wired Systems	Photosensor sends a wired signal (usually low-voltage) to a controller at the pre-determined setpoint(s); the controller then relays a control signal to the lighting to be turned OFF or dimmed

[6] Installed stock is presented DOE's study "in terms of lighting systems (lamp(s), ballast and fixture are counted as one unit)" (DOE 2016).

Table 7: Types of Dimming Control Strategies

Type of Photocontrol	Description
0-10 VDC	An analog controller that adjust the voltage from 0-10V with the low voltage wire pair connecting the controller to one or more LED drivers. There is no industry-wide standard for low end cutoff, which varies from OFF to 10 percent of full lighting output.
Digital, including Digital Addressable Lighting Interface (DALI)	A standard for digital control of individual fixtures via a low voltage communication protocol comprising of a single set of control wires form a low-voltage control bus. The digital control can send information to light fixtures while also receiving information from the fixtures. DALI protocol provides 254 levels of brightness between OFF and 100 percent of full lighting output.
Two-Wire Forward Phase	Reverse phase dimming controls the amount of voltage delivered to the fixture by turning off part of the trailing edge of the sine wave for a preset amount of time resulting in reduced lamp output. Forward phase uses the leading edge of the sine wave. The low-end cutoff is usually around 15 percent of full lighting output; some go as low as 1 percent of full lighting output.
Two-Wire Reverse Phase	Dimmer controls the voltage delivered by turning off part of the trailing edge of the sine wave for a preset time. Tends to offer a flicker free dimming experience of Electronic Low Voltage (ELV) transformers and common LED drivers.

The most common strategies for daylight dimming controls are 0-10 VDC and DALI due to the controls compatibility to dim fluorescent and LEDs without major flickering issues. The most frequently used driver for controlling daylighting diming controls is 0-10 VDC, for which the average time delay is two to six minutes of continuous light.

The three methods to setup a daylight dimming control system are open-loop, closed-loop, and hybrids systems that employ both open and closed-loop system concepts.

- Open-loop systems orient the photosensor to only sense daylight and adjust the electric light accordingly. An open-loop system will only respond to changes in daylight and may not accurately respond to actual light levels in the interior space.
- Closed-loop systems orient the photosensor to senses both daylight and electric lighting contributions. However, the photosensor is limited to a single zone and the system is unable to distinguish transient light level changes in daylight from occupant interference or reflectance shift. Thus, closed-loop systems are most appropriate in Skylit Zones with high bay lighting, where occupant interference and reflectance shift is minimal.
- Hybrids systems combine open-loop and closed-loop systems into a system with a proprietary name, such as “partial open loop” by Lutron or “dual loop systems” licensed to WattStopper. Since these systems combine the algorithms of closed-loop and open-loop systems, they are less reactive to reflectance shift.

The Statewide CASE Team conducted a survey to determine the market availability and current practices for daylight dimming controls. The results can be found in Appendix C.

While daylighting controls with OFF step are not widely deployed in California, two large retail chains – Wal-Mart and COSTCO – have been specifying daylighting controls with OFF step in their stores as a standard practice. Wal-Mart and COSTCO lighting fixtures turn OFF when the daylight illuminance exceeds the design illuminance. COSTCO stores began integrating daylighting controls and skylights in the late 1980s. WalMart has over 1,000 stores with skylights and daylighting controls while COSTCO has over 250 stores with skylights and daylighting controls.

In addition, daylight dimming plus OFF controls has been in ASHRAE 90.1 since the 2013 code cycle.

Mandatory Occupant Sensing Full OFF Controls in Nonresidential Restrooms

The Statewide CASE Team conducted a literature review as well as gathered input from stakeholders on the technical feasibility, market availability, and current practices of occupancy sensors in nonresidential restrooms. Based on stakeholder feedback and a review of the available technology, the Statewide CASE Team recommends that larger, multi-stall restrooms consider zoning and install more than one dual technology occupancy sensor to avoid false OFFs. Occupancy sensors with one technology, such as PIR, may be best suited for use in small restrooms without barriers. Occupancy sensing technology and the layout of the space should be discussed in the compliance manual. Table 8 summarizes the main available technology options for occupancy sensors, and a more detailed description of the technology follows.

Table 8: Types of Occupancy Sensor Controls Technology

Technology Type	Description
Passive Infrared (PIR)	Detects movement of sources hotter than ambient from one facet of the sensor view direction to another that would indicate occupancy.
Ultrasonic	Floods area space with high-frequency sound waves and then receives back the reflected signal; moving objects change the frequency of reflected signal (Doppler effect) and indicate occupancy.
Microphonics	Microphonic sensor detects sounds and processing algorithms determine which sounds indicate occupancy.
Dual	Typical PIR combined with either ultrasonic or microphonics technology. Triggering both technologies required to turn lights ON, while sensing of occupancy by either technology keeps the lights ON.
Microwave	Emits microwave signal and reflected signal of moving objects (Doppler shift) indicate occupancy in area.

Occupancy sensors with passive infrared (PIR) technology turn the lights ON or OFF by detecting a change in temperature. PIR technology works "best in small, enclosed spaces with high levels of occupant movement because they are engineered to detect major motion" (Lutron). PIR technology would be suitable in smaller restrooms, if the space is not an irregular shape, as PIR is needs a line of site and cannot see around objects.

Ultrasonic technology is suitable for larger restrooms as these sensors can detect minor motion and do not require an unobstructed line of sight between the sensor and the occupant, unlike PIR. Ultrasonic technology is thus able to detect occupancy behind or around "partitions, solid walls, and other obstructions" (Acuity Controls 2016).

Dual technology occupancy sensors with PIR and ultrasonic technology "can detect small motion better than PIR alone and do not require a line-of-sight to detect motion" (National Lighting Product Information Program 2015). An occupancy sensor with PIR and either ultrasonic or microphonics technology is "useful in rooms with obstructions such as bathrooms with stalls" (Acuity Controls 2016).

Microphonics technology is patented by an Acuity Brands company, Sensor Switch, Inc. A microphonics occupancy sensor control "utilizes a microphone inside of the sensor to literally hear sounds that indicate occupancy" and "is acoustically passive, meaning no sound waves are transmitted into a space, thus eliminating all potential for interference" (Acuity Controls 2016). In addition, Sensor Switch claims that Microphonics technology with PIR uses less energy than a dual-technology ultrasonic and PIR occupancy sensor (Acuity Controls 2016).

A technical feasibility study conducted by the National Lighting Product Information Program (NLPIP) in 2014 found that since "ultrasound detection requires more power than PIR detection," there is a limited availability of wireless ultrasonic and dual technology occupancy sensors on the market (NLPIP 2015). NLPIP concluded this is "presumably because of the limited energy available in wireless sensors (which rely on batteries and/or photovoltaic, or PV, modules)" (NLPIP 2015). In addition, the study

found the incremental cost of wireless controls compared to wired controls ranges from 54 percent to 128 percent higher (NLPIP 2015). The study identified three advantages of wireless lighting controls compared to wired lighting controls – "decreased installation labor for wiring, increased ability to add controls in spaces that do not have easy access to ceiling or wall cavities and surface conduit isn't desired, and increased ability to reposition sensors or add more sensors for improved coverage if needed" (NLPIP 2015).

One manufacturer recommends that in cases where a stall may not be covered by a sensor, the occupancy sensors to be programmed to have a "longer timeout (15 or 30 minutes) to help prevent the lights from turning off when someone is in the stall" (Lutron). In addition, one manufacturer suggested that projects do not install occupancy sensors close to restroom air vents and fans, "as the vibration and air flow can reduce the effectiveness of the sensor (PIR sensors should not be within 4 feet of an air vent, and ultrasonic sensors should not be within 6 feet of an air vent)" (Lutron).

The Statewide CASE Team gathering stakeholder input on the current practice of installing occupancy sensors in large restrooms to determine how frequently an occupancy sensor is installed instead of another Title 24, Part 6 compliant control type to shut OFF all lighting when the space is vacant. The survey results can be found in Appendix C.

Manual ON Commissioning for Automatic Time-Switch Controls

The code change proposed by the Statewide CASE Team will require automatic time-switches, should they be used to comply with 130.1(c), to have manual ON and automatic shut-OFF functionalities within the same mode of operation. Through a review of the products offered by several manufacturers, the Statewide CASE Team found that digital programmable time-switches, including centralized controllers, already dominate the market for indoor automatic time-switches, whereas mechanical automatic time-switches are more prevalent for outdoor lighting controls. Manual ON is already required for occupancy sensors and a functional override switch is required on other automatic time-switch controls. While most digital controls do not explicitly advertise a manual ON functionality, it is not proprietary technology and may be a default setting. For example, in discussions with staff at WattStopper, a lighting controls manufacturer, staff members indicated that the manual ON is a default setting for all relevant WattStopper products.

The automatic time-switch controls that have the appropriate technology to comply with the proposed code can be separated into three main classes:

- Programmable in-wall time-switch,
- Programmable switches with an integrated occupancy sensor, and
- Advanced digital control systems.

Programmable time-switches with occupancy sensors are the most common products used for indoor applications due to relatively low costs and familiarity. Many of these products include additional features, such as holiday modes, astronomic features, and daylight savings time adjustment. While astronomical time-switches are standard for outdoor applications, this is not the case for indoor controls due to a cost premium.

Digital control systems are typically operated at the building scale and may incorporate more advanced technologies (e.g., daylight harvesting, demand response, etc.). The controls are often complex, better suited for larger applications, and can use proprietary software making the system more expensive. However, for some retrofit or renovation projects, digital control systems can be a more cost-effective option due to the reduced need for building supplies, such as wiring and drywall patchwork.

Table 9 lists the relevant pricing of time-switch pathways.

Table 9: Compliant Automatic Time-Switch Products

Control Type	Typical features	Typical Applications	Hardware Costs (per unit price)	Source
Programmable in-wall time-switch	Programmable with ON/OFF schedule. Holiday schedule featured. Sometimes required. Astronomical a feature in many but not standard.	Conference rooms, small areas, smaller retail	• $20-40	• Home Depot • Gordon Electric Supply
Programmable switches with an integrated occupancy sensor	Programmable time for OFF.	Restrooms, conference rooms, multifamily common areas, etc.	• $20-30	• Sam's Club • Zoro
Programmable in-wall time-switch	Programmable, holiday schedules, thousands of separate events.	Schools, atriums, offices, retail stores	• $300-400	• Zoro
Advanced digital control systems	Programmable, holiday schedules usually standard. In alterations/ high tenant turnover a wireless solution will need less wiring and drywall/painting touch up.	Schools, institutions, large offices, retail, malls	• $194 (Relay) • $164 (Wireless Capable Switch)	• Zoro • Crescent Supply

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 by change in demand for new buildings and construction costs. 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.

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 cycles. As discussed in Section 3.3.1 all market actors should (and do) plan for training and education

that may be required to adjusting 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.

Mandatory daylighting controls were first introduced in the 2005 Title 24, Part 6 code cycle, making this type of control a standard practice in nonresidential buildings. The proposals included in this CASE Report enhance the daylighting control requirements. The Statewide CASE Team's market research found that controls available on the market already include the capability to turn the lighting OFF.

The Statewide CASE Team does not anticipate that requiring occupancy sensors in restrooms will significantly affect building designers as occupancy sensors in restrooms is a common measure.

The Statewide CASE Team does not anticipate that requiring automatic time-switches to be commissioned with Manual ON setting will significantly affect 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.

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.

An effort should be made to educate current and future occupants of the space about the daylight dimming plus OFF step. Stakeholders have recommended that a simple instruction sheet or label near the lighting controls that describes the intent and function of the daylight dimming controls would minimize user frustration and minimize contractor call backs.

Lawrence Berkeley National Laboratory (LBNL) and the Center for the Built Environment (CBE) at the University of California collaborated on an energy efficiency retrofit of the New York Times headquarters in New York City. There was a post-occupancy study performed, which included a survey to occupants after the installation of automatic daylight dimming controls plus OFF step. According to the report:

> Survey results indicated that overall, a significant fraction of the occupants were satisfied with the automatic lighting controls and with the lighting quality and visual comfort resulting from the lighting system (as defined by both the electric lighting system and the window). There were relatively few complaints that could be directly attributed to the electric lighting system (Lawrence Berkeley National Laboratory 2013).

The Statewide CASE Team does not anticipate that requiring occupancy sensors in restrooms will significantly affect building owners and occupants.

An effort should be made to educate current and future occupants of affected buildings about manual ON setting of automatic time-switch controls.

3.3.5 Impact on Building Component Retailers (including manufacturers and distributors)

The proposed measures may increase the number of control systems sold in California. The Statewide CASE Team interviewed manufacturers and concluded the proposed changes will not significantly

impact companies who manufacture, distribute, or sell lighting controls. Refer to Section 3.4.2 for more information.

3.3.6 Impact on Building Inspectors

The proposed code changes would have minimal impact to the existing inspection application phase process. The Statewide CASE Team conducted interviews with stakeholders, such as Acceptance Test Technicians, to determine if the inspection time would increase for the proposed measures, especially in regards to requiring automatic daylight dimming plus OFF controls. The Statewide CASE Team identified current lighting inspection forms and tables which will need to be updated in Section 7.5. Building inspectors and acceptance testers will need to be trained on the new control requirements as well as the field verified process through acceptance testing.

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. Installing lighting controls is a normal task in nonresidential buildings. There may be some minor increase in the time needed to install, commission, and verify the mandated control functions.

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*.[7] 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.

This proposal would increase the number of labor hours to install and calibrate occupancy sensors in restrooms. The daylighting proposal would have marginal impact on labor hours as daylighting controls

[7] 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."

are already required; however, the additional control step to turn the lights OFF will result in a slight increase in time to commission the controls.

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 ten times more than the total state economy between 2002 and 2012 (20 percent compared to two 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 and Heavey 2015). Adopting cost-effective code changes for the 2019 Title 24, Part 6 code cycle will help maintain the energy efficiency industry. Wei et al. (2010) estimates that energy efficiency creates 0.17 to 0.59 net job-years[8] per GWh saved (Wei, Patadia and 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 74.5 GWh, this measure will result in approximately 28.3 jobs created per first year. See Section 6 for statewide savings estimates.

In addition, the Statewide CASE Team does not expect the proposed code changes to make common existing building retrofits too expensive, burdensome, cause a reduction in retrofits.

Table 10 lists industries that will likely benefit from the proposed code change classified by their North American Industry Classification System (NAICS) Code.

The measures proposed are not expected to have a significant impact on the industry as the measures are not depended on emerging technologies and can be implemented with available technology and products.

The "Occupant Sensing Controls in Restrooms" proposed code change will increase the use of occupancy sensors used in nonresidential restrooms, since the current code allows for a variety of technologies to comply with the mandatory requirements.

The Statewide CASE Team does not expect any companies located in California to lose market advantage due to the proposed measures.

In addition, the Statewide CASE Team does not expect the proposed code changes to make common existing building retrofits too expensive, burdensome, cause a reduction in retrofits.

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

Table 10: Industries Receiving Energy Efficiency Related Investment, by North American Industry Classification System (NAICS) Code

Industry	NAICS Code
Nonresidential Building Construction	2362
Roofing Contractors	238160
Electrical Contractors	23821
Plumbing, Heating, and Air-Conditioning Contractors	23822
Asphalt Paving, Roofing, and Saturated Materials	32412
Manufacturing	32412
Other Nonmetallic Mineral Product Manufacturing	3279
Ventilation, Heating, Air-Conditioning, & Commercial Refrigeration Equip. Manf.	3334
Computer and Peripheral Equipment Manufacturing	3341
Communications Equipment Manufacturing	3342
Electric Lighting Equipment Manufacturing	3351
Engineering Services	541330
Building Inspection Services	541350
Environmental Consulting Services	541620
Other Scientific and Technical Consulting Services	541690
Advertising and Related Services	5418
Corporate, Subsidiary, and Regional Managing Offices	551114
Office Administrative Services	5611
Commercial & Industrial Machinery & Equip. (exc. Auto. & Electronic) Repair & Maint.	811310

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 and 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.

The proposed measures align Title 24, Part 6 with ASHRAE-90.1-2016, which will help to reduce the impacts of the proposed requirements on businesses within California in comparison to competing businesses in other states and across the globe where Title 24, Part 6 requirements will not be implemented.

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 the State General Fund, State Special Funds and Local Governments

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.

3.4.5.1 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.

The indoor controls measures will impact state buildings (new construction or alterations/additions). However, the proposed measures have been found to be cost-effective.

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.

3.4.5.2 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 home prices, the proposed code changes are not expected to have an impact on financing costs for business.

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

Mandatory Automatic Daylight Dimming Plus OFF Controls

For statewide energy savings, the Statewide CASE Team assumed the renovation rate of lighting fixtures in existing building stock is ten percent. This assumption is based on DOE's lighting market model, which "covers all upgrades/retrofits and renovations, regardless of their impetus, representing

replacements that occur prior to the failure of the existing lighting fixture" (Department of Energy 2016).

Nonresidential lighting alteration code (2016 Title 24, Part 6, Section 141.0 I and J) offers three options to comply with the alteration code. Only one of the three available compliance options (referred to as "85-100% of LPD allowance" in this report) requires automatic daylighting controls. Consequently, the renovation annual rate needs to be reduced further.

According to the alteration survey conducted by the Statewide CASE Team in 2017, 39 percent of lighting retrofit projects use "85-100% of LPD allowance" option to comply with the alteration code (refer to the 2019 CASE Report on Nonresidential Lighting Alterations). For this CASE Report, 15 percent of annual alteration floorspace (as opposed to 39 percent) is assumed to be subject to the proposed measure. For the final CASE Report, the Statewide CASE Team will revise this assumption to be consistent with the survey findings. Note that 15 percent is a more conservative assumption compared to the survey findings.

The Statewide CASE Team's interviews with stakeholders, such as manufacturers and engineers, determined that many lighting systems were commissioned to dim below the 2016 Title 24, Part 6 code requirement of 35 percent. The Statewide CASE Team's analysis used a conservative estimate for the baseline energy use, in which all areas were determined to dim to 20 percent as the lowest setting when the daylight illuminance is greater than 150 percent of the design illuminance. For more details on stakeholder responses to questions regarding the standard practice when it comes to the lowest dimmed state in which automatic daylighting controls will dim the lighting, please refer to Appendix C.

Table 11 summarizes the key assumptions used in energy savings analysis for "Daylight Dimming Plus OFF" measure.

Table 11: Key Assumptions Used in Energy Savings Analysis – "Daylight Dimming Plus OFF" Measure

Assumption	Value	Source/Notes
Renovation rate of lighting fixtures in existing building stock (as percent of entire existing building stock per year)	10%	Department of Energy, Energy Savings Forecast of Solid-State Lighting in General Illumination Applications Report (Department of Energy 2016). Note: This value may be updated in the final CASE Report to be consistent across all nonresidential lighting reports.
Percent of alterations subject to the "85-100% LPD allowance" compliance option that would require automatic daylighting controls	15%	Statewide CASE Team's survey on lighting alterations
Final percent of entire existing building stock subject to the "Daylight Dimming Plus OFF" measure per year	1.5%	Calculated value (15% of 10% = 1.5%)
Lowest setting of daylighting controls without the proposed standard requiring OFF step (as percent of full lighting output)	20%	Outreach to stakeholders, such as sales personnel and manufacturers
Present Value Adjustment Factor TDV Electric Nonresidential (15 year)	0.089	Energy Commission (Energy + Environmental Economics 2016)

The Statewide CASE Team's energy savings analysis used CBECC-Com, in which the default settings in each prototype building were used for the annual operating hours, affected square footage, as well as the ratio of Skylit, Primary, and Sidelit Daylit Zone. The proposed 2019 Title 24, Part 6 Indoor LPD are

presented in Table 12, which are based on the 2019 Nonresidential Lighting Indoor Light Sources CASE Report.

Table 12: Title 24, Part 6 Lighting Power Density Levels used in Building Prototypes

Area Category	2016 LPD	Proposed 2019 LPD
Auditorium Area	1.4	1.14
Classroom, Lecture, Training, Vocational Areas	1.2	0.72
Commercial and Industrial Storage Areas (conditioned and unconditioned) – Warehouse	0.6	0.42
Corridor	0.6	0.60
Restrooms	0.6	0.65
Stairwells	0.6	0.50
Dining Area	1.0	0.40
Electrical, Mechanical, Telephone Rooms	0.55	0.39
Exercise Center, Gymnasium Areas	1.0	0.50
Lounge, Breakroom, or Waiting	0.9	0.60
Kitchen	1.2	0.92
Library, Reading Area	1.1	0.77
Main Entry Lobby	0.95	0.82
Retail Merchandise Sales, Wholesale Showroom Areas	1.2	1.06

Mandatory Occupant Sensing Full OFF Controls in Nonresidential Restrooms

Table 13 and Table 14 below summarize key assumptions used in the spreadsheet-based analysis for the "Occupant Sensing Controls in Restrooms" measure.

Table 13: Key Assumptions Used in Energy Savings Analysis – "Occupant Sensing Controls in Restrooms" Measure

Assumption	Value	Source/Notes
Renovation rate of lighting fixtures in existing building stock (as percent of entire existing building stock per year)	10%	Department of Energy, Energy Savings Forecast of Solid-State Lighting in General Illumination Applications Report (Department of Energy 2016). Note: This value may be updated in the final CASE Report to be consistent across all nonresidential lighting reports.
Commercial retail rate for electricity in 2020	15.93 cents/kWh	Energy Commission. California Energy Demand 2017-2027 Final Forecast Mid-Case Final Baseline Demand Forecast Forms. Form 2.3 Electricity Prices by Sector. Updated January 23, 2017.
PV Adjustment Factor TDV Electric Nonresidential (15 year)	0.089	Energy Commission (Energy + Environmental Economics 2016)
Hours of operation (average value for restrooms)	2,272	California Database for Energy Efficiency Resources (DEER) version 2016. (Database for Energy Efficient Resources 2016). • DEER annual hours are informed by field monitoring data collected for multiple buildings over many years (post-retrofit buildings that went through an energy efficiency program). • Field monitoring data gathered as late as 2004 and 2005 as part of evaluation, measurement and verification (EM&V) studies are reflected in DEER2014 lighting profiles. DEER2014 lighting profiles have not changed since 2005. • DEER2016 profiles were further updated based on field monitoring data gathered in 2015. For most of building spaces, the annual hours for lighting load were reduced going from DEER2014 to DEER2016 lighting profiles. The Statewide CASE Team attributes the reduction to the higher uptake of lighting controls installed in the monitored buildings between 2004/2005 and 2015 (years when the field monitoring data was gathered).
Reduction in hours of operation with occupancy sensor	34%	ASHRAE 90.1-2010, Addendum 90.1-07 estimate of 34% reduction was based on two primary sources: Richman 1994 and VonNeida et. al. 2000 (Pacific Northwest National Laboratory 2011).
Lighting Power Density – Alterations	0.65 W/ft^2	Proposed 2019 Title 24, Part 6 Indoor Lighting Power Densities
Lighting Power Density – New Construction[1]	0.65 W/ft^2	Proposed 2019 Title 24, Part 6 Indoor Lighting Power Densities

1. If the 2019 proposed LPD value (0.65 W/ft^2) is not accepted, the 2016 LPD (0.6 W/ft^2) will be used. The energy savings will be the same for new construction and alterations.

Table 14: California DEER 2016 Hours of Operation for Restrooms by Building Type[1]

Building Type	Restroom Square Footage as Percent of Total Building Area by Building Type	Annual Hours of Use (Linear Fluorescent)	Coincident Demand Factor (Linear Fluorescent)
Assembly	5%	2,287	0.54
Primary School	5%	1,130	0.39
Secondary School	4%	1,130	0.39
Community College	7%	2,415	0.76
University	2%	2,551	0.96
Grocery	3%	4,526	0.70
Nursing Home	7%	1,415	0.19
Hotel	1%	2,411	0.26
Motel	1%	614	0.05
Manuf. Light Industrial	5%	1,209	0.28
Manufacturing Bio/Tech	3%	1,357	0.22
Office – Large	3%	987	0.24
Office – Small	4%	987	0.24
Restaurant – Fast Food	6%	3,567	0.66
Restaurant – Sit Down	6%	2,717	0.45
Retail – 3-Story (Department Store)	3%	4,967	1.00
Retail – Large (Big box)	3%	4,469	0.57
Retail – Small	4%	898	0.19
Refrigerated Warehouse	2%	3,522	0.70

1. DEER 2016 hours of operation for restrooms decreased compared to DEER 2014 by a range of 28 percent to 90 percent, depending on building type. The reductions were informed by EM&V data (DEER 2016 Commercial Indoor Lighting Profiles Development workbook, http://www.deeresources.com/index.php/deer-versions/deer2016#LightingProfiles).

Manual ON Commissioning for Automatic Time-Switch Controls

The Statewide CASE Team assumed that the "Manual ON Time-Switch" measure would only affect the building types and area categories listed in Table 15. The fraction of the total building area for each area category was determined using DEER 2016 building prototypes. The percentage of total new construction and alterations affected by the proposed measure was 30 and three percent, respectively. These assumptions are summarized in Table 16 and shown in more detail in Table 50.

Table 15: Fraction of Total Building Area for Spaces Affected by "Manual ON Time-Switch" Measure

Building Type	Area Category	Percent of Total Building Area
Office Small	Break	2%
	Office, Open	46%
Office Large	Break	4%
	Office, Open	36%
School Small	Office, General	8%
	Library, Reading	4%
	Dining	3%
	Gymnasium	8%
	Kitchen	5%

Table 16: Key Assumptions for "Manual ON Time-Switch" Measure

Assumption	Value	Source/Notes
Renovation rate of lighting fixtures in existing building stock	10%	Department of Energy, Energy Savings Forecast of Solid-State Lighting in General Illumination Applications Report (Department of Energy 2016). Note: This value may be updated in the final CASE Report to be consistent across all nonresidential lighting CASE Reports.
Percent of building area subject to the "Manual ON Time-Switch" measure per year	25-50%	Total area of the space types within each building that is subject to the measure, according to DEER 2016
Percent of buildings that use time-switches without Manual ON	5-20%	Best estimate decision made by the Statewide CASE Team based on feedback from several stakeholders.
Lighting Load	Varied	California DEER 2014 Lighting Load Tables
Present Value Adjustment Factor TDV Electric Nonresidential (15 year)	0.089	Energy Commission (Energy + Environmental Economics 2016)

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 will comply with the proposed requirements. There is an existing Title 24, Part 6 standard that covers the building system in question, so the existing conditions assume a building complies with the 2016 Title 24, Part 6 Standards.

The proposed conditions are defined as the design conditions that will comply with the proposed code change. LEDs emit less heat then the incumbent technologies, resulting in increased heating loads and decreased cooling loads in the building. These impacts are secondary, however, and were not calculated for this analysis. Energy savings from proposed indoor controls measures were therefore, assumed to be independent of climate and consistent across all California climate zones.

Mandatory Automatic Daylight Dimming Plus OFF Controls

The energy savings were modeled in CBECC-Com 2019 Research version, CBECC-Com 2019.0.1 RV. The Statewide CASE Team energy savings analysis used prototype building models that have compliance margins of zero when simulated with CBECC-Com 2019. Each of the considered building

models has a variant, which is specific to each of the 16 California climate zones. Two simulations for each building type were performed: one without the OFF step (baseline conditions) and another one with the OFF step (proposed conditions). The analysis considered the following building types:

- Hotel Small
- Office Medium
- Office Small
- Retail Large
- School Small
- Warehouse

Table 17 summarizes baseline and 2019 Standards conditions. Table 18 presents the details of the prototype buildings used in the analysis. Table 19 reports the total area of Skylit, Primary Sidelit, and Secondary Sidelit Daylit Zones within each building prototype.

Table 17: Baseline and Proposed Conditions for "Daylight Dimming Plus OFF" Measure

Baseline Conditions	Proposed Conditions
• For automatic daylighting controls: continuous dimming to 20% of full power when daylight illuminance is at 150% of design illuminance (including classroom areas of school building type)[1] • Proposed 2019 Title 24, Part 6 LPD levels[2] • Compliant with 2016 Title 24, Part 6 Standards	• For automatic daylighting controls in classroom spaces of school building type: continuous dimming to 20% of full power when daylight illuminance is at 125% of design illuminance (in other words, the daylighting controls will start dimming sooner than in the baseline conditions) • For automatic daylighting controls in all other considered areas: continuous dimming from 20% of full power to OFF when daylight illuminance is at 150% of design illuminance

1. The Statewide CASE Team's interviews with stakeholders found that many automatic daylight dimming control systems are currently commissioned to dim lower than the 2016 Title 24, Part 6 required 35 percent of full power. Thus, the baseline energy savings analysis modeled the mandatory daylighting dimming as at least 20 percent of full power in Skylit and Primary Sidelit Daylit Zones, when daylight illuminance is greater than 150 percent of design illuminance.
2. The LPDs in CBECC-Com were updated to the proposed 2019 indoor LPDs.

Table 18: Prototype Buildings used for Energy, Demand, Cost, and Environmental Impacts Analysis

Building Occupancy Types	Areas Modeled	Total Building Area (ft^2)	Number of Stories	Total Statewide Area for New Construction and Alterations (million ft^2)
Hotel Small	Front Lounge, Offices and Meeting Rooms	42,554	4	14.4
Office Medium	Perimeter Zones	53,628	3	60.1
Office Small	Perimeter Zones	5,502	1	16.1
Retail Large	All Daylit Zones	240,000	1	46.5
School Small	Lobby, Corridor, Cafeteria	24,413	1	23.5
Warehouse	All Daylit Zones	49,495	1	49.6

Table 19: Characteristics of Areas Available for Daylighting

Building Type	Areas with Daylighting	Total Area of Skylit Daylit Zone (ft^2)	Total Area of Primary Sidelit Daylit Zone (ft^2)	Total Area of Secondary Sidelit Daylit Zone (ft^2)	Total Area of Daylit Zones (ft^2)	Percent of Daylit Zones of Total Building Area
Hotel Small	Front Lounge, Offices and Meeting Rooms	0	2,023	2,023	4,046	9.5%
Office Medium	Perimeter Zones	0	11,784	10,074	21,858	40.8%
Office Small	Perimeter Zones	0	2,022	1,520	3,542	64.4%
Retail Large	Aisles, Main Entry, Register Area, Side Entry, Shelving	167,928	4,621	2,176	174,725	72.8%
School Small	Lobby, Corridor, Cafeteria	0	8,504	7,813	16,317	66.8%
Warehouse	All Areas	45,117	539	421	46,077	93.1%

The Statewide CASE Team was not able to use the results of the analysis performed to support a similar measure for ASHRAE 90.1. While ASHRAE 90.1 included a requirement for OFF step in 2013 code cycle, the energy savings for the OFF step were not calculated at that time. PNNL Report states that, while OFF step feature is made mandatory in ASHRAE 90.1-2013, it was assumed that this control type was already in practice when the daylighting control requirements were introduced in ASHRAE 90.1-2010 (PNNL 2013).

As a reference point, for 2016 Title 24, Part 6 code cycle, the CASE Report on Nonresidential Lighting Controls proposed ten percent PAF for automatic daylight dimming plus OFF control and stated that a PAF as high as 15 percent would be energy neutral (California Utilities Statewide Codes and Standards Team 2014).

Mandatory Occupant Sensing Full OFF Controls in Nonresidential Restrooms

The Statewide CASE Team's literature review found that an occupancy sensor's average reduction in hours of operation in restroom applications can range from 30 to 84 percent. The Statewide CASE Team's analysis used DEER 2016 hours of operation and a conservative estimate for the percent reduction in hours of operation to account for the current automatic shut-OFF code compliance option to install either an occupancy sensor control or an automatic time-switch control (which controls lighting based on the time of the day). See Table 13 for more details on the assumptions used in the analysis.

Since the proposed mandatory requirement for occupancy sensors in restrooms would be triggered for all three available options to comply with the alteration code, the Statewide CASE Team included the entire (subject to annual renovation rate) existing building stock in the energy savings calculations.

The Statewide CASE Team used Equation 1 to calculate the energy use per square foot for both the baseline and the standards case. To arrive at the energy savings per square foot, the CASE Team used the difference between the standards case and baseline case.

Equation 1: Occupant Sensing Controls in Restrooms Per-Unit Energy Use

$$Per-Unit\ Energy\ Use\ [kWh\ per\ square\ foot] = Lighting\ Power\ Density\ \left[\frac{W}{ft^2}\right] \times Annual\ Hours\ [hrs] \times \frac{1\ kW}{1{,}000\ W}$$

Equation 2: Occupant Sensing Controls in Restrooms Peak Demand Reduction Savings

$$Per-Unit\ Demand\ Reduction\ [kW\ per\ square\ foot] = \left(Baseline\ Lighting\ Power\ Density\ \left[\frac{W}{ft^2}\right] - Standard\ Lighting\ Power\ Density\ \left[\frac{W}{ft^2}\right]\right) \times Coincidence\ Factor \times \frac{1\ kW}{1{,}000\ W}$$

The lighting measures evaluated in this CASE Report have energy savings that are only secondarily impacted by climate. Installed wattage and hours of operation have significantly more impact on energy savings than climate. Interaction effects with HVAC are small and are neglected in this analysis. Thus, the cost-effectiveness of this measure is deemed to be independent of climate zone.

The peak demand reduction is zero because the LPD W/ft^2 does not change between the baseline to the standards case.

Energy savings, energy cost savings, and peak demand reductions were calculate using a TDV (Time Dependent Valuation) methodology.

Manual ON Commissioning for Automatic Time-Switch Controls

The Statewide CASE Team assumed, based on stakeholder feedback, that in certain nonresidential building and space types, automatic time-switch controls are automatically turned ON too early (i.e., when the area is vacant) for about one hour each workday. For these buildings and space types, the amount of energy consumed during this time relative to the overnight hourly energy consumption equals the energy that would be saved due to manual ON commissioning of automatic time-switch controls.

The proposed measure would only affect the space types in buildings that use time-switches to comply with Title 24, Part 6. The Statewide CASE Team first assessed the space types defined in DEER 2016 for the three building types considered for this measure (large offices, small offices, and schools) to determine whether the space type is covered by the proposed measure. For large offices, small offices, and schools, the Statewide CASE Team found that 48.5 percent, 39.3 percent, and 28.9 percent of the building areas, respectively, would be covered by this measure. The Statewide CASE Team then surveyed stakeholders to estimate the fraction of each space that would likely use time-switches (without manual ON) to comply with Title 24, Part 6. The final floorspace for each space type affected by the measure is shown in Table 50.

To calculate the energy savings for each building type, the Statewide CASE Team considered the typical occupancy hours of three building types: large offices, small offices, and small schools.[9] The starting hours for each building type were estimated by assessing the workday lighting profiles from DEER 2014. These values are reported in Table 20. The lighting profiles were also used to determine the lighting load for various space types of each building type for the hour preceding the starting hour representing that building type. The Statewide CASE Team compared this load to the typical overnight

[9] The Statewide CASE Team is currently exploring whether warehouses should also be included in the savings calculations.

load (arbitrarily taken as 3AM) to estimate the potential savings of manual ON. For example, the fractional full lighting load for school reading areas, seen in Figure 1, at 5:00AM fractional load of 0.6 would be reduced to 0.05, the 3:00AM value, since the building occupancy hour was determined to start at 6:00AM.

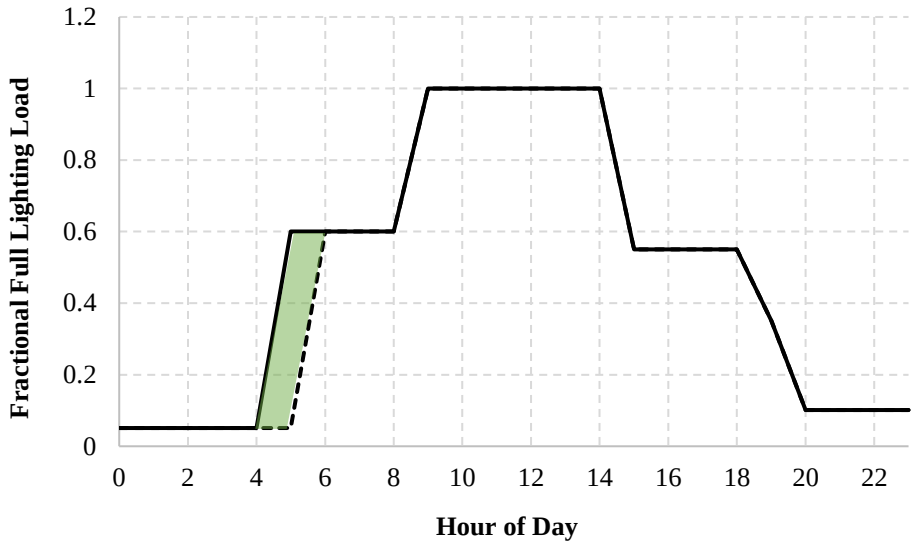

Figure 1: Lighting load profile for school classrooms, which was used as a proxy for reading areas (solid line). The Statewide CASE Team assumed that the proposed measure would reduce the lighting load at 5:00AM to the 4:00AM value (shaded area) in schools' reading areas.

The Statewide CASE Team assumed that the proposed measure would only alter the lighting profiles of the space types listed in Table 20. For each building space, the one-hour load reduction was multiplied by the 2019 minimally compliant LPD and the annual number of workday (251) to determine the annual energy savings per square foot of that space. A weighted sum of these values was calculated for each building type using the fraction of the total area of each space as provided by DEER 2016. This value was then multiplied by the statewide 2020 floor area of new construction and alterations that would be affected by this measure (presented in Table 44) to determine the statewide energy savings due to the "Manual ON Time-Switch" measure.

The methodology used to calculate the annual energy savings per square foot in this report is consistent with the methodology used for a similar measure for ASHARE 90.1-2010 (Addendum 90.1-07aa) and detailed in PNNL study titled "Achieving the 30% Goal: Energy and Cost Savings Analysis of ASHRAE Standard 90.1-2010" (Thornton, et al. 2011).

Table 20: Typical Building Occupancy Hour and Corresponding Previous-Hour Load Reduction for Space Types Affected by "Manual ON Time-Switch" Measure

Building Type	Space Types	Typical Occupancy Hour	Net Previous-Hour LPD Reduction for Space Types (W/ft^2)
Small Office	Break Room	9:00 AM	0.35
	Office space greater than 250 ft^2	9:00 AM	0.37
Large Office	Break Room	9:00 AM	0.38
	Office space greater than 250 ft^2	9:00 AM	0.40
Small School	Reading Area	6:00 AM	0.42
	Kitchen	9:00 AM	0.64
	Cafeteria	8:00 AM	0.00
	Office space greater than 250 ft^2	6:00 AM	0.35

4.3 Per-unit Energy Impacts Results

Mandatory Automatic Daylight Dimming Plus OFF Controls

Per-unit energy savings and peak demand reductions for new construction and alterations are presented in Table 21. Per-unit savings for the first year are expected to be 0.16 kilowatt-hours per year (kWh/yr). Demand reductions are expected to be 0.12 kilowatts (kW).

The per-unit TDV energy cost savings over the 15-year period of analysis are presented in Table 21 and Table 22. TDV energy cost savings are presented as the discounted present value of the energy cost savings over the analysis period.

The values below are weighted average of per-unit savings for 16 California climate zones for each considered building type. Also, note that values in the table below are normalized by the area subject to daylighting controls in the considered building prototype.

Table 21: First-Year Energy Impacts – Per Square Foot of Building Area Subject to Daylight Controls for Considered Building Prototypes – New Construction and Alterations

Building Prototype	Electricity Savings (kWh/ft^2/yr)	Peak Electricity Demand Reductions (W)	TDV Energy Savings (TDV kBtu/yr)
Hotel	0.23	6.9	6.53
Office Medium	0.22	11.8	9.84
Office Small	0.18	8.9	5.87
Retail Large	0.16	7.3	5.28
School Small	0.33	25.3	1.74
Warehouse	0.12	5.7	2.96

Mandatory Occupant Sensing Full OFF Controls in Nonresidential Restrooms

Per-unit energy savings and peak demand reductions are presented in Table 22, for new construction and alterations in 2020 respectively. Per square foot savings for the first year are expected to be 0.5 kWh/ft^2/yr for new construction and alterations. Peak demand reductions are expected to be 9.61 x 10^{-8} kW/ft^2/yr for new construction and alterations.

Table 22: First-Year Energy Impacts – Per Square Foot – "Occupant Sensing Controls in Restrooms" Measure for 2020

Construction Type	Electricity Savings (kWh/ft^2/yr)	Peak Electricity Demand Reductions (kW)	TDV Energy Savings (TDV kBtu/yr)
New Construction (CZ 1 through 16)	0.5	9.61×10^{-8}	15
Alterations (CZ 1 through 16)	0.5	9.61×10^{-8}	15

The per-unit TDV energy cost savings over the 15-year period of analysis are presented in Table 30. The energy cost savings are presented as the discounted present value of the energy cost savings over the analysis period.

Manual ON Commissioning for Automatic Time-Switch Controls

Per square foot electricity savings and peak demand reductions for the first year are presented in Table 23, which presents results for new construction and alterations by building prototype in 2020.

Peak demand reductions are expected to be zero because the proposed measure does not significantly affect peak load hours or the demand response potential of the building.

Table 23: First-Year Energy Impacts – Per Square Foot of Building Area Subject to Time-Switch Controls for Considered Building Prototypes for 2020

Building Type	Electricity Savings (kWh/ft^2/yr)	Peak Electricity Demand Reductions (kW)	TDV Energy Savings (TDV kBtu/ft^2/yr)
Large Office	0.10	0	2.38
Small Office	0.09	0	2.22
Schools	0.09	0	2.14

5. LIFECYCLE COST AND COST-EFFECTIVENESS

5.1 Energy Cost Savings Methodology

Time Dependent Value (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

Mandatory Automatic Daylight Dimming Plus OFF Controls

The first year TDV energy savings for considered building prototypes are estimated to be 3.11 TDV kBtu per square foot. The TDV methodology allows peak electricity savings to be valued more than electricity savings during non-peak periods.

Table 24: TDV Energy Cost Savings Over 15-Year Period of Analysis – Per Square Foot for Small Hotel Building Prototype

Climate Zone	15-Year TDV Electricity Cost Savings (2020 PV $)	Total 15-Year TDV Energy Cost Savings (2020 PV $)
1	$0.01	$0.01
2	$0.02	$0.02
3	$0.02	$0.02
4	$0.02	$0.02
5	$0.01	$0.01
6	$0.02	$0.02
7	$0.02	$0.02
8	$0.02	$0.02
9	$0.02	$0.02
10	$0.02	$0.02
11	$0.02	$0.02
12	$0.02	$0.02
13	$0.02	$0.02
14	$0.02	$0.02
15	$0.02	$0.02
16	$0.01	$0.01

Table 25: TDV Energy Cost Savings Over 15-Year Period of Analysis – Per Square Foot for Medium Office Building Prototype

Climate Zone	15-Year TDV Electricity Cost Savings (2020 PV $)	Total 15-Year TDV Energy Cost Savings (2020 PV $)
1	$0.13	$0.13
2	$0.18	$0.18
3	$0.16	$0.16
4	$0.18	$0.18
5	$0.16	$0.16
6	$0.20	$0.20
7	$0.20	$0.20
8	$0.21	$0.21
9	$0.21	$0.21
10	$0.20	$0.20
11	$0.19	$0.19
12	$0.18	$0.18
13	$0.17	$0.17
14	$0.20	$0.20
15	$0.21	$0.21
16	$0.15	$0.15

Table 26: TDV Energy Cost Savings Over 15-Year Period of Analysis – Per Square Foot for Small Office Building Prototype

Climate Zone	15-Year TDV Electricity Cost Savings (2020 PV $)	Total 15-Year TDV Energy Cost Savings (2020 PV $)
1	$0.16	$0.16
2	$0.19	$0.19
3	$0.17	$0.17
4	$0.20	$0.20
5	$0.18	$0.18
6	$0.22	$0.22
7	$0.21	$0.21
8	$0.23	$0.23
9	$0.23	$0.23
10	$0.22	$0.22
11	$0.19	$0.19
12	$0.20	$0.20
13	$0.19	$0.19
14	$0.20	$0.20
15	$0.22	$0.22
16	$0.15	$0.15

Table 27: TDV Energy Cost Savings Over 15-Year Period of Analysis – Per Square Foot for Large Retail Building Prototype

Climate Zone	15-Year TDV Electricity Cost Savings (2020 PV $)	Total 15-Year TDV Energy Cost Savings (2020 PV $)
1	$0.23	$0.23
2	$0.31	$0.31
3	$0.24	$0.24
4	$0.21	$0.21
5	$0.27	$0.27
6	$0.40	$0.40
7	$0.38	$0.38
8	$0.44	$0.44
9	$0.36	$0.36
10	$0.34	$0.34
11	$0.29	$0.29
12	$0.33	$0.33
13	$0.30	$0.30
14	$0.32	$0.32
15	$0.44	$0.44
16	$0.19	$0.19

Table 28: TDV Energy Cost Savings Over 15-Year Period of Analysis – Per Square Foot for Small School Building Prototype

Climate Zone	15-Year TDV Electricity Cost Savings (2020 PV $)	Total 15-Year TDV Energy Cost Savings (2020 PV $)
1	$0.02	$0.02
2	$0.01	$0.01
3	$0.01	$0.01
4	$0.01	$0.01
5	$0.01	$0.01
6	$0.01	$0.01
7	$0.01	$0.01
8	$0.01	$0.01
9	$0.00	$0.00
10	$0.01	$0.01
11	$0.02	$0.02
12	$0.02	$0.02
13	$0.01	$0.01
14	$0.02	$0.02
15	$0.02	$0.02
16	$0.02	$0.02

Table 29: TDV Energy Cost Savings Over 15-Year Period of Analysis – Per Square Foot for Warehouse Building Prototype

Climate Zone	15-Year TDV Electricity Cost Savings (2020 PV $)	Total 15-Year TDV Energy Cost Savings (2020 PV $)
1	$0.17	$0.17
2	$0.22	$0.22
3	$0.20	$0.20
4	$0.23	$0.23
5	$0.21	$0.21
6	$0.25	$0.25
7	$0.25	$0.25
8	$0.27	$0.27
9	$0.26	$0.26
10	$0.25	$0.25
11	$0.23	$0.23
12	$0.23	$0.23
13	$0.23	$0.23
14	$0.25	$0.25
15	$0.26	$0.26
16	$0.20	$0.20

Mandatory Occupant Sensing Full OFF Controls in Nonresidential Restrooms

Per-unit energy cost savings over the 15-year period of analysis is presented in Table 30 for new construction and alterations, respectively. The TDV methodology allows peak electricity savings to be valued more than electricity savings during non-peak periods.

It is estimated that the first year TDV energy savings are 14.21 TDV kBtu per square foot for new construction and 14.21 TDV kBtu per square foot for alterations. This measure does not have peak energy savings, as the measure does not propose a reduction in wattage per square foot. Since the measure will result in intermittent reduction in demand throughout the day, the peak energy savings are not claimed.

Table 30: TDV Energy Cost Savings Over 15-Year Period of Analysis – Per Square Foot – "Occupant Sensing Controls in Restrooms" Measure

Climate Zone	15-Year TDV Electricity Cost Savings (2020 PV $)	Total 15-Year TDV Energy Cost Savings (2020 PV $)
New Construction (CZ 1 through 16)	$1.27	$1.27
Alterations (CZ 1 through 16)	$1.27	$1.27

Manual ON Commissioning for Automatic Time-Switch Controls

Per-unit energy cost savings over the 15-year period of analysis is presented in Table 31 for new construction and alterations. The TDV methodology allows peak electricity savings to be valued more than electricity savings during non-peak periods.

It is estimated that the first year TDV energy savings are 2.22 TDV kBtu per square foot for Small Office, 2.14 TDV kBtu per square foot for Schools, and 2.38 TDV kBtu per square foot for Large Office. The energy savings are the same for new construction and alterations. This measure does not have peak energy savings, as the measure does not propose a reduction in wattage per square foot. Since

the measure will result in intermittent reduction in demand throughout the day, the peak energy savings are not claimed.

Table 31: TDV Energy Cost Savings Over 15-Year Period of Analysis – Per Square Foot – "Manual ON Time-Switch" Measure for New Construction and Alterations

Building Type	15-Year TDV Electricity Cost Savings (2020 PV $)	Total 15-Year TDV Energy Cost Savings (2020 PV $)
Large Office	$1.74	$1.74
Small Office	$1.82	$1.82
Small School	$1.94	$1.94

5.3 Incremental First Cost

The Statewide CASE Team estimated the Current Incremental Construction Costs and Post-Adoption Incremental Construction Costs. The Current Incremental Construction Cost represents the incremental cost of the measure if a building meeting the proposed standard 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 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.

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

Mandatory Automatic Daylight Dimming Plus OFF Controls

The "Daylight Dimming Plus OFF" measure proposes a different initial configuration for automatic daylight dimming controls that are already required by the 2016 Title 24, Part 6 code. Thus, the incremental cost for hardware and commissioning is assumed to be zero dollars.

Mandatory Occupant Sensing Full OFF Controls in Nonresidential Restrooms

The Statewide CASE Team determined the incremental cost of the propose code change in a similar manner as PNNL's analysis for ASHRAE 90.1-2010. Table 32 and Table 33 list the average price for occupancy sensors, based on the 2017 Grainger online catalog. The manufacturer brands and quantity of sensors included in the incremental cost dataset are as follows: 38 occupancy sensors from Acuity, 45 occupancy sensors from Hubbell, 46 occupancy sensors from Leviton, 14 occupancy sensors from Lutron, and 35 occupancy sensors from WattStopper.

PNNL's cost estimates for occupancy sensors were gathered from the 2012 Grainger catalog and 2012 RS Means Electrical Cost Data. For more information, see PNNL's Cost-effectiveness of ASHRAE Standard 90.1-2013 Cost Estimate spreadsheet, which accompanied the report National Cost-effectiveness of ANSI/ASHRAE/IES Standard 90.1-2013 (PNNL 2015).

Table 34 lists the costs published in the 2015 NLPIP Comparison Lighting Controls Report. NLPIP comparison found that wireless occupancy sensors have lower installation labor costs and take less time to commission. However, wireless occupancy sensors have higher material costs compared to wired occupancy sensors, ranging from 54 percent to 128 percent (NLPIP 2015).

The commissioning costs for functional testing of occupancy sensors in PNNL's 2013 cost-effectiveness analysis were based on three documents (WSU 2005, Fimek 2011, and Peterson and Haasl 1994), and the study concluded that commissioning has "an added cost of $0.01/ft^2" (PNNL 2013).

PNNL's analysis used labor costs sourced from RS Means 2012, which the CASE Team updated to account for inflation.

Table 32: 2017 Occupancy Sensor Cost

Technology	Mounting Type	Average Area Coverage (ft^2 per sensor)	Average Price ($/each)
Passive Infrared		**1,511**	**$129**
	Ceiling	1,420	$150
	Ceiling, Wall	1,745	$147
	Corner	1,200	$141
	Corner Mount, Ceiling, Wall	2,000	$196
	Fixture	2,463	$122
	Wall	1,483	$112
Passive Infrared/Microphonic		**1,811**	**$169**
	Ceiling	1,960	$174
	Corner	1,200	$197
	Wall	1,695	$157
Passive Infrared/Ultrasonic		**1,491**	**$186**
	Ceiling	1,217	$224
	Ceiling, Wall	2,000	$372
	Wall	1,617	$156
	Ultrasonic	1,409	$209
	Ceiling	1,462	$212
	Wall	300	$144
Ultrasonic		**1,409**	**$209**
	Ceiling	1,462	$211
	Wall	300	$144
	Average	**1,518**	**$157**

Table 33: Average Price of Occupancy Sensor by Manufacturer

Manufacturer and Mounting Type	Number of Occupancy Sensors	Average Price of Occupancy Sensor (each)
Acuity Sensor Switch	**38**	**$138**
Ceiling	17	$157
Ceiling, Wall	2	$145
Corner	2	$169
Fixture	1	$122
Wall	16	$114
Hubbell	**45**	**$181**
Ceiling	19	$187
Ceiling, Wall	1	$262
Wall	25	$148
Leviton	**46**	**$143**
Ceiling	9	$176
Ceiling, Wall	3	$89
Wall	34	$138
Lutron	**14**	**$115**
Wall	14	$115
WattStopper	**35**	**$191**
Ceiling	19	$222
Ceiling, Wall	5	$204
Corner Mount, Ceiling, Wall	2	$196
Wall	9	$117
Average across all manufacturers	**178**	**$157**

Table 34: 2015 Online retail prices for retrofit occupancy sensor systems[1]

Brand	Sensor Connection	Motion Sensor System				Price of Wireless Compared to Wired Occupancy System	
		Hardware Function	Model	Price per Component ($)	Price per System ($)	($)	(%)
Leviton	Wired	Sensor	OSC04-RIW	$76	$111	$89	80%
		Controller	OSP20-ND0	$35			
	Wireless	Sensor	WSC04-IRW	$108	$200		
		Controller	WSS10-GUZ	$92			
Lutron	Wired	Sensor	LOS-CIR-450-WH	$80	$110	$59	54%
		Controller	PP-120H	$30			
	Wireless	Sensor	LRF2-OCR2B-P-WH	$60	$169		
		Controller	RMJ-ECO32-DV-B	$109			
WattStopper	Wired	Sensor	CI-200-1	$84	$114	$146	128%
		Controller	BZ-150	$30			
	Wireless	Sensor	EOPC-100	$125	$260		
		Controller	EOSW-101	$135			

1. Source: NLPIP, "Comparison of Wired and Wireless Lighting Controls for Single Rooms." "Occupancy sensor system cost includes one sensor and one controller. Prices are current as of March 2015 and are for a quantity of one for each component purchased separately (i.e. not in a bundle) excluding shipping and tax. Lutron prices are from Pro Lighting Group at http://www.prolighting.com. Leviton prices are from Gordon Electric Supply at http://www.gordonelectricsupply.com. WattStopper prices are from Ready Wholesale Electric Supply at http://www.readywholesaleelectric.com."

Table 35: Incremental Costs for "Occupant Sensing Controls in Restrooms" Measure

Measure	Typical Restroom Type	Sensor Equipment Type	Material [1]	Labor Cost[2]	Incremental Commissioning Cost[2]	Maintenance Cost	Total Incremental Cost over 15-year Period of Analysis (2020 PV $)
New Construction	Single occupant	• Dual technology Ultrasonic/PIR • Wall Mount • Wired	$113	$19	$6	$0	$137
New Construction	Single occupant	• PIR • Wall Mount • Wired	$29	$19	$6	$0	$54
New Construction	Multiple occupant	• Dual Technology Ultrasonic/PIR • Wired	$112	$65	$8	$0	$185
Alterations	Single occupant	• Dual technology Ultrasonic/PIR • Wall Mount • Wired	$113	$19	$6	$0	$137
Alterations	Single occupant	• PIR • Wall Mount • Wired	$29	$19	$6	$0	$54
Alterations	Multiple occupant	• Dual technology Ultrasonic/PIR • Wireless	$162	$65	$10	$0	$237

1. 2017 Grainger Catalogue and NLPIP Study, July 2015
2. Cost-effectiveness of ASHRAE Standard 90.1-2013-Cost Estimate, which used RS Means 2012 for the labor estimates andNC3/Dodge database for the incremental commissioning costs. The Statewide CASE Team updated the values to account for inflation.

Manual ON Commissioning for Automatic Time-Switch Controls

The "Manual ON Time-Switch" measure proposes to require a different initial configuration for automatic time-switch controls when the controls are used to comply with Title 24, Part 6, Section 130.1(c). Thus, the incremental cost for hardware and commissioning is assumed to be zero dollars.

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):

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

Mandatory Automatic Daylight Dimming Plus OFF Controls

The anticipated lifetime incremental maintenance costs associated with the OFF step of automatic daylighting control is zero dollars. With appropriate use of illuminance deadband and time delay algorithms, the daylight switching of lamps is reduced to several times per day. The maintenance costs for lighting systems are expected to be comparable whether daylight controls are commissioned to dim lighting to a certain non-zero value or to OFF.

Mandatory Occupant Sensing Full OFF Controls in Nonresidential Restrooms

The Statewide CASE Team gathered anticipated lifetime incremental maintenance costs associated with occupancy controls in restrooms from stakeholders through interviews, surveys, as well as soliciting input at the Utility-Sponsored Stakeholder meetings held in September 2016 and March 2017. The incremental maintenance cost in the CASE Report analysis is assumed to be zero dollars.

Manual ON Commissioning for Automatic Time-Switch Controls

The anticipated lifetime incremental maintenance costs associated with Manual ON commissioning is zero dollars. The maintenance costs for automatic time-switch controls are expected to be comparable whether time-switch controls are commissioned with automatic ON setting or with manual ON setting. Therefore, the incremental costs in the CASE Report analysis is assumed to be zero dollars.

5.5 Lifecycle Cost-Effectiveness

Mandatory Automatic Daylight Dimming Plus OFF Controls

The "Daylight Dimming Plus OFF" 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 "Daylight Dimming Plus OFF" measure provides energy costs savings without the incremental costs. For a detailed explanation of incremental costs, see Section 5.3. The proposed measure saves money over the 15-year period of analysis relative to the existing conditions. The proposed code change is cost-effective for new construction and alterations.

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

Mandatory Occupant Sensing Full OFF Controls in Nonresidential Restrooms

The "Occupant Sensing Controls in Restrooms" 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 Benefit-to-Cost (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 of the per-unit lifecycle cost-effectiveness analyses are presented in Table 36. More information regarding the incremental costs calculations can be found in see Section 5.3.

The proposed measure saves money over the 15-year period of analysis relative to the existing conditions. The proposed code change is cost-effective for new construction and alterations.

Table 36: Lifecycle Cost-effectiveness Summary Per Square Foot – "Occupant Sensing Controls in Restrooms" Measure

Measure	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
New Construction (CZ 1 through 16)	$1.27	$0.64	1.97
Alterations (CZ 1 through 16)	$1.27	$0.71	1.78

1. **Benefits: TDV Energy Cost Savings + Other PV Savings:** Benefits include TDV energy cost savings over the period of analysis (CEC 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 Benefit/Cost Ratio is Infinite.

Code Language Cleanup – Removal of Exception 1 to Section 130.1(b)

During the development of the 2013 CASE Report proposal on Requirements for Controllable Lighting, classrooms were exempted from the dimming requirements. At the time, the default technology was linear fluorescent, and the addition of dimming ballasts to fluorescent luminaires was relatively expensive. Classrooms were singled out as being exempt, because of fewer full load hours than other space types. The 2019 CASE Report on Indoor Controls assumed that energy savings from dimming lighting is approximately 15 percent due to institutional tuning of dimmable lighting to better match design illuminance. Without institutional tuning, spaces are over-lighted due to discrete spacing choices (i.e., lining up with the two or four-foot grid spacing of suspended ceilings) and discrete light output from luminaires (California Utilities Statewide Codes and Standards Team 2011).

The 2013 CASE Report proposal on Requirements for Controllable Lighting analysis calculated a $0.48 per square foot breakeven point for schools and an incremental cost of $0.65 per square foot. Though the detailed calculations for the cost of schools are not shown in the appendix, the majority of the cost for the other space types is based on the cost of the fluorescent dimming ballasts, which is no longer needed.

The analysis used the schedule for "School Buildings" in the Alternative Calculation Method Manual and multiplied these values by the TDV time dependent valuation multipliers. The annual full load hours are 2,110 hours per year and the TDV present valued energy cost is $5.36 per watt of lighting.

The proposed 2019 LPD for classrooms is 0.72 W/ft^2. A typical California classroom is 960 square feet. The total wattage per classroom is 690 watts. Using the same calculation methodology as was used for the 2013 CASE Report proposal for "Controllable Lighting," the wattage reduction could be 103 Watts. Using the TDV multiplier of PV $5.36/W, the present valued savings over 15 years from the dimming system is PV $555.

The 2019 CASE Report on Nonresidential Indoor Sources is based on LED light sources as they have a lower lifecycle cost than fluorescent lighting systems. In most cases, LED general lighting luminaires

come with dimming drivers as the default driver, thus adding dimming has no incremental cost or negligible incremental cost. A dimmer switch for an LED troffer system is around $100 (The Home Depot 2017). The incremental cost would be even less if one considered the additional cost of adding another circuit for bi-level switching.

Thus, striking the exception for classrooms is cost-effective as the dimming control has a B/C ratio of five to one, if one uses the same rationale as was used in the 2013 CASE Report proposal on Requirements for Controllable Lighting (California Utilities Statewide Codes and Standards Team 2011).

6. FIRST-YEAR STATEWIDE IMPACTS

6.1 Statewide Energy Savings and Lifecycle Energy Cost Savings

Mandatory Automatic Daylight Dimming Plus OFF Controls

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 and expected alterations for 2020, which are presented in more detail in Appendix A. The first-year energy impacts represent the first-year annual savings from considered types of buildings that were completed or renovated in 2020. The lifecycle energy cost savings represent the energy cost savings over the entire 15-year analysis period, and the results are presented in Table 37.

Given data regarding the new construction forecast for 2020 and expected annual alterations subject to the measure, the Statewide CASE Team estimates that the proposed code change will reduce annual statewide electricity use by 40.1 GWh with an associated demand reduction of 1.7 MW. There will be no associated reduction in natural gas consumption. The energy savings for buildings constructed and renovated in 2020 are associated with a present valued energy cost savings of approximately PV $43 million in (discounted) energy costs over the 15-year period of analysis.

In Table 37, since per-unit energy savings were normalized by daylit area, the results are scaled to the statewide affected floor stock of considered buildings types. Note that per-unit energy and statewide savings accounts for:

- Dimming reduction at 125 percent illuminance only in classroom areas in the Small School Prototype.
- There were no Sidelit retail areas in the Large Retail prototype thus all Sidelit areas (Side Entry and Main Entry) were modeled with the OFF step.
- Any savings reduction from occupant adjusting controls after commissioning.

Table 37: Statewide Energy and Energy Cost Impacts – Per Prototype for New Construction and Alterations

Building Type (Residential, Retail, Office, etc.)	Affected Statewide Floor Stock in 2020 (million ft^2)	First-Year Electricity Savings (GWh)	First-Year Electrical Demand Savings (MW)	Present Valued Energy Cost Savings (PV $ million)
Hotel				
New Construction	0.25	0.06	0.002	0.001
Alterations	0.22	0.05	0.001	0.001
Office Medium & Large				
New Construction	7.61	1.66	0.090	1.127
Alterations	5.59	1.22	0.065	0.606
Office Small				
New Construction	3.25	0.58	0.029	0.169
Alterations	2.67	0.48	0.024	0.114
Retail Large				
New Construction	21.03	3.36	0.154	6.292
Alterations	12.39	1.99	0.090	2.192
School				
New Construction	0.97	0.32	0.025	0.028
Alterations	0.87	0.28	0.022	0.022
Warehouse				
New Construction	26.83	3.23	0.153	7.717
Alterations	18.98	2.29	0.106	3.860
Subtotal New Construction	59.9	9.2	0.452	15.3
Subtotal Alterations	40.7	6.3	0.308	6.8
Total	**100.7**	**15.5**	**0.8**	**22.1**

Mandatory Occupant Sensing Full OFF Controls in Nonresidential Restrooms

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 and expected alterations for 2020, which are presented in more detail in Appendix A. The first-year energy impacts represent the first-year annual savings from all buildings that were completed in 2020. The lifecycle energy cost savings represents the energy cost savings over the entire 15-year analysis period. Results are presented in in Table 38.

Given data regarding the new construction forecast for 2020 and expected annual alterations subject to the measure, the Statewide CASE Team estimates that the proposed code change will reduce annual statewide electricity use by 13.3 GWh. The energy savings for buildings constructed in 2020 are associated with a present valued energy cost savings of approximately PV $33.4 million in (discounted) energy costs over the 15-year period of analysis.

Table 38: Statewide Energy and Energy Cost Impacts – "Occupant Sensing Controls in Restrooms" Measure

Climate Zone	Affected Statewide Floor Stock in 2020 (million ft^2)	First-Year Electricity Savings (GWh)[1]	First-Year Peak Electrical Demand Reduction (MW)	Lifecycle[2] Present Valued Energy Cost Savings (PV$ million)
New Construction (CZ 1 through 16)	4.9	2.5	4.5×10^{-4}	$6.2
Alterations (CZ 1 through 16)	21.6	10.9	1.9×10^{-3}	$27.2
Total	**26.6**	**13.3**	2.4×10^{-3}	$33.4

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.

Manual ON Commissioning for Automatic Time-Switch Controls

The Statewide CASE Team estimates that a total of 21.5 million square feet of indoor nonresidential buildings will be affected by the proposed measure, which will result in 2.1 GWh of energy savings and $38.3 million in cost savings over 15-year period. Since the incremental measure cost was determined to be zero dollars, the lifecycle cost savings equals the total cost of the energy saved. This value assumes that occupants would not adjust the time-switch to automatic OFF after commissioning.

Table 39: Statewide Energy and Energy Cost Impacts for Manual ON Commissioning for Automatic Time-Switch Controls

Climate Zone	Affected Statewide Floor Stock in 2020 (million ft^2)	First-Year Electricity Savings (GWh) [1]	First-Year Peak Electrical Demand Reduction (MW)	Lifecycle[2] Present Valued Energy Cost Savings (PV$ million)
New Construction (CZ 1 through 16)	3.88	0.38	-	$0.81
Alterations (CZ 1 through 16)	17.6	1.72	-	$37.5
Total	**21.5**	**2.10**	**-**	**$38.3**

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

6.1 Statewide Water Use Impacts

The proposed code change will not result in water savings.

6.2 Statewide Material Impacts

The proposed code change in daylight control commissioning will not result in any additional material impacts.

The Statewide CASE Team expects minimal statewide material impacts from the Mandatory Occupant Sensing Full OFF Controls in Nonresidential Restrooms.

The proposed code change in commissioning time-switch controls will not result in any additional material impacts.

6.3 Other Non-Energy Impacts

For the "Daylight Dimming Plus OFF" measure, interviewed stakeholders indicated that some end-users are likely to have an issue with fixtures being OFF when the users expect lighting to be ON. As noted above, training, outreach, and education initiatives are essential to manage user acceptance of the measure.

No non-energy impacts are anticipated for the "Occupant Sensing Controls in Restrooms" measure.

For the "Manual ON Automatic Time-Switch Controls" measure, building occupants may initially be confused on how to operate lighting system. Training building occupants on how to use building's lighting system is essential to manage user acceptance of this measure. Also, it will need to stated clearly in the code and compliance manual that this measure is a commissioning step and that, if otherwise appropriate, can be adjusted after commissioning.

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).

Note that code changes related to the general cleanup of code are not highlighted with any color. Other proposed code changes are color coded as follows:

- daylight dimming controls;
- occupant sensing controls in restrooms;
- automatic time-switch controls (i.e., commissioning with manual ON setting);
- lighting alterations (separating the requirement for partial OFF occupant sensing controls in stairwells from the same requirement applied to corridors); and
- general cleanup of code related to indoor controls (simplifying the code language or retiring the portions of the code no longer relevant with the advance of Solid State Lighting technology).

7.1 Standards

Please note that Title 24, Part 6, Section 130.1 Mandatory Indoor Lighting Controls is reproduced in full below to capture all the recommended changes. Note that general cleanup changes are aimed to simplify the code language or retire the portions of the code no longer relevant (with the advance of Solid State Lighting technology).

SECTION 100.1 – DEFINITIONS AND RULES OF CONSTRUCTION

VERTICAL FENESTRATION is all fenestration other than skylights.

SKYLIGHT is fenestration installed on a roof less than 60 degrees from the horizontal.

WINDOW HEAD HEIGHT is the height from the floor to the top of the ~~window~~ vertical fenestration.

OVERHANG PROJECTION is the horizontal distance, measured outward horizontally from the surface of exposed exterior glazing at the ~~head of a window~~ top of the vertical fenestration to the outward edge of an overhang.

SECTION 130.1 – MANDATORY INDOOR LIGHTING CONTROLS

Nonresidential, high-rise residential and hotel/motel buildings shall comply with the applicable requirements of Sections 130.1(a) through 130.1~~(e)~~ (f).

(a) Area Controls.

1. All luminaires shall be functionally controlled with manual ON and OFF lighting controls. Each area enclosed by ceiling-height partitions shall be independently controlled.

   EXCEPTION to Section 130.1(a)1: Up to 0.2 watts per square foot of lighting in any area within a building may be continuously illuminated to allow for means of egress illumination, if:

   A. The area is designated for means of egress on the plans and specifications submitted to the enforcement agency under Section 10-103(a)2 of Part 1; and

   B. The controls for the egress lighting are not accessible to unauthorized personnel.

2. The lighting controls shall meet the following requirements:

   A. Be readily accessible; and

   B. Be operated with a manual control that is located in the same room or area with the lighting that is controlled by that lighting control.

   EXCEPTION 1 to Section 130.1(a)2: In malls and atria, auditorium areas, retail merchandise sales areas, wholesale showroom areas, commercial and industrial storage areas, general commercial and industrial work areas, convention centers, and arenas, the lighting control shall be located so that a person using the lighting control can see the lights or area controlled by that lighting control, or so that the area being lit is annunciated.

   EXCEPTION 2 to Section 130.1(a)2: Public restrooms having two or more stalls, parking areas, stairwells, and corridors may use a manual control not accessible to unauthorized personnel.

~~3. **Other Lighting Controls.**~~

   ~~A. Other lighting controls may be installed in addition to the manual lighting controls provided they do not override the functionality of controls installed in accordance with Section 130.1(a)1, 2, or 4.~~

4. **Separately Controlled Lighting Systems.** In addition to the requirements in Section 130.1(a)1~~,~~ and 2~~, and 3~~:

   A. General lighting shall be separately controlled from all other lighting systems in an area.

   B. Floor and wall display, window display, case display, ornamental, and special effects lighting shall each be separately controlled on circuits that are 20 amps or less.

   C. When track lighting is used, general, display, ornamental, and special effects lighting shall each be separately controlled.

(b) **Multi-Level Lighting Controls.** The general lighting of any enclosed ~~area~~ space 100 square feet or larger, with a connected lighting load that exceeds 0.5 watts per square foot shall provide multi-level lighting control that meets the following requirements:

1. Lighting shall have the required number of control steps and meet the uniformity requirements in accordance with TABLE 130.1-A;
2. Multi-level lighting controls shall not override the functionally of other lighting controls required for compliance with Sections 130.1(a), and (c) through (e); and
3. Dimmable luminaires shall be controlled by a dimmer control that is capable of controlling lighting through all required lighting control steps and that allows the manual ON and OFF functionality required by Section 130.1(a).

~~**EXCEPTION 1 to Section 130.1(b):** Classrooms with a connected general lighting load of 0.7 watts per square feet or less and public restrooms shall have at least one control step between 30-70 percent of full rated power.~~

EXCEPTION ~~2~~ 1 to Section 130.1(b): An area enclosed by ceiling height partitions that has only one luminaire with no more than two lamps.

EXCEPTION ~~3~~ 2 to Section 130.1(b): The areas specified in Sections 130.1(c)6, 130.1(c)7 and 130.1(c)8 are not also required to meet the requirements of Section 130.1(b).

EXCEPTION 3 to Section 130.1(b): Restrooms

(c) **Shut-OFF Controls**

1. In addition to lighting controls installed to comply with Sections 130.1(a) and (b), all installed indoor lighting shall be equipped with controls that meet the following requirements:
   A. Shall be controlled with an occupant sensing control, automatic time-switch control, or other control capable of automatically shutting OFF all of the lighting when the space is typically unoccupied; and
   B. Separate controls for the lighting on each floor, other than lighting in stairwells; and
   C. Separate controls for ~~a~~ each space enclosed by ceiling height partitions~~;~~ and no greater than ~~not exceeding~~ ~~5,000 square feet~~ 3,000 watts of lighting is controlled by each control; and

      EXCEPTION to Section 130.1(c)1C: ~~In the following function areas the area controlled may not exceed 20,000 square feet:~~ Malls, auditoriums, single tenant retail, industrial, convention centers, and arenas, with separate controls for each enclosed space and no greater than 15,000 Watts of lighting controlled by each control.

   D. Separate controls for general, display, ornamental, and display case lighting.

   EXCEPTION 1 to Section 130.1(c)1: Where the lighting is serving an area that is in continuous use, 24 hours per day/365 days per year.

   EXCEPTION 2 to Section 130.1(c)1: Lighting complying with Section 130.1(c)5 or 7.

   EXCEPTION 3 to Section 130.1(c)1: Up to 0.1 watts per square foot of lighting in any area within a building may be continuously illuminated, provided that the area is designated for means of egress on the plans and specifications submitted to the enforcement agency under Section 10-103(a)2 of Part 1.

   EXCEPTION 4 to Section 130.1(c)1: Electrical equipment rooms subject to Article 110.26(D) of the California Electrical Code.

EXCEPTION 5 to Section 130.1(c): Illumination provided by lighting equipment that is designated for emergency lighting, connected to an emergency power source or battery supply, and is intended to function in emergency mode only when normal power is absent.

2. Countdown timer switches shall not be used to comply with the automatic shut-OFF control requirements in Section 130.1(c)1.

EXCEPTION 1 to Section 130.1(c)2: ~~Single-stall bathrooms less than 70 square feet, and~~ Closets less than 70 square feet may use countdown timer switches with a maximum setting capability of ten minutes to comply with the automatic shut-OFF requirements.

EXCEPTION 2 to Section 130.1(c)2: Lighting in a Server Aisle in a Server Room, as defined in Section 100.1, may use countdown timer switches with a maximum setting capability of 30 minutes to comply with the automatic shut-OFF requirements.

3. If an automatic time-switch control~~, other than an occupant sensing control,~~ is installed to comply with Section 130.1(c)1, it shall incorporate all of the following features: ~~an override lighting control that~~

A. Each space shall have an area control that complies with Section 130.1(a) and is capable of turning lights OFF; and

B. ~~Allows~~ Area controls are capable of initiating a timed override of the time-switch control. When the area control turns lights ON during normally unoccupied periods, the lighting ~~to~~ shall remain ON for no more than 2 hours ~~when~~ after an override is initiated; and

C. Automatic time-switch shall be configured to operate in manual-ON mode. Lights shall not turn on until area controls are manually activated.

EXCEPTION to Section 130.1(c)3B: In the following function areas, the override time may exceed 2 hours: Malls, auditoriums, single tenant retail, industrial, and arenas where captive-key override is utilized.

EXCEPTION to Section 130.1(c)3C: Automatic ON time-switch control is allowed in the following function spaces: industrial, single tenant retail, malls, auditoriums, concourses, lobbies and other areas open to the general public.

~~4~~D. If an automatic time-switch control, ~~other than an occupant sensing control~~, is installed to comply with Section 130.1(c)1, it shall incorporate an automatic holiday "shut-OFF" feature that turns OFF all loads for at least 24 hours, and then resumes the normally scheduled operation.

EXCEPTION to Section 130.1(c)~~4~~ 3D: In retail stores and associated malls, restaurants, grocery stores, churches, and theaters, the automatic time-switch control is not required to incorporate an automatic holiday shut-OFF feature.

4. Reserved *[Placeholder until following sections renumbered in Section 130.1 and new numbering reflected in 141.0(b)2I, J, and K].*

5. **Areas where Occupant Sensing Controls are required to shut OFF All Lighting**. In offices 250 square feet or smaller, multipurpose rooms of less than 1,000 square feet, classrooms of any size, ~~and~~ conference rooms of any size, and restrooms of any size, lighting shall be controlled with occupant sensing controls to automatically shut OFF all of the lighting when the ~~room~~ space is unoccupied. In addition, area controls shall be provided that allow the lights to be manually shut-OFF in accordance with Section 130.1(a) regardless of occupancy sensor status.

   ~~In areas required by Section 130.1(b) to have multi-level lighting controls, the occupant~~ Occupant sensing controls shall function either as a:

   A. Partial-ON Occupant Sensor capable of automatically activating between 50-70 percent of controlled lighting power, or

   B. Manual-ON Vacancy Sensor where all lighting responds to a manual ON input only.

   EXCEPTION to 130.1(c)5A & B: In areas not required by Section 130.1(b) to have multi-level lighting controls, lighting is permitted to be controlled by an occupancy sensor that automatically turns ON all lighting when the room is occupied.

   ~~In areas not required by Section 130.1(b) to have multi-level lighting controls, the occupant sensing controls shall function either as a:~~

   ~~A. Occupant Sensor; or~~

   ~~B. Partial-ON Occupant Sensor, or~~

   ~~C. Vacancy Sensor, where all lighting responds to a manual ON input only.~~

   ~~In addition, controls shall be provided that allow the lights to be manually shut-OFF in accordance with Section 130.1(a) regardless of the sensor status.~~

6. **Areas where full or partial OFF occupant sensing controls are required.** Lighting installed in the following areas shall meet the following requirements in addition to complying with Section 130.1(c)1.

   A. In aisle ways and open areas in warehouses, lighting shall be controlled with occupant sensing controls that automatically reduce lighting power of each luminaire by at least 50 percent when the areas are unoccupied. The occupant sensing controls shall independently control lighting in each aisle way, and shall not control lighting beyond the aisle way being controlled by the sensor.

      ~~**EXCEPTION 1 to Section 130.1(c)6A:** In aisle ways and open areas in warehouses in which the installed lighting power is 80 percent or less of the value allowed under the Area Category Method, occupant sensing controls shall reduce lighting power by at least 40 percent.~~

      ~~**EXCEPTION 2 to Section 130.1(c)6A:** When metal halide lighting or high pressure sodium lighting is installed in warehouses, occupant sensing controls shall reduce lighting power by at least 40 percent.~~

   B. In library book stack aisles 10 feet or longer that are accessible from only one end, and library book stack aisles 20 feet or longer that are accessible from both ends, lighting shall be controlled with occupant sensing controls that automatically reduce lighting power of each luminaire by at least 50 percent when the areas are unoccupied. The occupant sensing controls shall independently control lighting in each aisle way, and shall not control lighting beyond the aisle way being controlled by the sensor.

C. Lighting installed in corridors ~~and stairwells~~ shall be controlled by occupant sensing controls that separately reduce the lighting power of each luminaire in each space by at least 50 percent when the space is unoccupied. The occupant sensing controls shall be capable of automatically turning the lighting fully ON only in the separately controlled space, and shall be automatically activated when entered from all designed paths of egress.

D. Lighting installed in stairwells shall be controlled by occupant sensing controls that separately reduce the lighting power of each luminaire in each space by at least 50 percent when the space is unoccupied. The occupant sensing controls shall be capable of automatically turning the lighting fully ON only in the separately controlled space, and shall be automatically activated when entered from all designed paths of egress.

7. **Areas where partial OFF occupant sensing controls are required.** Lighting installed in the following areas shall meet the following requirements instead of complying with Section 130.1(c)1.

A. Lighting in ~~stairwells and~~ common area corridors that provide access to guestrooms and dwelling units of high-rise residential buildings and hotel/motels shall be controlled with occupant sensing controls that automatically reduce lighting power of each luminaire by at least 50 percent when the areas are unoccupied. The occupant sensing controls shall be capable of automatically turning the lighting fully ON only in the separately controlled space, and shall be automatically activated when entered from all designed paths of egress.

~~**EXCEPTION to Section 130.1(c)7A:** In corridors and stairwells in which the installed lighting power is 80 percent or less of the value allowed under the Area Category Method, occupant sensing controls shall reduce power by at least 40 percent.~~

B. Lighting in stairwells that provide access to guestrooms and dwelling units of high-rise residential buildings and hotel/motels shall be controlled with occupant sensing controls that automatically reduce lighting power of each luminaire by at least 50 percent when the areas are unoccupied. The occupant sensing controls shall be capable of automatically turning the lighting fully ON only in the separately controlled space, and shall be automatically activated when entered from all designed paths of egress.

~~B~~C. In parking garages, parking areas and loading and unloading areas, general lighting shall be controlled by occupant sensing controls having at least one control step that reduces the lighting power of each controlled luminaire to between 20 percent and 50 percent of design lighting power. No more than 500 watts of rated lighting power shall be controlled together as a single zone. ~~A reasonably uniform level of illuminance shall be achieved in accordance with the applicable requirements in TABLE 130.1-A.~~ The occupant sensing controls shall be capable of automatically turning the lighting fully ON only in the separately controlled ~~space~~ zone, and shall be automatically activated when entered from all designed paths of egress.

Interior areas of parking garages are classified as indoor lighting for compliance with Section 130.1(c)7B. Parking areas on the roof of a parking structure are classified as outdoor hardscape and shall comply with the applicable provisions in Section 130.2.

~~**EXCEPTION to Section 130.1(c)7B:** Metal halide luminaires with a lamp plus ballast mean system efficacy of greater than 75 lumens per watt, used for general lighting in~~

~~parking garages, parking areas and loading and unloading areas, shall be controlled by occupant sensing controls having at least one control step between 20 percent and 60 percent of design lighting power.~~

8. Hotel motel guest rooms shall have captive card key controls, occupancy sensing controls, or automatic controls such that, no longer than 30 minutes after the guest room has been vacated, lighting power is switched off.

   EXCEPTION to Section 130.1(c)8: One high efficacy luminaire as defined in TABLE 150.0-A that is switched separately and where the switch is located within 6 feet of the entry door.

(d) **Automatic Daylighting Controls.**

1. Daylit Zones shall be defined as follows:

   A. **SKYLIT DAYLIT ZONE** is the rough area in plan view under each skylight, plus 0.7 times the average ceiling height in each direction from the edge of the rough opening of the skylight, minus any area on a plan beyond a permanent obstruction that is taller than ~~the following: A permanent obstruction that is taller than~~ one-half the distance from the floor to the bottom of the skylight. The bottom of the skylight is measured from the bottom of the skylight well for skylights having wells, or the bottom of the skylight if no skylight well exists.

   For the purpose of determining the skylit daylit zone, the geometric shape of the skylit daylit zone shall be identical to the plan view geometric shape of the rough opening of the skylight; for example, for a rectangular skylight the skylit daylit zone plan area shall be rectangular, and for a circular skylight the skylit daylit zone plan area shall be circular.

   For skylight(s) located in an atrium, the Skylit Daylit Zone shall include the floor area directly under the atrium, and the top floor that is directly under the skylight, plus 0.7 times the average ceiling height for that floor, in each direction from the edge of the rough opening of the skylight, minus any area on a plan beyond a permanent obstruction that is taller than one-half the distance from the top floor to the bottom of the skylight.

   EXCEPTION 1 to 130.1(d)1A: Areas under skylights where it is documented that existing adjacent structures or natural objects block direct sunlight for more than 1,500 daytime hours per year between 8 a.m. and 4 p.m.

B. **PRIMARY SIDELIT DAYLIT ZONE** is the area in plan view and is directly adjacent to each vertical glazing in an exterior wall, one window head height deep into the area, and ~~window~~ vertical fenestration width plus 0.5 times window head height wide on each side of the rough opening of the ~~window~~ vertical fenestration, minus any area on a plan beyond a permanent vertical obstruction that is 6 feet or taller as measured from the floor and minus any area that is in a skylit daylit zone.

C. **SECONDARY SIDELIT DAYLIT ZONE** is the area in plan view ~~and is~~ directly adjacent to the Primary Sidelit Daylit Zone ~~each vertical glazing~~, and extends two window head heights deep from the vertical fenestration into the area, and is the ~~window~~ vertical fenestration width plus 0.5 times window head height wide on each side of the rough opening of the ~~window~~ vertical fenestration, minus any area on a plan beyond a permanent vertical obstruction that is 6 feet or taller as measured from the floor and minus any area that is in a Skylit Daylit Zone or in a Primary Sidelit Zone.

Note: Modular furniture walls shall not be considered a permanent obstruction.

EXCEPTION to 130.1(d)1B&C: Areas adjacent to vertical fenestration with overhangs and no vertical fenestration above the overhang, where the ratio of the overhang projection to the window head height is greater than 1.0.

2. Luminaires providing general lighting that are in or are partially in the Skylit Daylit Zones or the Primary Sidelit Daylit Zones shall be controlled independently by fully functional automatic daylighting controls that meet the applicable requirements of Section 110.9, and the applicable requirements below:

A. All Skylit Daylit Zones and Primary Sidelit Daylit Zones shall be shown on the plans.

B. Luminaires in the Skylit Daylit Zone, ~~shall be controlled separately from those in the~~ Primary Sidelit Daylit Zone shall be controlled separately from each other.

~~C. Luminaires that fall in both a Skylit and Primary Sidelit Daylit Zone shall be controlled as part of the Skylit Daylit Zone.~~

~~D~~ C. **Automatic Daylighting Control Installation and Operation**. For luminaires providing general lighting in daylight zones, automatic daylighting controls shall be installed and configured to operate according to all of the following requirements:

i. Photosensors shall be located so that they are not readily accessible to unauthorized personnel. The location where calibration adjustments are made to automatic daylighting controls shall be readily accessible to authorized personnel and may be inside a locked case or under a cover which requires a tool for access.

ii. Automatic daylighting controls shall provide functional multilevel lighting having at least the number of control steps specified in TABLE 130.1-A.

EXCEPTION 1 to Section 130.1(d)2~~D~~Cii: Controlled lighting having a lighting power density less than 0.3 W/ft^2 is not required to provide multilevel lighting controls.

iii. For each ~~space~~ daylight zone, the combined illuminance from the controlled lighting and daylight shall not be less than the illuminance from controlled lighting when no daylight is available.

iv. ~~In areas served by lighting that is daylight controlled, when~~ When daylight illuminance in the daylit zone is greater than ~~150~~ 125 percent of the design illuminance received from the general lighting system at full power, the daylight

controlled general lighting power in that daylight zone shall be reduced by a minimum of 65 percent.

v. When daylight illuminance in the daylit zone is greater than 150 percent of the design illuminance received from the general lighting system at full power, the daylight controlled general lighting power in that daylight zone shall be turned OFF.

EXCEPTION 1 to Section 130.1(d)2Cv: Sidelit daylit zones in Retail Merchandise Sales and Wholesale Showroom areas.

EXCEPTION 2 to Section 130.1(d)2Cv: Classroom, Lecture, Training, and Vocational Areas.

EXCEPTION 1 to Section 130.1(d)2: ~~Rooms~~ Daylighting controls are not required for luminaires in Skylit Daylit Zone(s) and Primary Sidelit Daylit Zone(s) in enclosed spaces in which the combined total installed general lighting power in the Skylit Daylit Zone and Primary Sidelit Daylit Zone in the space is less than 120 Watt.

EXCEPTION 2 to Section 130.1(d)2: ~~Rooms~~ Enclosed spaces that have a total glazing area of less than 24 square feet.

EXCEPTION 3 to Section 130.1(d)2: Parking garages complying with Section 130.1(d)3.

EXCEPTION 4 to Section 130.1(d)2: Luminaires providing display, ornamental, and display case lighting

3. **Parking Garage Daylighting Requirements**. In a parking garage area with a combined total of 36 square feet or more of glazing or opening, luminaires providing general lighting that are in the combined primary and secondary sidelit daylit zones shall be controlled independently from other lighting in the parking garage by automatic daylighting controls, and shall meet the following requirements as applicable:

   A. All primary and secondary sidelit daylit zones shall be shown on the plans.

   B. Automatic Daylighting Control Installation and Operation. Automatic daylighting control shall be installed and configured to operate according to all of the following requirements:

      i. Automatic daylighting controls shall have photosensors that are located so that they are not readily accessible to unauthorized personnel. The location where calibration adjustments are made to the automatic daylighting controls shall be readily accessible to authorized personnel but may be inside a locked case or under a cover which requires a tool for access.

      ii. Automatic daylighting controls shall be multilevel, continuous dimming or ON/OFF.

      iii. The combined illuminance from the controlled lighting and daylight shall not be less than the illuminance from controlled lighting when no daylight is available.

      iv. When illuminance levels measured at the farthest edge of the secondary sidelit zone away from the glazing or opening are greater than 150 percent of the illuminance provided by the controlled lighting when no daylight is available, the controlled lighting power consumption shall be zero.

   EXCEPTION 1 to Section 130.1(d)3: Luminaires located in the daylight transition zone and luminaires for only dedicated ramps. Daylight transition zone and dedicated ramps are defined in Section 100.1.

EXCEPTION 2 to Section 130.1(d)3: The total combined general lighting power in the primary sidelit daylight zones is less than 60 watts.

(e) **Demand Responsive Controls.**

1. Buildings larger than 10,000 square feet, after excluding spaces with a lighting power density of 0.5 watts per square foot or less, shall be capable of automatically reducing lighting power in response to a Demand Response Signal; so that the total lighting power of non-excluded spaces can be lowered by a minimum of 15 percent below the total installed lighting power when a Demand Response Signal is received. ~~Lighting shall be reduced in a manner consistent with uniform level of illumination requirements in TABLE 130.1-A.~~

   EXCEPTION to Section 130.1(e): Lighting not permitted by a health or life safety statute, ordinance, or regulation to be reduced shall not be counted toward the total lighting power.

2. Demand responsive controls and equipment shall be capable of receiving and automatically responding to at least one standards-based messaging protocol by enabling demand response after receiving a demand response signal.

(f) Controls Coordination. No control shall override any of the required lighting controls in Section 130.1. that results in an increase in the energy consumption of the controlled lighting system.

Exception 1 to Section 130.1(f): The timed override area control in Section 130.1(c)3B may override a timed switch control during periods that lighting is scheduled OFF and turn lights ON for a duration not to exceed two hours. The override of time-switch controls may exceed two hours in malls, auditoriums, single tenant retail, industrial, and areas where captive-key override is utilized as specified in Exception to Section 130.1(c)3C.

Exception 2 to Section 130.1(f): A time-switch control compliant with the Exception to Section 130.1(c)4 may turn lights ON at the next scheduled time lights are scheduled to be turned ON regardless of prior operation of area controls.

Exception 3 to Section 130.1(f): Where occupancy sensors are not required to be manual ON, the occupancy sensor controls may automatically activate lighting after the space has been vacated and re-occupied regardless of prior operation of area controls.

TABLE 130.1-A MULTI-LEVEL LIGHTING CONTROLS AND UNIFORMITY REQUIREMENTS

Luminaire Type	Minimum Required Control Steps (percent of full rated)	Uniform level of illuminance shall be achieved by:
Line-voltage sockets except GU-24	Continuous dimming 10-100 percent	
Low-voltage incandescent systems		
LED luminaires and LED source systems		
GU-24 rated for LED		

Luminaire Type	Minimum Required Control Steps (percent of full rated)	Uniform level of illuminance shall be achieved by:
GU-24 sockets rated for fluorescent > 20 watts	Continuous dimming 20-100 percent	
Pin-based compact fluorescent > 20 watts[2]		
GU-24 sockets rated for fluorescent ≤ 20 watts	Minimum one step between 30-70 percent	Stepped dimming; or Continuous dimming; or Switching alternate lamps in a luminaire
Pin-based compact fluorescent ≤ 20 watts[2]		
Linear fluorescent and U-bent fluorescent ≤ 13 watts		
Linear fluorescent and U-bent fluorescent >13 watts	~~Minimum one step in each~~ Continuous dimming 20-100 percent ~~20-40 %~~ ~~50-70 %~~ ~~75-85 %~~	~~Stepped dimming; or~~ ~~Continuous dimming; or~~ ~~Switching alternate lamps in each luminaire, having a minimum of 4 lamps per luminaire illuminating the same area and in the same manner~~
Track Lighting	Minimum one step between 30 – 70 percent	Step dimming; or Continuous dimming; or Separately switching circuits in multi-circuit track with a minimum of two circuits.
HID > 20 watts	Minimum one step between 50 - 70 percent	Stepped dimming; or Continuous dimming; or Switching alternate lamps in each luminaire, having a minimum of 2 lamps per luminaire, illuminating the same area and in the same manner.
Induction > 25 watts		
Other light sources		
1. Full rated input power of ballast and lamp, corresponding to maximum ballast factor		

SECTION 140.6 – PRESCRIPTIVE REQUIREMENTS FOR INDOOR LIGHTING

(a) Calculation of Actual Indoor Lighting Power. The actual indoor Lighting Power of all proposed building areas is the total watts of all planned permanent and portable lighting systems in all areas of the proposed building; subject to the applicable adjustments under Subdivisions 1 through 3 of this subsection and the requirements of Subdivision 4 of this subsection.

2. Reduction of wattage through controls. In calculating actual indoor Lighting Power, the installed watts of a luminaire providing general lighting in an area listed in TABLE 140.6-A may be reduced by the product of (i) the number of watts controlled as described in TABLE 140.6-A, times (ii) the applicable Power Adjustment Factor (PAF), if all of the following conditions are met:

…

H. To qualify for the PAF for daylight dimming plus OFF control, the daylight control and controlled luminaires shall comply with Section 130.1(d), 130.4(a)3 and 130.4(a)7, and shall additionally turn lights completely OFF when the daylight available in the daylit zone is greater than 150 percent of the illuminance received from the general lighting system at full power. The PAF shall apply only to the luminaires general lighting in primary sidelit daylit zones in Retail Merchandise Areas, or Wholesale Showrooms, or Classroom, Lecture, Training, and Vocational Areas in the primary sidelit daylit zone and the skylit daylit zone.

[The Indoor Controls CASE Report recommends keeping in Section 140.6(d) and the Statewide CASE Team is soliciting feedback on whether the Secondary sidelit controls requirements should be moved to Section 130.1(d).]

(d) Automatic Daylighting Controls in Secondary Daylit Zones. All luminaires providing general lighting that is in, or partially in a Secondary Sidelit Daylit Zone as defined in Section 130.1(d)1C~~, and that is not in a Primary Sidelit Daylit Zone~~ shall:

1. Be controlled independently from all other luminaires by automatic daylighting controls that meet the applicable requirements of Section 110.9; and

2. Be controlled in accordance with the applicable requirements in Section 130.1(d)2C; and

3. All Secondary Sidelit Daylit Zones shall be shown on the plans submitted to the enforcing agency.

EXCEPTION 1 to Section 140.6(d): Enclosed spaces ~~Luminaires in Secondary Sidelit Daylit Zone(s) in areas~~ where the total wattage of general lighting in the Secondary Sidelit Daylit Zone(s) in the space is less than 120 Watts or where total wattage of the general lighting in the combined Primary Sidelit Daylit and the Secondary Sidelit Daylit Zone(s) in the space is less than 240 Watts.

TABLE 140.6-A LIGHTING POWER ADJUSTMENT FACTORS (PAF)

TYPE OF CONTROL	TYPE OF AREA	FACTOR
a. To qualify for any of the Power Adjustment Factors in this table, the installation shall comply with the applicable requirements in Section 140.6(a)2 b. Only one PAF may be used for each qualifying luminaire unless combined below. c. Lighting controls that are required for compliance with Part 6 shall not be eligible for a PAF		

1. Daylight Dimming plus OFF Control	Luminaires providing general lighting in primary sidelit daylit zones in Retail Merchandise Areas, Wholesale Showrooms, Classroom, Lecture, Training, or Vocational Areas in skylit daylit zone or primary sidelit daylit zones	0.10

7.2 Reference Appendices

7.2.1 Mandatory Automatic Daylight Dimming Plus OFF Controls

For the "Daylight Dimming Plus OFF" measure, 2016 Nonresidential Appendix NA7 "Installation and Acceptance Requirements for Nonresidential Buildings and Covered Processes" will need to be updated

(chapter NA7.6.1 Automatic Daylighting Control Acceptance).

NA7.6.1 Automatic Daylighting Controls Acceptance Tests

NA 7.6.1.1 Construction Inspection

Verify that automatic daylighting controls qualify as one of the required control types, are installed, and fully functional in accordance with each applicable requirement in Section 130.1(d), and list each specific exception claimed, from Section 130.1(d).

NA 7.6.1.2 Functional testing

All photocontrols serving more than 5,000 square feet of daylit area shall undergo functional testing. Photocontrols that are serving smaller spaces may be sampled as follows: For buildings with up to five photocontrols, all photocontrols shall be tested. For buildings with more than five photocontrols, sampling may be done on spaces with similar sensors and cardinal orientations of glazing; sampling shall include a minimum of one photocontrol for each group of up to five additional photocontrols. If the first photocontrol in the sample group passes the functional test, the remaining building spaces in the sample group also pass. If the first photocontrol in the sample group fails the functional test, the rest of the photocontrols in the group shall be tested. If any tested photocontrol fails the functional test, it shall be repaired, replaced or adjusted until it passes the test.

For each photocontrol to be tested do the following:

(a) Test each group of lights controlled separately by the photocontrol according to the following protocol. In all interior spaces other than parking garages, a separate test shall be conducted for daylighting control of the primary sidelit zone separate from the secondary sidelit zone. A single photocontrol containing a single sensor can control separately the primary sidelit zone from the secondary sidelit zone as long as it has two control channels with different setpoints. The primary sidelit zone will have a different reference location than the secondary sidelit zone.

NA 7.6.1.2.1 Continuous Dimming Control Systems

This requirement is for systems that have more than ten levels of controlled light output in a given zone.

(a) Identify the minimum daylighting location in the controlled zone (Reference Location). This can be identified using either the illuminance method or the distance method.

Illuminance Method

(b) Turn OFF controlled lighting and measure daylight illuminance within zones illuminated by controlled luminaires.

(c) Identify the Reference Location; this is the task location with lowest daylight illuminance in the zone illuminated by controlled luminaires. This location will be used for illuminance measurements in subsequent tests.

Distance Method

Identify the task location within the zone illuminated by controlled luminaires that is farthest away from daylight sources. This is the Reference Location and will be used for illuminance measurements in subsequent tests.

(d) No daylight test. Simulate or provide conditions without daylight. Verify and document the following:

1. Automatic daylight control system provides appropriate control so that electric lighting system is providing full light output unless otherwise specified by design documents.

2. Document the reference illuminance, which is the electric lighting illuminance level at the reference location identified in Step 1.

3. Light output is stable with no discernable flicker.

(e) Full daylight test. Simulate or provide bright conditions. Note one can shine a flashlight or other bright source into the light sensor for this test. Verify and document the following:

1. For all applications covered by Section 130.1(d)2Cv: Controlled lighting in the daylit zone is turned OFF.

Note: Sidelit areas in Retail Merchandise Sales and Wholesale Showrooms and all daylit areas in Classroom, Lecture, Training, and Vocational Areas are required to be daylight controlled but only need to reduce lighting power by 65 percent and do not need to be turned OFF.

2. Only luminaires in daylit zones are affected by daylight control. If the daylighting controls control lighting outside of the daylight zones including those behind obstructions as described in Section 130.1(d)1, the control system is not compliant.

3. If a Power Adjustment Factor is claimed for Daylight Dimming plus OFF controls in accordance with Section 140.6(a)2H, compliant systems shall automatically turn OFF the luminaires that are receiving this credit. This portion of the full daylight test does not apply to lighting systems that are not claiming a Power Adjustment Factor for Daylight Dimming plus OFF controls.

(f) Partial daylight test. Simulate or provide daylight conditions where illuminance (fc) from daylight only at the Reference Location is between 60 and 95 percent of Reference Illuminance (fc) documented in Step 2. Verify and document the following:

1. Measure that the combined illuminance of daylight and controlled electric lighting (fc) at the reference location is no less than the electric lighting illuminance (fc) at this location during the no daylight test documented in Step (d)2.

2. Measure that the combined illuminance of daylight and controlled electric lighting (fc) at the Reference Location is no greater than 150 percent of the reference illuminance (fc) documented in Step (d)2.

3. Light output is stable with no discernable flicker.

NA 7.6.1.2.2 Stepped Switching or Stepped Dimming Control Systems

This requirement is for systems that have no more than ten discrete steps of control of light output.

If the control has three steps of control or less, conduct the following tests for all steps of control. If the control has more than three steps of control, testing three steps of control is sufficient for showing compliance.

(a) Identify the minimum daylighting location(s) in the controlled zone. (Reference Location). This can be identified using either the illuminance method or the distance method.

Illuminance Method

1. Turn OFF controlled lighting and measure daylight illuminances within a zone illuminated by controlled luminaires.
2. Identify the reference location; this is the task location with lowest daylight illuminance in the zone illuminated by controlled luminaires. This location will be used for illuminance measurements in subsequent tests.
3. Turn controlled lights back ON.

Distance Method

1. Identify the task location within the zone illuminated by controlled luminaires that is farthest away from daylight sources. This is the reference location and will be used for illuminance measurements in subsequent tests.

(b) No daylight test. Simulate or provide conditions without daylight for a stepped switching or stepped dimming control system. Verify and document the following:

1. If the control is manually adjusted (not self-commissioning), make note of the time delay and override time delay or set time delay to minimum setting. This condition shall be in effect through step 4.
2. Automatic daylight control system turns ON all stages of controlled lights unless it is documented that multi-level luminaires have been "tuned" to less than full output and providing design illuminance (fc) levels
3. Stepped dimming control system provides reduced flicker over the entire operating range as specified by §110.9.
4. Document the reference illuminance which is the electric lighting illuminance level measured at the reference location identified in Step 1.

(c) Full daylight test. Simulate or provide bright conditions. Note one can shine a flashlight or other bright source into the light sensor for this test. Verify and document the following:

1. For all applications covered by Section 130.1(d)2Cv: Controlled lighting in the daylit zone is turned OFF.

Note: Sidelit zones in Retail Merchandise Sales and Wholesale Showrooms and all daylit zones in Classroom, Lecture, Training, and Vocational Areas are required to be daylight controlled but only need to reduce lighting power by 65 percent but do not need to be turned OFF.

2. Only luminaires in daylit zones (toplit zone, primary sidelit zone and secondary sidelit zone) are affected by daylight control. If the daylighting controls control lighting outside of the daylight zones including those behind obstructions as described in Section 130.1(d)1, the control system is not compliant.

Note: all general lighting luminaires in toplit zone and in primary sidelit zone are required to have daylighting controls. General lighting luminaires in the secondary sidelit zone are required to be controlled by daylighting controls if complying using the prescriptive approach or if specified in the proposed design of the performance approach as having daylighting controls.

(d) Partial daylight test. For each control stage that is tested in this step, the control stages with lower setpoints than the stage tested are left ON and those stages of control with higher setpoints are dimmed or controlled off. Simulate or provide conditions so that each control stage turns on and off or dims. Verify and document the following for each control stage:

1. Document the total daylight and electric lighting illuminance level measured at its reference location just after the stage of control dims or shuts off a stage of lighting:
   A. The total measured illumination shall be no less than the reference illuminance measured at this location during the no daylight test documented in Step 2.
   B. The total measured illumination shall be no greater than 150 percent of the reference illuminance.
2. The control stage shall not cycle on and off or cycle between dim and undimmed while daylight illuminance remains constant.
3. Only luminaires in daylit zones (toplit zone, primary sidelit zone, and secondary sidelit zone) are affected by daylight control.

(e) Verify time delay.

1. Verify that time delay automatically resets to normal mode within 60 minutes.
2. Set normal mode time delay to at least three minutes.
3. Confirm that there is a time delay of at least 3 minutes between the time when illuminance exceeds the setpoint for a given dimming stage and when the control dims or switches off the controlled lights.

7.2.2 Mandatory Occupant Sensing Full OFF Controls in Nonresidential Restrooms

For the "Occupant Sensing Controls in Restrooms" measure, there are no proposed changes to the Reference Appendices.

7.3 ACM Reference Manual

The compliance software will need to be capable of allowing daylight dimming controls to dim to a 65% reduction at 125% Illuminance while also dimming to OFF once at 150% illuminance. Compliance software will also need to be able to allow for tradeoffs in the performance approach. Software Sensitivity tests for Dimming will likely need to updated to test for appropriate capacity.

7.4 Compliance Manuals

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

- Chapter 5.2 General Requirements for Mandatory Measures
- Chapter 5.4.3.4 Areas where Occupant Sensing Controls are required to shut OFF all Lighting
    - Based on stakeholder feedback and review of the available technology, the Statewide CASE Team recommends that larger, multi-stall restrooms consider zoning and install more than one dual-technology occupancy sensor to avoid false OFFs. Occupancy sensing technology and the layout of the space should be discussed in the compliance manual.
- Chapter 5.4.1 Area Lighting Controls
- Chapter 5.4.4.4 Automatic Daylighting Control Installation and Operation
- Chapter 5.4.8 Summary of Mandatory Controls
- Chapter 5.5 Prescriptive Daylighting Requirements
- Chapter 13.1 New or Modified Acceptance Test Requirements for 2016
- Chapter 13.24 NA7.6.1 Automatic Daylighting Control Acceptance
- Chapter 5.4.3.1 General Exceptions to §130.1(c)1

7.5 Compliance Document

Mandatory Automatic Daylight Dimming Plus OFF Controls

For "Daylight Dimming Plus OFF" measure, "2016-NRCA-LTI-03-A Automatic Daylighting Control Acceptance Document" document will need to be updated. In addition, any Equivalent Performance Forms generated on per project basis.

Manual ON Commissioning for Automatic Time-Switch Controls

For "Manual ON Commissioning for Automatic Time-Switch Controls" measure, "2016-NRCA-LTI-02-A Lighting Control Acceptance Document" and "2016-NRCC-LTI-01-E Certificate of Compliance" documents will need to be updated.

8. BIBLIOGRAPHY

Acuity Controls. 2016. "Occupancy Sensor Technologies: Microphonics vs. Ultrasonic." https://www.acuitybrands.com/-/media/Files/Acuity/Brands/Controls/Sensor%20Switch/occupancy%20sensor%20technologies%20white%20paper%20pdf.pdf.

Bonneville Power Authority. 2015. "2015 Non-Residential Lighting Market Characterization." October. https://www.bpa.gov/EE/Utility/research-archive/Documents/Momentum-Savings-Resources/2015_Non-Res_Lighting_Mkt_Characterization.pdf.

BW Research Partnership. 2016. *Advanced Energy Jobs in California: Results of the 2016 California Advanced Energy.* Advanced Energy Economy Institute.

CA DWR (California Department of Water Resources). 2016. "California Counties by Hydrologic Regions." Accessed April 3, 2016. http://www.water.ca.gov/landwateruse/images/maps/California-County.pdf.

California Energy Commission. 2015. "2016 Building Energy Efficiency Standards: Frequently Asked Questions." Accessed February 2, 2017. http://www.energy.ca.gov/title24/2016standards/rulemaking/documents/2016_Building_Energy_Efficiency_Standards_FAQ.pdf.

California Public Utilities Commission. 2015a. "Water/Energy Cost-Effectiveness Analysis: Errata to the Revised Final Report." Prepared by Navigant Consulting, Inc. . http://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=5350.

—. 2015b. "Water/Energy Cost-Effectiveness Analysis: Revised Final Report." Prepared by Navigant Consulting, Inc. http://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=5360.

California Utilities Statewide Codes and Standards Team. 2011. *Nonresidential Daylighting.* October. http://www.energy.ca.gov/title24/2013standards/prerulemaking/documents/current/Reports/Nonresidential/Lighting_Controls_Bldg_Power/2013_CASE_NR_Daylighting_Oct_2011.pdf.

California Utilities Statewide Codes and Standards Team. 2014. *Nonresidential Lighting Controls: Clarification and Control Credits.* October. http://www.energy.ca.gov/title24/2016standards/rulemaking/documents/dru_title24_parts_01_06/T24%202016%20CASE%20Report%20-%20Lighting%20Clarification%20+%20%20PAF%20Oct2014.pdf.

California Utilities Statewide Codes and Standards Team. 2011. "Requirements for Controllable Lighting." http://www.energy.ca.gov/title24/2013standards/prerulemaking/documents/current/Reports/Nonresidential/Lighting_Controls_Bldg_Power/2013_CASE_NR_Controllable_Lighting.pdf.

Database for Energy Efficient Resources. 2016. *DEER2016.* http://www.deeresources.com/index.php/deer-versions/deer2016.

Department of Energy. 2016. "Energy Savings Forecast of Solid-State Lighting in General Illumination Applications." https://energy.gov/eere/ssl/downloads/2016-ssl-forecast-report.

DOE. 2016. "Energy Savings Forecast of Solid-State Lighting in General Illumination Applications." https://energy.gov/sites/prod/files/2016/09/f33/energysavingsforecast16_2.pdf.

Energy + Environmental Economics. 2016. "Time Dependent Valuation of Energy for Developing Building Efficiency Standards: 2019 Time Dependent Valuation (TDV) Data Sources and Inputs." Prepared for the California Energy Commission. July.

http://docketpublic.energy.ca.gov/PublicDocuments/16-BSTD-06/TN212524_20160801T120224_2019_TDV_Methodology_Report_7222016.pdf.

Ettenson, Lara , and Christa Heavey. 2015. *California's Golden Energy Efficiency Opportunity: Ramping Up Success to Save Billions and Meet Climate Goals.* Natural Resources Defense Council & Environmental Entrepreneurs (E2).

Lawrence Berkeley National Laboratory. 2013. "A Post-Occupancy Monitored Evaluation of the Dimmable Lighting, Automated Shading, and Underfloor Air Distribution System in The New York Times Building." https://buildings.lbl.gov/sites/all/files/lbnl-6023e.pdf.

Lutron. n.d. "Occupancy/Vacancy Senor Design and Application Guide." https://www.lutron.com/TechnicalDocumentLibrary/3683197.pdf.

National Energy Assistance Directors Association. 2011. "2011 National Energy Assistance Survey Final Report." Accessed February 2, 2017. http://www.appriseinc.org/reports/Final%20NEADA%202011%20Report.pdf.

National Lighting Product Information Program. 2015. "Comparison of Wired and Wireless Lighting Controls for Single Rooms ." July. http://www.lrc.rpi.edu/programs/NLPIP/lightinganswers/pdf/PRINT/LA_WirelessControls.pdf.

Pacific Northwest National Laboratory. 2011. *Achieving the 30% Goal: Energy and Cost Savings Analysis of ASHRAE Standard 90.1-2010.* May. https://www.energycodes.gov/sites/default/files/documents/BECP_Energy_Cost_Savings_STD2010_May2011_v00.pdf.

—. 2013. "Analysis of Daylighting Requirements within ASHRAE Standard 90.1." August. http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-22698.pdf.

PNNL. 2015. "National Cost-effectiveness of ANSI/ASHRAE/IES Standard 90.1-2013 ." http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-23824.pdf.

—. 2013. "National Cost-effectiveness of ASHRAE Standard 90.1-2010 Compared to ASHRAE Standard 90.1-2007." November. https://www.energycodes.gov/sites/default/files/documents/PNNL-22972.pdf.

Statewide CASE Team. 2016. *Statewide Utility-Sponsored Stakeholder Meetings.* http://title24stakeholders.com/publicmeetings/.

Stone, Nehemiah, Jerry Nickelsburg, and William Yu. 2015. *Codes and Standards White Paper: Report - New Home Cost v. Price Study.* Pacific Gas and Electric Company. Accessed February 2, 2017. http://docketpublic.energy.ca.gov/PublicDocuments/Migration-12-22-2015/Non-Regulatory/15-BSTD-01/TN%2075594%20April%202015%20Codes%20and%20Standards%20White%20Paper%20-%20Report%20-%20New%20Home%20Cost%20v%20Price%20Study.pdf.

The Home Depot. 2017. *Lithonia Lighting LED Troffer Dimmer Switch.* Accessed April 2017. http://www.homedepot.com/p/Lithonia-Lighting-LED-Troffer-Dimmer-Switch-ISD-BC-120-277-WH-M10/202986061?cm_mmc=Shopping%7cTHD%7cG%7c0%7cG-BASE-PLA-D27L-CeilingFans%7c&gclid=CITo3YnMvdMCFUtqfgodj3QK6Q&gclsrc=aw.ds.

Thornberg, Christopher, Hoyu Chong, and Adam Fowler. 2016. *California Green Innovation Index - 8th Edition.* Next 10.

Thornton, B A, M I Rosenberg, W Wang, H Cho, B Liu, Y Xie, V V Mendon, E E Richman, J Zhang, and R A Athalye. 2011. *Achieving the 30% Goal: Energy and Cost Savings Analysis of ASHRAE Standard 90.1-2010.* Study of Savings Anaylsis, U.S Department of Energy, Richland,

Washington: Pacific Northwest National Laboratory. http://www.pnl.gov/main/publications/external/technical_reports/PNNL-20405.pdf.

U.S. Census Bureau, Population Division. 2014. "Annual Estimates of the Resident Population: April 1, 2010 to July 1, 2014." http://factfinder2.census.gov/bkmk/table/1.0/en/PEP/2014/PEPANNRES/0400000US06.05000.

U.S. Energy Information Administration. 2016. *2012 CBECS Survey Data.* May 20. http://www.eia.gov/consumption/commercial/data/2012/.

U.S. EPA (United States Environmental Protection Agency). 2011. "Emission Factors for Greenhouse Gas Inventories." Accessed December 2, 2013. http://www.epa.gov/climateleadership/documents/emission-factors.pdf.

Wei, Max, Shana Patadia, and Daniel M. Kammen. 2010. "Putting renewables and energy efficiency to work: How many jobs can the clean energy industry generate in the US?" *Energy Policy* 38: 919-931.

Zilllow. 2017. "Zillow Home Value Index: Single-Family Homes Time Series ($)." Accessed February 20, 2017. https://www.zillow.com/research/data/#median-home-value.

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 40, Table 42, and Table 44. 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 41, Table 43, and Table 44.

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 45).
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 47 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 48, Table 49, and Table 50 and discussed further below.
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 48, Table 49, and Table 50 and discussed further below.
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 40, Table 42, Table 43, and Table 44.

DOE's lighting market model assumes a constant ten percent rate of lighting fixture renovations each year. Thus, Table 41, Table 43, and Table 44 should show that ten percent of existing floorspace will be impacted in 2020 by the proposed code change.

Table 40: Estimated New Nonresidential Floorspace Impacted by Proposed Code Change in 2020, by Climate Zone and Building Type – "Daylight Dimming Plus OFF" Measure (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	0.049	0.02	0.085	0.029	0.05	0.00	0.07	0.03	0.00	0.03	0.05	0.4
2	0.21	0.09	0.71	0.19	0.60	0.05	0.33	0.16	0.00	0.24	0.83	3.4
3	0.69	0.39	3.18	0.74	3.57	0.23	1.22	0.74	0.00	1.34	5.58	17.7
4	0.46	0.21	1.69	0.44	1.35	0.12	0.74	0.36	0.00	0.52	1.85	7.8
5	0.09	0.04	0.33	0.09	0.26	0.02	0.14	0.07	0.00	0.10	0.36	1.5
6	0.66	0.48	2.76	0.69	2.72	0.12	0.83	0.48	0.00	0.64	3.64	13.0
7	0.88	0.26	1.70	0.52	1.14	0.01	0.90	0.39	0.00	0.56	1.83	8.2
8	0.91	0.69	3.97	0.99	3.86	0.16	1.21	0.67	0.00	0.92	5.31	18.7
9	0.89	0.76	4.19	1.02	4.13	0.14	1.23	0.78	0.00	1.06	7.16	21.4
10	0.98	0.64	3.06	0.86	3.28	0.07	1.65	0.55	0.00	0.59	1.73	13.4
11	0.28	0.09	0.65	0.22	0.80	0.09	0.44	0.14	0.00	0.14	0.33	3.2
12	1.53	0.44	3.60	0.95	3.76	0.28	1.80	0.69	0.00	0.90	3.69	17.6
13	0.60	0.20	1.42	0.48	1.53	0.25	0.95	0.28	0.00	0.32	0.63	6.7
14	0.16	0.12	0.60	0.16	0.64	0.02	0.30	0.10	0.00	0.11	0.43	2.6
15	0.22	0.09	0.53	0.18	0.72	0.02	0.30	0.07	0.00	0.13	0.22	2.5
16	0.22	0.14	0.76	0.21	0.67	0.04	0.32	0.17	0.00	0.15	1.00	3.7
TOTAL	8.8	4.7	29.2	7.8	29.1	1.6	12.4	5.7	0.0	7.8	34.6	142

Table 41: Estimated Existing Nonresidential Floorspace Impacted by Proposed Code Change in 2020 (Alterations), by Climate Zone and Building Type – "Daylight Dimming Plus OFF" Measure (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	0.04	0.013	0.054	0.02	0.036	0.002	0.1	0.02	0	0.03	0.04	0.3
2	0.2	0.1	0.408	0.1	0.4	0.03	0.3	0.1	0	0.2	0.6	2
3	0.6	0.3	1.7	0.5	2.0	0.14	1.2	0.5	0	0.9	3.8	12
4	0.4	0.2	1.0	0.3	0.9	0.08	0.7	0.3	0	0.4	1.5	6
5	0.1	0.0	0.2	0.1	0.2	0.01	0.1	0.1	0	0.1	0.3	1
6	0.6	0.4	1.7	0.6	2.1	0.09	1.0	0.4	0	0.6	2.8	10
7	0.7	0.2	1.0	0.4	0.9	0.01	0.7	0.3	0	0.6	1.5	6
8	0.8	0.6	2.4	0.8	3.0	0.12	1.4	0.6	0	0.9	4.0	15
9	0.7	0.6	2.3	0.8	2.8	0.10	1.3	0.6	0	0.9	4.9	15
10	0.9	0.6	2.0	0.8	2.9	0.06	1.3	0.4	0	0.6	1.5	11
11	0.2	0.1	0.4	0.2	0.5	0.06	0.3	0.1	0	0.1	0.2	2
12	1.1	0.3	2.0	0.7	2.4	0.19	1.4	0.5	0	0.7	2.6	12
13	0.5	0.1	0.8	0.4	0.9	0.15	0.7	0.2	0	0.2	0.4	4
14	0.1	0.1	0.4	0.1	0.5	0.02	0.2	0.1	0	0.1	0.3	2
15	0.2	0.1	0.3	0.1	0.5	0.01	0.2	0.0	0	0.1	0.2	2
16	0.2	0.1	0.5	0.2	0.5	0.03	0.3	0.1	0	0.1	0.7	3
TOTAL	**7.3**	**3.6**	**17.2**	**6.1**	**20.6**	**1.1**	**11.1**	**4.3**	**0.0**	**6.6**	**25.4**	**103**

Table 42: Estimated New Nonresidential Floorspace Impacted by Proposed Code Change in 2020, by Climate Zone and Building Type – "Occupant Sensing Controls in Restrooms" Measure (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	0.062	0.021	0.108	0.036	0.046	0.003	0.083	0.035	0.039	0.032	0.069	**0.534**
2	0.263	0.116	0.890	0.234	0.596	0.048	0.412	0.205	0.265	0.296	1.044	**4.368**
3	0.859	0.485	3.951	0.918	3.573	0.231	1.513	0.913	1.047	1.664	6.928	**22.083**
4	0.587	0.264	2.138	0.555	1.353	0.119	0.931	0.461	0.636	0.661	2.343	**10.047**
5	0.114	0.051	0.415	0.108	0.263	0.023	0.181	0.089	0.123	0.128	0.455	**1.951**
6	0.788	0.577	3.311	0.828	2.717	0.118	1.000	0.572	0.632	0.771	4.366	**15.681**
7	1.055	0.317	2.042	0.628	1.143	0.011	1.076	0.471	0.668	0.674	2.200	**10.285**
8	1.097	0.830	4.779	1.189	3.860	0.164	1.459	0.802	0.963	1.108	6.392	**22.642**
9	1.076	0.918	5.048	1.225	4.133	0.138	1.480	0.943	1.369	1.275	8.623	**26.227**
10	1.233	0.802	3.831	1.075	3.283	0.075	2.066	0.689	0.815	0.738	2.170	**16.779**
11	0.349	0.108	0.807	0.275	0.800	0.095	0.538	0.173	0.260	0.179	0.412	**3.996**
12	1.871	0.538	4.394	1.158	3.759	0.279	2.197	0.845	1.237	1.104	4.504	**21.885**
13	0.757	0.250	1.789	0.603	1.533	0.246	1.191	0.346	0.564	0.402	0.790	**8.470**
14	0.201	0.153	0.757	0.204	0.641	0.023	0.376	0.122	0.161	0.139	0.544	**3.321**
15	0.270	0.106	0.665	0.226	0.718	0.021	0.380	0.092	0.113	0.167	0.272	**3.030**
16	0.278	0.170	0.957	0.258	0.670	0.042	0.406	0.209	0.237	0.189	1.247	**4.661**
TOTAL	**10.860**	**5.706**	**35.882**	**9.519**	**29.088**	**1.635**	**15.288**	**6.968**	**9.128**	**9.527**	**42.359**	**175.960**

Table 43: Estimated Existing Nonresidential Floorspace Impacted by Proposed Code Change in 2020 (Alterations), by Climate Zone and Building Type – "Occupant Sensing Controls in Restrooms" Measure (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	0.273	0.088	0.478	0.162	0.238	0.013	0.353	0.182	0.207	0.167	0.284	**2.444**
2	1.217	0.454	3.630	0.960	2.539	0.201	1.978	1.078	1.349	1.278	4.220	**18.902**
3	3.863	1.817	15.104	3.513	13.195	0.912	7.678	4.517	5.316	6.060	25.374	**87.349**
4	2.768	1.022	8.774	2.282	5.986	0.508	4.531	2.479	3.205	2.944	9.868	**44.367**
5	0.538	0.198	1.704	0.443	1.162	0.099	0.880	0.481	0.622	0.572	1.916	**8.614**
6	3.856	2.566	15.151	3.793	14.100	0.572	6.706	3.758	3.997	4.209	18.570	**77.279**
7	4.542	1.319	9.167	2.780	6.131	0.056	4.403	2.399	3.287	3.902	10.079	**48.066**
8	5.332	3.668	21.643	5.396	19.841	0.791	9.433	5.173	5.895	5.971	26.976	**110.122**
9	4.816	3.863	20.886	5.110	18.763	0.638	8.368	5.509	7.112	5.870	32.538	**113.472**
10	5.716	3.687	18.133	5.035	19.392	0.372	8.658	3.565	4.241	4.129	9.729	**82.656**
11	1.471	0.426	3.227	1.102	3.501	0.407	2.173	0.891	1.296	0.724	1.555	**16.775**
12	7.491	2.141	17.869	4.718	15.980	1.234	9.247	4.213	6.274	4.657	17.587	**91.410**
13	3.199	0.962	6.946	2.337	5.941	1.014	4.908	1.818	2.737	1.515	2.786	**34.164**
14	0.942	0.698	3.478	0.934	3.618	0.110	1.630	0.638	0.844	0.724	2.263	**15.879**
15	1.193	0.465	2.837	0.943	3.497	0.091	1.382	0.406	0.563	0.711	1.082	**13.171**
16	1.229	0.716	4.158	1.118	3.267	0.181	1.773	1.087	1.233	0.882	4.672	**20.316**
TOTAL	**48.447**	**24.090**	**153.185**	**40.627**	**137.151**	**7.199**	**74.100**	**38.194**	**48.179**	**44.315**	**169.499**	**784.986**

Table 44: Estimated New and Existing Nonresidential Baseline Floorspace in 2020, by Climate Zone and Building Type – "Manual ON Time-Switch" Measure (Million ft^2)

Climate Zone	New Construction in 2020				Alteration in 2020				GRAND TOTAL
	OFF-SMALL	OFF-LRG	SCHOOL	SUB-TOTAL	OFF-SMALL	OFF-LRG	SCHOOL	SUB-TOTAL	
1	0.062	0.069	0.083	0.214	0.273	0.284	0.353	0.909	**1.124**
2	0.263	1.044	0.412	1.719	1.217	4.220	1.978	7.414	**9.134**
3	0.859	6.928	1.513	9.300	3.863	25.374	7.678	36.915	**46.216**
4	0.587	2.343	0.931	3.860	2.768	9.868	4.531	17.167	**21.028**
5	0.114	0.455	0.181	0.750	0.538	1.916	0.880	3.333	**4.083**
6	0.788	4.366	1.000	6.154	3.856	18.570	6.706	29.133	**35.287**
7	1.055	2.200	1.076	4.331	4.542	10.079	4.403	19.025	**23.356**
8	1.097	6.392	1.459	8.947	5.332	26.976	9.433	41.742	**50.689**
9	1.076	8.623	1.480	11.179	4.816	32.538	8.368	45.721	**56.900**
10	1.233	2.170	2.066	5.469	5.716	9.729	8.658	24.103	**29.572**
11	0.349	0.412	0.538	1.299	1.471	1.555	2.173	5.199	**6.498**
12	1.871	4.504	2.197	8.571	7.491	17.587	9.247	34.324	**42.895**
13	0.757	0.790	1.191	2.738	3.199	2.786	4.908	10.893	**13.631**
14	0.201	0.544	0.376	1.121	0.942	2.263	1.630	4.835	**5.956**
15	0.270	0.272	0.380	0.922	1.193	1.082	1.382	3.657	**4.579**
16	0.278	1.247	0.406	1.931	1.229	4.672	1.773	7.674	**9.605**
TOTAL	**10.860**	**42.359**	**15.288**	**68.507**	**48.447**	**169.499**	**74.100**	**292.046**	**360.553**

Table 45: 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**
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%
	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%
	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%
	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%
	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%
	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%
	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%
	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%
	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%
	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%
	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%
	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%
	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%
	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%
	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%
	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%

Table 46: 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 ft^2	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.

Energy Commission Building Type ID	Energy Commission Description	Prototype Description			
		Prototype ID	**Floor Area (ft^2)**	**Stories**	**Notes**
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 ft^2	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 47: 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 ft^2) [C] = B × 0.11	Revised 2020 Forecast (Million ft^2) [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 48: Statewide Energy and Energy Cost Impacts – Per Prototype for New Construction and Alterations

Building Type *Building sub-type*	**Composition of Building Type by Sub-types [1]**	**Percent of Square Footage Impacted [2]**	
		New Construction	**Existing Building Stock (Alterations) [3]**
Small office		100%	10%
Restaurant		100%	10%
Retail		100%	10%
Stand-Alone Retail	*10%*	*100%*	*10%*
Large Retail	*75%*	*100%*	*10%*
Strip Mall	*5%*	*100%*	*10%*
Mixed-Use Retail	*10%*	*100%*	*10%*
Food		100%	10%
Non-refrigerated warehouse		100%	10%
Refrigerated warehouse		100%	10%
Schools		100%	10%
Small school	*60%*	*100%*	*10%*
Large school	*40%*	*100%*	*10%*
College		100%	10%
Small Office	*5%*	*100%*	*10%*
Medium Office	*15%*	*100%*	*10%*
Medium Office/Lab	*20%*	*100%*	*10%*
Public Assembly	*5%*	*100%*	*10%*
Large School	*30%*	*100%*	*10%*
High Rise Apartment	*25%*	*100%*	*10%*
Hospital		100%	10%
Hotel/motel		100%	10%
Large offices		100%	10%
Medium Office	*50%*	*100%*	*10%*
Large Office	*50%*	*100%*	*10%*

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 49: Percent of Floorspace Impacted by Proposed Measure, by Building Type– "Occupant Sensing Controls in Restrooms" Measure

Building Type *Building sub-type*	Composition of Building Type by Sub-types [1]	Percent of Square Footage Impacted [2]	
		New Construction	Existing Building Stock (Alterations) [3]
Small office		100%	10%
Restaurant		100%	10%
Retail		100%	10%
Stand-Alone Retail	*10%*	*100%*	*10%*
Large Retail	*75%*	*100%*	*10%*
Strip Mall	*5%*	*100%*	*10%*
Mixed-Use Retail	*10%*	*100%*	*10%*
Food		100%	10%
Non-refrigerated warehouse		100%	10%
Refrigerated warehouse		100%	10%
Schools		100%	10%
Small school	*60%*	*100%*	*10%*
Large school	*40%*	*100%*	*10%*
College		100%	10%
Small Office	*5%*	*100%*	*10%*
Medium Office	*15%*	*100%*	*10%*
Medium Office/Lab	*20%*	*100%*	*10%*
Public Assembly	*5%*	*100%*	*10%*
Large School	*30%*	*100%*	*10%*
High Rise Apartment	*25%*	*100%*	*10%*
Hospital		100%	10%
Hotel/motel		100%	10%
Large offices		100%	10%
Medium Office	*50%*	*100%*	*10%*
Large Office	*50%*	*100%*	*10%*

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 50: Percent of Floorspace Impacted by Proposed Measure, by Building Type– "Measure ON Time-Switch" Measure

Building Type *Building sub-type*	**Composition of Building Type by Sub-types [1]**	**Percent of Square Footage Impacted [2]**	
		New Construction	**Existing Building Stock (Alterations) [3]**
Small office		3.4%	0.34%
Restaurant		0%	0%
Retail			
Stand-Alone Retail	*10%*	*0%*	*0%*
Large Retail	*75%*	*0%*	*0%*
Strip Mall	*5%*	*0%*	*0%*
Mixed-Use Retail	*10%*	*0%*	*0%*
Food		0%	0%
Non-refrigerated warehouse		0%	0%
Refrigerated warehouse		0%	0%
Schools			
Small school	*60%*	*2.5%*	*0.25%*
Large school	*40%*	*2.5%*	*0.25%*
College			
Small Office	*5%*	*0%*	*0%*
Medium Office	*15%*	*0%*	*0%*
Medium Office/Lab	*20%*	*0%*	*0%*
Public Assembly	*5%*	*0%*	*0%*
Large School	*30%*	*0%*	*0%*
High Rise Apartment	*25%*	*0%*	*0%*
Hospital		0%	0%
Hotel/motel		0%	0%
Large offices			
Medium Office	*50%*	*7.4%*	*0.74%*
Large Office	*50%*	*7.4%*	*0.74%*

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 51: Percent of Floorspace Impacted by Proposed Measure, by Climate Zone – "Occupant Sensing Controls in Restrooms" Measure

Climate Zone	Percent of Square Footage 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.

In statewide savings calculations for the "Daylight Dimming Plus OFF Controls" and "Manual ON Time-Switch" measures, adjusting impacted floorspace by climate zone was not needed.

Appendix B: Discussion of Impacts of Compliance Process on Market Actors

This section discusses how the recommended compliance process, which is described in Section 2.4.4.1, could impact various market actors. The Statewide CASE Team asked stakeholders for feedback on how the measure will impact various market actors during public Utility-Sponsored Stakeholder Meetings that were held on September 8, 2016 and March 22, 2017 (Statewide CASE Team 2016). The Statewide CASE Team also conducted a survey and informational interviews to gather information from stakeholders about how the proposed code change could impact market actors. The survey results can be found in Appendix C. The key results from feedback received during stakeholder meetings and other target outreach efforts are detailed below.

Table 52 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.

This code change proposal will primarily affect buildings that use the prescriptive or performance approach to compliance. The key step changes to the compliance process are summarized below:

- **Design Phase**: The proposed code changes would have minimal impact on the existing design phase process. Certificate of Compliance Forms, NRCC forms, would need minimal changes for the proposed measure. In general, as more lighting controls are required in the code, additional documentation and understanding of the code requirements is required by the designers.
- **Permit Application Phase**: The proposed code changes would have minimal impact to the existing permit application phase process. Additional time will be required to make sure design documents include these requirements properly.
- **Construction Phase**: The proposed code changes would have minimal impact to the existing permit construction phase process. Coordination and understanding of the controls (and the exceptions) that will affect the time and cost associated with the job. The Statewide CASE Team recommends the Compliance Manual include recommendations for the appropriate occupancy sensing technology to be installed in multiple occupant restrooms.
- **Inspection Phase**: The proposed code changes would have minimal impact to the existing inspection application phase process. The Statewide CASE Team is conducting interviews with stakeholders, such as Acceptance Test Technicians, to determine if the inspection time would increase for the proposed measures, especially in regards to requiring automatic daylight dimming plus OFF controls. The CASE Team suggests which current lighting inspection forms and tables will need to be updated in Section 7. Building inspectors and acceptance testers will need to be trained on the new control requirements as well as the field verification process through acceptance testing.
- **Commissioning Phase:** The Statewide CASE Team recommends this phase includes educating the building occupants about the daylight dimming controls to minimize issues and callbacks. In addition, an effort should be made to educate future occupants of the space who are not present during the initial education. Stakeholders have recommended that a simple instruction sheet or label near the lighting controls that describes the intent and function of the daylight dimming controls would minimize user frustration and minimize contractor call backs.

Table 52: 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 Designers	• They design the lighting and ensure it conforms to Title 24 requirements. • They are experts in lighting technology, both luminaires and controls. They are knowledgeable about energy efficiency. • Work Tasks: They design both indoor and outdoor lighting and ensure it complies with the code. They fill out Compliance Forms and ensure everything is working properly. They work with other team members to ensure the system performs to owner specifications/needs, such as the Commissioning Agent, installer and Acceptance Test Technician (ATT). • They work from their office but also need to collect data/info from the site.	• Their product is the lighting system design and to the complete design compliance forms. (New construction/ major renovations produce (a) specifications (b) plan sets (c) compliance forms (NRCC LTI and LTO forms). Retro-fits produce (a) a work order (b) compliance forms (NRCC-LTI and LTO forms). • They need to coordinate with manufacturers/dealers to know what products are available. They also coordinate with building owner to determine what their needs/wants are. • Coordinate with mechanical designers, architect, energy modeler, commissioning agent and plans examiner • The lighting system is successful if it is designed to the building owner's specific needs (technologically, economically, etc.) and it falls within compliance. • Compliance should fit within workflow and not create extra tasks, code &	• Clear code requirements. • Designation on products about whether or not they meet code requirements. • Simplify some aspects of work flow because of the alignment with ASHRAE 90.1.	• We recommend including the following in the Compliance Manual • Examples showing systems that are Title 24 compliant. • Examples showing systems that are not Title 24 compliant with explanations of why they are not. • 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
		forms should be clear and quick to use.		
Contractor/Builder	• They do not necessarily understand the code or need to – just follow the lighting design for new construction buildings. • They probably have a high level of technology expertise since they install/work with it. • They receive lighting designs and build the system in new construction buildings. • Their work is performed on-site.	• They are responsible for following what is in the design – if they do not, the system can end up out of compliance. They complete installation compliance forms. • They buy from retailers/ distributors and need to coordinate with the lighting designer/electrician. They also coordinate with the commissioning agent and ATT. They need to coordinate to ensure the design is followed and stays in compliance. They also need to buy the appropriate products. • Contractors want to quickly finish the job, pass Cx or Acceptance Test, pass inspection. They want a design that is clear and easy to understand so they can complete the work in the least amount of site visits.	• Minimal/ simple paperwork that asks them for info they know.	• Documents explaining who they can speak with for help on code compliance. • Documents showing exactly what their role in Title 24 compliance is/how to complete compliance tasks. • Code requirements clearly communicated within drawings/specs so it is included in bid.

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
Electrician	• They must understand the code at least on a basic level as they might be responsible for designing the lighting system. They might also play a similar role to contractor/builder and just follow lighting design. • They likely have a high level of technology expertise since they install/work with it. • They might design the lighting systems/build it or they might just receive lighting designs and build the system. • Their work is performed on-site or in their office.	• If designing the system, they are responsible for ensuring it follows the code. They would also be responsible for filling out design compliance forms. If they are only building the system, they are responsible for following what is in the design – if they do not, the system can end up out of compliance. They would complete installation compliance forms. • If designing the system, they will need to work with building owners and manufacturers to know what is on the market. If building the system, they buy from manufacturers and need to coordinate with the lighting designer/electrician/whoever designed the system. They need to coordinate to ensure the design is followed and stays in compliance. They also need to buy the appropriate products. • It is a success if they design the system to the owner's specs, and it is within compliance. If just building the system, it is a success if the system is built to the design and works properly	• Designation on products about whether or not they meet code requirements. • Minimal/ simple paperwork that asks them for info they know.	• Examples showing systems that are Title 24 compliant. • Examples showing systems that are not Title 24 compliant with explanations of why they are not. • 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. • Code requirements clearly communicated within drawings/specs so it is included in bid. • Clear code requirements

Appendix C: Stakeholder Survey Results for Indoor Controls Measures

The Statewide CASE Team conducted as survey in 2017 to receive stakeholder feedback on the proposed measures. The anonymized responses are shown below.

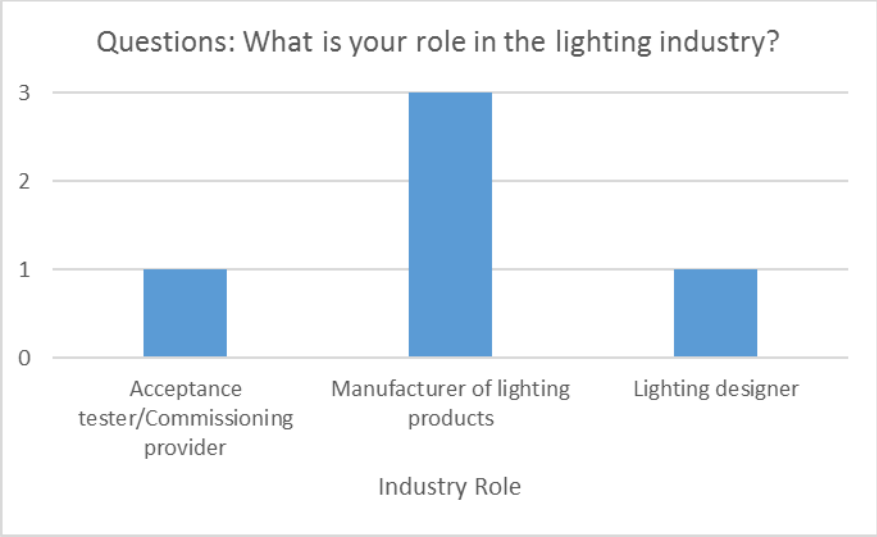

Figure 2: Stakeholder survey respondents' industry role

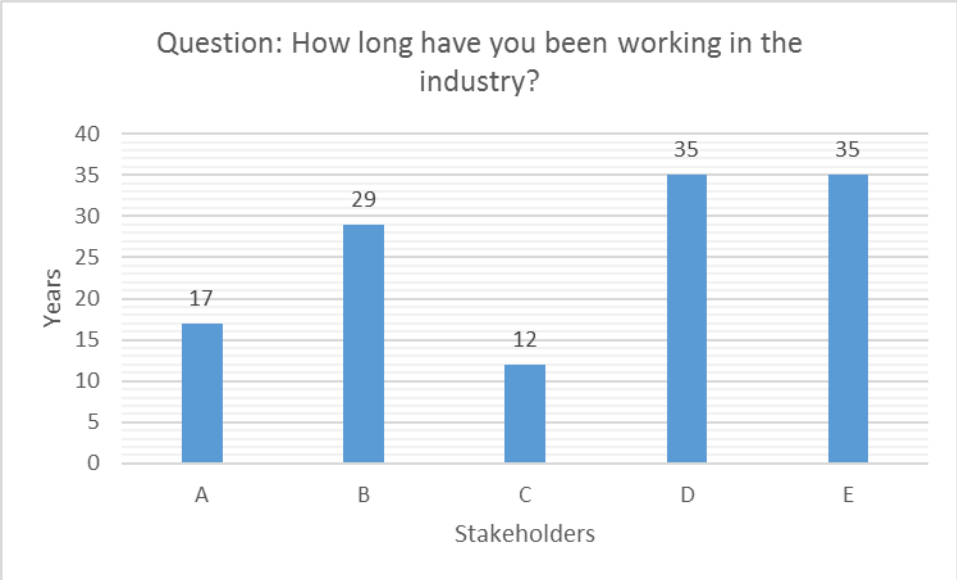

Figure 3: Stakeholder survey respondents' experience in lighting industry (as number of years)

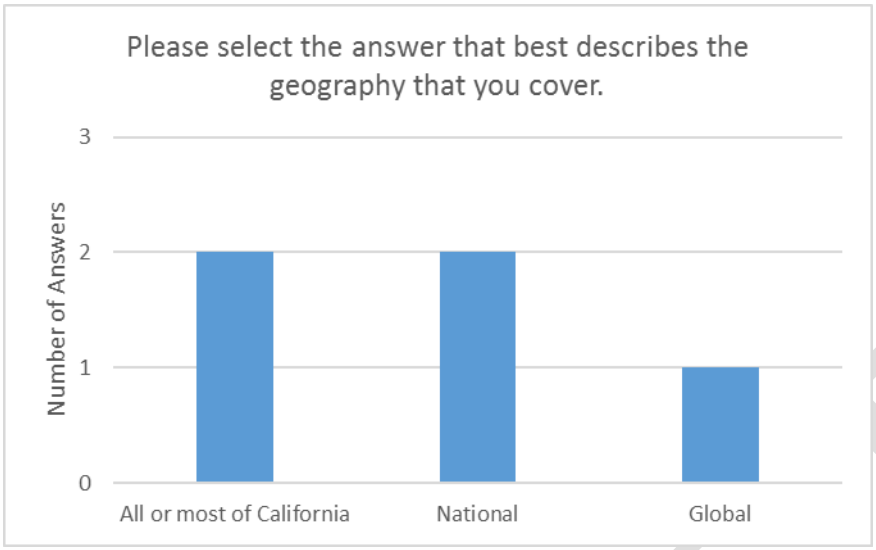

Figure 4: Stakeholder survey respondents' geography

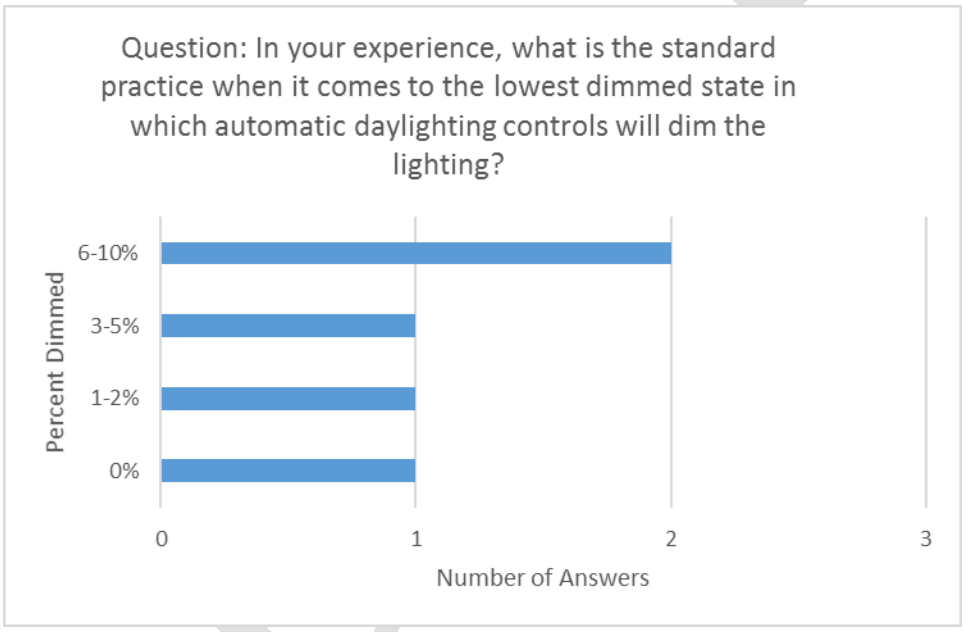

Figure 5: Standard practice for lowest dimmed state in which automatic daylighting controls dim the lighting

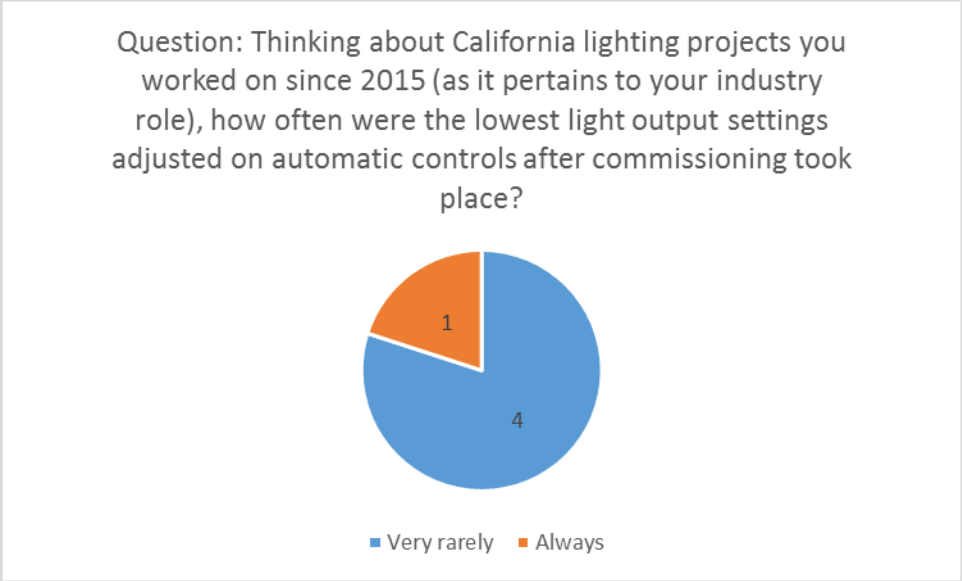

Figure 6: Frequency of adjusting automatic daylighting controls

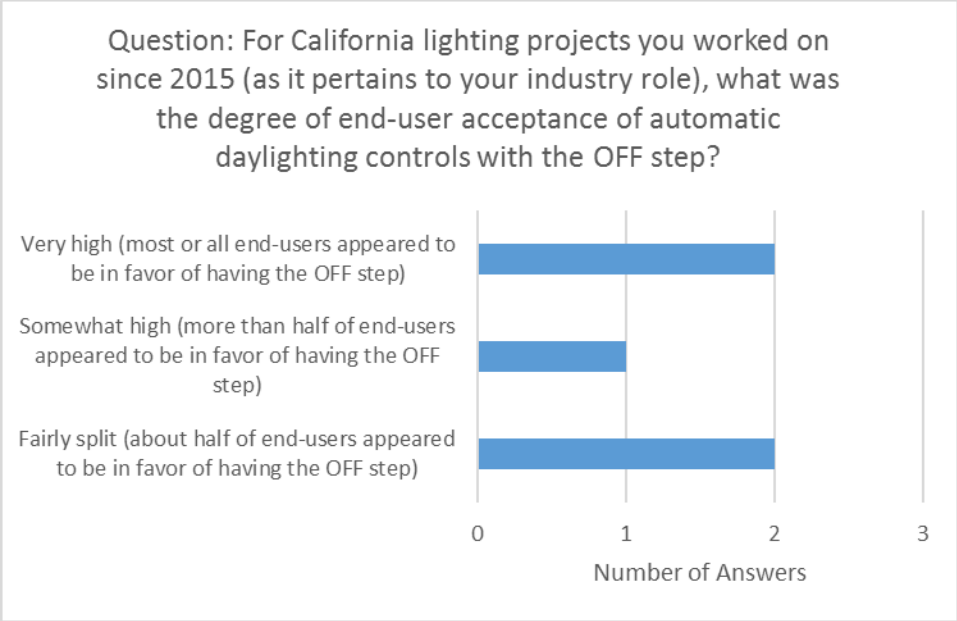

Figure 7: End-user acceptance of automatic daylighting controls with the OFF step

Table 53: Automatic Daylighting Controls with the OFF Step in Functional Areas and/or Building Types

Question: How appropriate are automatic daylighting controls with the OFF step for the following functional areas and/or building types?					
Building Type	**Response A**	**Response B**	**Response C**	**Response D**	**Response E**
Office	Somewhat appropriate	Somewhat appropriate	Somewhat appropriate	Appropriate	Not appropriate
Large retail	Appropriate	Appropriate	Not appropriate	Somewhat appropriate	Not appropriate
Warehouses	Appropriate	Appropriate	Appropriate	Appropriate	Somewhat appropriate
Common areas in hotels	Not appropriate	Appropriate	Somewhat appropriate	Appropriate	Not appropriate
Common areas in schools	Appropriate	Appropriate	Somewhat appropriate	Appropriate	Somewhat appropriate
Common areas in dorms	Appropriate	Appropriate	Somewhat appropriate	Appropriate	Somewhat appropriate
Common areas in high-rise multifamily	Somewhat appropriate	Appropriate	Somewhat appropriate	Appropriate	Somewhat appropriate

Table 54: Adjustments to Light Output Level

Question: For each adjustment type listed below, provide a percent estimate of the California lighting projects you worked on since 2015 (as it pertains to your industry role) that involved installation of automatic daylighting controls. The total percent should not add up to over 100%.				
	Response A	**Response B**	**Response C**	**Response D**
Projects that increase the initial lowest light output setting, %	0%	9%	5%	0%
Projects that further lower the lowest initial light output setting, %	5%	1%	5%	100%
Projects that do not require any adjustments to the lowest light output setting, %	95%	90%	90%	0%

Table 55: Acceptance Tests for Automatic Daylighting Controls

Question: Please briefly describe your thoughts on the following three topics as they pertain to Title 24, Part 6, NA7.6.1 Acceptance Tests for automatic daylighting controls.	
Response A	Duration of Acceptance Test: Six hours Challenges: • "Self-commissioning" systems that do not work.

	• Drive by testers that do not test the systems and make up numbers to get them to pass. Suggestion for improvement: • Statewide CASE Team should seek input from commissioning agents that are experts in testing lighting systems.
Response B	Challenges: • Timing to test for all daylight conditions, which may require multiple site visits to test conditions during the daytime, night time, and when the conditions provide the 60-95% daylight. Systems with auto-calibration can make the task more manageable. In an install and construction environment, doing precisely as NA outlines doesn't take long itself, but being able to be there or have the exact daylight to do the three tests is the challenge. Solution: • Verified auto-calibration routine as part of Title 20. • Experienced technician.
Response C	Recommendations: • Simplify the acceptance requirements. • Make sure there are no additional requirements added in the acceptance forms. • Explain how to do the testing when there are multiple daylight zones (primary and secondary).
Response D	Recommendations: • There are some spaces that daylight will never penetrate the space of into the secondary zone. The AT should describe and photograph the conditions when it is not possible, instead of adding light for the purpose of verification that the hardware works. Adding lighting or blocking out light just to pass the test is not effective.

Table 56: Occupant Sensing Lighting Controls in Restrooms by Building Types

Question: How appropriate are occupant-sensing lighting controls in restrooms located in the following nonresidential building types?

Building Type	Response A	Response B	Response C	Response D	Response E
Office buildings	Somewhat appropriate	Appropriate	Appropriate	Appropriate	Appropriate
Primary and secondary schools	Not appropriate	Appropriate	Appropriate	Appropriate	Appropriate
Common restrooms in hotels	Not appropriate	Appropriate	Appropriate	Appropriate	Appropriate
Universities (e.g., gym, library, cafeteria)	Not appropriate	Appropriate	Appropriate	Appropriate	Appropriate
Public libraries (non-	Not appropriate	Appropriate	Appropriate	Appropriate	Appropriate

government facilities)					
Sports complex (e.g., stadiums, fields)	Somewhat appropriate	Appropriate	Appropriate	Appropriate	Appropriate
Convention centers	Somewhat appropriate	Appropriate	Appropriate	Appropriate	Appropriate
Movie theaters	Not appropriate	Appropriate	Appropriate	Somewhat appropriate	Appropriate
Restaurants	Somewhat appropriate	Appropriate	Appropriate	Appropriate	Appropriate
Airports	Not appropriate	Appropriate	Appropriate	Appropriate	Appropriate

Table 57: Type of Controls Installed in Restrooms

Question: With respect to the California lighting projects you worked on since 2015 (as it pertains to your industry role), please provide a percent estimate for nonresidential restrooms with 1) occupant sensing controls, 2) automatic time-switch controls, and 3) manual area controls.

Building Type	Response A	Response B	Response C	Response E
Restrooms with occupant sensing controls	90%	85%	60%	100%
Restrooms with automatic time-switch controls	8%	5%	40%	0%
Restrooms without any lighting controls	4%	10%	0%	0%

Table 58: Commissioning Automatic Time-Switch Controls by Building Types

Question: How appropriate is commissioning automatic time-switch controls as manual ON for the following building types?					
Building Type	**Response A**	**Response B**	**Response C**	**Response D**	**Response E**
Auditorium buildings	Not appropriate	Appropriate	Not appropriate	Appropriate	Not appropriate
Convention center buildings	Not appropriate	Appropriate	Not appropriate	Appropriate	Not appropriate
Office buildings	Appropriate	Appropriate	Somewhat appropriate	Appropriate	Not appropriate
Schools	Appropriate	Appropriate	Somewhat appropriate	Appropriate	Not appropriate
Libraries	Not appropriate	Somewhat appropriate	Somewhat appropriate	Appropriate	Appropriate
Warehouses	Somewhat appropriate	Appropriate	Somewhat appropriate	Appropriate	Appropriate
Other	Storage closets	Gymnasiums, Multipurpose rooms, Malls, Arcades, and Retail store general lighting (non-display and sales oriented lighting)			

Table 59: Building Types Not Appropriate for Commissioning Automatic Time-Switch Controls

Question: Please list the nonresidential building types that are not appropriate for commissioning automatic time-switch control as manual ON that are not already listed above.	
Response A	Any space with a long distance to the switch.
Response B	Lobbies & primary entrances (ok, not a building type, but space types where auto-on makes sense), retail display and open hour sales lighting.
Response C	Spaces that do not have an "owner" are not appropriate; common spaces like lobbies are not appropriate.

Appendix D: Detailed Description of Building Prototypes Used for "Daylight Dimming Plus OFF" Measure

Building prototypes are managed by NORESCO, LLC. Six of the 18 available building prototypes were used across each of the 16 California climate zones. Six prototypes used for the "Daylight Dimming Plus OFF" measure include:

- Hotel Small
- Office Medium
- Office Small
- Retail Large
- School Small
- Warehouse

Table 60: Building Prototype Descriptions and Adjustments for "Daylight Dimming Plus OFF" Measure

Building Prototype	Description	Adjustments
Hotel Small	• Four-story hotel with 77 guest rooms. • WWR: 11%	LPDs were updated to the 2019 proposed LPD values in the affected areas. Laundry Area function area was changed from "Office greater than 250 square feet" to "Laundry". Lounge areas modified from "hotel function" to "Lounge area"
Office Medium	• 3-story office building with five zones • Ceiling plenum on each floor. • WWR: 0.33%	LPDs were updated to the 2019 proposed LPD values in the affected areas.
Office Small	• One-story office building with five zones • Pitched roof and unconditioned attic. • WWR: 0.24%	LPDs were updated to the 2019 proposed LPD values in the affected areas.
Retail Large	• Big-box type Retail building • WWR: 12% • SRR: 0.82%	LPDs were updated the 2019 proposed LPD values. It is important to note that the only sidelit areas considered in this building prototype were "entry ways," which are not subject to the proposed exemption and therefore modeled with the "Plus OFF" measure.
School Small	• Similar to an elementary school with classrooms, support spaces, and small dining area. • WWR: 0.36%	LPDs were updated to the 2019 proposed LPD values in the affected areas. Illuminance setpoint changed in "model 2" in Classroom areas to 125% illuminance (229 lux versus 275 lux)
Warehouse	• Single story high ceiling warehouse • Includes one office space. • WWR: 0.7% • SRR: 5%	LPDs were updated to the 2019 proposed LPD values in the affected areas.

Appendix E: Detailed Per-Unit Energy Impact Results

Table 61: First-Year Energy Impacts – Per Square Foot for Small Hotel Building Prototype

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	TDV Energy Savings (TDV kBtu/yr)
1	0.22	8.5×10^{-6}	4.54
2	0.22	8.3×10^{-6}	5.95
3	0.23	9.2×10^{-6}	5.62
4	0.21	7.8×10^{-6}	5.82
5	0.22	6.5×10^{-6}	5.13
6	0.25	6.9×10^{-6}	7.63
7	0.23	5.2×10^{-6}	7.05
8	0.24	5.7×10^{-6}	7.57
9	0.23	6.1×10^{-6}	7.09
10	0.22	5.5×10^{-6}	6.82
11	0.21	7.4×10^{-6}	6.05
12	0.21	7.8×10^{-6}	5.96
13	0.20	6.8×10^{-6}	5.56
14	0.21	4.9×10^{-6}	6.02
15	0.22	4.5×10^{-6}	7.18
16	0.20	7.2×10^{-6}	4.95

Table 62: First-Year Energy Impacts – Per Square Foot for Medium Office Building Prototype

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	TDV Energy Savings (TDV kBtu/yr)
1	0.21	1.6×10^{-5}	6.81
2	0.03	2.6×10^{-5}	9.36
3	0.22	1.4×10^{-5}	8.25
4	0.21	1.4×10^{-5}	9.27
5	0.20	1.1×10^{-5}	8.32
6	0.22	9.9×10^{-6}	10.28
7	0.21	7.9×10^{-6}	10.10
8	0.22	7.9×10^{-6}	10.88
9	0.24	1.1×10^{-5}	10.74
10	0.25	8.7×10^{-6}	10.27
11	0.24	1.7×10^{-5}	9.66
12	0.21	1.4×10^{-5}	9.42
13	0.21	1.2×10^{-5}	8.74
14	0.22	9.1×10^{-6}	9.98
15	0.22	8.3×10^{-6}	10.68
16	0.21	1.5×10^{-5}	7.74

Table 63: First-Year Energy Impacts – Per Square Foot for Small Office Building Prototype

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	TDV Energy Savings (TDV kBtu/yr)
1	0.18	1.2×10^{-5}	4.93
2	0.19	0	5.84
3	0.00	1.2×10^{-5}	0.00
4	0.19	9.3×10^{-6}	6.08
5	0.19	7.9×10^{-6}	5.51
6	0.20	7.0×10^{-6}	6.58
7	0.20	6.9×10^{-6}	6.34
8	0.20	8.2×10^{-6}	6.97
9	0.20	6.9×10^{-6}	6.97
10	0.20	1.1×10^{-5}	6.63
11	0.18	1.2×10^{-5}	5.82
12	0.19	9.8×10^{-6}	6.21
13	0.19	7.5×10^{-6}	5.76
14	0.18	6.7×10^{-6}	6.24
15	0.19	1.2×10^{-5}	6.72
16	0.18	0	4.63

Table 64: First-Year Energy Impacts – Per Square Foot for Large Retail Building Prototype

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	TDV Energy Savings (TDV kBtu/yr)
1	0.16	9.6×10^{-6}	3.52
2	0.15	9.0×10^{-6}	4.80
3	0.14	8.6×10^{-6}	3.71
4	0.12	9.3×10^{-6}	3.31
5	0.16	8.8×10^{-6}	4.20
6	0.21	7.0×10^{-6}	6.19
7	0.18	5.6×10^{-6}	5.98
8	0.19	6.0×10^{-6}	6.92
9	0.17	6.0×10^{-6}	5.61
10	0.15	5.1×10^{-6}	5.27
11	0.12	8.8×10^{-6}	4.46
12	0.15	1.1×10^{-5}	5.20
13	0.14	7.6×10^{-6}	4.68
14	0.13	5.1×10^{-6}	4.95
15	0.15	4.9×10^{-6}	6.90
16	0.11	8.5×10^{-6}	2.98

Table 65: First-Year Energy Impacts – Per Square Foot for Small School Building Prototype

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	TDV Energy Savings (TDV kBtu/yr)
1	0.06	1.5×10^{-5}	2.21
2	0.28	2.7×10^{-5}	1.99
3	0.69	5.4×10^{-5}	1.67
4	0.85	6.5×10^{-5}	1.99
5	0.19	1.8×10^{-5}	1.71
6	0.25	2.0×10^{-5}	1.49
7	0.31	2.0×10^{-5}	1.72
8	0.25	1.6×10^{-5}	1.61
9	0.00	0	0.00
10	0.26	1.5×10^{-5}	1.86
11	0.28	2.8×10^{-5}	2.78
12	0.27	2.8×10^{-5}	2.33
13	0.39	3.0×10^{-5}	1.99
14	0.27	1.7×10^{-5}	2.49
15	0.40	1.9×10^{-5}	2.50
16	0.29	3.0×10^{-5}	2.59

Table 66: First-Year Energy Impacts – Per Square Foot for Warehouse Building Prototype

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	TDV Energy Savings (TDV kBtu/yr)
1	0.12	7.7×10^{-6}	2.11
2	0.12	7.0×10^{-6}	2.70
3	0.12	7.0×10^{-6}	2.49
4	0.12	6.9×10^{-6}	2.79
5	0.12	6.1×10^{-6}	2.59
6	0.12	5.6×10^{-6}	3.06
7	0.12	4.2×10^{-6}	3.02
8	0.12	4.4×10^{-6}	3.26
9	0.12	5.5×10^{-6}	3.21
10	0.12	4.3×10^{-6}	3.04
11	0.12	6.8×10^{-6}	2.81
12	0.12	6.9×10^{-6}	2.84
13	0.12	6.4×10^{-6}	2.78
14	0.12	4.8×10^{-6}	3.08
15	0.12	4.3×10^{-6}	3.21
16	0.12	6.8×10^{-6}	2.41