Codes and Standards Enhancement (CASE) Initiative

2019 California Building Energy Efficiency Standards

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

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Nonresidential Lighting

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EXECUTIVE SUMMARY

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 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 improve energy efficiency and energy performance in California buildings. This report and the code change proposals presented herein are 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" 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. Among other items, the code language cleanup includes splitting and reordering partial OFF controls requirements to allow partial OFF controls in stairwells to be part of the requirements when undertaking a lighting alteration using the wattage reduction method. This measure is addressed in the 2019 Title 24, Part 6 Nonresidential Lighting Alterations CASE Report. The proposed splitting and re-ordering of the partial OFF control requirements is repeated in this CASE Report for consistency.

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 the 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 apply only 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 align with ASHRAE 90.1-2016 for new construction and lighting alterations.

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. The commissioning with a manual ON setting would be verified by Acceptance Test Technician Certification Providers (ATTCP) during acceptance testing, when applicable. This proposal would exempt automatic time-switch controls used in the following functional 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.

Scope of Code Change Proposal

Table 1 summarizes the scope of the proposed changes and which sections of the Standards, Reference Appendices, Alternative Calculation Method (ACM) Reference Manual, and compliance documents will need modification 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 Tests	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 Shut-OFF Controls Acceptance Tests	No	NRCC-LTI-02-E "Mandatory Declaration Statements"
Manual ON Time-Switch Controls	Mandatory	Section 130.1	NA7.6.2.4 Automatic Time Switch Lighting Control Construction Inspection	No	2016-NRCA-LTI-02-A Lighting Control Acceptance Document
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 for occupancy and daylighting controls is well established.

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

The proposed changes to Title 24, Part 6 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 B/C ratio for the "Daylight Dimming Plus OFF" measure is 9.0 for new construction and 5.7 for alterations. 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 2.0 for new construction and 1.8 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 statewide 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[a] 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 (Total)[b]	**18.7**	**0.90**	**N/A**	**N/A**
New Construction	8.9	0.43	N/A	N/A
Additions/Alterations	9.8	0.46	N/A	N/A
Occupant Sensing Controls in Restrooms (Total)	**9.7**	**3.4×10^{-3}**	**N/A**	**N/A**
New Construction	2.5	8.7×10^{-4}	N/A	N/A
Additions/Alterations	7.2	2.5×10^{-3}	N/A	N/A
Manual ON Time-Switch Controls (Total)	**1.5**	**3.5×10^{-11}**	**N/A**	**N/A**
New Construction	0.4	9.0×10^{-12}	N/A	N/A
Additions/Alterations	1.1	2.6×10^{-11}	N/A	N/A

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

b. 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 compliance and enforcement process and to identify the impacts that this process will have on various market actors. The compliance process is described in Section 2.5. The impacts that the proposed measure will have on various market actors are 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 Sections 2.5 and 7.3.
- Existing Occupancy Sensor Control Acceptance Test requirements and the 2016 Nonresidential Compliance Manual will need revision to recommend the appropriate occupancy sensor technology as it applies to different restroom configurations and restroom stalls.

Although a needs analysis was 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 implement the adopted code requirements effectively, a plan should be developed that identifies potential barriers to compliance when rolling-out the code change and suggests approaches that should be deployed to minimize these barriers.

1. 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 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 the 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 Standards.

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, 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 underlined (additions) language for the Standards, Reference Appendices, Alternative Calculation Method (ACM) Reference Manual, Compliance Manual, and compliance documents.

2. MEASURE DESCRIPTION

2.1 Measure Overview

This CASE Report proposes three mandatory measures as well as 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 American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard 90.1-2016.

Mandatory Automatic Daylight Dimming Plus OFF Controls

The "Daylight Dimming Plus OFF" measure proposes that the nonresidential automatic daylight dimming controls requirements 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. For new construction and alterations projects that use the prescriptive approach (versus the performance approach), the proposed daylight dimming plus OFF control step would be required for luminaires in Secondary Sidelit Daylit Zones. The proposed measure includes an exemption for classroom areas and Primary and Secondary Sidelit retail spaces. The existing exemption for Secondary Sidelit Daylit Zones where lighting power in total Secondary Sidelit Daylit Zones is less than 120 watts (W) would also 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:

- Daylight control exception based on lighting power: 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 W. ASHRAE 90.1-2016 exempts rooms if the lighting power is less than 150 W. The Statewide CASE Team recommends leaving the Title 24, Part 6 lighting power exemption in place for daylight controls as opposed to harmonizing with ASHRAE 90.1-2016. The cost of energy is higher in California and Title 24, Part 6 uses a lower discount rate than ASHRAE-90.1, which results in daylight controls being cost effective even in lower lighting power applications.
- Daylight control exception based on total glazing area: Title 24, Part 6 currently exempts rooms with a total glazing area of less than 24 square feet (ft^2). ASHRAE 90.1-2016 exempts sidelit

areas where the total glazing area is less than 20 ft^2. 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 Statewide CASE Team included savings estimates in Table 24, from an alternative code change proposal that would require lighting in the daylight zones to dim to five percent when the daylight illuminance in the daylit zone is greater than 150 percent of the design illuminance received from the general lighting system at full power. Section 4.3 quantifies the difference in savings per square foot between the Statewide CASE Team's proposed code change and the alternative proposal, which reduces the stringency of the proposed code change. The Stateside CASE Team explored this alternative proposal in response to stakeholder concerns about requiring the OFF step as well as in response to the Energy Commission. Stakeholders expressed that dimming to a lower level, but not all the way to OFF, would minimize user confusion, disabling the controls, and contractor call backs. Section 2.5 provides more detail on user acceptance issues and solutions.

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.

Mandatory Occupant Sensing Full OFF Controls in Nonresidential Restrooms

The "Occupant Sensing Controls in Restrooms" measure proposes that the mandatory occupant sensing full OFF controls in nonresidential restrooms to align with ASHRAE 90.1-2016 for new construction and lighting alterations. This measure would apply to all nonresidential restrooms.

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

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. The commissioning with a manual ON setting would be verified by Acceptance Test Technician Certification Providers (ATTCP) during acceptance testing, when applicable.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 an automatic ON setting after acceptance testing is 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 and increasing the minimum diming level in classrooms to harmonize with ASHRAE 90.1.

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 simplified significantly. Specifically, the 2013 CASE Report on nonresidential daylighting proposed a Watt Calculation Method to simplify the method 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 requirements for the access to the calibration adjustment controls 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 by authorized personnel so that adjustments to daylighting controls can be completed in response to changes in geometry or reflectance of the interior, changes in occupancy or tasks, or occupant requests for more or less light.

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 that one of the goals 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 included in ASHRAE 90.1 since the 2013 code cycle. No publicly available and well-documented evidence was identified by the Statewide CASE Team to indicate this measure would be rejected by occupants.

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 that "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 to have multi-level controls in rooms 100 ft^2 or larger, with a Lighting Power Density (LPD) greater than 0.5 watts per square foot (W/ft^2). This essentially requires a dimming driver or ballast. However, EXCEPTION 1 to Section 130.1(b) adds that "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. The code language states: "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."

The 2016 Title 24, Part 6 controls permitted for restrooms are as follows:

1. Section 130.1(a) Area Controls: Required, but manual control not accessible to unauthorized personnel is allowed for restrooms with two or more stalls.
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 ft^2 or larger;
    b. Restrooms with a connected lighting load that exceeds 0.5 W/ft^2;

    Additionally, restrooms with only one luminaire with no more than two lamps are exempt from the requirements of this section.
3. Section 130.1(c) Shut-OFF Controls: Options include:
    a. A countdown timer when the restroom is 70 ft^2 or smaller; or
    b. An occupancy sensor; or
    c. Automatic timeclock based control with a timed override switch (if the restroom has two or more stalls, this override must be inaccessible to unauthorized personnel).

[2] With assistance from Mudit Saxena, author of the 2019 Title 24 CASE Report on Advance Daylighting Design

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 starting with the 2008 code cycle. In the utility-sponsored stakeholder meeting held on September 8, 2016, the Statewide CASE Team received feedback from several manufacturers who suggested that automatic time-switch controls should be commissioned as manual 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 that nonresidential indoor lighting is turned ON when there are no occupants present in the space.

Stakeholders felt certain public function spaces should be exempt from the proposed code change and that the code should include the option to reprogram the switch to automatic ON after acceptance testing. The Statewide CASE Team included these suggestions in the proposed code language.

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

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 an OFF step in automatic daylight dimming controls to maximize savings from daylight harvesting and to be more aligned with ASHRAE 90.1-2016. 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 is selected to comply with other provisions of the Title 24, Part 6 code. The 2016 Standards require daylight controls to dim the affected lighting to 35 percent of rated power (or lower) when daylight illuminance is 150 percent design illuminance or greater. The Statewide CASE Team is proposing to require dimming to 35 percent or lower when daylight illuminance exceeds 125 percent design illuminance, and dimming to OFF when daylight illuminance exceeds 150 percent design illuminance. In response to stakeholder feedback, the proposed measure includes an exemption for classroom areas and Primary and Secondary Sidelit retail spaces.

Section 140.6(d), Table 140.6-A Lighting Power Adjustment Factors (PAF): The Statewide CASE Team proposes to revise the PAF for daylight dimming plus OFF controls to be applicable to areas that are proposed to be exempt in Section 130.1(d)2C.

2.3.1.1 Rationale for Proposed General Cleanup 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: Industry stakeholders expressed to the Statewide CASE Team that 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 list of the four applications where area controls can be overridden by automatic lighting controls 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 they have fewer full load hours than other space types. This report assumed that energy savings is approximately 15 percent due to institutional tuning of dimmable lighting to better match design illuminance.
    - 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 dimming light-emitting diode (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 0.70 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 requires *"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 ft^2. 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 ft^2 was selected to be 3,000 W. This was selected based on average 0.65 W/ft^2 whole building LPDs for the spaces served which yields 3,250 W, and this was rounded down to the closest increment of 1,000 W yielding a 3,000-watt maximum power per control.
- **EXCEPTION to Section 130.1(c)1C:**
    - The Statewide CASE Team proposes to modify the code language in this exception, which is applicable certain space types, to more clearly indicate the original intent of the code. 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 to mean that 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 ft^2 of lighting. The Statewide CASE Team 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>.*"
    - The Statewide CASE Team proposes to convert the maximum controlled area from 20,000 ft^2 to 15,000 W of controlled power. A majority of the exempted spaces have low lighting power densities that are around 0.65 W/ft^2. One exception is single tenant retail which has a whole building LPD of 0.85 W/ft^2. The Statewide CASE Team proposes the 15,000 W of controlled power because a 20,000 square foot building with 0.65 W/ft^2 has a total of 13,000 W and with 0.85 W/ft^2 has a total of 17,000 W.
    - 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 W (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 W. 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 manual 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 industry stakeholders who indicated that the manual ON control would reduce energy use without adding cost. In addition to the energy savings associated with delaying the ON time until the space is occupied, this control reduces energy use in situations such as when the occupancy rates are low due to a shift in workforce commuting patterns (i.e. telecommuting or hoteling), when holidays are not correctly programmed into the lighting control, or when a portion of a building is not occupied due to the space not being leased. **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 subsequent sections of 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 turning 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 clarify 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 industry stakeholders, the Statewide CASE Team added the term "manual ON" to better reflect the terms used by industry practitioners. Industry stakeholders suggested the term "vacancy sensor" should be removed so projects have the option of installing 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 being used in the lifecycle cost analysis for lighting certain applications, such as warehouses. The Statewide CASE Team concludes this is no longer necessary. As is shown in the Interior Lighting Sources CASE Report for the 2019 Standards, LED light sources

are more controllable, save energy, and have a lower lifecycle cost. In ASHRAE 90.1-2016, the sections designed to protect metal halide lighting from functional requirements that would otherwise apply were removed. Removing this exception aligns with the ASHRAE 90.1-2016 controls requirements and reflects the increasingly common use of LEDs.

- 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.
- The Statewide CASE Team added item B to separate a provision for corridors and stairwells in code language into two provisions, so requirements in the alteration code could simply reference a corresponding provision on occupant sensing controls for stairwells only. Note that 2016 Title 24, Part 6 lighting alteration code exempts stairwells and corridors from occupant sensing controls under one of the compliance options (Option 3). In the Nonresidential Indoor Lighting Alterations CASE Report, the CASE Team proposes to require partial OFF occupant sensing controls for stairwells under Option 3 (while continuing to exempt corridors from partial OFF occupant sensing controls under Option 3). The rational is as follows. The installation of occupant sensing controls in stairwells during a retrofit project is generally feasible, unlike the installation of occupant sensing controls in corridors. The luminaires in stairwells are often larger and can have occupancy sensors built into the luminaires. In addition, the wiring in stairwells is often exposed (so rewiring is less challenging). However, the luminaires in corridors are often smaller and lack the space for occupancy sensors. The wiring in corridors is often concealed in hard ceilings or walls (leading to higher lighting retrofit cost). For more details, see the Nonresidential Indoor Lighting Alterations CASE Report.
- Items A&B (Warehouses and Stairwells) are organized first so that these two items are called out as being required for retrofits with using compliance option 3. For more details, see the Nonresidential Indoor Lighting Alterations CASE Report.
- **In items B and C**, 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.*"

Section 130.1(c)7, Areas where Partial OFF Occupant Sensing Controls are Required:

- **Item B, Lighting in stairwells:** By adding item B, the Statewide CASE Team proposes to separate a provision for corridors and stairwells in code language into two provisions, so requirements in the alteration code could simply reference a corresponding provision on occupant sensing controls for stairwells only. Note that 2016 Title 24, Part 6 lighting alteration code exempts stairwells and corridors from occupant sensing controls under one of the compliance options (Option 3). In the Nonresidential Indoor Lighting Alterations CASE Report, the CASE Team proposes to require partial OFF occupant sensing controls for stairwells under Option 3 (while continuing to exempt corridors from partial OFF occupant sensing controls under Option 3). The rational is as follows. The installation of occupant sensing controls in stairwells during a retrofit project is generally feasible, unlike the installation of occupant sensing controls in corridors. The luminaires in stairwells are often larger and can have occupancy sensors built into the luminaires. In addition, the wiring in stairwells is often exposed (so rewiring is less challenging). However, the luminaires in corridors are often smaller and lack the space for occupancy sensors. The wiring in corridors is often concealed in hard ceilings or

walls (leading to higher lighting retrofit cost). For more details, see the Nonresidential Indoor Lighting Alterations CASE Report.

- **Item C. 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)7C** for controls that reduce power by 40 percent if they are less than 80 percent of area category LPD. An additional ten percent savings is obtained by not maintain the exception for HID luminaires that allowed for the reduction in 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. This is aligned with the requirements in Section 130.1(b).
    - 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 other part of the path of egress is occupied.

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 8:00 AM to 4:00 PM. 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" only refers to a surface 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 subtracted 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).
- Refer to the 2019 Title 24, Part 6 Advanced Daylighting Design CASE Report for more information.

Section 130.1(d)2: Daylighting Controls:

- 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 overlooking the language in Section 130.1(d)2 that indicates this section only applies to general lighting. 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 reduce the requirement at which the lights dim to 35 percent of rated power when the daylight illuminance level in the daylit zone is 125 percent of design illuminance. The current requirement to dim the lights is set at 150 percent of design illuminance. The proposed change would require lights being turned OFF when daylight illuminance exceeds 150 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 ten 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 at the edge of the daylit zone furthest from the window.
- **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 of this report.
- **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 comments received from stakeholders about an ambiguity in the code with respect to the sequence of operation when multiple controls are installed that control the same lighting system. This section is also in response to questions about whether a designer can install controls that override the automatic controls.

Prior to the 2008 Title 24, Part 6 Standards, the standards only specified the equipment characteristics and the control capabilities. Prior to the 2008 Standards, the controls were required to be "*capable* of reducing power…" Since the 2008 code cycle, acceptance tests were added specifying how devices are required to behave at time of inspection, 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." Stakeholders have expressed confusion about whether the standards prohibit occupants from changing the functioning of controls during building operation. Occupants can change the functioning of the controls during building operation, as long as 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.

The Statewide CASE Team's proposal is to clarify that no control is allowed to override the controls required by the standards in a manner that increases 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 either timed or respond to occupancy, so 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 if they *reduce* 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 proposes that this capability would 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 "*the space has been vacated and re-occupied regardless of prior operation of area controls.*" 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 sections specify spaces that 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
- NA7.6.2.4 Automatic Time Switch Lighting Control Construction Inspection
- 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 Document Change Summary

The proposed code change will modify the compliance document listed below. Examples of the revised documents are presented in Section 7.5.

- 2016-NRCA-LTI-02-A Lighting Control Acceptance Document
- 2016-NRCA-LTI-03-A Automatic Daylighting Control Acceptance Document
- 2016-NRCC-LTI-01-E Certificate of Compliance
- 2016-NRCC-LTI-02-E Certificate of Compliance
- 2016-NRCA-LTI-02-A Lighting Control Acceptance Document
- 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 controlled with manual ON and OFF lighting controls."[4] 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

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

> "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."[5]

The 2013 CALGreen included the following 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."[6]

However, the 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.

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

[4] 2016 Building Energy Efficiency Standards for Residential and Nonresidential Buildings, California Energy Commission. Section 130.1(d)1 (2017).

[5] 2016 California Green Building Standards Code, Part 11, California Energy Commission. Appendix A5 (2017).

[6] 2016 California Green Building Standards Code, Part 11, California Energy Commission. Appendix A5 (2017).

In addition, 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 required 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, the wattage threshold was updated 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 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 ft^2, 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 for sidelighting.

Mandatory Occupant Sensing Full OFF Controls in Nonresidential Restrooms

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

The automatic full OFF controls requirement in ASHRAE 90.1-2016 Section 9.4.1.1[h] specifies that "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."[7] Table 3 shows the minimum control requirements for restrooms established in ASHRAE 90.1-2016.

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

Manual ON Commissioning for Automatic Time-Switch Controls

Per 2016 ASHRAE 90.1, Table 9.6.1, all space types are required to restrict lighting control 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 shall 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."

2.4.4.2 International Energy Conservation Code (IECC) 2015

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, Section C405.2.1 Item 7, requires the use of a 50 percent ON occupancy sensor or manual ON vacancy sensor in all restrooms.

2.5 Compliance and Enforcement

The Statewide CASE Team collected input during the stakeholder outreach process on what compliance and enforcement issues may be associated with these measures. 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 approaches 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 Documents and NRCC documents 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 each job. The Statewide CASE Team recommends that 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 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. 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 consensus view expressed was the proposed code change would not increase the time or cost to complete the Automatic Daylighting Control Acceptance Test due to the proposed code change.

The Statewide 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 online survey are included in Appendix C.

As part of commissioning process of lighting controls, the Statewide CASE Team recommends to educate 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 suggested 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 contractor call backs. The Statewide CASE Team also recognizes the importance of educating building occupants about Manual ON time-switch controls if occupants are 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 any new occupant orientation communications.

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 as well as ways 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, the California Building Energy Code Compliance for Nonresidential Buildings software (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 as measured in thousands of British Thermal Units per square foot ($kBtu/ft^2$) 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 most difficult to adopt in office buildings and other areas where users expect to have more control over their electric lighting. However, one Certified Lighting Controls Acceptance Provider noted that it could be appropriate to deploy daylight dimming plus OFF controls in offices, provided that 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 lowering 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 noticeable flicker when dimmed to very low levels.

The Statewide CASE Team conducted a survey to determine the current practices and end-user acceptance of daylight dimming controls. Figure 1 illustrates the response to a question about end-user acceptance, in which 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. Refer to Appendix C for more details on stakeholder outreach.

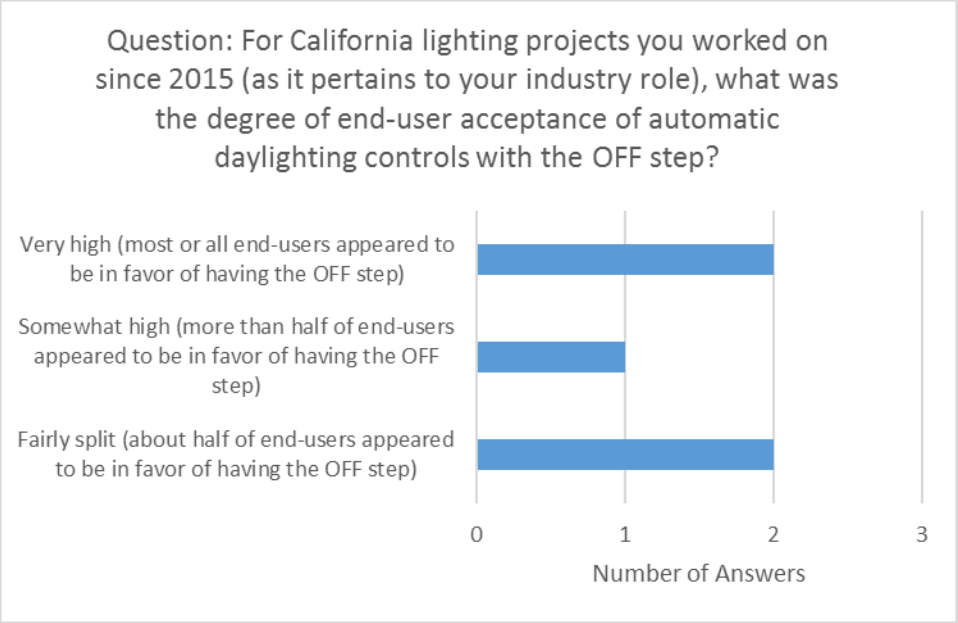

Figure 1: End-user acceptance of automatic daylighting controls with the OFF step.

The Statewide CASE Team interviewed several Acceptance Test Technicians, and the consensus view expressed was the proposed code change would not increase the time or cost to complete the Automatic Daylighting Control Acceptance Test due to the proposed code change. However, several interviewed stakeholders expressed frustration about existing Automatic Daylighting Control Acceptance Test requirements. The Statewide CASE Team will work with the Utility Compliance Improvement Team to incorporate stakeholder feedback when updating the Acceptance Test requirements. Table 4 summarizes the stakeholder feedback gathered regarding Title 24, Part 6, NA7.6.1 Acceptance Tests for automatic daylighting controls.

Table 4: 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 percent 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 secondary zone. The ATT should describe and photograph the conditions when it is not possible, instead of adding light to verify that the hardware works. Adding lighting or blocking out light just to pass the test is not effective.

Mandatory Occupant Sensing Full OFF Controls in Nonresidential Restrooms

The Statewide CASE Team does not foresee any challenges regarding the feasibility of compliance with and enforcement of 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 regarding the feasibility of compliance with and enforcement of 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, and 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 stakeholders 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 for wired and wireless photocontrols, occupancy controls, and automatic time-switches is well established in the United States (U.S.). Table 5 summarizes the market actors in the commercial lighting distribution chain.

Table 5: 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 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 distribution. Furthermore, both independent and in-house manufacturer representatives act as brokers for deals, thus playing an important role in the distribution chain (Bonneville Power Authority 2015). Table 6 summarizes the key points about each distribution channel.

Table 6: 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, which enables easier integration of lighting controls and provides opportunities to provide non-lighting related features as part of a lighting system, 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, WattStopper, Lutron, Organic Response, OSRAM Encelium, Philips Lighting Controls, PLC-Multipoint, Inc., Schneider Electric, and Sensor Switch, Inc.

Many of these large companies along with emerging 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). NLPIP's outreach to 152 lighting specifiers not associated with a particular manufacturer concluded that the most frequently selected brands of wireless lighting controls are Leviton, Lutron, and 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 present 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 present in 15 percent of the U.S. buildings, which account for 41 percent of total floor area (U.S. Energy Information Administration 2016).

In a 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. This study estimates that the 2015 installed lighting stock[8] penetration of lighting controls in the 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).

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

The 2014 California Commercial Saturation (CSS) survey by Itron prepared for the California Public Utilities Commission collected "information on the distribution of interior lamps by control type and the business's participation in IOU EE lighting, EE lighting control, and DR registration" (Itron, Inc. 2014). The study found that "participants have a statistically significant smaller share of their lamps manually controlled than non-participants and a higher share of their lamps controlled by EMS, occupancy sensors, motion sensors, and photocells and time clocks than non-participants" (Itron, Inc. 2014).

Table 7: Distribution of Indoor Lamps by Control Type and EE/DR Participation

Control Type	Non-Participants	EE Lighting Participants	EE Lighting Control Participants	DR Participants
Daylighting & Other	0.1%	1.4%	2.9%	2.1%

Source: California Commercial Saturation, Iron.

Although the 2012 CBECS, 2016 DOE study, and the 2014 CSS survey 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 reveal 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 harvesting systems which include dimmable fixtures and controls. Wireless and wired as well as stand-alone and luminaire level daylighting controls are widely available from multiple distribution channels. According to staff interviewed at Acuity Brands, Lutron, CJS Lighting, Performance Lighting Systems and one Certified Lighting Controls Acceptance Test Provider, most daylight controls and integrated fixtures with daylight controls have the option to be configured to dim to OFF.

Technology used to dim to OFF is not proprietary, so the market is capable of increasing 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 are categorized in three types as summarized in Table 8. Table 9 summarizes common dimming strategies.

Table 8: 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

Table 9: Types of Dimming Control Strategies

Type of Photocontrol	Description
0-10 VDC	Analog controller adjusts the voltage from 0-10 volts (V) 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 ten 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 one 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 0-10VDC and DALI due to these controls' ability to dim fluorescent and LED luminaires without major flicker issues. In order to dim from the lowest setting to OFF, a control relay is employed. The controls method used most frequently for daylight dimming control is 0-10VDC, for which the average time delay is two to six minutes of continuous light.

The three configuration methods for daylight dimming control systems are open-loop, closed-loop, and hybrid systems employing both open and closed-loop system concepts.

- Open-loop systems orient the photosensor to sense daylight only, and adjust the electric light accordingly. An open-loop system will respond only to changes in daylight and may not accurately respond to actual light levels in the interior space.
- Closed-loop systems orient the photosensor to sense 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.

While the Statewide CASE Team did not locate sources to confirm the rate at which daylighting controls with OFF step are deployed in California, two large retail chains – Wal-Mart and COSTCO – specify daylighting controls with OFF step in their stores as a standard practice. Wal-Mart and COSTCO luminaires turn OFF when the daylight illuminance exceeds the design illuminance. COSTCO stores began integrating daylighting controls and skylights in the late 1980s. Wal-Mart 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 have been included in the mandatory measures in ASHRAE 90.1 since the 2013 code cycle.

The Statewide CASE Team conducted a survey to determine the market availability and current practices for daylight dimming controls, as well as to gather feedback on end-user acceptance of automatic daylighting controls with the OFF step. The complete results can be found in Appendix C. The standard practice for the lowest dimmed state in which automatic daylighting controls dim the electric lighting is shown in Figure 8. Figure 9 shows that the lowest light output levels for automatic daylighting controls are rarely adjusted after commissioning.

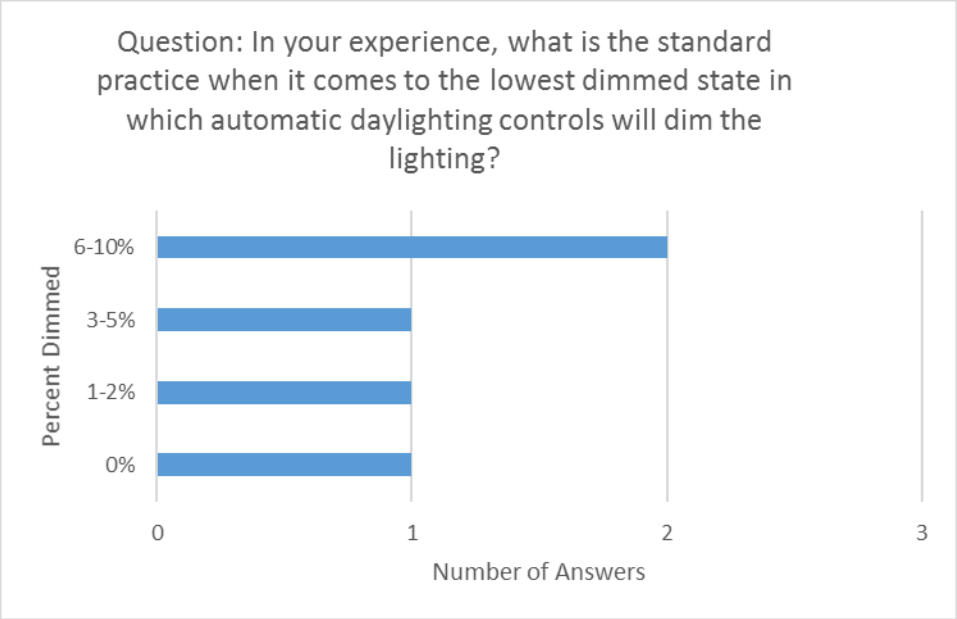

Figure 2: Standard practice for lowest dimmed state in which automatic daylighting controls dim the lighting.

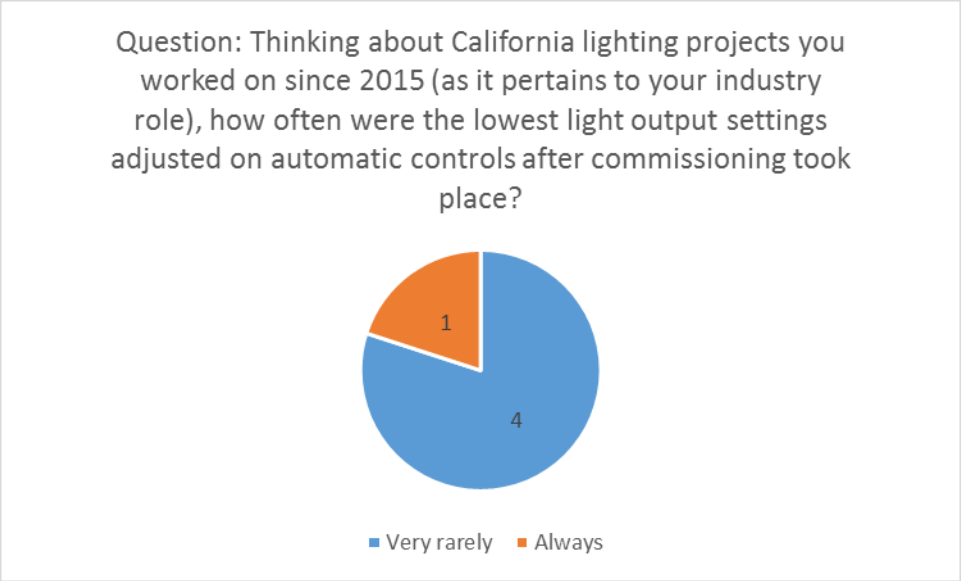

Figure 3: Frequency of adjusting automatic daylighting controls.

A report by Green Light New York states that "surveys have repeatedly found that most building occupants are dissatisfied with the lighting when it goes on and off regularly while they are in the space" and concludes that continuously dimming ballasts are needed "to ensure long term functionality" and avoid the controls being disabled (Green Light New York 2012). 2016 Title 24, Part 6 Section 130.1 Table 130.1-A requires continuous dimming for LED luminaires from ten to 100 percent and stepped dimming or continuous dimming for linear fluorescent fixtures. In addition, Title 24, Part 6 requires the general lighting power in the daylight zone to be reduced by a minimum of 65 percent "when the daylight illuminance is greater than 150 percent of the design illuminance received from the general lighting system" (2016 Title 24, Part 6).

Lawrence Berkeley National Laboratory's (LBNL) report, "Integrated Daylighting Systems," suggests that "when implementing a control protocol that switches lights off completely, lights should be dimmed to minimum setting and remain at this minimum continuously for a period of time (i.e. 5 mins) to ensure that lights are not turning on and off in response to unstable ambient light conditions (such as a cloudy sky)" (Robinson, Custodio and Selkowitz 2014).

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. The post-occupancy study performed 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" (LBNL 2013).

<u>Mandatory Occupant Sensing Full OFF Controls in Nonresidential Restrooms</u>

The Statewide CASE Team conducted a literature review and 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 10 summarizes the main available technology options for occupancy sensors, and a more detailed description of each technology type follows.

Table 10: 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 Technology	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 needs a direct line of sight and cannot see around objects.

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

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).

A technical feasibility study conducted by NLPIP in 2014 found that since "ultrasound detection requires more power than PIR detection," there is limited market availability of wireless ultrasonic and dual technology occupancy sensors (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).

In cases where a stall may not be covered by a sensor, one manufacturer recommends programming occupancy sensors 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, the 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 gathered 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, such a setting is not proprietary technology and may be a default setting. For example, in discussions with 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 technology appropriate for compliance 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 or demand response). The controls are often complex and better suited for larger applications, but may use proprietary software that makes 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 11 lists the relevant pricing of time-switch pathways.

Table 11: 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	• $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 90.1) are typically updated on 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 adjust design practices for 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 how 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 existing 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 are 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 Division of Occupational Safety and Health. 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. The Statewide CASE Team does not expect the proposed code change for the 2019 code cycle to impact building owners or occupants adversely.

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, describing the intent and function of the daylight dimming controls, would minimize user confusion and minimize contractor call backs.

LBNL and CBE, both 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" (LBNL 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 the 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 a minimal impact on 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 a 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 spent 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 overall statewide employment grew three percent (BW Research Partnership 2016). LBNL's report titled *Energy Efficiency Services Sector: Workforce Size and Expectations for Growth* (2010) provides details 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*.[9] Title 24, Part 6 creates jobs in all three categories with a significant quantity of these attributed to 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 from energy efficiency measures. Wei, Patadia, and Kammen (2010) estimate that energy efficiency creates 0.17 to 0.59 net job-years[10] per GWh saved. 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

[9] 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."

[10] One job-year (or ''full-time equivalent'' FTE job) is full time employment for one person for a duration of 1 year.

result in a statewide first-year savings of 29.9 GWh, this measure will result in approximately 11.4 jobs created in the first year. See Section 6 for statewide savings estimates.

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 are already required in most projects; 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 in California

Approximately 43,000 businesses 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 sustain the energy efficiency industry.

Table 12 lists industries that will likely benefit from the proposed code change classified by their North American Industry Classification System (NAICS) Code.

The proposed measures 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 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 alterations too expensive or burdensome, or to cause a reduction in retrofits.

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.

Table 12: Industries Receiving Energy Efficiency Related Investment, by North American Industry Classification System (NAICS) Code

Industry	NAICS Code
Nonresidential Building Construction	2362
Electrical Contractors	23821
Manufacturing	32412
Other Nonmetallic Mineral Product Manufacturing	3279
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
Corporate, Subsidiary, and Regional Managing Offices	551114
Office Administrative Services	5611
Commercial & Industrial Machinery & Equipment (except Automotive & Electronic) Repair & Maintenance	811310

3.4.3 Competitive Advantages or Disadvantages for Businesses in California

In 2014, California's statewide electricity 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). By 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 compared

to businesses located elsewhere. Money saved on energy costs can be otherwise invested, which provides California businesses with an advantage that will only be strengthened by the adoption of the proposed code 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. 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 likely increase construction costs, but there is no statistical evidence that the increased construction cost associated with Title 24, Part 6 compliance impacts building purchase prices.

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). 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.

3.4.6 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 that construction costs are not well correlated with building prices, the proposed code changes are not expected to have an impact on financing costs for business.

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 net savings depending on if and how landlords account for energy costs when determining rent prices.

4. ENERGY SAVINGS

4.1 Key Assumptions for Energy Savings Analysis

Mandatory Automatic Daylight Dimming Plus OFF Controls

Table 13 summarizes the key assumptions used in energy savings analysis for "Daylight Dimming Plus OFF" measure.

Table 13: Key Assumptions Used in Energy Savings Analysis – "Daylight Dimming Plus OFF" Measure

Assumption	Value	Source/Notes
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
Renovation rate of lighting fixtures in existing building stock (as percent of entire existing building stock per year)	6.67%	The Revised Impact Analysis for the 2016 Update to the California Energy Efficiency Standards for Residential and Nonresidential Buildings assumed lighting systems are replaced every 15 years (NORESCO 2016).
Percent of alterations subject to the "85-100% LPD allowance" compliance option that would require automatic daylighting controls	37%	Statewide CASE Team's survey on lighting alterations. Refer to 2019 Title 24, Part 6 CASE Report on nonresidential lighting alterations for more information.
Final percent of entire existing building stock subject to the "Daylight Dimming Plus OFF" measure per year	2.46%	Calculated value (37% of 6.67% = 2.46%)
Present Value Adjustment Factor TDV Electric Nonresidential (15 year)	0.089	Energy Commission (Energy + Environmental Economics 2016)

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 was greater than 150 percent of the design illuminance. Refer to Appendix C

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. The same baseline was used for both new construction and alterations.

For statewide energy savings, the Statewide CASE Team assumed that the renovation rate of lighting fixtures in existing building stock is 6.67 percent. This estimate is from the Revised Impact Analysis for the 2016 Update to the California Energy Efficiency Standards for Residential and Nonresidential Buildings which assumed lighting systems are replaced every 15 years (NORESCO 2016).

Nonresidential lighting alteration code (2016 Title 24, Part 6, Section 141.0 I and J) offers three options to comply with the prescriptive alteration code. Only one of the three available prescriptive compliance pathways, referred to as "85-100% of LPD allowance" in this report, requires automatic daylighting controls. According to the alteration survey conducted by the Statewide CASE Team in 2017, 37 percent of lighting retrofit projects use the "85-100% of LPD allowance" option to comply with the alteration code (refer to the 2019 CASE Report on nonresidential lighting alterations). Consequently, the assumed annual renovation rate for projects installing daylight controls is 2.46 percent (37 percent of 6.67 percent = 2.46 percent).

The Statewide CASE Team used CBECC-Com to calculate the per unit energy savings. For each porotype building that was included in the analysis, the following Standard Design assumptions were used in all calculations: annual operating hours, affected square footage, and the ratio of Skylit, Primary, and Sidelit Daylit Zones. The proposed 2019 Title 24, Part 6 maximum allowable indoor LPD levels, which are presented in Table 14, were used for both the baseline and proposed cases. The proposed LPD requirements are presented in the 2019 CASE Report for nonresidential lighting indoor light sources. See Section 4.2 for additional information about how CBECC-com was used to complete the energy savings analysis. Additional assumptions about the baseline and proposed cases are presented in Table 15.

Table 14: Title 24, Part 6 Lighting Power Density Levels Used in Building Prototypes

Area Category	2016 LPD	Proposed 2019 LPD
Auditorium Area	1.4	0.70
Classroom, Lecture, Training, Vocational Areas	1.2	0.70
Commercial and Industrial Storage Areas (conditioned and unconditioned) – Warehouse	0.6	0.45
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	0.40
Exercise Center, Gymnasium Areas	1.0	0.50
Lounge, Breakroom, or Waiting	0.9	0.65
Kitchen	1.2	0.95
Library, Reading Area	1.1	0.80
Main Entry Lobby	0.95	0.85
Office - > 250 ft^2	0.75	0.65
Office - ≤ 250 ft^2	1.0	0.70
Retail Merchandise Sales, Wholesale Showroom Areas	1.2	0.95

Table 15: Baseline and Proposed Conditions for "Daylight Dimming Plus OFF" Measure

Baseline Conditions	Proposed Conditions
• For automatic daylighting controls: continuous dimming to 20 percent of full power when daylight illuminance is at 150 percent of design illuminance (including classroom areas of school building type)[a] • Proposed maximum 2019 Title 24, Part 6 LPD levels • Compliant with 2016 Title 24, Part 6 Standards	• For automatic daylighting controls in classroom spaces of school building type: continuous dimming to 20 percent of full power when daylight illuminance is at 125 percent 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 percent of full power to OFF when daylight illuminance is at 150 percent of design illuminance

a. 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. Additionally, the default in CBECC-Com is 20 percent of controlled lighting power and output. 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.

b. The default LPDs in CBECC-Com are the maximum allowable LPDs for the 2016 Standards. These values were updated to the proposed maximum 2019 LPDs.

Mandatory Occupant Sensing Full OFF Controls in Nonresidential Restrooms

Table 16 and Table 17 below summarize key assumptions used in the spreadsheet-based analysis for the "Occupant Sensing Controls in Restrooms" measure.

Table 16: 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)	6.67%	The Revised Impact Analysis for the 2016 Update to the California Energy Efficiency Standards for Residential and Nonresidential Buildings assumed lighting systems are replaced every 15 years (NORESCO 2016).
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 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 DEER 2014 lighting profiles. DEER 2014 lighting profiles have not changed since 2005. • DEER 2016 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 DEER 2014 to DEER 2016 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 were 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[a]	0.65 W/ft^2	Proposed 2019 Title 24, Part 6 Indoor Lighting Power Densities

a. 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 17: California DEER 2016 Hours of Operation for Restrooms by Building Type[a]

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

a. 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 18. The fraction of the total building area for each area category was determined using DEER 2016 building prototypes. The percentages of total new construction and alterations affected by the proposed measure were thirty and three percent, respectively. These assumptions are summarized in Table 19 and shown in more detail in Table 60.

Table 18: Fraction of Total Building Area for Spaces Affected by "Manual ON Time-Switch" Measure

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

Table 19: Key Assumptions for "Manual ON Time-Switch" Measure

Assumption	Value	Source/Notes
Renovation rate of lighting fixtures in existing building stock	6.67%	The Revised Impact Analysis for the 2016 Update to the California Energy Efficiency Standards for Residential and Nonresidential Buildings assumed lighting systems are replaced every 15 years (NORESCO 2016).
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 it is assumed that existing building conditions comply 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 than 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. Two simulations for each building type were performed: one without the OFF step (baseline conditions) and another with the OFF

step (proposed conditions). Table 15 summarizes key assumptions for the baseline and 2019 Standards conditions.

The Statewide CASE Team used the following prototype building to complete the analysis:

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

The Energy Commission provided the prototype buildings that were used for the analysis. Table 20 presents relevant details for each prototype buildings used in the analysis.

The Statewide CASE Team used CBECC-Com to calculate energy use from the baseline and proposed conditions for each building prototype in each of the 16 California climate zones. With this information, the Statewide CASE Team calculated energy savings per prototype building in each climate zone.

Next, the Statewide CASE Team used characteristics about the daylit area in the building prototype to determine energy savings per square foot of floorspace that will be impacted by the proposed code change. That is, the per-unit savings presented in this report represent the savings per square foot of daylit area. Table 21 presents the total area of Skylit, Primary Sidelit, and Secondary Sidelit Daylit Zones within each building prototype – information that was used to calculate savings per square foot of daylit area. The Sidelit retail areas in the Large Retail prototype is not available, so all Sidelit areas (Side Entry and Main Entry) were modeled with the OFF step in the per-square-foot and statewide savings analyses.

Finally, the Statewide CASE Team used the statewide new construction and alterations forecast to move from per-unit savings by climate zone to calculate the construction-weighted average per-unit energy savings. The statewide construction forecast provides estimated square footage of new construction and alterations by climate zone. See Appendix A for additional details on the statewide construction forecast.

As discussed in Section 2.1, the Energy Commission requested that the Statewide CASE Team evaluate the energy impacts of an alternative proposal (dimming to five percent) as a comparison to the proposed measure (of dimming to OFF). In response to this request, the Statewide CASE Team evaluated energy savings from three of the seven prototype buildings (large offices, large retail, and non-refrigerated warehouses). Savings were only calculated for Climate Zone 3. Savings do not vary significantly by climate zone, but Climate Zone 3 represents savings that are slightly lower than the average savings for all climate zones. CBECC-Com does not have the functionality to calculate energy impacts associated with dimming to five percent, but EnergyPlus does provide this functionality. The Statewide CASE Team imported the CBECC-Com files (with all modeling assumptions intact) into EnergyPlus version 8.7.0 and adjusted the dimming level to five percent. The Daylight Dimming factor for the alternate proposal used twenty percent as the baseline dimming percentage and five percent as the proposed lowest dimming setpoint. The Statewide CASE Team used the hourly energy impacts information from EnergyPlus and the 2019 TDV factors to calculate TDV kBtu savings and peak demand reductions.

Table 20: 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	Front Lounge, Offices and Meeting Rooms	42,554	4	14.4
Medium Office	Perimeter Zones	53,628	3	17.0
Small Office	Perimeter Zones	5,502	1	2.0
Large Office	Perimeter Zones	498,589	12	17.0
Large Retail	All Daylit Zones	240,000	1	74.4
Small School	Lobby, Corridor, Cafeteria	24,413	1	1.85
Large School	Lobbies, Auditorium, Library/Media Center, Gyms, Restrooms, and Offices	45,186	2	25.9
Non-Refrigerated Warehouse	All Daylit Zones	49,495	1	5.73

Table 21: 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)	Percent of Affected Daylit Zones of Total Building Area	Total Affected Area of Daylit Zones by Mandatory Measure (ft^2)
Hotel	Front Lounge, Offices and Meeting Rooms	0	2,023	2,023	4.8%	2,023
Medium Office	Perimeter Zones	0	11,784	10,074	22.0%	11,784
Small Office	Perimeter Zones	0	2,022	1,520	34.8%	2,022
Large Office	Perimeter Zones	0	24,706	19,660	5.0%	24,706
Large Retail	All Daylit Zones	167,928	4,621	2,176	71.9%	172,549
Small School	Lobby, Corridor, Cafeteria		8,504	7,813	34.8%	8,504
Non-Refrigerated Warehouse	All Daylit Zones	45,117	539	421	92.2%	49,495

The Statewide CASE Team was not able to use the results of the analysis performed for 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. A PNNL Report that discusses the savings from the ASHRAE 90.1 requirements 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 16 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 Statewide CASE Team used the difference between the standards case and baseline case.

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

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

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 can be assumed to be negligible 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 and the standards case.

Energy savings, energy cost savings, and peak demand reductions were calculated 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 60.

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.[11] The starting hours for each building type were estimated by assessing the workday lighting profiles from DEER 2014. These values are reported in Table 22. The lighting profiles were also used to determine the lighting load for various space types within 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 load, arbitrarily taken as 3:00 AM, to estimate the potential savings of manual ON. For example, the fractional full lighting load for school reading areas at a 5:00 AM fractional load of 0.6 would be reduced to 0.05, the 3:00 AM value, since the building occupancy hour was determined to start at 6:00 AM, as shown in Figure 4.

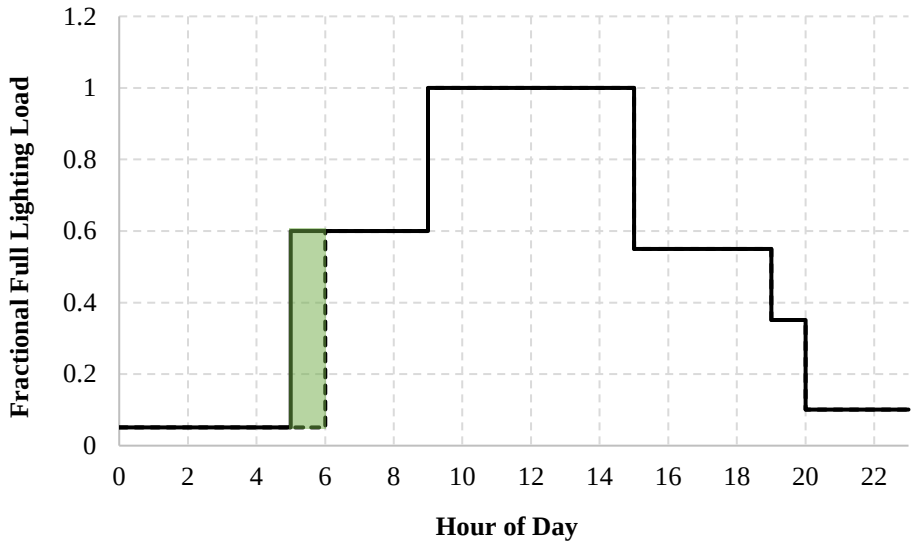

Figure 4: Lighting load profile for school classrooms, which was used as a proxy for reading areas (solid line).

The Statewide CASE Team assumed that the proposed measure would only alter the lighting profiles of the space types listed in Table 22. For each building space, the one-hour load reduction was multiplied by the 2019 minimally compliant LPD and the annual number of workdays (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 53, to determine 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).

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

Table 22: Typical Building Occupancy Hour and Corresponding Previous-Hour Load Reduction for Space Types Affected by "Manual ON Time-Switch" Measure

Building Type	Space Type	Typical Occupancy Hour	Net Previous-Hour LPD Reduction for Space Type (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

The energy savings and peak demand reductions per square foot of daylit area for both new construction and alterations are presented in Table 23. The values in Table 23 represent the construction-weighted average savings per square foot of daylit area for all 16 California climate zones. See Section 6.1 of this report for estimated statewide savings from new construction and alterations. The per-unit energy savings estimates do not take naturally occurring market adoption or compliance rates into account.

Table 23: First-Year Energy Impacts – Per Square Foot of Building Area Subject to "Daylight Dimming Plus OFF" Measure by Prototype Building – Construction-Weighted Average Savings for New Construction and Alterations

Building Prototype	Electricity Savings ($kWh/ft^2/yr$)	Peak Electricity Demand Reductions (W/ft^2)	TDV Energy Savings (TDV kBtu/yr)
Hotel	0.15	4.74×10^{-3}	4.50
Large Office	0.73	3.92×10^{-2}	20.24
Medium Office	0.22	1.18×10^{-2}	9.83
Small Office	0.18	8.63×10^{-3}	37.06
Large Retail	0.16	7.28×10^{-3}	5.27
Small School	0.32	2.42×10^{-2}	3.18
Non-Refrigerated Warehouse	2.72	1.27×10^{-1}	57.46

As discussed in Section 2.1, the Energy Commission requested that the Statewide CASE Team evaluate the energy impacts of an alternative proposal (dimming to five percent) as a comparison to the proposed measure (of dimming to OFF). The Statewide CASE Team completed this analysis on three of the seven prototype buildings in Climate Zone 3. Results are presented in Table 24 and represent the average savings per square foot of daylit floorspace.

Table 24: First-Year Energy – Per Square Foot of Building Area Subject to "Daylight Dimming to Five Percent" Measure (*Alternative Measure*) by Prototype Building – Savings for New Construction and Alterations in Climate Zone 3

Building Prototype	Electricity Savings ($kWh/ft^2/yr$)	Peak Electricity Demand Reductions (W/ft^2)	TDV Energy Savings (TDV kBtu/yr)
Large Office	0.45	3.8×10^{-2}	11.7
Large Retail	0.09	4.5×10^{-3}	2.1
Non-Refrigerated Warehouse	1.78	0.9×10^{-1}	32.8

Mandatory Occupant Sensing Full OFF Controls in Nonresidential Restrooms

Per-unit energy savings and peak demand reductions are presented in Table 25, for new construction and alterations in 2020 respectively. Energy savings per square foot 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 1.8×10^{-4} W/ft^2 for new construction and alterations.

The per-square-foot savings TDV energy cost savings over the 15-year period of analysis are presented in Table 34. The energy cost savings are presented as the discounted present value of the energy cost savings over the analysis period.

Table 25: First-Year Energy Impacts Per Square Foot of Nonresidential Restroom – "Occupant Sensing Controls in Restrooms" Measure

Construction Type	Electricity Savings ($kWh/ft^2/yr$)	Peak Electricity Demand Reductions (W/ft^2)	TDV Energy Savings (TDV kBtu/yr)
New Construction and Alterations (CZ 1 through 16)	0.5	1.8×10^{-4}	14

Manual ON Commissioning for Automatic Time-Switch Controls

Per-square-foot energy savings and peak demand reductions for the first year are presented in Table 26, which presents results for new construction and alterations by building prototype in 2020.

Table 26: First-Year Energy Impacts Per Square Foot of Building Area Subject to "Manual ON Time-Switch" Measure for New Construction and Alterations for Considered Building Prototypes

Building Type	Electricity Savings ($kWh/ft^2/yr$)	Peak Electricity Demand Reductions (W/ft^2)	TDV Energy Savings ($TDV\ kBtu/ft^2/yr$)
Large Office	0.10	2.53×10^{-12}	2.37
Small Office	0.09	2.35×10^{-12}	2.21
Schools	0.09	7.16×10^{-13}	2.13

5. LIFECYCLE COST AND COST-EFFECTIVENESS

5.1 Energy Cost Savings Methodology

TDV energy is a normalized format for comparing electricity and natural gas cost savings that accounts for the cost of electricity and natural gas consumed during each hour of the year. The TDV values are based on long term discounted costs of 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 methodology allows peak electricity savings to be valued more than electricity savings during non-peak periods. The TDV cost impacts are presented in 2020 present value (PV) 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 TDV energy cost savings per square foot over the 15-year period of analysis are presented in Table 27 through Table 33 for seven building prototypes that were evaluated.

Table 27: TDV Energy Cost Savings Over 15-Year Period of Analysis – Per Square Foot of Building Area Subject to "Daylight Dimming Plus OFF" for Small Hotel Building Prototype

Climate Zone	15-Year TDV Electricity Cost Savings (2020 PV $)	15-Year TDV Natural Gas Cost Savings (2020 PV $)	Total 15-Year TDV Energy Cost Savings (2020 PV $)
1	$0.28	$0.00	$0.28
2	$0.36	$0.00	$0.36
3	$0.34	$0.00	$0.34
4	$0.36	$0.00	$0.36
5	$0.31	$0.00	$0.31
6	$0.47	$0.00	$0.47
7	$0.43	$0.00	$0.43
8	$0.46	$0.00	$0.46
9	$0.43	$0.00	$0.43
10	$0.42	$0.00	$0.42
11	$0.37	$0.00	$0.37
12	$0.37	$0.00	$0.37
13	$0.34	$0.00	$0.34
14	$0.37	$0.00	$0.37
15	$0.44	$0.00	$0.44
16	$0.30	$0.00	$0.30

Table 28: TDV Energy Cost Savings Over 15-Year Period of Analysis – Per Square Foot of Building Area Subject to "Daylight Dimming Plus OFF" for Large Office Building Prototype

Climate Zone	15-Year TDV Electricity Cost Savings (2020 PV $)	15-Year TDV Natural Gas Cost Savings (2020 PV $)	Total 15-Year TDV Energy Cost Savings (2020 PV $)
1	$1.64	$0.00	$1.64
2	$1.78	$0.00	$1.78
3	$1.78	$0.00	$1.78
4	$1.78	$0.00	$1.78
5	$1.70	$0.00	$1.70
6	$1.84	$0.00	$1.84
7	$1.81	$0.00	$1.81
8	$1.69	$0.00	$1.69
9	$1.89	$0.00	$1.89
10	$1.83	$0.00	$1.83
11	$1.70	$0.00	$1.70
12	$1.84	$0.00	$1.84
13	$1.72	$0.00	$1.72
14	$1.91	$0.00	$1.91
15	$1.88	$0.00	$1.88
16	$1.67	$0.00	$1.67

Table 29: TDV Energy Cost Savings Over 15-Year Period of Analysis – Per Square Foot of Building Area Subject to "Daylight Dimming Plus OFF" for Medium Office Building Prototype

Climate Zone	15-Year TDV Electricity Cost Savings (2020 PV $)	15-Year TDV Natural Gas Cost Savings (2020 PV $)	Total 15-Year TDV Energy Cost Savings (2020 PV $)
1	$0.61	$0.00	$0.61
2	$0.83	$0.00	$0.83
3	$0.73	$0.00	$0.73
4	$0.83	$0.00	$0.83
5	$0.74	$0.00	$0.74
6	$0.91	$0.00	$0.91
7	$0.90	$0.00	$0.90
8	$0.97	$0.00	$0.97
9	$0.96	$0.00	$0.96
10	$0.91	$0.00	$0.91
11	$0.86	$0.00	$0.86
12	$0.84	$0.00	$0.84
13	$0.78	$0.00	$0.78
14	$0.89	$0.00	$0.89
15	$0.95	$0.00	$0.95
16	$0.69	$0.00	$0.69

Table 30: TDV Energy Cost Savings Over 15-Year Period of Analysis – Per Square Foot of Building Area Subject to "Daylight Dimming Plus OFF" for Small Office Building Prototype

Climate Zone	15-Year TDV Electricity Cost Savings (2020 PV $)	15-Year TDV Natural Gas Cost Savings (2020 PV $)	Total 15-Year TDV Energy Cost Savings (2020 PV $)
1	$3.17	$0.00	$3.17
2	$3.43	$0.00	$3.43
3	$3.24	$0.00	$3.24
4	$3.43	$0.00	$3.43
5	$3.22	$0.00	$3.22
6	$3.69	$0.00	$3.69
7	$3.52	$0.00	$3.52
8	$3.86	$0.00	$3.86
9	$3.83	$0.00	$3.83
10	$3.62	$0.00	$3.62
11	$3.41	$0.00	$3.41
12	$3.58	$0.00	$3.58
13	$3.33	$0.00	$3.33
14	$3.53	$0.00	$3.53
15	$3.57	$0.00	$3.57
16	$3.00	$0.00	$3.00

Table 31: TDV Energy Cost Savings Over 15-Year Period of Analysis – Per Square Foot of Building Area Subject to "Daylight Dimming Plus OFF" for Large Retail Building Prototype

Climate Zone	15-Year TDV Electricity Cost Savings (2020 PV $)	15-Year TDV Natural Gas Cost Savings (2020 PV $)	Total 15-Year TDV Energy Cost Savings (2020 PV $)
1	$0.31	$0.00	$0.31
2	$0.43	$0.00	$0.43
3	$0.33	$0.00	$0.33
4	$0.29	$0.00	$0.29
5	$0.37	$0.00	$0.37
6	$0.55	$0.00	$0.55
7	$0.53	$0.00	$0.53
8	$0.62	$0.00	$0.62
9	$0.50	$0.00	$0.50
10	$0.47	$0.00	$0.47
11	$0.40	$0.00	$0.40
12	$0.46	$0.00	$0.46
13	$0.42	$0.00	$0.42
14	$0.44	$0.00	$0.44
15	$0.61	$0.00	$0.61
16	$0.27	$0.00	$0.27

Table 32: TDV Energy Cost Savings Over 15-Year Period of Analysis – Per Square Foot of Building Area Subject to "Daylight Dimming Plus OFF" for Small School Building Prototype

Climate Zone	15-Year TDV Electricity Cost Savings (2020 PV $)	15-Year TDV Natural Gas Cost Savings (2020 PV $)	Total 15-Year TDV Energy Cost Savings (2020 PV $)
1	$0.32	$0.00	$0.32
2	$0.29	$0.00	$0.29
3	$0.25	$0.00	$0.25
4	$0.29	$0.00	$0.29
5	$0.25	$0.00	$0.25
6	$0.22	$0.00	$0.22
7	$0.25	$0.00	$0.25
8	$0.24	$0.00	$0.24
9	$0.25	$0.00	$0.25
10	$0.27	$0.00	$0.27
11	$0.41	$0.00	$0.41
12	$0.34	$0.00	$0.34
13	$0.29	$0.00	$0.29
14	$0.37	$0.00	$0.37
15	$0.37	$0.00	$0.37
16	$0.38	$0.00	$0.38

Table 33: TDV Energy Cost Savings Over 15-Year Period of Analysis – Per Square Foot of Building Area Subject to "Daylight Dimming Plus OFF" for Non-Refrigerated Warehouse Building Prototype

Climate Zone	15-Year TDV Electricity Cost Savings (2020 PV $)	15-Year TDV Natural Gas Cost Savings (2020 PV $)	Total 15-Year TDV Energy Cost Savings (2020 PV $)
1	$3.65	$0.00	$3.65
2	$4.65	$0.00	$4.65
3	$4.30	$0.00	$4.30
4	$4.81	$0.00	$4.81
5	$4.47	$0.00	$4.47
6	$5.29	$0.00	$5.29
7	$5.22	$0.00	$5.22
8	$5.64	$0.00	$5.64
9	$5.54	$0.00	$5.54
10	$5.26	$0.00	$5.26
11	$4.85	$0.00	$4.85
12	$4.91	$0.00	$4.91
13	$4.80	$0.00	$4.80
14	$5.32	$0.00	$5.32
15	$5.54	$0.00	$5.54
16	$4.15	$0.00	$4.15

Mandatory Occupant Sensing Full OFF Controls in Nonresidential Restrooms

Per-square-foot energy cost savings over the 15-year period of analysis are presented in Table 34 for new construction and alterations, respectively.

It is estimated that the first-year TDV energy savings are 14.21 TDV kBtu/ft^2 for new construction and 14.21 TDV kBtu/ft^2 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 34: TDV Energy Cost Savings Over 15-Year Period of Analysis – Per Square Foot of Building Area subject to "Occupant Sensing Controls in Restrooms" Measure

Climate Zone	15-Year TDV Electricity Cost Savings (2020 PV $)	15-Year TDV Natural Gas Cost Savings (2020 PV $)	Total 15-Year TDV Energy Cost Savings (2020 PV $)
New Construction and Alterations (CZ 1 through 16)	$1.27	$0.00	$1.27

Manual ON Commissioning for Automatic Time-Switch Controls

Per-square-foot energy cost savings over the 15-year period of analysis are presented in Table 35 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/ft^2 for Small Offices, 2.14 TDV kBtu/ft^2 for Schools, and 2.38 TDV kBtu/ft^2 for Large Offices. Since industry stakeholders have suggested that savings will likely occur during early morning, non-peak hours, the peak demand reduction is small, albeit non-zero.

Table 35: TDV Energy Cost Savings Over 15-Year Period of Analysis – Per Square Foot of Building Area subject to "Manual ON Time-Switch" Measure for New Construction and Alterations

Building Type	15-Year TDV Electricity Cost Savings (2020 PV $)	15-Year TDV Natural Gas Cost Savings (2020 PV $)	Total 15-Year TDV Energy Cost Savings (2020 PV $)
Large Office	$1.74	$0.00	$1.74
Small Office	$1.82	$0.00	$1.82
Small School	$1.94	$0.00	$1.94

5.3 Incremental First Cost

The Statewide CASE Team estimated the current incremental construction costs, which represent the incremental cost of the measure if a building meeting the proposed standard were built today.

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 the automatic daylight dimming controls that are already required under the 2016 Title 24, Part 6 code.

The Statewide CASE Team surveyed manufacturers and industry stakeholders and concluded the incremental cost for this measure would be negligible for a vast majority of systems. In order to verify this assumption, the Statewide CASE Team conducted a literature review of daylighting controls with fluorescent luminaries and a cost-effectiveness analysis of four daylighting control systems with LED luminaries to show the incremental costs under certain applications, using cost estimates collected in August 2017. The Statewide CASE Team assumed LED systems will be the predominate system in

2020; however, to provide historical context as systems transition from fluorescent to LED, two studies are presented below which offer insight into the costs associated with daylighting controls in fluorescent systems. In reviewing costs for daylighting control systems, it is important to note that the cost of daylighting control systems depends on "the complexity and flexibility of the system" and can range "from $0.75 to $3 per square foot" (Hackel and Schuetter 2013).

LBNL conducted a long-term study of five daylighting projects, including a cost-effectiveness analysis and occupant surveys. The integrated daylighting systems at the five sites included "photosensors and electronic dimming ballasts to control fluorescent electric lighting, which was the preferred technology at the time of the study between 2012 and 2013" (Robinson, Custodio and Selkowitz 2014). The study did not evaluate daylighting systems with LED-based fixtures. The report found that dimming ballasts for fluorescent fixtures cost, on average, $25 each with a labor cost of $0.3/ft^2. Table 36 lists the initial costs for daylight dimming systems at five sites.

Table 36: Summary of Initial Costs from Integrated Daylighting Systems Study

Site	Daylight Dimming Initial Costs ($/ft^2)		Set Point Tuning and Daylight Dimming Initial Costs ($/ft^2)	
	Equipment	Labor	Equipment	Labor
Ron Dellums	0.33	0.28	1.08	0.88
Roybal	0.26	0.27	0.89	0.88
Cottage Way	0.30	0.40	0.85	0.98
Hammond	0.21	0.20	0.74	0.89
Dirksen	0.43	0.30	1.92	0.94

Source: Robinson, Custodio and Selkowitz 2014).

Green Light New York also conducted a study on daylight controls in fluorescent systems, and found that "discussions with suppliers suggest that dimmable ballasts could be manufactured in large volume at a $5 premium rather than the $20–60 per ballast cost often quoted today (Green Light New York 2012). The report concluded that "improved sensors and wireless communications will further reduce the networking and communications costs involved in making these systems work effectively" (Green Light New York 2012).

The Statewide CASE Team's analysis used a similar approach as PNNL's ASHRAE 90.1-2010 cost-effectiveness analysis. The affected prototypes, space types, as well as the typical area specifications are listed in Table 37. The Statewide CASE Team gathered cost data for LED drivers with the capability to dim either to one, five, or ten percent as well as dim to OFF. The four lighting control systems researched are shown in Table 38.

Table 37: Incremental Cost Area Specifications for "Daylight Dimming Plus OFF" Measure

Affected Prototype and Space Type	Area Specifications			
Daylighting Controls, Skylit or Sidelit Areas	**Skylit or Sidelit Area ft^2**	**Quantity of Fixtures**	**Quantity of Sensors and Controlled Banks of Lights**	**Increased Commissioning Cost[a]**
Standalone Retail - Core Retail Skylit Areas	8,614	238	1	$14.15
Primary School - Multipurpose Room Skylit Areas	3,843	44	1	$14.15
Small Office Sidelighting Control	1,220	28	4	$56.60
Large Office Sidelighting Control	65,220	1,500	150	$2,122.50
Primary School Sidelighting Control	15,411	171	40	$566.00
Small Hotel Sidelighting Control	423	4	1	$14.15

a. Automatic Daylighting Control Acceptance Test to test controls turn OFF, which is assumed would take additional 15 minutes per sensor.

Table 38: Daylight System Material Price for System with Ten Luminaires per Controller

System Number	Description	Control Range	Quantity	Cost	Total Cost
1	Base Case: 0-10 VDC Controlled Standard Driver	100% to 10%	10	$81.43	$814.33
1	Daylight Dimming Controller	0-10VDC	1	$50.00	$50.00
1	**Total Performance**	**100% to 10%**			**$864.33**
2	Base Case: 0-10 VDC Controlled Standard Driver	100% to 10%	10	$81.43	$814.33
2	Daylight Dimming Plus OFF Controller	0-10VDC + ON/OFF Relay	1	$109.46	$109.46
2	**Total Performance**	**100% to 10% + OFF**			**$923.78**
3	0-10 VDC Controlled Architectural Driver	100% to 1%	10	$163.80	$1,637.95
3	Daylight Dimming Plus OFF Controller	0-10VDC	1	$58.69	$58.69
3	**Total Performance**	**100% to 1%**			**$1,696.64**
4	Digital Controlled Driver Dim to OFF	100% to 10% + OFF	10	$130.50	$1,304.96
4	Digital Dimming Plus OFF Controller	Digital	1	$109.12	$109.12
4	**Total Performance**	**100% to 10% + OFF**			**$1,414.08**

Table 39 lists the total cost per-square-foot per system and Table 40 lists the incremental cost for each system. The lifecycle cost-effectiveness analysis calculated the incremental cost as the difference between system one and system two, because system two represents the most typical and cost-effective configuration to meet the proposed standards. The Statewide CASE Team interviewed several Acceptance Test Technicians and the consensus view expressed was that the proposed code change would not require an increase in time or cost to complete the Automatic Daylighting Control Acceptance Test. However, as a conservative estimate and based on PNNL's analysis, the Statewide CASE Team's analysis accounted for an additional 15 minutes per sensor to complete Automatic

Daylighting Control Acceptance Test to test controls turn OFF. The cost per square foot is a weighted average based on the affected prototype square footage.

Table 39: Total Cost Per Square Foot Per Affected Prototype for "Daylight Dimming Plus OFF" Measure

Affected Prototype and Space Type	Total Cost per ft^2 per Prototype			
Daylighting Controls, Skylit or Sidelit Areas	**System 1**	**System 2**	**System 3**	**System 4**
Standalone Retail - Core Retail Skylit Areas	$2.25	$2.26	$4.53	$3.62
Primary School - Multipurpose Room Skylit Areas	$0.95	$0.96	$2.10	$1.53
Small Office Sidelighting Control	$2.03	$2.27	$4.00	$3.40
Large Office Sidelighting Control	$1.99	$2.16	$3.93	$3.28
Primary School Sidelighting Control	$1.03	$1.22	$2.01	$1.77
Small Hotel Sidelighting Control	$0.89	$1.06	$1.72	$1.53
Weighted Average[a]	**$1.81**	**$1.96**	**$3.59**	**$2.99**

a. The cost per square foot is a weighted average based on the affected prototype square footage.

Table 40: Incremental Cost Per Square Foot Per Affected Prototype for "Daylight Dimming Plus OFF" Measure

Affected Prototype and Space Type (Daylighting Controls, Skylit or Sidelit Areas)	Incremental Cost per ft^2 (System 1 versus System 2)
Standalone Retail - Core Retail Skylit Areas	$0.01
Primary School - Multipurpose Room Skylit Areas	$0.02
Small Office Sidelighting Control	$0.24
Large Office Sidelighting Control	$0.17
Primary School Sidelighting Control	$0.19
Small Hotel Sidelighting Control	$0.17
Weighted Average[a]	$0.15

a. The cost per square-foot is a weighted average based on the affected prototype square footage.

Mandatory Occupant Sensing Full OFF Controls in Nonresidential Restrooms

The Statewide CASE Team determined the incremental cost of the proposed code change in a similar manner to that used in PNNL's analysis for ASHRAE 90.1-2010. Table 41 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).

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 cost-effectiveness analysis for ASHRAE 90.1-2013 used labor costs sourced from RS Means 2012 and the incremental commissioning costs were from the NC3/Dodge database. The Statewide CASE Team used labor costs from RS Means 2017 and updated the incremental commissioning costs to account for inflation.

Table 41: 2017 Grainger Catalog Costs for Occupancy Sensors

Technology	Mounting Type	Quantity	Average Area Coverage (ft^2 per sensor)	Average Price ($/each)
Passive Infrared		**106**	**1,511**	**$129**
	Ceiling	22	1,420	$150
	Ceiling, Wall	10	1,745	$147
	Corner	1	1,200	$141
	Corner Mount, Ceiling, Wall	2	2,000	$196
	Fixture	1	2,463	$122
	Wall	70	1,483	$112
Passive Infrared/Microphonic		**14**	**1,811**	**$169**
	Ceiling	8	1,960	$174
	Corner	1	1,200	$197
	Wall	5	1,695	$157
Passive Infrared/Ultrasonic		**35**	**1,491**	**$186**
	Ceiling	12	1,217	$224
	Ceiling, Wall	1	2,000	$372
	Wall	22	1,617	$156
Ultrasonic		**23**	**1,409**	**$209**
	Ceiling	22	1,462	$211
	Wall	1	300	$144
Average/Total		**178**	**1,518**	**$157**

Source: Grainger 2017 Online Catalog.

Table 42 lists the costs published in the 2015 NLPIP Comparison Lighting Controls Report. The NLPIP comparison found that wireless occupancy sensors have lower installation labor costs and take less time to commission than wired occupancy sensors. However, wireless occupancy sensors have higher material costs; wireless sensor costs range from 54 percent to 128 percent higher than costs for wired sensors (NLPIP 2015).

Table 42: 2015 Online Retail Prices for Wired versus Wireless Occupancy Sensor Systems[a]

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	180%
		Controller	OSP20-ND0	$35			
	Wireless	Sensor	WSC04-IRW	$108	$200		
		Controller	WSS10-GUZ	$92			
Lutron	Wired	Sensor	LOS-CIR-450-WH	$80	$110	$59	154%
		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	228%
		Controller	BZ-150	$30			
	Wireless	Sensor	EOPC-100	$125	$260		
		Controller	EOSW-101	$135			

a. 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 of 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 43 shows the total incremental cost over the 15-year period of analysis. The Statewide CASE Team's analysis use the typical area for restrooms from PNNL's analysis. The typical single occupant restroom is 75 ft^2 or 10 feet by 7.5 feet and the typical multiple occupant restroom is 320 ft^2 or 20 feet by 16 feet.

Table 43: Incremental Costs for "Occupant Sensing Controls in Restrooms" Measure

Typical Restroom Type	Sensor Equipment Type	Material [a]	Labor Cost[b]	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	$5	$0	$137
Single Occupant	• PIR • Wall Mount • Wired	$29	$19	$5	$0	$53
Multiple Occupant	• Dual Technology Ultrasonic/PIR • Wired	$112	$70	$7	$0	$189
Alterations						
Single Occupant	• Dual Technology Ultrasonic/PIR • Wall Mount • Wired	$113	$19	$5	$0	$137
Single Occupant	• PIR • Wall Mount • Wired	$29	$19	$5	$0	$53
Multiple Occupant	• Dual Technology Ultrasonic/PIR • Wireless	$162	$70	$9	$0	$241

a. 2017 Grainger Catalogue and NLPIP Study, July 2015.

b. The cost-effectiveness analysis for ASHRAE Standard 90.1-2013-Cost Estimate used RS Means 2012 for the labor estimates and NC3/Dodge database for the incremental commissioning costs. The Statewide CASE Team used RS Means 2017 for the labor estimates and updated the incremental commissioning costs to account for inflation.

Manual ON Commissioning for Automatic Time-Switch Controls

The "Manual ON Time-Switch" measure proposes only 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. The zero-cost assumption was confirmed by discussions with two separate manufacturers.

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:

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

Mandatory Automatic Daylight Dimming Plus OFF Controls

The anticipated lifetime incremental maintenance cost associated with the OFF step of automatic daylighting control is zero dollars. With appropriate adjustment of illuminance deadband, fade rate, 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 and surveys, and solicited 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 cost associated with Manual ON commissioning is assumed to be 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.

5.5 Lifecycle Cost-Effectiveness

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 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 and the incremental costs of code compliance verification were not included.

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

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.

Results of the per-unit lifecycle cost-effectiveness analyses are presented in Table 44. More information regarding the incremental cost calculations can be found in 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 44: Lifecycle Cost-Effectiveness Summary Per Square Foot of Building Area Subject to "Daylight Dimming Plus OFF" Measure

Measure	Benefits: TDV Energy Cost Savings + Other PV Savings[a] (2020 PV $)	Costs: Total Incremental PV Costs[b] (2020 PV $)	Benefit-to-Cost Ratio
Hotel			
New Construction	$0.40	$0.17	2.30
Alterations	$0.40	$0.15	2.60
Large Office			
New Construction	$0.87	$0.17	5.17
Alterations	$0.19	$0.17	1.12
Medium Office			
New Construction	$1.34	$0.17	7.91
Alterations	$0.96	$0.17	5.70
Small Office			
New Construction	$3.30	$0.24	13.67
Alterations	$3.30	$0.24	13.67
Retail Large			
New Construction	$0.47	$0.01	32.71
Alterations	$0.47	$0.01	32.71
School			
New Construction	$0.26	$0.19	1.34
Alterations	$0.26	$0.19	1.34
Non-Refrigerated Warehouse			
New Construction	$5.11	$0.17	30.21
Alterations	$5.11	$0.17	30.21
Total New Construction (Weighted Average)	**$1.39**	**$0.15**	**9.03**
Total Alterations (Weighted Average)	**$0.87**	**$0.15**	**5.67**

a. **Benefits: TDV Energy Cost Savings + Other PV Savings:** Benefits include TDV energy cost savings over the period of analysis (Energy + Environmental Economics 2016). 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 PV maintenance cost savings if PV of proposed maintenance cost is less than the PV of current maintenance costs.

b. **Costs: Total Incremental PV 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 PV 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 PV costs, the B/C ratio is infinite

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.

Results of the per-unit lifecycle cost-effectiveness analyses are presented in Table 45. More information regarding the incremental cost calculations can be found in 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 45: Lifecycle Cost-Effectiveness Summary Per Square Foot – "Occupant Sensing Controls in Restrooms" Measure

Measure	Benefits: TDV Energy Cost Savings + Other PV Savings[a] (2020 PV $)	Costs: Total Incremental PV Costs[b] (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

a. **Benefits: TDV Energy Cost Savings + Other PV Savings:** Benefits include TDV energy cost savings over the period of analysis (Energy + Environmental Economics 2016). 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 PV maintenance cost savings if PV of proposed maintenance cost is less than the PV of current maintenance costs.

b. **Costs: Total Incremental PV 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 PV 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 PV costs, the B/C 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 luminaries, and the addition of dimming ballasts to fluorescent luminaires was relatively expensive. Classrooms were singled out as being exempt because they required fewer full load hours than other space types. The 2019 CASE Report on Indoor Controls assumed that energy savings from dimming lighting are 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 (e.g., 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 cost calculations for schools are not shown in the appendix of the 2013 CASE Report, the majority of the costs for the other space types are based on the cost of fluorescent dimming ballasts, which are no longer needed.

The analysis used the schedule for "School Buildings" in the ACM Reference Manual and multiplied those values by the TDV 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 0.70 W/ft^2. A typical California classroom is 960 ft^2. The total wattage per classroom is 690 W. Using the same calculation methodology as was used for the 2013 CASE Report proposal for "Controllable Lighting," the wattage reduction would be 103 W. Using the TDV multiplier of PV $5.36 per watt, the present valued savings over 15 years from the dimming system is $555.

The 2019 CASE Report on Nonresidential Indoor Sources is based on LED light sources because they have a lower lifecycle cost than fluorescent lighting systems. In most cases, LED general lighting luminaires use 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 lower if the additional cost of adding another circuit for bi-level switching was considered.

Thus, because the dimming control has a B/C ratio of five to one, striking the exception for classrooms is cost-effective according to the rationale 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 savings per square foot of daylight floor area, which are presented in Section 4.3, by estimates of newly constructed and altered floorspace that will be completed in 2020 and will be subject to the proposed daylighting requirements. The floorspace estimates represent daylit floorspace in each building type, not total floorspace for each building type. See Appendix A for more detail on the statewide construction forecast.

The first-year energy impacts represent the first-year annual savings from buildings that will be completed or renovated in 2020. The Statewide CASE Team believes the statewide savings estimates are conservative because they only include savings from building types that were modeled for this analysis. The statewide estimates presented in this report capture a majority of the savings; however, there will be some additional savings from building types that were not modeled for this analysis.

The lifecycle energy cost savings, which represent the energy cost savings over the 15-year analysis period, are presented in Table 46.The Statewide CASE Team estimates that the proposed code change will reduce annual statewide electricity use by 18.7 GWh during the first year with an associated demand reduction of 0.9 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 $46.8 million in (discounted) energy costs over the 15-year period of analysis.

Note that per-unit and statewide energy savings account for:

- Dimming reduction at 125 percent illuminance only in classroom areas in the Small School Prototype.
- Any savings reduction from occupant adjusting controls after commissioning.

Table 46: Statewide Energy and Energy Cost Impacts – Per Prototype for New Construction and Alterations for "Daylight Dimming Plus OFF" Measures

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	0.45	0.07	0.002	$0.18
Alterations	0.52	0.08	0.002	$0.21
Large Office				
New Construction	4.66	1.02	0.055	$4.08
Alterations	4.59	1.00	0.054	$0.87
Medium Office				
New Construction	1.05	0.77	0.041	$1.90
Alterations	1.04	0.76	0.040	$1.80
Small Office				
New Construction	0.52	0.09	0.004	$1.70
Alterations	0.57	0.10	0.005	$1.87
Large Retail				
New Construction	19.35	3.09	0.142	$9.08
Alterations	20.37	3.27	0.147	$9.56
Small School				
New Construction	0.39	0.12	0.009	$0.11
Alterations	0.52	0.17	0.013	$0.15
Non-Refrigerated Warehouse				
New Construction	1.38	3.76	0.178	$7.07
Alterations	1.61	4.37	0.202	$8.22
Subtotal New Construction [a]	**27.8**	**8.92**	**0.432**	**$24.12**
Subtotal Alterations [a]	**29.2**	**9.76**	**0.464**	**$22.69**
Total [a]	**57.0**	**18.67**	**0.896**	**$46.82**

a. Sum of values may not add to totals rows due to rounding.

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 represent the energy cost savings over the entire 15-year analysis period. Results are presented in in Table 47.

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 9.7 GWh. The energy savings for buildings constructed in 2020 are associated with a present valued energy cost savings of approximately PV $24.4 million in (discounted) energy costs over the 15-year period of analysis.

Table 47: 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)[a]	First-Year Peak Electrical Demand Reduction (MW)	Lifecycle[b] Present Valued Energy Cost Savings (PV $ million)
New Construction (CZ 1 through 16)	4.9	2.5	8.6×10^{-4}	$6.2
Alterations (CZ 1 through 16)	14.4	7.2	2.5×10^{-3}	$18.1
Total	**19.4**	**9.7**	**3.4×10^{-3}**	**$24.4**

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

b. 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 15.6 million square feet of indoor nonresidential buildings will be affected by the proposed measure, which will result in 1.5 GWh of energy savings and $25.7 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 will not adjust the time-switch to automatic OFF after commissioning.

Table 48: Statewide Energy and Energy Cost Impacts for "Manual ON Time-Switch" Measure for New Construction and Alterations

Climate Zone	Affected Statewide Floor Stock in 2020 (million ft^2)	First-Year Electricity Savings (GWh) [a]	First-Year Peak Electrical Demand Reduction (MW)	Lifecycle[b] Present Valued Energy Cost Savings (PV $ million)
New Construction (CZ 1 through 16)	3.88	0.381	9.0×10^{-12}	$0.81
Alterations (CZ 1 through 16)	11.8	1.14	2.6×10^{-11}	$24.9
Total	**15.6**	**1.52**	**3.5×10^{-11}**	**$25.7**

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

b. 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 "Occupant Sensing Controls in Restrooms" measure.

The "Manual ON Automatic 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 managing 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 the lighting system. Training building occupants on how to use building's lighting system is essential to managing user acceptance of this measure. Also, it must be stated clearly in the code and compliance manual that this measure is a commissioning step and that, if appropriate, the measure 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 re-ordering so it is easier to combine subsections which are required for alterations); and
- General cleanup of code related to indoor controls (simplifying code language or retiring portions of the code that are no longer relevant with the advance of Solid State Lighting technology).

7.1 Standards

Section 130.1, Mandatory Indoor Lighting Controls, is reproduced in full below to capture all the recommended changes.

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, religious facilities, 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. 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.

   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.

   ~~B~~ D. 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.

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.

~~B~~A. 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.~~

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.

~~A~~ C. 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.~~

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 8:00 AM and 4:00 PM.

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~~ daylit 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, 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 general lighting power in that daylit zone shall be automatically 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~~ Luminaires in Skylit Daylit Zone(s) in an enclosed space, ~~in which~~ where the combined total installed general lighting power in all the Skylit Daylit Zone(s) in the space ~~and Primary Sidelit Daylit Zone~~ is less than 120 Watts.

EXCEPTION 2 to Section 130.1(d)2: Luminaires in Primary Sidelit Daylit Zone(s) in an enclosed space, ~~in which~~ where the combined total installed general lighting power in all the Primary Daylit Zone(s) in the space is less than 120 Watts.

EXCEPTION ~~2~~3 to Section 130.1(d)2: Rooms Enclosed spaces that have a total glazing area of less than 24 square feet.

EXCEPTION ~~3~~4 to Section 130.1(d)2: Parking garages complying with Section 130.1(d)3.

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 that 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

<table>
<tr><th>Luminaire Type</th><th>Minimum Required Control Steps
(percent of full rated)</th><th>Uniform level of illuminance shall be achieved by:</th></tr>
<tr><td>Line-voltage sockets except GU-24</td><td colspan="2" rowspan="4">Continuous dimming 10-100 percent</td></tr>
<tr><td>Low-voltage incandescent systems</td></tr>
<tr><td>LED luminaires and LED source systems</td></tr>
<tr><td>GU-24 rated for LED</td></tr>
<tr><td>GU-24 sockets rated for fluorescent > 20 watts</td><td colspan="2" rowspan="2">Continuous dimming 20-100 percent</td></tr>
<tr><td>Pin-based compact fluorescent > 20 watts[2]</td></tr>
<tr><td>GU-24 sockets rated for fluorescent ≤ 20 watts</td><td rowspan="3">Minimum one step between
30-70 percent</td><td rowspan="3">Stepped dimming; or
Continuous dimming; or
Switching alternate lamps in a luminaire</td></tr>
<tr><td>Pin-based compact fluorescent ≤ 20 watts[2]</td></tr>
<tr><td>Linear fluorescent and U-bent fluorescent ≤ 13 watts</td></tr>
<tr><td rowspan="2">Linear fluorescent and U-bent fluorescent >13 watts</td><td>~~Minimum one step in each~~</td><td rowspan="2">~~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~~</td></tr>
<tr><td><u>Continuous dimming 20-100 percent</u>
~~20-40 %~~
~~50-70 %~~
~~75-85 %~~</td></tr>
<tr><td>Track Lighting</td><td>Minimum one step between
30 – 70 percent</td><td>Step dimming; or
Continuous dimming; or
Separately switching circuits in multi-circuit track with a minimum of two circuits.</td></tr>
</table>

Luminaire Type	Minimum Required Control Steps (percent of full rated)	Uniform level of illuminance shall be achieved by:
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.

(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 the primary sidelit zone separately from the secondary sidelit zone as long as it has two control channels with different setpoints. The primary sidelit zone shall 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~~ visible flicker.

(e) Full daylight test. Simulate or provide bright conditions. Shining a flashlight or other bright source into the light sensor is an acceptable method of conducting 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. ~~1. Lighting power reduction is at least 65 percent under fully dimmed conditions and light output is stable with no discernable flicker.~~

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. Shining a flashlight or other bright source into the light sensor is an acceptable method of conducting 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. ~~1. Lighting power reduction of controlled luminaires is at least 65 percent.~~

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 (skylit 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 the skylit 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 (skylit 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.

7.2.3 Manual ON Commissioning for Automatic Time-Switch Controls

NA7.6.2.4 Automatic Time Switch Lighting Control Construction Inspection

Prior to Functional testing, verify and document the following:

(a) Automatic time switch control is programmed with acceptable weekday, weekend, and holiday (if applicable) schedules.

(b) Document for the owner automatic time switch programming including weekday, weekend, holiday schedules as well as all set-up and preference program settings.

(c) Verify the correct time and date is properly set in the time switch.

(d) Verify the battery back-up (if applicable) is installed and energized.

(e) Override time limit is set to no more than 2 hours.

(f) Override switches remote from area with controlled luminaires have annunciator lights.

(g) Verify time switch is manual ON.

7.3 ACM Reference Manual

The compliance software must be capable of allowing daylight dimming controls to dim to a 65 percent reduction at 125 percent Illuminance while also dimming to OFF once at 150 percent 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 Documents

Mandatory Automatic Daylight Dimming Plus OFF Controls

For “Daylight Dimming Plus OFF” measure, “2016-NRCA-LTI-03-A Automatic Daylighting Control Acceptance Document” will need to be updated. In addition, any Equivalent Performance Forms must be generated on a 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” will need to be updated.

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Appendix A: STATEWIDE SAVINGS METHODOLOGY

The projected nonresidential new construction forecast that will be impacted by the proposed code change in 2020 is presented in Table 49, Table 51, and Table 53. 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 50, Table 52, and Table 53.

To calculate first-year statewide savings, the Statewide CASE Team multiplied the per-unit savings by statewide new construction estimates for 2020, the first year that the standards will be in effect. The Energy Commission Demand Analysis Office provided the Statewide CASE Team with the nonresidential new construction forecast. The raw data presented annual total building stock and new construction estimates for twelve building types by forecast climate zones (FCZ).

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 standards climate zones (BSCZ). Since Title 24, Part 6 uses BSCZ, the Statewide CASE Team converted the construction forecast from FCZ to BSCZ using conversion factors supplied by the Energy Commission. The conversion factors which are presented in Table 48 represent the percentage of building square footage in FCZ that is also in BSCZ. For example, looking at the first column of conversion factors in Table 48, 22.5 percent of the building square footage in FCZ 1 is also in BSCZ 1 and 0.1 percent of building square footage in FCZ 4 is in BSCZ 1. To convert from FCZ to BSCZ, the total forecasted construction for a specific building type in each FCZ was multiplied by the conversion factors for BSCZ 1, then all square footage from all FCZs that were found to be in BSCZ 1 were summed to arrive at the total construction for that building type in BSCZ 1. This process was repeated for every climate zone and every building type. See Table 50 for an example calculation to convert from FCZ to BSCZ. In this example, construction BSCZ 1 is made up of building floorspace from FCZs 1, 4, and 14.
2. Redistributed square footage allocated to the "Miscellaneous" building type. The building types included in the Energy Commissions' forecast are summarized in Table 49. 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 50 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 58, Table 59, and Table 60 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 58, Table 59, and Table 60 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 49, Table 51, Table 52, and Table 53.

The Revised Impact Analysis for the 2016 Update to the California Energy Efficiency Standards for Residential and Nonresidential Buildings assumed lighting systems are replaced every 15 years. Thus,

Table 50, Table 52, and Table 53 should show that 1/15th percent of existing floorspace will be impacted in 2020 by the proposed code change.

Table 49: 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)											
	Small Office	Restaurant	Retail	Food	Non-Refrigerated Warehouse	Refrigerated Warehouse	School	College	Hospital	Hotel	Large Office	TOTAL
1	0.06	0.02	0.08	0.04	0.05	0.00	0.08	0.03	0.00	0.03	0.07	**0.5**
2	0.26	0.12	0.67	0.23	0.60	0.00	0.41	0.15	0.00	0.30	1.04	**3.8**
3	0.86	0.49	2.96	0.92	3.57	0.00	1.51	0.69	0.00	1.66	6.93	**19.6**
4	0.59	0.26	1.60	0.56	1.35	0.00	0.93	0.35	0.00	0.66	2.34	**8.6**
5	0.11	0.05	0.31	0.11	0.26	0.00	0.18	0.07	0.00	0.13	0.45	**1.7**
6	0.79	0.58	2.48	0.83	2.72	0.00	1.00	0.43	0.00	0.77	4.37	**14.0**
7	1.06	0.32	1.53	0.63	1.14	0.00	1.08	0.35	0.00	0.67	2.20	**9.0**
8	1.10	0.83	3.58	1.19	3.86	0.00	1.46	0.60	0.00	1.11	6.39	**20.1**
9	1.08	0.92	3.79	1.23	4.13	0.00	1.48	0.71	0.00	1.28	8.62	**23.2**
10	1.23	0.80	2.87	1.08	3.28	0.00	2.07	0.52	0.00	0.74	2.17	**14.8**
11	0.35	0.11	0.61	0.28	0.80	0.00	0.54	0.13	0.00	0.18	0.41	**3.4**
12	1.87	0.54	3.30	1.16	3.76	0.00	2.20	0.63	0.00	1.10	4.50	**19.1**
13	0.76	0.25	1.34	0.60	1.53	0.00	1.19	0.26	0.00	0.40	0.79	**7.1**
14	0.20	0.15	0.57	0.20	0.64	0.00	0.38	0.09	0.00	0.14	0.54	**2.9**
15	0.27	0.11	0.50	0.23	0.72	0.00	0.38	0.07	0.00	0.17	0.27	**2.7**
16	0.28	0.17	0.72	0.26	0.67	0.00	0.41	0.16	0.00	0.19	1.25	**4.1**
TOTAL	**10.9**	**5.7**	**26.9**	**9.5**	**29.1**	**0.0**	**15.3**	**5.2**	**0.0**	**9.5**	**42.4**	**154**

Table 50: 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	Alterations in 2020 (million ft^2)											
	Small Office	Restaurant	Retail	Food	Non-Refrigerated Warehouse	Refrigerated Warehouse	School	College	Hospital	Hotel	Large Office	TOTAL
1	0.1	0.0	0.1	0.0	0.059	0	0.1	0.0	0.0	0.0	0.1	0.5
2	0.3	0.1	0.7	0.2	0.6	0	0.5	0.2	0.0	0.3	1.0	4
3	1.0	0.4	2.8	0.9	3.3	0	1.9	0.8	0.0	1.5	6.3	19
4	0.7	0.3	1.6	0.6	1.5	0	1.1	0.5	0.0	0.7	2.4	9
5	0.1	0.0	0.3	0.1	0.3	0	0.2	0.1	0.0	0.1	0.5	2
6	1.0	0.6	2.8	0.9	3.5	0	1.7	0.7	0.0	1.0	4.6	17
7	1.1	0.3	1.7	0.7	1.5	0	1.1	0.4	0.0	1.0	2.5	10
8	1.3	0.9	4.0	1.3	4.9	0	2.3	1.0	0.0	1.5	6.7	24
9	1.2	1.0	3.9	1.3	4.6	0	2.1	1.0	0.0	1.4	8.0	24
10	1.4	0.9	3.4	1.2	4.8	0	2.1	0.7	0.0	1.0	2.4	18
11	0.4	0.1	0.6	0.3	0.9	0	0.5	0.2	0.0	0.2	0.4	3
12	1.8	0.5	3.3	1.2	3.9	0	2.3	0.8	0.0	1.1	4.3	19
13	0.8	0.2	1.3	0.6	1.5	0	1.2	0.3	0.0	0.4	0.7	7
14	0.2	0.2	0.6	0.2	0.9	0	0.4	0.1	0.0	0.2	0.6	3
15	0.3	0.1	0.5	0.2	0.9	0	0.3	0.1	0.0	0.2	0.3	3
16	0.3	0.2	0.8	0.3	0.8	0	0.4	0.2	0.0	0.2	1.2	4
TOTAL	12.0	5.9	28.3	10.0	33.8	0	18.3	7.1	0.0	10.9	41.8	168

Table 51: 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)											
	Small Office	Restaurant	Retail	Food	Non-Refrigerated Warehouse	Refrigerated Warehouse	School	College	Hospital	Hotel	Large Office	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 52: 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)											
	Small Office	Restaurant	Retail	Food	Non-Refrigerated Warehouse	Refrigerated Warehouse	School	College	Hospital	Hotel	Large Office	TOTAL
1	0.182	0.059	0.318	0.108	0.159	0.009	0.235	0.121	0.138	0.111	0.189	**1.630**
2	0.811	0.302	2.420	0.640	1.693	0.134	1.318	0.718	0.899	0.852	2.813	**12.601**
3	2.575	1.211	10.069	2.342	8.796	0.608	5.119	3.011	3.544	4.040	16.916	**58.233**
4	1.846	0.681	5.849	1.521	3.991	0.339	3.020	1.653	2.137	1.963	6.579	**29.578**
5	0.358	0.132	1.136	0.295	0.775	0.066	0.586	0.321	0.415	0.381	1.277	**5.743**
6	2.571	1.711	10.101	2.529	9.400	0.381	4.471	2.505	2.665	2.806	12.380	**51.519**
7	3.028	0.879	6.111	1.854	4.087	0.038	2.936	1.599	2.191	2.602	6.720	**32.044**
8	3.555	2.445	14.429	3.597	13.228	0.527	6.289	3.449	3.930	3.981	17.984	**73.414**
9	3.210	2.575	13.924	3.407	12.509	0.425	5.579	3.673	4.741	3.913	21.692	**75.648**
10	3.811	2.458	12.089	3.356	12.928	0.248	5.772	2.377	2.827	2.753	6.486	**55.104**
11	0.981	0.284	2.151	0.735	2.334	0.271	1.448	0.594	0.864	0.483	1.037	**11.183**
12	4.994	1.428	11.912	3.146	10.653	0.823	6.164	2.809	4.183	3.105	11.725	**60.940**
13	2.132	0.642	4.631	1.558	3.961	0.676	3.272	1.212	1.825	1.010	1.858	**22.776**
14	0.628	0.465	2.319	0.623	2.412	0.073	1.087	0.425	0.562	0.483	1.509	**10.586**
15	0.795	0.310	1.891	0.629	2.331	0.061	0.922	0.271	0.376	0.474	0.721	**8.780**
16	0.820	0.477	2.772	0.745	2.178	0.121	1.182	0.724	0.822	0.588	3.115	**13.544**
TOTAL	**32.298**	**16.060**	**102.123**	**27.085**	**91.434**	**4.799**	**49.400**	**25.463**	**32.119**	**29.544**	**113.000**	**523.324**

Table 53: 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 (Million ft^2)				Alterations in 2020 (Million ft^2)				GRAND TOTAL
	Small Offices	Large Offices	School	SUB-TOTAL	Small Offices	Large Offices	School	SUB-TOTAL	
1	0.062	0.069	0.083	0.214	0.182	0.189	0.235	0.606	**0.820**
2	0.263	1.044	0.412	1.719	0.811	2.813	1.318	4.943	**6.662**
3	0.859	6.928	1.513	9.300	2.575	16.916	5.119	24.610	**33.911**
4	0.587	2.343	0.931	3.860	1.846	6.579	3.020	11.445	**15.305**
5	0.114	0.455	0.181	0.750	0.358	1.277	0.586	2.222	**2.972**
6	0.788	4.366	1.000	6.154	2.571	12.380	4.471	19.422	**25.576**
7	1.055	2.200	1.076	4.331	3.028	6.720	2.936	12.684	**17.015**
8	1.097	6.392	1.459	8.947	3.555	17.984	6.289	27.828	**36.775**
9	1.076	8.623	1.480	11.179	3.210	21.692	5.579	30.481	**41.660**
10	1.233	2.170	2.066	5.469	3.811	6.486	5.772	16.068	**21.537**
11	0.349	0.412	0.538	1.299	0.981	1.037	1.448	3.466	**4.765**
12	1.871	4.504	2.197	8.571	4.994	11.725	6.164	22.883	**31.454**
13	0.757	0.790	1.191	2.738	2.132	1.858	3.272	7.262	**10.000**
14	0.201	0.544	0.376	1.121	0.628	1.509	1.087	3.223	**4.344**
15	0.270	0.272	0.380	0.922	0.795	0.721	0.922	2.438	**3.360**
16	0.278	1.247	0.406	1.931	0.820	3.115	1.182	5.116	**7.047**
TOTAL	**10.860**	**42.359**	**15.288**	**68.507**	**32.298**	**113.000**	**49.400**	**194.698**	**263.204**

Table 54: Translation from Forecast Climate Zone (FCZ) to Building Standards Climate Zone (BSCZ)

		Building Standards Climate Zone (BSCZ)															
		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 55: Description of Building Types and Sub-types (Prototypes) in Statewide Construction Forecast

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

Table 56: Converting from Forecast Climate Zone (FCZ) to Building Standards Climate Zone (BSCZ) – Example Calculation

Climate Zone	Total Statewide Small Office Square Footage in 2020 by FCZ (million ft^2) **[A]**	Conversion Factor FCZ to BSCZ 1 **[B]**	Small Office Square Footage in BSCZ 1 (million ft^2) **[C] = A x B**
1	0.204	22.5%	0.046
2	0.379	0.0%	0.000
3	0.857	0.0%	0.000
4	1.009	0.1%	0.001
5	0.682	0.0%	0.000
6	0.707	0.0%	0.000
7	0.179	0.0%	0.000
8	1.276	0.0%	0.000
9	0.421	0.0%	0.000
10	0.827	0.0%	0.000
11	0.437	0.0%	0.000
12	0.347	0.0%	0.000
13	1.264	0.0%	0.000
14	0.070	2.9%	0.002
15	0.151	0.0%	0.000
16	0.035	0.0%	0.000
Total	**8.844**	**N/A**	**0.049**

Table 57: 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**	N/A	N/A	N/A
Large offices	0.055	13%	0.014	0.069
Total	0.534	100%	**0.111**	0.534

Table 58: Statewide Energy and Energy Cost Impacts – Per Prototype for New Construction and Alterations – "Daylight Dimming Plus OFF" Measure

Building Type *Building Sub-type*	**Composition of Building Type by Sub-types** [a]	**Percent of Square Footage Impacted** [b]	
		New Construction	**Existing Building Stock (Alterations)** [c]
Small Office		100%	6.7%
Restaurant		100%	6.7%
Retail		100%	6.7%
Stand-Alone Retail	*10%*	*100%*	*6.7%*
Large Retail	*75%*	*100%*	*6.7%*
Strip Mall	*5%*	*100%*	*6.7%*
Mixed-Use Retail	*10%*	*100%*	*6.7%*
Food		100%	6.7%
Non-Refrigerated Warehouse		100%	6.7%
Refrigerated Warehouse		100%	6.7%
Schools		100%	6.7%
Small School	*60%*	*100%*	*6.7%*
Large School	*40%*	*100%*	*6.7%*
College		100%	6.7%
Small Office	*5%*	*100%*	6.7%
Medium Office	*15%*	*100%*	*6.7%*
Medium Office/Lab	*20%*	*100%*	*6.7%*
Public Assembly	*5%*	*100%*	*6.7%*
Large School	*30%*	*100%*	*6.7%*
High Rise Apartment	*25%*	*100%*	*6.7%*
Hospital		100%	6.7%
Hotel/Motel		100%	6.7%
Large Offices		100%	6.7%
Medium Office	*50%*	*100%*	*6.7%*
Large Office	*50%*	*100%*	*6.7%*

a. 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.

b. When the building type is comprised of multiple sub-types, the overall percentage for the main building category has been calculated by weighing the contribution of each sub-type.

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

Table 59: 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** [a]	**Percent of Square Footage Impacted** [b]	
		New Construction	**Existing Building Stock (Alterations)** [c]
Small Office		100%	6.7%
Restaurant		100%	6.7%
Retail		100%	6.7%
Stand-Alone Retail	*10%*	*100%*	*6.7%*
Large Retail	*75%*	*100%*	*6.7%*
Strip Mall	*5%*	*100%*	*6.7%*
Mixed-Use Retail	*10%*	*100%*	*6.7%*
Food		100%	6.7%
Non-Refrigerated Warehouse		100%	6.7%
Refrigerated Warehouse		100%	6.7%
Schools		100%	6.7%
Small School	*60%*	*100%*	*6.7%*
Large School	*40%*	*100%*	*6.7%*
College		100%	6.7%
Small Office	*5%*	*100%*	6.7%
Medium Office	*15%*	*100%*	*6.7%*
Medium Office/Lab	*20%*	*100%*	*6.7%*
Public Assembly	*5%*	*100%*	*6.7%*
Large School	*30%*	*100%*	*6.7%*
High Rise Apartment	*25%*	*100%*	*6.7%*
Hospital		100%	6.7%
Hotel/Motel		100%	6.7%
Large Offices		100%	6.7%
Medium Office	*50%*	*100%*	*6.7%*
Large Office	*50%*	*100%*	*6.7%*

a. 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.

b. When the building type is comprised of multiple sub-types, the overall percentage for the main building category has been calculated by weighing the contribution of each sub-type.

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

Table 60: Percent of Floorspace Impacted by Proposed Measure, by Building Type – "Manual ON Time-Switch" Measure

Building Type *Building Sub-type*	**Composition of Building Type by Sub-types** [a]	**Percent of Square Footage Impacted** [b]	
		New Construction	**Existing Building Stock (Alterations)** [c]
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%*

a. 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.

b. When the building type is comprised of multiple sub-types, the overall percentage for the main building category has been calculated by weighing the contribution of each sub-type.

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

Table 61: 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) [a]
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%

a. 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

The Statewide CASE Team collected input during the stakeholder outreach process on what compliance and enforcement issues may be associated with these measures. 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 approaches 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 Documents and NRCC documents 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 each job. The Statewide CASE Team recommends that 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 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. 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 consensus view expressed was the proposed code change would not increase the time or cost to complete the Automatic Daylighting Control Acceptance Test due to the proposed code change.

The Statewide 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 online survey are included in Appendix C.

As part of commissioning process of lighting controls, the Statewide CASE Team recommends to educate 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 suggested 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 contractor call backs. The Statewide CASE Team also recognizes the importance of educating building occupants about Manual ON time-switch controls if occupants are 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 any new occupant orientation communications.

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 as well as ways to minimize barriers to compliance.

Table 62: 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	• Design both indoor and outdoor lighting. • Ensure lighting and lighting design conform to Title 24 requirements and any other applicable code. • Serve as experts in lighting technology, both luminaires and controls; be knowledgeable about energy efficiency. • Fill out compliance documents and ensure everything is working properly. • Work with other team members, such as the Commissioning Agent, installer and Acceptance Test Technician (ATT), to ensure the system performs to owner specifications/needs. • Work from their office but be able to collect data/info from the site.	• Produce the lighting system design and the complete design compliance documents. New construction/major renovations produce (a) specifications (b) plan sets (c) compliance documents (NRCC LTI and LTO forms). Retrofits produce (a) a work order (b) compliance documents (NRCC-LTI and LTO forms. • Coordinate with manufacturers/dealers to know what products are available. • Coordinate with building owner to determine owner's needs and wants. • Coordinate with mechanical designers, architect, energy modeler, commissioning agent and plans examiner. • Create successful lighting system by designing to the building owner's specific needs (technologically, economically, etc.) and ensuring system is code-compliant. • Perform compliance such that it fits within workflow and does not create extra	• Establish clearer code requirements. • Clarify designation about whether or not products meet code requirements. • Simplify some aspects of work flow because of the alignment with ASHRAE 90.1.	The Statewide Codes and Standards Team recommends that the Compliance Manual include the following: • 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
		tasks; code & forms should be clear and quick to use.		
Contractor/Builder	• Follow the lighting design for new construction buildings; they do not necessarily understand the code or need to. • Generally, maintain a high level of technology expertise since they install and work with it. • Receive lighting designs and build the system in new construction buildings. • Perform work on-site.	• Remain responsible for following what is in the design – if they do not, the system can end up out of compliance. • Complete installation compliance documents. • Work with retailers/ distributors to buy the appropriate products. • Coordinate with the lighting designer/electrician to ensure the design is followed and stays in compliance and to buy the appropriate products. • Coordinate with the commissioning agent and ATT to ensure the design is followed and stays in compliance. • Finish the job, pass Cx or Acceptance Test, and complete inspection quickly. • Obtain a design that is clear and easy to understand so they can complete the work in the least amount of site visits.	• Allow builders and contractors to complete minimal/ simple paperwork that asks them for information they know.	The Statewide Codes and Standards Team recommends creating the following: • Documents explaining who contractors and builders 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	• Understand the code at least on a basic level, as they might be responsible for designing the lighting system, even though they might also play a similar role to contractor/builder and just follow lighting design on some projects. • Generally, maintain a high level of technology expertise since they install and work with it. • Design and build the lighting systems, or just receive lighting designs and build the system. • Perform work both on-site and in their office.	• If designing the system: ensure it follows the code and fill out design compliance documents. • If they are only building the system: follow what is in the design, since the system can end up out of compliance if they fail to do so, and complete installation compliance documents. • If designing the system: work with building owners and manufacturers to know what is on the market. • If building the system: buy from manufacturers and coordinate with the lighting designer/electrician/whoever designed the system, to ensure both that the design is followed and that it stays in compliance. • If building the system: buy the appropriate products. • If designing the system: achieve success by designing the system to the owner's specs and ensuring system is within compliance. • If building the system: achieve success by building the system to the design and ensuring it works properly.	• Clarify designation about whether or not products meet code requirements. • Allow electricians to complete minimal/ simple paperwork that asks them for information they know.	The Statewide Codes and Standards Team recommends creating the following: • 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 electricians' 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.

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
Acceptance Test Technician	• Test equipment to ensure it functions properly. • Pass or fail equipment and provide feedback.	• Coordinate with building owners/designers/plan checkers/building inspectors. • Quickly and easily determine if equipment is installed/functions correctly. • Quickly and easily provide comments that will resolve issues.	• Proposed changes to the automatic daylight dimming controls will change the Acceptance Test Technicians' work flow.	• Clear documentation of how the new code differs from the old in terms of changes to acceptance tests and changes/new equipment to test. • Clear documentation of what paperwork they need to receive and/or other tasks they need to perform.

Appendix C: Stakeholder Survey Results for Indoor Controls Measures

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

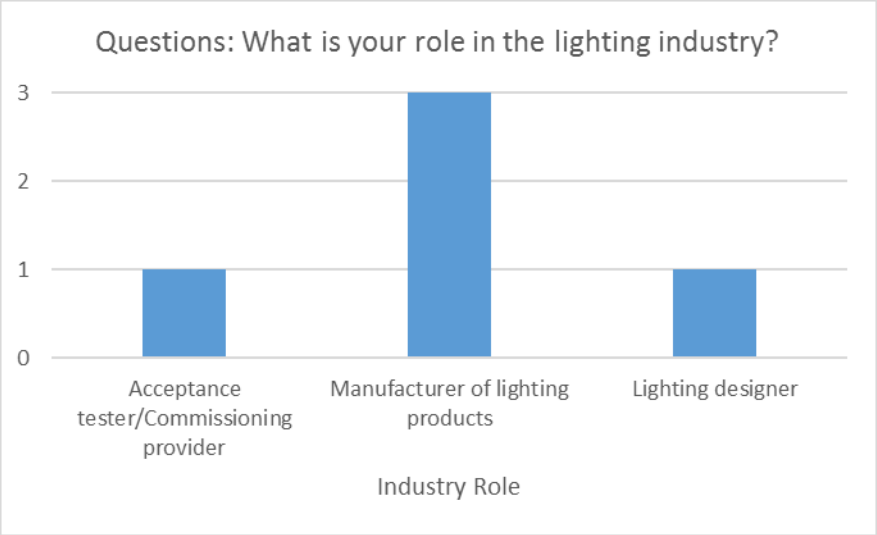

Figure 5: Stakeholder survey respondents' industry role.

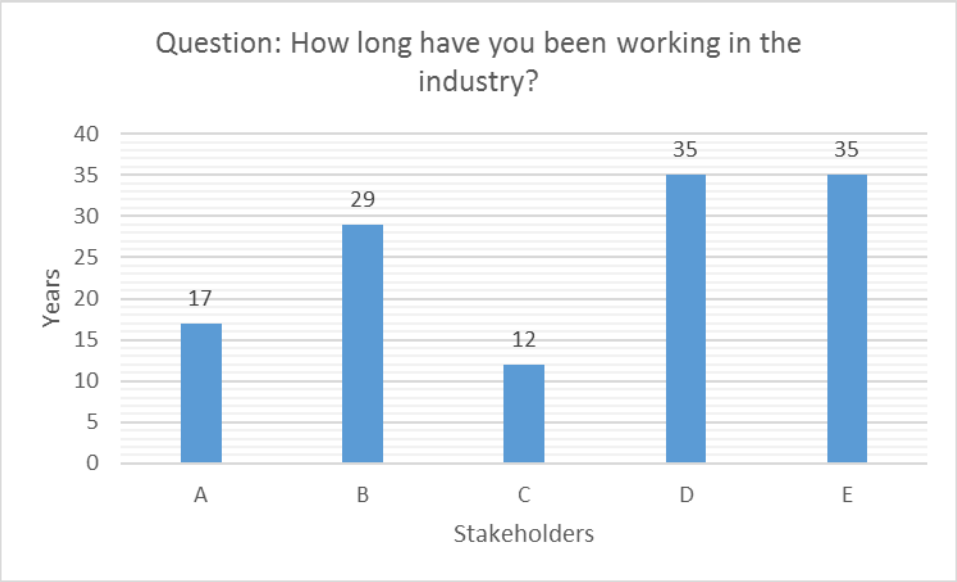

Figure 6: Stakeholder survey respondents' years of experience in lighting industry.

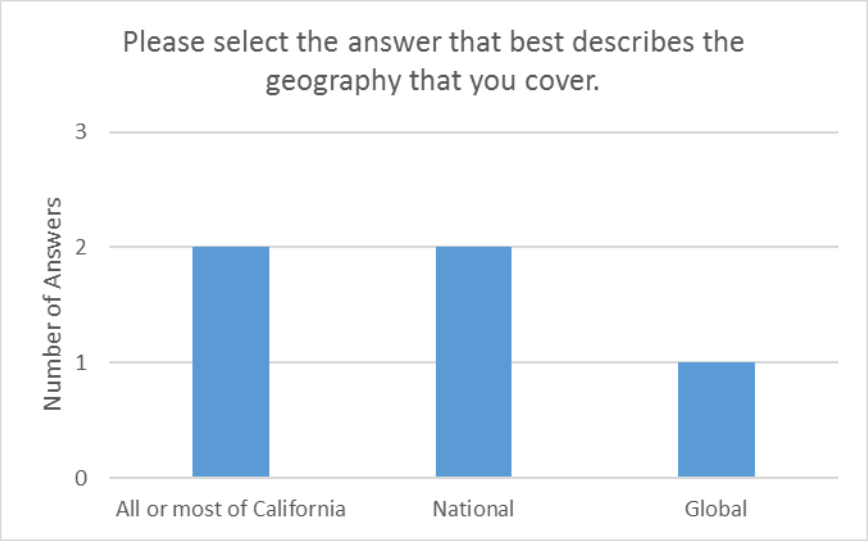

Figure 7: Stakeholder survey respondents' geography.

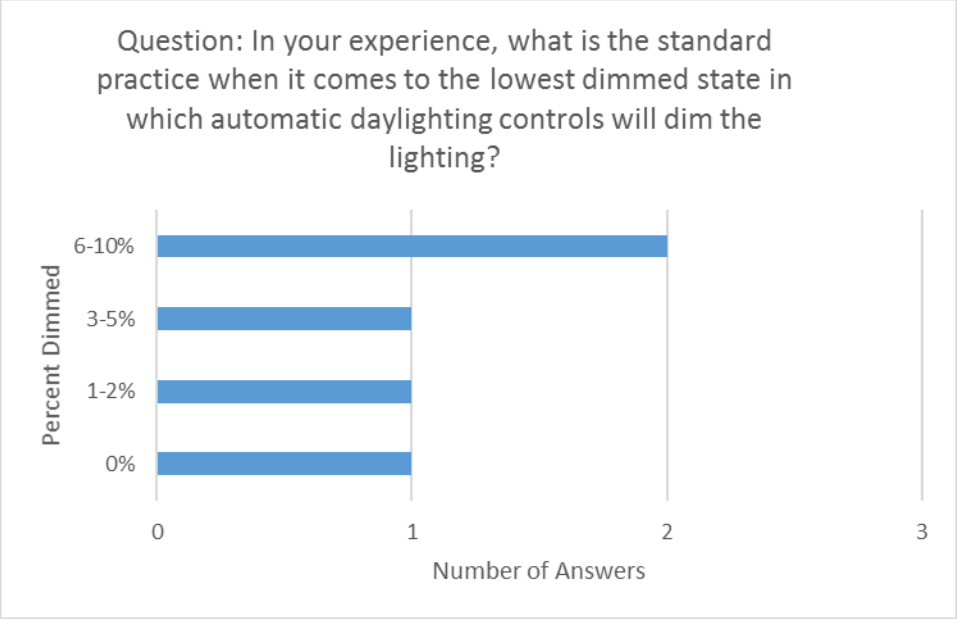

Figure 8: Standard practice for lowest dimmed state in which automatic daylighting controls dim the lighting.

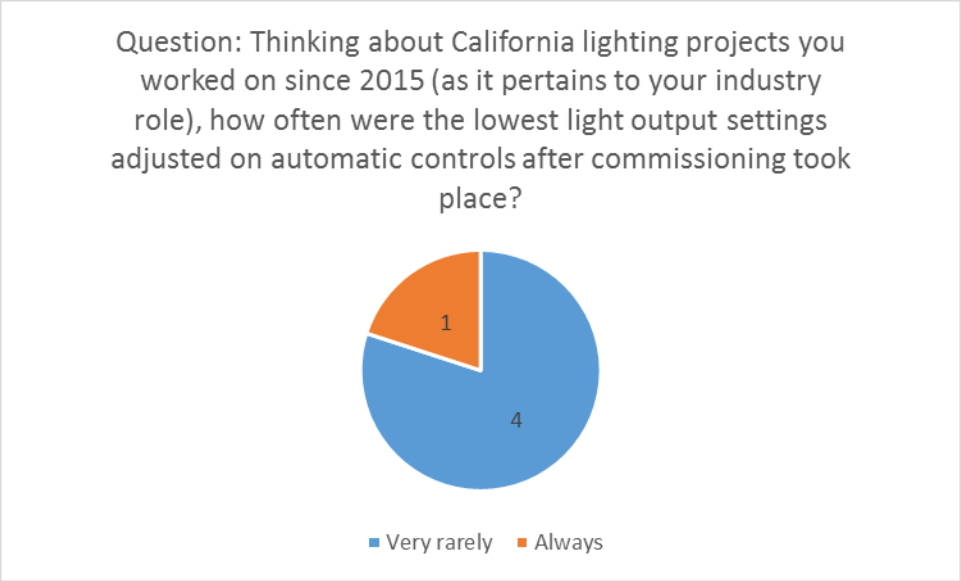

Figure 9: Frequency of adjusting automatic daylighting controls.

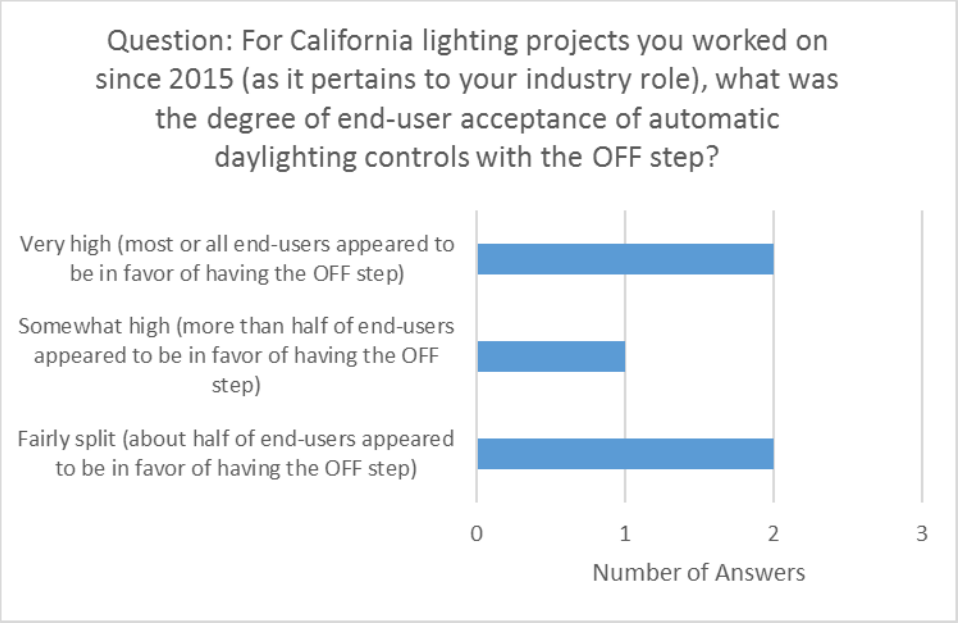

Figure 10: End-user acceptance of automatic daylighting controls with the OFF step.

Table 63: 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 64: 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%.				
Adjustment Type	**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 65: 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 into the secondary zone. The ATT should describe and photograph the conditions when it is not possible, instead of adding light to verify that the hardware works. Adding lighting or blocking out light just to pass the test is not effective.

Table 66: Occupant Sensing Lighting Controls in Restrooms by Building Type

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-government facilities)	Not appropriate	Appropriate	Appropriate	Appropriate	Appropriate
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 67: 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 68: Commissioning Automatic Time-Switch Controls by Building Type

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 (Fill in)	Storage closets	Gymnasiums, Multipurpose rooms, Malls, Arcades, and Retail store general lighting (non-display and sales oriented lighting)			

Table 69: 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
- Large Office
- Medium Office
- Small Office
- Large Retail
- Small School
- Non-Refrigerated Warehouse

Table 70: Building Prototype Descriptions and Adjustments for "Daylight Dimming Plus OFF" Measure

Building Prototype	Description	Adjustments
Small Hotel	• 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"
Large Office	• 12 story + 1 basement office building with 5 zones • Ceiling plenum on each floor • WWR-0.40	LPDs were updated to the 2019 proposed LPD values in the affected areas.
Medium Office	• Three-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.
Small Office	• 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.
Large Retail	• 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.
Small School	• 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)
Non-Refrigerated Warehouse	• One-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 for "Daylight Dimming Plus OFF" Measure

Table 71 through Table 77 present the first-year energy savings for each building prototype analyzed and for each climate zone.

Table 71: First-Year Energy Impacts – Per Square Foot for Small Hotel Building Prototype

Climate Zone	Annual Electricity Savings (kWh/ft^2)	Peak Electricity Demand Reductions (kW/ ft^2)	Annual TDV Energy Savings ($TDV\ kBtu/ ft^2$)
1	0.15	5.83×10^{-6}	3.12
2	0.15	5.73×10^{-6}	4.10
3	0.16	6.33×10^{-6}	3.87
4	0.15	5.34×10^{-6}	4.01
5	0.15	4.45×10^{-6}	3.53
6	0.17	4.75×10^{-6}	5.25
7	0.16	3.56×10^{-6}	4.85
8	0.16	3.95×10^{-6}	5.21
9	0.16	4.20×10^{-6}	4.88
10	0.15	3.76×10^{-6}	4.69
11	0.14	5.09×10^{-6}	4.16
12	0.14	5.39×10^{-6}	4.10
13	0.14	4.70×10^{-6}	3.83
14	0.15	3.36×10^{-6}	4.14
15	0.15	3.06×10^{-6}	4.94
16	0.14	4.94×10^{-6}	3.41

Table 72: First-Year Energy Impacts – Per Square Foot for Large Office Building Prototype

Climate Zone	Annual Electricity Savings (kWh/ft^2)	Peak Electricity Demand Reductions (kW/ ft^2)	Annual TDV Energy Savings ($TDV\ kBtu/ ft^2$)
1	0.74	5.78×10^{-5}	18.42
2	0.75	5.16×10^{-5}	19.96
3	0.75	5.13×10^{-5}	20.05
4	0.75	5.13×10^{-5}	20.05
5	0.76	4.06×10^{-5}	19.11
6	0.76	3.57×10^{-5}	20.65
7	0.75	2.85×10^{-5}	20.39
8	0.66	2.49×10^{-5}	19.01
9	0.74	3.48×10^{-5}	21.22
10	0.75	2.84×10^{-5}	20.57
11	0.68	4.86×10^{-5}	19.09
12	0.75	5.13×10^{-5}	20.65
13	0.75	4.39×10^{-5}	19.29
14	0.76	3.25×10^{-5}	21.46
15	0.76	2.94×10^{-5}	21.13
16	0.75	5.24×10^{-5}	18.74

Table 73: First-Year Energy Impacts – Per Square Foot for Medium Office Building Prototype

Climate Zone	Annual Electricity Savings (kWh/ft^2)	Peak Electricity Demand Reductions (kW/ ft^2)	Annual TDV Energy Savings ($TDV\ kBtu/ ft^2$)
1	0.21	1.63×10^{-5}	6.81
2	0.03	2.61×10^{-5}	9.36
3	0.22	1.44×10^{-5}	8.25
4	0.21	1.45×10^{-5}	9.27
5	0.20	1.08×10^{-5}	8.32
6	0.22	9.89×10^{-6}	10.28
7	0.21	7.94×10^{-6}	10.10
8	0.22	7.93×10^{-6}	10.88
9	0.24	1.12×10^{-5}	10.74
10	0.25	8.69×10^{-6}	10.27
11	0.24	1.72×10^{-5}	9.66
12	0.21	1.44×10^{-5}	9.42
13	0.21	1.23×10^{-5}	8.74
14	0.22	9.07×10^{-6}	9.98
15	0.22	8.32×10^{-6}	10.68
16	0.21	1.49×10^{-5}	7.74

Table 74: First-Year Energy Impacts – Per Square Foot for Small Office Building Prototype

Climate Zone	Annual Electricity Savings (kWh/ft^2)	Peak Electricity Demand Reductions (kW/ ft^2)	Annual TDV Energy Savings ($TDV\ kBtu/ ft^2$)
1	0.18	1.19 x 10-5	35.60
2	0.19	0.00E+00	38.56
3	0.19	1.16 x 10-5	36.40
4	0.19	8.92×10^{-6}	38.51
5	0.19	7.90×10^{-6}	36.21
6	0.20	6.79×10^{-6}	41.42
7	0.19	6.70×10^{-6}	39.55
8	0.20	8.16×10^{-6}	43.33
9	0.19	6.69×10^{-6}	43.03
10	0.19	1.13×10^{-5}	40.63
11	0.18	1.14×10^{-5}	38.30
12	0.19	9.49×10^{-6}	40.19
13	0.19	7.12×10^{-6}	37.38
14	0.18	6.41×10^{-6}	39.71
15	0.19	1.13×10^{-5}	40.09
16	0.18	1.12×10^{-5}	33.67

Table 75: First-Year Energy Impacts – Per Square Foot for Large Retail Building Prototype

Climate Zone	Annual Electricity Savings (kWh/ft^2)	Peak Electricity Demand Reductions (kW/ ft^2)	Annual TDV Energy Savings ($TDV\ kBtu/ ft^2$)
1	0.16	9.57×10^{-6}	3.52
2	0.15	9.04×10^{-6}	4.80
3	0.14	8.55×10^{-6}	3.71
4	0.12	9.31×10^{-6}	3.31
5	0.16	8.77×10^{-6}	4.20
6	0.21	6.98×10^{-6}	6.19
7	0.18	5.55×10^{-6}	5.98
8	0.19	5.95×10^{-6}	6.92
9	0.17	5.96×10^{-6}	5.61
10	0.15	5.09×10^{-6}	5.27
11	0.12	8.85×10^{-6}	4.46
12	0.15	1.08×10^{-6}	5.20
13	0.14	7.63×10^{-6}	4.68
14	0.13	5.13×10^{-6}	4.95
15	0.15	4.94×10^{-6}	6.90
16	0.11	8.54×10^{-6}	2.98

Table 76: First-Year Energy Impacts – Per Square Foot for Small School Building Prototype

Climate Zone	Annual Electricity Savings (kWh/ft^2)	Peak Electricity Demand Reductions (kW/ ft^2)	Annual TDV Energy Savings ($TDV\ kBtu/ ft^2$)
1	0.05	1.46×10^{-5}	3.64
2	0.26	2.55×10^{-5}	3.28
3	0.65	5.06×10^{-5}	2.76
4	0.80	6.17×10^{-5}	3.28
5	0.18	1.68×10^{-5}	2.82
6	0.24	1.93×10^{-5}	2.46
7	0.29	1.91×10^{-5}	2.84
8	0.24	1.48×10^{-5}	2.65
9	0.23	1.19×10^{-5}	2.82
10	0.24	1.44×10^{-5}	3.07
11	0.27	2.65×10^{-5}	4.59
12	0.25	2.66×10^{-5}	3.85
13	0.37	2.86×10^{-5}	3.28
14	0.26	1.61×10^{-5}	4.10
15	0.38	1.81×10^{-5}	4.12
16	0.27	2.80×10^{-5}	4.27

Table 77: First-Year Energy Impacts – Per Square Foot for Non-Refrigerated Warehouse Building Prototype

Climate Zone	Annual Electricity Savings (kWh/ft^2)	Peak Electricity Demand Reductions (kW/ ft^2)	Annual TDV Energy Savings ($TDV\ kBtu/ ft^2$)
1	2.69	1.73×10^{-4}	40.98
2	2.72	1.57×10^{-4}	52.29
3	2.72	1.57×10^{-4}	48.30
4	2.72	1.57×10^{-4}	54.06
5	2.72	1.39×10^{-4}	50.23
6	2.73	1.25×10^{-4}	59.46
7	2.72	9.49×10^{-5}	58.64
8	2.72	9.89×10^{-5}	63.32
9	2.72	1.23×10^{-4}	62.27
10	2.72	9.75×10^{-5}	59.05
11	2.69	1.54×10^{-4}	54.50
12	2.72	1.56×10^{-4}	55.20
13	2.71	1.44×10^{-4}	53.98
14	2.69	1.09×10^{-4}	59.73
15	2.70	9.66×10^{-5}	62.22
16	2.70	1.53×10^{-4}	46.68