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Codes and Standards Enhancement (CASE) Initiative 2022 California Energy Code

Nonresidential Daylighting

2022-NR-LIGHT1-F **|** Nonresidential Lighting **|** September 2020 FINAL CASE REPORT

Prepared by Energy Solutions

Please submit comments to info@title24stakeholders.com.

CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

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Executive Summary

This document presents recommended code changes that the California Energy Commission will be considering for adoption in 2021. If you have comments or suggestions prior to the adoption, please email info@title24stakeholders.com*. Comments will not be released for public review or will be anonymized if shared.*

Introduction

The Codes and Standards Enhancement (CASE) Initiative presents recommendations to support the California Energy Commission's (Energy Commission) efforts to update the California Energy Code (Title 24, Part 6) to include new requirements or to upgrade existing requirements for various technologies. Three California Investor Owned Utilities (IOUs) – Pacific Gas and Electric Company, San Diego Gas and Electric, and Southern California Edison – and two Publicly Owned Utilities – Los Angeles Department of Water and Power and Sacramento Municipal Utility District (herein referred to as the Statewide CASE Team when including the CASE Author) – 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 2022 Title 24 website for information about the rulemaking schedule and how to participate in the process: https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/2022-building-energy-efficiency.

The overall goal of this CASE Report is to present a code change proposal that would affect the daylighting controls requirements as they apply to nonresidential applications. The report contains pertinent information supporting the code change.

Measure Description

Background Information

Mandatory requirements for automatic daylighting controls were first introduced in the 2005 Title 24, Part 6 Standards. The daylighting control requirements were structured to accommodate the most common illumination technology solution available at the time: fluorescent sources with stepped dimming. Automatic daylighting controls were required to reduce light output of the general lighting by at least half when there was adequate daylighting. The automatic daylighting control requirements were refined in the 2008, 2013, and 2016 code cycles to adjust for changes in technology, address ambiguities, and simplify code compliance. Notably, for the 2013 code cycle, a requirement was added to clarify that multi-level lighting controls were mandatory in enclosed areas 100 square feet and larger with a connected lighting load greater than 0.5W/ft^2 (Section 130.1(b)), and that LED luminaires and LED sources must have the capability to continuously dim between 10 to 100 percent (Table 130.1-A). For the 2019 code cycle, lighting power densities (LPDs) were updated to use an LED baseline, which means LEDs have become the Standard Design and normal design practice. Nearly all spaces will have continuous dimming between 10 and 100 percent capabilities. The proposed code change would align the automatic daylighting control requirements with the capabilities of lighting systems that are commonly installed in nonresidential buildings today. Specifically, the code requirement would require that systems have the capability to dim down to 10 percent or lower as opposed to the current requirement of 35 percent.

The Statewide CASE Team often hears feedback from stakeholders that the code requirements are overly complex. This is particularly true for the lighting control requirements. The second proposed code change presented in this report would simplify the prescriptive lighting control requirements in response to stakeholders' requests.

Proposed Code Change

The Statewide CASE Team recommends two revisions to the daylighting controls requirements in Title 24, Part 6, as described below.

Daylight Dimming to 10 Percent

This proposed code change would update the mandatory automatic daylight dimming controls provisions to require deeper reductions in lighting power when illuminance levels are met with daylight. Current code requires general lighting power in the daylit zone to be reduced to 35 percent or less when daylight illuminance is greater than 150 percent of design illuminance. The proposed requirements would require general lighting power to be reduced to 10 percent or less when daylight illuminance is greater than 150 percent of design illuminance. There are no changes to the maximum daylight illuminance level at which lighting power has to be reduced by at least 90 percent.[1] This

[1] Illuminance is the amount of light on the surface of an area. Daylight illuminance is the amount of daylight on the surface of an area. For the automatic daylighting controls requirements to be triggered, the amount of sunlight, or daylight illuminance, that reaches the photosensor must exceed 150 percent of the design illuminance for general lighting of the space. Design illuminance is the light level that a space

measure leverages the proliferation of solid-state lighting and its dimming capability in the nonresidential sector and takes full advantage of the 10-100 percent dimming range that is already required for LED luminaires and sources found in Table 130.1-A of Title 24, Part 6. The existing mandatory requirements for automatic daylight dimming controls apply to new construction, additions, and alterations of nonresidential, high-rise residential, and hotel/motel buildings. The proposed changes would not apply to parking garages.

Currently, automatic daylighting controls are only required in rooms where the combined installed general lighting power in the Skylight Daylit Zone and Primary Sidelit Daylit Zone is 120 Watts or higher. American Society of Heating, Refrigerating and Air-Conditioning Engineers Standard 90.1 – Energy Standards for Buildings Except Low-Rise Residential Buildings 2019 edition (ASHRAE 90.1-2019) includes a similar threshold requirement wherein automatic daylighting controls are only required if the combined general lighting power is 150 Watts or higher. At the time this Final CASE Report was published, there is a pending revision to ASHRAE 90.1-2019 that would reduce the wattage threshold in 90.1 from 150W to 75W. This revision is expected to be approved by the full ASHRAE 90.1 committee in November 2020.[2] The Statewide CASE Team supports this revision and recommends that the Energy Commission align with the pending revision to ASHRAE 90.1 and require automatic daylighting controls when the combined general lighting power is 75W or higher. This proposed change would modify Exception 3 to Section 130.1(d). This report does not present supporting documentation for this proposed change, but the Statewide CASE Team is analyzing the cost effectiveness and energy savings associated with revising the wattage threshold requirement and will be provide results to the Energy Commission in advance of the Energy Commission's pre-rulemaking workshop where the revisions to daylighting requirements will be discussed.

The proposed code change does not update the prescriptive power adjustment factor (PAF) value for daylight dimming plus OFF controls in Section 140.6(a)2H. However, language has been updated to clarify that only continuous dimming systems qualify. Stepped dimming systems would not qualify for the daylight continuous dimming plus

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has been designed to have. General lighting refers to luminaires and lamps that are designed to provide overall lighting to a space, as opposed to task lighting which is designed to provide illumination for a specific need or task. As an example, if an office lighting system has been designed to deliver 10 foot-candles of general lighting to desk areas, the amount of daylight illuminance that needs to enter the space and reach the photosensor must be more than 15 foot-candles for the automatic daylighting controls to reduce power to the general lighting system.

[2] The proposed revisions to the wattage threshold for advanced daylighting controls in 90.1 were recommended in Addendum o to ASHRAE 90.1-2019. This addendum has gone through a public review period and was voted on by the full ASHRAE 90.1 committee in summer 2020. One additional full committee vote is required before the addendum is approved.

OFF credit. Language has also been updated so the PAF can now be applied to secondary sidelit daylit zones.

Mandatory Controls in Secondary Sidelit Daylit Zones

This proposed code change would move the prescriptive requirements for automatic daylighting controls in secondary sidelit daylit zones (SDZs) to Section 130.1, the mandatory indoor lighting controls section of Title 24, Part 6. Currently, the requirement for automatic daylighting controls in SDZs is the only prescriptive lighting control requirement. Stakeholders have reported there is confusion and uncertainty during the code compliance verification process as to whether controls in SDZs are required, particularly when the building complies using the performance approach where this is the only lighting control requirement that a designer could opt not to install as long as they achieve the required energy budget. Moving the requirements for controls in SDZs to the mandatory section would simplify the lighting control requirements and subsequently the compliance and enforcement process for lighting controls would be simplified and unambiguous. This change would also align the daylighting requirements in Title 24, Part 6 with daylighting requirements in ASHRAE 90.1, as similar secondary sidelit zone control requirements in ASHRAE 90.1 have been mandatory since the 2013 version. Finally, the proposed change would provide certainty about when daylighting controls in SDZs are required, which would make it more likely that lighting in SDZs are controlled with photocontrols.

Daylighting Controls Acceptance Test Cleanup

The proposed code change would update the Advanced Daylighting Controls Acceptance Tests to fix editorial errors and improve the technical feasibility of completing the test. The suggested revisions address stakeholders' comments that the existing test procedure is unclear and difficult or impossible to execute as written. Specifically, the proposed changes would:

1. Adjust procedures to verify and document that the lighting power reduction of controlled luminaires is at least 90 percent instead of 65 percent.
2. Fix numbering errors.
3. Adjust language and formatting to clearly depict the step where the "Reference Location" is identified. This is helpful because the Reference Location is mentioned multiple times throughout the remainder of the test procedure.
4. Allow the full daylight condition to be simulated by shining a bright light into the photosensor, which makes it easier for the technicians to complete the test.
5. Clarification that the automatic daylighting controls acceptance test is intended to be applied to the secondary sidelit daylit zone.

6. Add an alternative partial daylight test to address stakeholder concerns with the feasibility of using the current partial daylight test in all conditions, particularly in daylit spaces with dark glazing or small window areas.

Stakeholders have expressed similar concerns about the Advanced Daylighting Controls Acceptance Tests to the Energy Commission. In response the Energy Commission has developed suggested revisions to the tests. The Energy Commission stated their intent to update the tests during a public workshop held on March 10, 2020 (California Energy Commission 2020a) and released marked-up language for public review on August 13, 2020 (California Energy Commission 2020d). The Statewide CASE Team agrees with many of the improvements the Energy Commission has suggested, but suggests some additional clarifications that are discuseed in the body of this report.

Scope of Code Change Proposal

Table 1 summarizes the scope of the proposed changes and which sections of Standards, Reference Appendices, Alternative Calculation Method (ACM) Reference Manual, and compliance documents that would be modified as a result of the proposed change(s).

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	Would Compliance Software Be Modified	Modified Compliance Document(s)
Daylight Dimming to 10%	Mandatory	Section 130.1(d)	Nonresidential Appendix 7 Section NA 7.6.1	Yes	Yes
Mandatory Controls in Secondary Sidelit Daylit Zones	Mandatory	Sections 130.1(e) and 140.6(D)	No	Yes	Yes
Daylighting Controls Acceptance Test Cleanup	Acceptance Test	N/A	Nonresidential Appendix 7 Section NA 7.6.1	No	Yes

Market Analysis and Regulatory Assessment

The market for this measure is well established. Many manufacturers produce a plethora of products that can be used to meet the proposed requirements. The Statewide CASE Team found that as solid-state lighting technology advances, more manufacturers have added lighting controls to their product offerings. Likewise, more manufacturers are offering whole-building energy management solutions which include photocontrols and occupancy controls. Despite their wide availability and the presence of various requirements within state and national model energy codes, studies have shown a relatively low penetration rate of occupancy sensors and daylighting controls which indicates opportunity for energy savings.

The proposed measure would increase stringency of existing daylight dimming requirements in Title 24, Part 6 while simultaneously aligning with the existing continuous dimming requirements. Specifically, automatic daylighting controls are already required to dim to 35 percent; the proposal would require dimming to 10 percent. Likewise, Table 130.1-A requires LEDs to be capable of continuous dimming between 10 and 100 percent, so the proposed changes to daylight dimming would require use of the full dimming capability – to 10 percent. The proposed update would move the Title 24, Part 6 requirements into closer alignment with requirements in ASHRAE 90.1-2019, though Title 24, Part 6 would remain less stringent than ASHRAE 90.1. Beginning in 2013 version and continuing through the current version, ASHRAE 90.1 requires automatic daylight dimming to OFF, whereas this proposed update would require dim to 10 percent. There are no additional requirements in other parts of the California Building Code that are directly related. However, there are voluntary requirements in Title 24, Part 11 that encourage the use of daylight redirecting devices. Daylight redirecting devices increase daylight penetration into a space which is beneficial for spaces to achieve the 150 percent design light level required for the automatic daylight dimming to 10 percent to activate.

Cost Effectiveness

There are no additional costs associated with the proposed daylight dimming to 10 percent code change because LEDs are already required to dim to 10 percent. Since reducing lighting power to 10 percent will yield energy cost savings in all building types and climate zones, the proposed code change has an infinite B/C ratio in all climate zones. See the energy cost savings (benefit) of the proposed code change by building type and climate zone in Appendix H: . See Section 5 for methodology and assumptions.

A cost-effectiveness analysis is not needed to move the prescriptive requirements for automatic daylighting controls in SDZs to the mandatory section. This submeasure was already proven to be cost effective in order to be added to the prescriptive requirements (California Utilities Statewide Codes and Standards Team 2011).

Statewide Energy Impacts: Energy, Water, and Greenhouse Gas (GHG) Emissions Impacts

Table 2 presents the estimated energy and demand impacts of the proposed code change that would be realized statewide during the first 12 months that the 2022 Title 24, Part 6 requirements are in effect. First-year statewide energy impacts are represented by the following metrics: electricity savings in gigawatt-hours per year (GWh/yr), peak electrical demand reduction in megawatts (MW), natural gas savings in million therms per year (MMTherms/yr), and time dependent valuation (TDV) energy savings in kilo British thermal units per year (TDV kBtu/yr). See Section 6 for more details on the first-year statewide impacts calculated by the Statewide CASE Team. Section 4 contains details on the per-unit energy savings calculated by the Statewide CASE Team.

Table 2: First-Year Statewide Energy and Impacts

Measure	Electricity Savings (GWh/yr)	Peak Electrical Demand Reduction (MW)	Natural Gas Savings (MMTherms/yr)	TDV Energy Savings (million TDVkBtu/yr)
Daylight Dimming to 10%	55.5	0.8	(0.3)	1,209.5
New Construction	12.6	0.2	(0.1)	274.5
Additions and Alterations	42.9	0.6	(0.3)	935.0
Mandatory Controls in Secondary Sidelit Daylit Zones	N/A	N/A	N/A	N/A
Daylighting Controls Acceptance Test Cleanup	N/A	N/A	N/A	N/A

Table 3 presents the estimated avoided GHG emissions associated with the proposed code change for the first year the standards are in effect. Avoided GHG emissions are measured in metric tons of carbon dioxide equivalent (metric tons CO2e). Assumptions used in developing the GHG savings are provided in Section 6.2 and Appendix C: of this report. The monetary value of avoided GHG emissions is included in TDV cost factors and is thus included in the cost-effectiveness analysis.

Table 3: First-Year Statewide GHG Emissions Impacts

Measure	Avoided GHG Emissions (Metric Tons CO2e/yr)	Monetary Value of Avoided GHG Emissions ($2023)
Daylight Dimming to 10%	11,516	$1,223,006
Mandatory Controls in Secondary Sidelit Daylit Zones	N/A	N/A
Daylighting Controls Acceptance Test Cleanup	N/A	N/A

Water and Water Quality Impacts

The proposed measure is not expected to have any impacts on water use or water quality, excluding impacts that occur at power plants.

Compliance and Enforcement

Overview of Compliance Process

The Statewide CASE Team worked with stakeholders to develop a recommended compliance and enforcement process and to identify the impacts this process would have on various market actors. The compliance process is described in Section 2.5. Impacts that the proposed measure would have on market actors is described in Section 3.3 and Appendix E: . Automatic daylighting controls requirements have been in place since the 2005 code cycle and the proposed refinements to the requirements are minimal. Changes to the compliance process that has been in place for over a decade would be minimal.

Field Verification and Acceptance Testing

Automatic daylighting controls require acceptance testing as part of the code compliance process. The procedure is described in Section 7.6.1 of the Nonresidential Appendix, Automatic Daylighting Controls Acceptance Tests. The proposed code change would make minor revisions to the protocol to account for the requirement to dim to 10 percent. These methods are described in Section 2.5, Section 7.6, and Appendix E: .

1. Introduction

This document presents recommended code changes that the California Energy Commission will be considering for adoption in 2021. If you have comments or suggestions prior to the adoption, please email info@title24stakeholders.com. Comments will not be released for public review or will be anonymized if shared.

The Codes and Standards Enhancement (CASE) initiative presents recommendations to support the California Energy Commission's (Energy Commission) efforts to update the California Energy Code (Title 24, Part 6) to include new requirements or to upgrade existing requirements for various technologies. Three California Investor Owned Utilities (IOUs) – Pacific Gas and Electric Company, San Diego Gas and Electric, and Southern California Edison – and two Publicly Owned Utilities – Los Angeles Department of Water and Power and Sacramento Municipal Utility District (herein referred to as the Statewide CASE Team when including the CASE Author) – sponsored this effort. The program goal is to prepare and submit proposals that would result in cost-effective enhancements to improve energy efficiency and energy performance in California buildings. This report and the code change proposal 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 2022 Title 24 website for information about the rulemaking schedule and how to participate in the process: https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/2022-building-energy-efficiency.

The objective of this CASE Report is to recommend that existing mandatory daylight dimming controls requirements be updated such that systems must dim to 10 percent instead of 35 percent. This CASE Report also proposes moving existing prescriptive requirements for daylight dimming in secondary daylight zones to the mandatory section of code and contains pertinent information supporting these code changes.

When developing the code change proposal and associated technical information presented in this report, the Statewide CASE Team worked with a number of industry stakeholders including acceptance testing technicians, manufacturers, builders, utility incentive program managers, Title 24 energy analysts, and others involved in the code compliance process. The proposal incorporates feedback received during a public stakeholder workshop that the Statewide CASE Team held on September 5, 2019, and March 3, 2020.

The following is a brief summary of the contents of this report:

- Section 2 – Measure Description of this CASE Report describes the measure and its background. This section also presents how this code change is accomplished in the various sections and documents that make up the Title 24, Part 6 Standards.
- Section 3 – In addition to the Market Analysis, this section includes 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 – Energy Savings presents the per-unit energy, demand reduction, and energy cost savings associated with the proposed code change. This section also describes the methodology that the Statewide CASE Team used to estimate per-unit energy, demand reduction, and energy cost savings.
- Section 5 – This section includes a discussion of the materials and labor required to implement the measure and a quantification of the incremental cost. It also includes estimates of incremental maintenance costs, i.e., equipment lifetime and various periodic costs associated with replacement and maintenance during the period of analysis.
- Section 6 – First-Year Statewide Impacts presents the statewide energy savings and environmental impacts of the proposed code change for the first year after the 2022 code takes effect. This includes the amount of energy that would 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 by the state of California. Statewide water consumption impacts are also reported in this section.
- Section 7 – Proposed Revisions to Code Language concludes the report with specific recommendations with ~~strikeout~~ (deletions) and <u>underlined</u> (additions) language for the Standards, Reference Appendices, Alternative Calculation Manual (ACM) Reference Manual, Compliance Manual, and compliance documents.
- Section 8 – Bibliography presents the resources that the Statewide CASE Team used when developing this report.
- Appendix A: Statewide Savings Methodology presents the methodology and assumptions used to calculate statewide energy impacts.
- Appendix B: Embedded Electricity in Water Methodology presents the methodology and assumptions used to calculate the electricity embedded in

water use (e.g., electricity used to draw, move, or treat water) and the energy savings resulting from reduced water use.

- Appendix C: Environmental Impacts Methodology presents the methodologies and assumptions used to calculate impacts on GHG emissions and water use and quality.
- Appendix D: California Building Energy Code Compliance (CBECC) Software Specification presents relevant proposed changes to the compliance software (if any).
- Appendix E: Impacts of Compliance Process on Market Actors presents how the recommended compliance process could impact identified market actors.
- Appendix F: Summary of Stakeholder Engagement documents the efforts made to engage and collaborate with market actors and experts.
- Appendix G: Nominal Savings Tables presents the energy cost savings in nominal dollars by building type and climate zone.
- Appendix H: Per Unit Energy and Cost Results by Prototypical Building present energy savings per square foot for each prototypical building modeled and the 15-year energy cost savings associated with energy savings in 2023 present value dollars.

2. Measure Description

2.1 Measure Overview

The Statewide CASE Team recommends two revisions to the daylighting controls requirements in Title 24, Part 6, as described below.

2.1.1 Daylight Dimming to 10 Percent

This proposed code change would update the mandatory automatic daylight dimming controls provisions to require deeper reductions in lighting power when illuminance levels are met with daylight. Current code requires general lighting power in the daylit zone to be reduced to 35 percent or less when daylight illuminance is greater than 150 percent of design illuminance. [3] The proposed requirements would require general lighting power to be reduced to 10 percent or less. This proposed code change leverages the proliferation of solid-state lighting and its dimming capability in the nonresidential sector and takes full advantage of the 10-100 percent dimming range that is already required for LED luminaires and sources found in Table 130.1-A of Title 24, Part 6.

The existing mandatory requirements for automatic daylight dimming controls apply to new construction, additions, and alterations of nonresidential, high-rise residential, and hotel/motel buildings. The proposed changes would not apply to parking garages.

Currently, automatic daylighting controls are only required in rooms where the combined installed general lighting power in the Skylight Daylit Zone and Primary Sidelit Daylit Zone is 120 Watts or higher. American Society of Heating, Refrigerating and Air-Conditioning Engineers Standard 90.1 – Energy Standards for Buildings Except Low-Rise Residential Buildings 2019 edition (ASHRAE 90.1-2019) includes a similar threshold requirement wherein automatic daylighting controls are only required if the combined general lighting power is 150 Watts or higher. At the time this Final CASE Report was published, there is a pending revision to ASHRAE 90.1-2019 that would reduce the wattage threshold in 90.1 from 150W to 75W. This revision is expected to be

[3] Illuminance is the amount of light on the surface of an area. Daylight illuminance is the amount of daylight on the surface of an area. For the automatic daylighting controls requirements to be triggered, the amount of sunlight, or daylight illuminance, that reaches the photosensor must exceed 150 percent of the design illuminance for general lighting of the space. Design illuminance is the light level that a space has been designed to have. General lighting refers to luminaires and lamps that are designed to provide overall lighting to a space, as opposed to task lighting which is designed to provide illumination for a specific need or task. As an example, if an office lighting system has been designed to deliver 10 foot-candles of general lighting to desk areas, the amount of daylight illuminance that needs to enter the space and reach the photosensor must be more than 15 foot-candles for the automatic daylighting controls to reduce power to the general lighting system.

approved by the full ASHRAE 90.1 committee in November 2020.[4] The Statewide CASE Team supports this revision and recommends that the Energy Commission align with the pending revision to ASHRAE 90.1 and require automatic daylighting controls when the combined general lighting power is 75W or higher. This proposed change would modify Exception 3 to Section 130.1(d). This report does not present supporting documentation for this proposed change, but the Statewide CASE Team is analyzing the cost effectiveness and energy savings associated with revising the wattage threshold requirement and will be provide results to the Energy Commission in advance of the Energy Commission's pre-rulemaking workshop where the revisions to daylighting requirements will be discussed.

The proposed code change does not update the prescriptive power adjustment factor (PAF) value for daylight dimming plus OFF controls in Section 140.6(a)2H. However, language has been updated to clarify that only continuous dimming systems qualify. Stepped dimming systems would not qualify for the daylight continuous dimming plus OFF credit. Language has also been updated so the PAF can now be applied to secondary sidelit daylit zones.

2.1.2 Mandatory Controls in Secondary Sidelit Daylit Zones

This proposed code change would move the prescriptive requirements for automatic daylighting controls in secondary sidelit daylit zones (SDZs) to Section 130.1, the mandatory indoor lighting controls section of Title 24, Part 6. Currently, the requirement for automatic daylighting controls in SDZs is the only prescriptive lighting control requirement. Since this is the only prescriptive lighting control requirement, stakeholders have reported there is confusion and uncertainty during code compliance verification process whether controls in SDZs are required, particularly when the building complies using the performance approach where this is the only lighting control requirement that a designer could opt not to install as long as they achieve the required energy budget. Moving the requirements for controls in SDZs to the mandatory section would simplify the lighting control requirements and subsequently the compliance and enforcement process for lighting controls. This change would also align the daylighting requirements in Title 24, Part 6 with daylighting requirements in ASHRAE 90.1. Finally, the proposed change would provide certainty about when daylighting controls in SDZs are required, which would make it more likely that lighting in SDZs are controlled with photocontrols.

[4] The proposed revisions to the wattage threshold for advanced daylighting controls in 90.1 were recommended in Addendum o to ASHRAE 90.1-2019. This addendum has gone through a public review period and was voted on by the full ASHRAE 90.1 committee in summer 2020. One additional full committee vote is required before the addendum is approved.

2.1.3 Daylighting Controls Acceptance Test Cleanup

The proposed code change would update the Advanced Daylighting Controls Acceptance Tests to fix editorial errors and improve the technical feasibility of completing the test. The suggested revisions address stakeholders' comments that the existing test procedure is unclear and difficult or impossible to execute as written. Specifically, the proposed changes would:

7. Adjust procedures to verify and document that the lighting power reduction of controlled luminaires is at least 90 percent instead of 65 percent.
8. Fix numbering errors.
9. Adjust language and formatting to clearly depict the step where the "Reference Location" is identified. This is helpful because the Reference Location is mentioned multiple times throughout the remainder of the test procedure.
10. Allow the full daylight condition to be simulated by shining a bright light into the photosensor, which makes it easier for the technicians to complete the test.
11. Clarification that the automatic daylighting controls acceptance test is intended to be applied to the secondary sidelit daylit zone.
12. Add an alternative partial daylight test to address stakeholder concerns with the feasibility of using the current partial daylight test in all conditions, particularly in daylit spaces with dark glazing or small window areas.

Stakeholders have expressed similar concerns about the Advanced Daylighting Controls Acceptance Tests to the Energy Commission. In response the Energy Commission has developed suggested revisions to the tests. The Energy Commission stated their intent to update the tests during a public workshop held on March 10, 2020 (California Energy Commission 2020a) and released marked-up language for public review on August 13, 2020 (California Energy Commission 2020d). The Statewide CASE Team agrees with many of the improvements the Energy Commission has suggested, but suggests some additional clarifications that are discuseed in the body of this report.

2.2 Measure History

2.2.1 Daylight Dimming to 10 Percent

Mandatory requirements for automatic daylighting controls were first introduced in the 2005 Title 24, Part 6 Standards. The daylighting control requirements were structured to accommodate the most common illumination technology solution that was available at the time: fluorescent sources with stepped dimming. Automatic daylighting controls were required to reduce light output of the general lighting by least half when there was adequate daylighting. The automatic daylighting control requirements were refined in the 2008, 2013, and 2016 code cycles to adjust for changes in technology, address ambiguities, and simplify code compliance. Several of these multi-cycle refinements have a connection to the proposals in this report.

In the 2008 Standards, the automatic daylighting controls requirements were updated to require that lighting output be reduced by at least 35 percent when adequate daylighting is available. This requirement has not been updated since this code iteration, even though lighting and controls technologies have evolved over the past decade.

In the 2013 Title 24, Part 6 Standards, the requirements for automatic daylighting controls were simplified significantly. As described in the 2013 CASE Report on nonresidential daylighting for the 2013 code, a wattage calculation method was introduced to simplify the method to calculate the savings from daylighting controls (California Utilities Statewide Codes and Standards Team 2011). Compliance processes were simplified further by addressing the threshold that triggered photocontrol requirements. Table 130.1-A was also added in the 2013 code cycle and included the requirements for LEDs to have the capability to continuously dim between 10 to 100 percent.

In the 2016 Title 24, Part 6 code cycle, requirements for the access to the calibration adjustment controls for photocontrol systems were updated to prevent tampering with the photosensor and to allow calibration controls to be readily accessible so authorized personnel can make adjustments to daylighting controls in response to changes such as revisions to interior geometry, reflectance, changes in occupancy, or occupant requests for more or less light.

In addition, the 2016 Title 24, Part 6 Standards added a PAF for daylighting controls that include the OFF step (i.e., controls that turn OFF lights when enough daylight is available). The goal of the new optional PAF was to prepare the market for this control strategy as a mandatory measure in the 2019 code cycle. These revisions are described in the 2016 CASE Report on nonresidential lighting controls (California Utilities Statewide Codes and Standards Team 2017).

In the 2019 Title 24, Part 6 code cycle, definitions of daylit spaces were updated. The Statewide CASE Team also pursued a code change proposal that would have updated the mandatory automatic daylighting control requirements such that luminaires in daylit zones would need to include an OFF setting when sufficient daylighting was available. The 2019 CASE Report on nonresidential indoor lighting controls includes a submeasure, “mandatory automatic daylight dimming plus OFF controls.” This report explores the technical feasibility, market readiness, energy savings, and cost effectiveness of a mandatory dimming plus OFF requirement. As discussed in the report, the Statewide CASE Team found that dimming plus OFF was technically feasible and cost effective (California Utilities Statewide Codes and Standards Team 2017).

In response to the Statewide CASE Team's proposal for the 2019 code cycle, some stakeholders stated that adding an OFF setting implied the need for architectural dimming systems, which have continuous dimming to one percent or lower and is more expensive than standard dimming technology. However, the Statewide CASE Team did not intend to require architectural dimming. The intent was to have an OFF setting, but not continuous dimming all the way to OFF. The Statewide CASE Team interviewed industry experts to gather more information on the cost and reliability issues associated with daylight dimming plus OFF. Through these interviews, the Statewide CASE Team verified that the cost and time required to dim plus OFF were not significantly greater than those required to dim to power levels below 35 percent. Some experts attested, though, that dimming plus OFF could jeopardize the long-term reliability of lighting systems due to line noise and frequent high/low cycling.

Other stakeholders raised concerns regarding building occupant confusion and/or dissatisfaction resulting from daylight dimming plus OFF in office buildings, classrooms, and other areas where users expect to have more control over their electric lighting. These stakeholders argued that in buildings with indoor lights that dimmed and turned OFF, building occupants may be inclined to believe that the lighting system was malfunctioning when dimmed and then shut OFF and potential disable the entire daylight dimming system. Due to concerns regarding both cost and occupant confusion, the Energy Commission did not adopt the Statewide CASE Team's proposal for mandatory automatic daylight dimming plus OFF controls in the 2019 code cycle.

When considering code change proposals for the 2022 code cycle, the Statewide CASE Team continued investigations into market acceptance concerns raised during the 2019 code cycle with the intent of finding assurance that market actors in California would feel comfortable with a plus OFF requirement similar to what has been ASHRAE 90.1 for several code cycles. The Statewide CASE Team conducted outreach to manufacturers, contractors, designers, and acceptance test technicians (ATTs). Specifically, the Statewide CASE Team asked over three dozen manufacturers, contractors, designers and other stakeholders for their feedback daylight harvesting[5] when attending LightFair 2019, Strategies in Light, Design Light Expo, and LightShow West. The Statewide CASE Team also worked with California Lighting Technology Center (CLTC) who conducted research and stakeholder outreach, including discussions with the California Energy Alliance.[6] Finally, the Statewide CASE Team conducted a survey of ATTs and asked for feedback during the first utility-sponsored stakeholder meeting held on September 5, 2020 (Statewide CASE Team 2019).

[5] Daylight harvesting refers to strategies for using daylighting to offset the amount of electric lighting needed. Daylight dimming plus OFF is an example of a daylight harvesting strategy.

[6] California Energy Alliance's website can be found here: https://caenergyalliance.org/.

The continued investigation into the dimming plus OFF requirements aimed to:

- Confirm that dimming plus OFF (without architectural dimming) is technically feasible and cost-effective.
- Find quantitative data to determine building occupants' satisfaction with daylighting dimming plus OFF.
- Identify a solution to concerns that building occupant confusion and/or dissatisfaction would result in daylighting controls being disabled, should it occur.

The Statewide CASE Team has confirmed findings in the 2019 CASE Report that dimming plus OFF is technically feasibility and cost effective. Despite a significant attempt, the Statewide CASE Team did not find qualitative data indicating dissatisfaction with daylight dimming plus OFF controls. There were no specific examples, anecdotal or qualitative, to determine that dimming plus OFF yields occupant dissatisfaction. Outreach did reveal, however, that some stakeholders contend that building occupants would be confused by a dimming plus OFF system. Some stakeholders also reported an aversion for dimming plus OFF and noted that designer/specifier prefer architectural dimming and may elect architectural dimming to comply with a dimming plus OFF requirement despite the additional costs.

Despite hearing anecdotal evidence that both supported and refuted claims that the plus OFF step would face market acceptance challenges, with the absence of quantitative data the Statewide CASE Team cannot offer concrete evidence that market acceptance concerns are resolved. As a result, the Statewide CASE Team is pursuing a code change that would expand the automatic daylighting control requirements to require deeper power reductions (90 percent reduction in power or 10 percent power remaining).

2.2.2 Mandatory Controls in Secondary Sidelit Daylit Zones

When speaking with stakeholders about potential revisions to the daylighting requirements, the Statewide CASE Team received confirmation that moving the automatic daylighting control requirements for SDZs to the mandatory section would make the code easier to understand and comply with. Currently, to understand automatic daylighting controls requirements readers must go through multiple sections to comprehend all the requirements. This results in perceived complexity with the daylighting section of the code. Moving the prescriptive requirement for secondary daylighting controls to the mandatory section will reduce code complexity.

2.2.3 Daylighting Controls Acceptance Test Cleanup

The Automatic Daylighting Controls Acceptance Test aims to deploy a simple methodology to confirm that the required automatic daylighting controls are installed and that they are functioning correctly to meet the intent of the code requirements. The functional component of the acceptance tests verifies that controls: 1) reduce lighting power by the required amount when there is full daylight, and 2) do not over- or under-dim when there is partial daylight. Full daylight is the condition when there is 150 percent of the no-daylight electric lighting illuminance value in the space. Over-dimming during partial daylight conditions can result in the space being darker during the day than it would be at night (i.e., no daylighting) with the lights on. Under-dimming can result in over-lit spaces and diminishes the energy savings from the controls.

To verify that lighting power is reduced by 90 percent or more during full daylight conditions and that lights are not over- or under-dimmed during partial daylight conditions, the technician completes tests at three conditions as described below. The current acceptance test provides unique test methodologies for each of the three daylight conditions for continuous dimming systems (tests described in NA7.6.1.2.1) and stepped switching or stepped dimming control systems (tests described in NA7.6.1.2.2).

1. **No Daylight Test**: The No Daylight Test is conducted at night or with the blinds drawn and skylights covered during the day. This test confirms the electric lighting is providing the full output and there are no inadvertent calibration problems. The test accounts for modifications to full output for intentional calibration for high-end trim. This test defines the Reference Illuminance, which is the minimum amount of total illuminance (electric lighting and daylight) that should be available.
2. **Full Daylight Test:** The Full Daylight Test confirms whether the daylighting control functions. During this test, high levels of daylight are brought into the room. This test confirms that the system will reduce lighting power by the correct amount. For the 2019 code, lighting power must be reduced by 65 percent or more. The proposed code change would require lighting power to be reduced by at least 90 percent or turn off at high daylight levels. Some lights might flicker when dimmed to their minimum setting. If flicker is observed, it should be fixed. If the flicker is not fixed, occupants may become annoyed and disable the dimming system. The Statewide CASE Team recommends a modification to this test that would allow technicians to simulate high daylight levels by shining a bright light into the photocontrol sensor. This revision makes it feasible for the technician to complete the test even if full daylighting is not available when they are on site.
3. **Partial Daylight Test.** The Partial Daylight Test is used to confirm the control gain (the ratio of electric power reduction to the total illuminance sensed by the photocontrol) is adjusted correctly. Setting the gain too high will result in the electric lighting over-dimming during the day, leaving people with less light than they would have when there is no daylighting (e.g., at night). Setting the gain too

low would result in minimal dimming, which would reduce the energy savings potential of the system. To conduct the Partial Daylight Test, there should be a relatively high amount of daylight in the space so the effect on the control gain is readily observable. However, having too much daylight in the space makes it difficult to evaluated whether the control is dimming enough during typical daylight conditions. Currently, the Partial Daylight Test requires that at the Reference Location (opposite side of sidelit zones from windows) the interior daylight illuminance is between 60 and 95 percent of the electric lighting design illuminance. The purpose of this limitation it to assist in verifying that the gain of the daylighting controls is neither too high and underlighting the space nor too low and not saving enough energy.

Lighting ATTs have provided feedback that the current criteria that defines acceptable partial daylight conditions (i.e., daylight illuminance between 60 and 95 percent for electric lighting design illuminance) makes it extremely difficult or impossible to conduct the Partial Daylight Test for daylit spaces with dark glazing or small window areas. This problem is compounded when attempting to conduct the Partial Daylighting Test for the secondary sidelit daylit zone where the Reference Location is approximately twice as far away from windows than the Reference Location for the primary sidelit zone, thus even less daylight is available to confirm the controls for the secondary sidelit zone are functioning as required.

To address this problem, the Statewide CASE Team is recommending adding an Alternative Partial Daylight Test that could be used for continuous dimming control systems. This additional optional test does not place any limitation on using the current Partial Daylight Test. Rather, it provides an additional option that technicians can use in any building and may be particularly useful for daylit spaces with dark glazings or small window areas. The Alternative Partial Daylight Test provides additional flexibility while retaining the key characteristics of the existing Partial Daylight Test.

The Alternative Partial Daylight Test uses a different metric to determine if there is sufficient illuminance to complete the test. It also uses a different approach to determine if the combined electric lighting and daylight illuminance at the Reference Location is within an appropriate range. Both of these alternatives are discussed below.

The current Partial Daylight Test for continuous dimming systems uses indoor illuminances at the Reference Location to define whether daylight conditions are sufficient to complete the test. Specifically, daylight illuminance must be between 65 percent and 95 percent of the Reference Illuminance. The proposed Alternative Daylight Test would use outdoor horizontal illuminance to determine if there is sufficient daylight illuminance to conduct the test. Specifically, the test would require that the total horizontal ambient illuminance outdoors is greater than 4,000 foot-candles and the indoor illuminance at the Reference Location is less than 95 percent of the Reference

Illuminance. This outdoor illuminance level is achieved several hours per day in the winter when there are clear skies and most of the day other times of year under clear skies.

To establish this revised approach to determine if there is sufficient daylight to complete the test, the Stateside CASE Team conducted a spreadsheet analysis to evaluate the annual clear sky illuminances using the equations in a clear sky model (Gillette G. 1984). The spreadsheet evaluates the application of sufficient illumination and frequency trade-offs with this alternative test method. This model is a function of latitude and sun angle and includes both direct beam and diffuse daylight components. It tabulates the clear sky total illuminance by hour over the range that would be experienced over a year. Results are presented in Table 4. The shaded cells indicate the hours that illuminance is higher than the proposed threshold criteria of 4,000 total horizontal foot-candles. This threshold meets the desire to have a criteria that allows the test to be conducted any time of year as long as the sky is clear and at around half of typical middle of the day illuminances. The ambient daylight is large enough to provide enough interior daylight to result in a measurable change in the controlled lighting system power or light output for a successful use of the Partial Daylight Test. This proposal would expand the range of applications where the Partial Daylight Test could be conducted using ambient daylight for this test.

Figure 1 depicts the current acceptance test, including the text conditions and compliant illuminance ranges for the No Daylight Test, Full Daylight Test, and Partial Daylight Test.

As shown in Figure 2, the daylight illuminance in the space at the Reference Location can be much lower using the Alternative Partial Daylight Test than the current Partial Daylight Test.

Table 4: 1984 Clear Sky Model; Total Horizontal Illuminance by Hour of Day for Winter and Summer Solstice and Spring and Fall Equinox

Hour	Total Horizontal Illuminance on Winter Solstice (fc)	Total Horizontal Illuminance on Fall and Spring Equinox (fc)	Total Horizontal Illuminance on Summer Solstice (fc)
1	0	0	0
2	0	0	0
3	0	0	0
4	0	0	0
5	0	0	0
6	0	0	372
7	0	1,040	1,784
8	644	3,093	3,840
9	2,066	5,118	5,889
10	3,430	6,762	7,696
11	4,348	7,869	9,113
12	4,699	8,353	10,036
13	4,447	8,178	10,400
14	3,618	7,357	10,181
15	2,313	5,953	9,393
16	841	4,082	8,091
17	0	1,968	6,370
18	0	362	4,365
19	0	0	2,278
20	0	0	589
21	0	0	0
22	0	0	0
23	0	0	0
24	0	0	0

Note: Hours where the total horizontal illuminance is over the proposed threshold criteria of 4,000 total horizontal foot-candles are highlighted in yellow.

Source: (Gillette G. 1984)

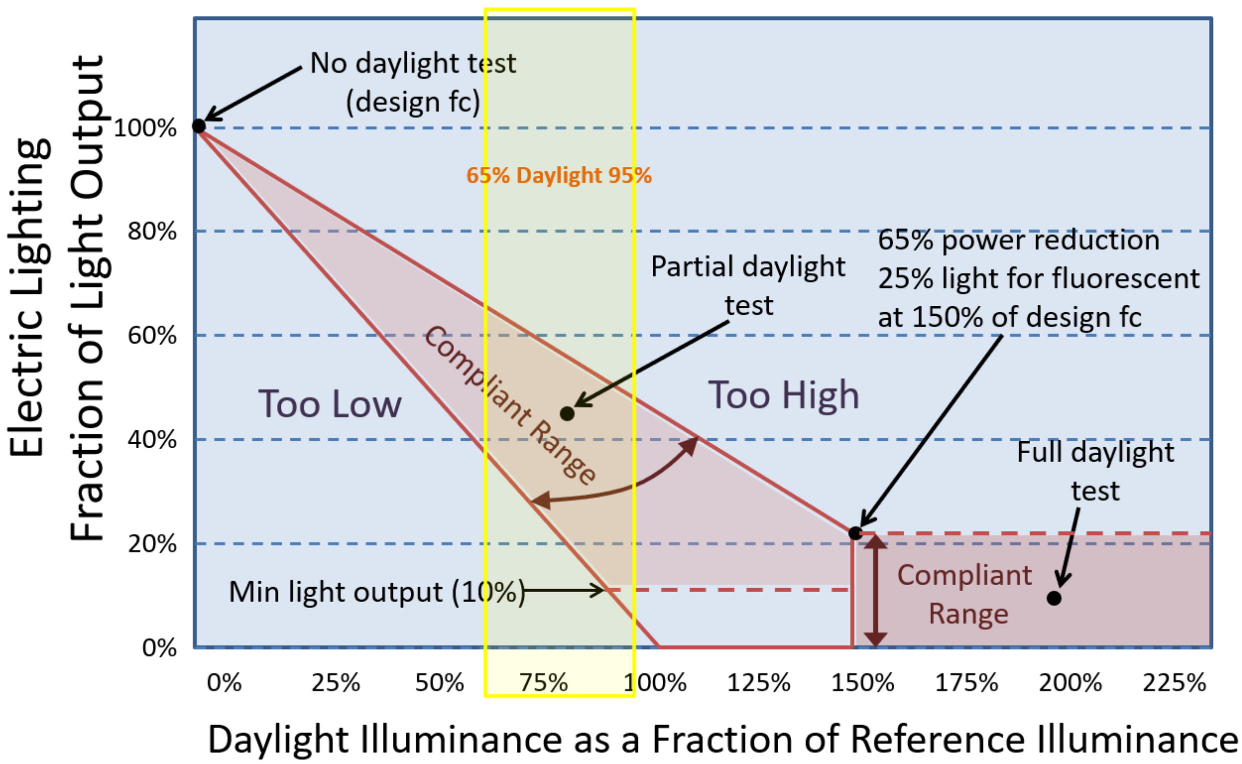

Figure 1: 2019 Code: Daylighting Controls Compliant Ranges of Electric Lighting Output Relative to Daylight Fraction of Reference Illuminance

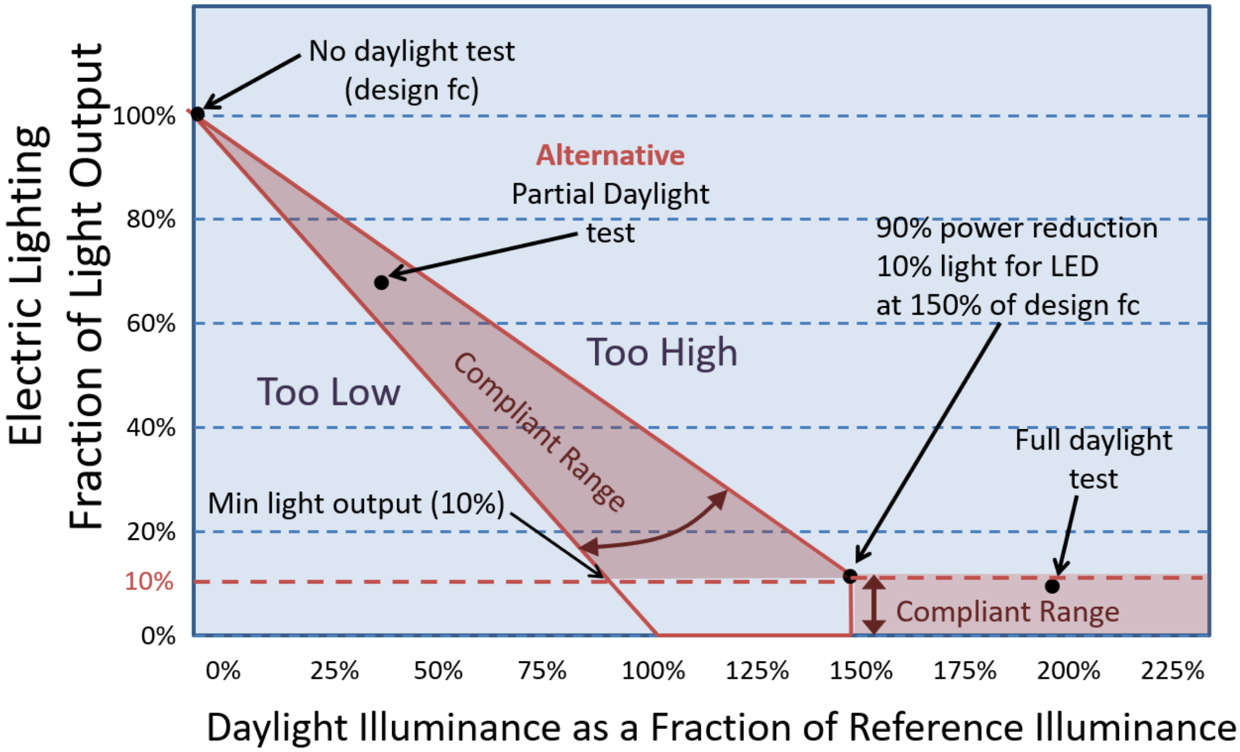

Figure 2: Proposed Alternative Partial Daylight Test: Daylighting Controls Compliant Ranges of Electric Lighting Output Relative to Daylight Fraction of Reference Illuminance for Continuous Dimming to 10 percent

Under the current Partial Daylight Test for continuous dimming systems, complying dimming systems must have a combined electric lighting and daylight illuminance at the Reference Location that is between the Reference Illuminance and 150 percent of the Reference Illuminance. The acceptable range confirms that the space will not be darker in the day than in the night and that electric lights will be dimmed somewhat to achieve energy savings (see Figure 2).

Under the proposed Alternate Partial Daylight Test, complying dimming systems must have a combined electric lighting and daylight illuminance at the reference location that is between the reference illuminance and a partial dimming combined illuminance maximum (PDCI Max), that is:

PDCI Max = Reference Illuminance + 0.40 X Daylight Illuminance.

The rationale behind the equation for PDCI Max can be observed from the PDCI Max line in Figure 3. This represented the combined light output of daylight and a LED that is continuously dimming from full output (reference illuminance) when no daylight is available to 10 percent light output when daylight is providing 150 percent of the reference illuminance. At full dimming, the combined illuminance is 160 percent of the reference illuminance. All points in between are interpolated.

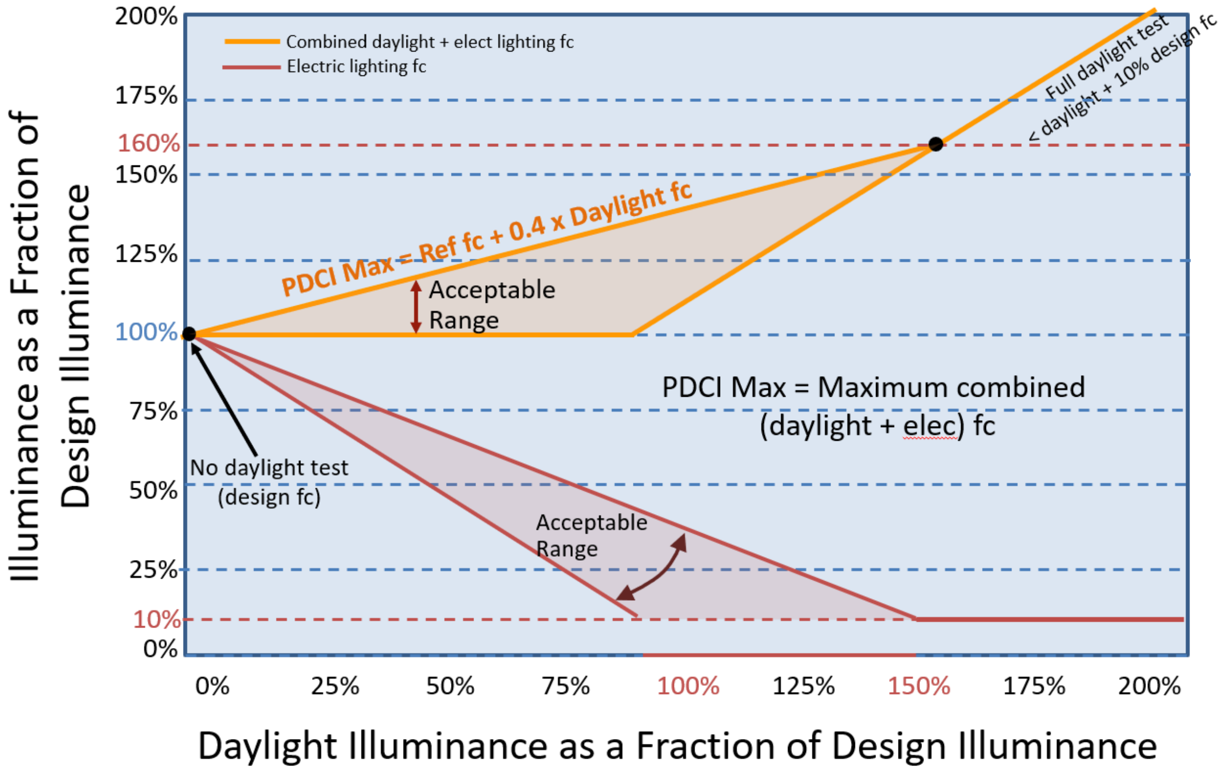

Figure 3: Proposed Alternative Partial Daylight Test: Daylighting Controls Compliant Electric Lighting Output and Combined Illuminance Relative to Daylight Fraction of Reference Illuminance for Continuous Dimming to 10%

2.3 Summary of Proposed Changes to Code Documents

The sections below summarize how the standards, Reference Appendices, Alternative Calculation Method (ACM) Reference Manuals, and compliance documents would be modified by the proposed change. See Section 7 of this report for detailed proposed revisions to code language.

2.3.1 Summary of Changes to the Standards

This proposal would modify the following sections of Title 24, Part 6, as shown below. See Section 7.2 of this report for marked-up code language.

— **SECTION 100.1 – Definitions and Rules of Construction**

- **Section 100.1(b)1-2:** A definition of "Daylight Continuous Dimming Control". This change is necessary to clarify the type of daylight control that is required to calim the dim to OFF PAF.

— **SECTION 130.1 – Mandatory Indoor Lighting Controls**

- **Section 130.1(d):** The purpose of this change is to move the prescriptive requirements for automatic daylighting controls in SDZs from Section 140.6(d) here. No additional changes are proposed to the code language. This change is necessary because stakeholders have reported there is confusion and uncertainty during code compliance verification process whether controls in SDZs are required and this change would make the code easier to understand and comply with.
- **Section 130.1(d):** The purpose of this change is to capitalize defined terms throughout Section 130.1(d). This change is necessary to help improve readability.
- **Exception to 130.1(d)2:** The purpose of this change is to describe how LEDs and other solid state lighting sources shall be treated with respect to daylighting control requirements. This change is necessary to remove ambiguity.
- **Section 130.1(d)3C:** The purpose of this change is a reduction in lighting power to 10 percent or lower when daylight illuminance exceeds 150 percent design illuminance. This results in a deeper reduction in light power when illuminance levels are met with daylight as the 2019 Standards require daylight controls to reduce the general lighting to 35 percent of rated power (or lower) when daylight illuminance is 150 percent design illuminance or greater.

— **SECTION 140.6 – Prescriptive Requirements for Indoor Lighting**

- **Section 140.6(a)2H:** The purpose of this change is to clarify that to qualify for the daylight dimming to OFF the controls must provide continuous dimming.
- **Section 140.6(d):** The purpose of this change is to move requirements for automatic daylighting controls in SDZs from the prescriptive section (Section 140.6(b)) to the mandatory section (Section 130.1(d)). This change is necessary because stakeholders have reported there is confusion and uncertainty during code compliance verification process whether controls in SDZs are required and this change would make the code easier to understand and comply with. Although it looks like all language in Section 140.6(b) has been struck in its entirety, all requirements for SDZs have been incorporated into Section 130.1(d) including all exceptions.

- **Table 140.6-A:** This proposed change renames the PAF for Daylight Dimming plus OFF Control to clarify that stepped dimming systems do not qualify.

2.3.2 Summary of Changes to the Reference Appendices

- **NA7.6.1.2.1 Continuous Dimming Control Systems:** Revisions to this section include:
    - Adjust procedures to verify and document that the lighting power reduction of controlled luminaires is at least 90 percent instead of 65 percent.
    - Add clarification to identify the step where the Reference Location is defined.
    - Add clarification that full daylight conditions can be simulated by shining a bright light on the photocontrol.
    - Add an alternative partial daylight test to address stakeholder concerns with the feasibility of using the current partial daylight test in all conditions, particularly in daylit spaces with dark glazing or small window areas.
- **NA7.6.1.2.2 Stepped Switching or Stepped Dimming Control Systems:** Adjust procedures to verify and document that the lighting power reduction of controlled luminaires is at least 90 percent instead of 65 percent.

See Section 7.3 of this report for the detailed proposed revisions to the text of the reference appendices.

2.3.3 Summary of Changes to the Nonresidential ACM Reference Manual

Section 5.4.5 of the ACM Reference Manual would be updated to reflect that the standard design power fraction and light output is 0.1. Currently, the minimum dimming light output fraction or power fraction used in the Standard Design vary based on the lighting source. There is a lookup table (Table 8 in the ACM Reference Manual) to identify power fraction or light output fraction by lighting source. The proposed changes would set the minimum power fraction and light output to 0.1, which is consistent with the values for LED lighting source in the lookup table. This results in simplification because the lookup table would no longer be referenced and would be deleted from the ACM Reference Manual.

Section 5.4.5 of the ACM Reference Manual would be updated to note that daylighting controls for SDZs are mandatory, not prescriptive.

See Section 7.4 of this report for the detailed proposed revisions to the text of the ACM Reference Manual. Appendix D: presents proposed changes to the compliance software, which includes modifying the default Standard Design to use dim to 10 percent instead of the current default of dim to 20 percent.

2.3.4 Summary of Changes to the Nonresidential Compliance Manual

The proposed code change would modify the following sections of the Nonresidential Compliance Manual:

- Chapter 5.2 General Requirements for Mandatory Measures
- 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

The compliance manual would need to be updated to account for daylighting dimming to 10 percent because it currently provides guidance on dimming to 35 percent. It would also need to update language to note that automatic daylighting controls for SDZs are mandatory and move them from Chapter 5.5.3 to Chapter 5.4.4.

See Section 7.5 of this report for the detailed proposed revisions to the text of the Compliance Manuals.

2.3.5 Summary of Changes to Compliance Documents

The proposed code change would modify the NRCA-LTI-03-A Automatic Daylighting Control Acceptance Document. In addition, any equivalent performance forms must be generated on a per-project basis. Examples of the revised documents are presented in Section 7.6.

2.4 Regulatory Context

2.4.1 Existing Requirements in the California Energy Code

The Mandatory Indoor Lighting Controls section of Title 24, Part 6 (Section 130.1) includes requirements for lighting control, including automatic daylighting controls in Section 130.1(d). Current requirements specify that general lighting luminaries in or partially in Skylit Daylit Zones or Primary Sidelit Daylit Zones need to be controlled independently and lighting power be reduced to 35 percent when the area receives daylight that is 150 percent or greater than the designed lighting level. Likewise, Section

140.6 has the same requirements for all general lighting luminaires in or partially in the Secondary Sidelit Daylit Zones that are not in the Primary Sidelit Daylit Zones.[7]

General lighting in enclosed spaces that are 100 square feet or larger with a connected lighting load of 0.5W/ft^2 or greater must have multi-level controls that comply with the number of control steps in Table 130.1-A. Table 130.1-A requires LEDs to be capable of continuous dimming between 10 and 100 percent.

2.4.2 Relationship to Requirements in Other Parts of the California Building Code

There are no requirements directly related to the minimum dimming requirements in other parts of the California Building Code. However, there are voluntary requirements in 2019 California Green Building Standards (CALGreen or Title 24, Part 11) that encourage daylight devices. To meet the Tier 1 and Tier 2 energy efficiency levels in CALGreen, either one or two prerequisite requirements must be met, respectively. Installing daylighting devices that comply with Title 24, Part 6 Section 140.3(d) is one of the five prerequisite options. Installing daylight devices (i.e., clerestory fenestration, interior and exterior horizontal slats, or interior and exterior light shelves) brings more daylight into the space and would therefore increase the opportunity for the luminaires to dim.

2.4.3 Relationship to Local, State, or Federal Laws

There are no relevant local, state, or federal laws.

2.4.4 Relationship to Industry Standards

ASHRAE 90.1 includes mandatory daylight dimming control requirements for sidelighting and toplighting in Section 9.4.1.1(e) and (f), respectively. For both sidelighting and toplighting, the controls must reduce lighting power continuously down to 20 percent and have an OFF setting. ASHRAE 90.1 has included daylighting dimming plus OFF requirement since 2013. ASHRAE 90.1-2013 and 90.1-2019 requires automatic daylight dimming for all space types except guestrooms, interior parking areas, storage rooms less than 50 square feet, living quarters in dormitories, sleeping quarters in fire stations, facilities for the visually impaired, and imaging and operating rooms at healthcare facilities. For the sales area space type, automatic daylight dimming controls are required for skylit areas only, not sidelit areas.

[7] Daylit Zones are areas that are either under skylights or near windows that receive daylight. Skylit Daylit Zones are the areas that receive daylighting from skylights. Primary Sidelit Daylit Zones are areas adjacent to windows that receive daylight. Secondary Sidelit Daylit Zones are areas that are close to windows but not directly adjacent to them. They still receive some daylight despite not being directly adjacent to windows (CLTC 2016).

2.5 Compliance and Enforcement

This section describes how to comply with the proposed code change. It also describes the compliance verification process. Appendix E: presents how the proposed 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.

The activities that need to occur during each phase of the project are described below. Automatic daylighting controls requirements have been in place since the 2005 code cycle and the proposed refinements to the requirements are minimal. Changes to the compliance process that has been in place for over a decade would be minimal.

- **Design Phase:** During the design phase, the lighting designer is responsible for ensuring automatic daylighting controls are incorporated into the design and specifying controls that meet the code requirements. The design team documents intent to comply in the NRCC-LTI-E Indoor Lighting Certificate of compliance document and other lighting design documents.
- **Permit Application Phase:** Plans examiner review design documents and confirm that the design complies with the daylighting control requirements.
- **Construction Phase:** The automatic daylighting controls are installed and commissioned during the construction phase. The details and capabilities of these controls are documented in NRCI-LTI-03-E, the Certificate of Installation for Energy Management Control System or Lighting Control System. If using the daylight dimming plus OFF PAF credit, details are documented on the NRCI-LTI-05 Power Adjustment Factors form. The controls must be programmed/configured so the system can automatically implement the control strategy that is tested during the acceptance test. A certified ATT conducts functional performance testing on the control system to complete required acceptance tests and the commissioning process. Automatic daylighting controls do require acceptance testing. The acceptance test procedure is described in Section 7.6.1 of the Nonresidential Appendix, Automatic Daylighting Controls Acceptance Tests. The proposed code change would make minor revisions to the protocol to account for the requirement to dim to 10 percent. The ATT completes the NRCA-LTI-03-A: Daylighting Control Acceptance Document a passing score on the acceptance test.
- **Inspection Phase:** The building inspector confirms acceptance tests were completed and the appropriate controls were installed to complete those tests by reviewing the NRCA documents during inspection.

3. Market Analysis

3.1 Market Structure

The Statewide CASE Team performed a market analysis with the goals of identifying current technology availability, current product availability, and market trends. The Statewide CASE Team then considered how the proposed standard may impact the market in general as well as individual market actors. Information was gathered 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 actors. In addition to conducting personalized outreach, the Statewide CASE Team discussed the current market structure and potential market barriers during public stakeholder meetings that the Statewide CASE Team held on September 5, 2020 and March 3, 2020.

The market for daylighting control solutions, including luminaire level lighting controls (LLLCs), wired and wireless photocontrols, 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 2015 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 retail facilities
Online Only	• Selling only through websites and shipping directly from a central warehouse • Offering minimal customer service
Direct	• Smallest channel used by large customers • Product direct to consumer without use of third-party representatives

A number of luminaire manufacturers have been adding lighting controls to their product lines as the demand for lighting controls increases.[8] With the advancement of solid-state lighting technology, which enables easier integration of lighting controls and opportunities to include non-lighting related features within a lighting system, manufacturers have been shifting the focus from stand-alone products, such as lamps and ballasts, to full-system offerings.

Companies that offer lighting control solutions that could be used to comply with the proposed requirements include Acuity Controls, CREE Lighting, Digital Lumens, Douglas Lighting Controls, Cooper Lighting Solutions, Enlighted, Finelite, Hubbell Control Solutions, Leviton, Legrand/WattStopper, Lutron, Organic Response, Signify, and Schneider Electric.

A 2015 study conducted by the National Lighting Product Information Program (NLPIP) 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 Legrand’s 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:

[8] The DesignLights Consortium (DLC) maintains a database of networked lighting conrols (NLCs) that are eligible for utility incentives and rebates. While the database is not exhaustive, it is regularly updated with new products as they become available. The latest version is can be downloaded online: https://www.designlights.org/default/assets/File/Lighting%20Controls/DLC_NLC-QPL-v4-07-14-2020%20(1).xlsm

- Daylighting controls are present in two percent of the U.S. buildings, but account for seven percent of total floor area, since larger buildings are more likely to have daylighting controls.
- 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 (U.S. DOE) study released in 2016, 140 sources of published literature were reviewed to assess market penetration of and energy savings from lighting controls. This study made the following estimations for the 2015 installed lighting stock[9] penetration of lighting controls in the commercial sector:

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

The 2014 California Commercial Saturation (CSS) survey conducted by Itron and 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 (sic: energy efficient) lighting, EE lighting control, and DR (sic: demand response) 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 (sic: energy management systems), occupancy sensors, motion sensors, photocells, and time clocks than non-participants” (Itron, Inc. 2014).

Table 7 describes the percentage of distribution of interior lamps with daylighting controls by business participants in IOU Energy Efficiency and Demand Response Programs. The data shows that few businesses utilize daylighting and other controls unless they participate in IOU Energy Efficiency and Demand Response Programs. Those businesses that utilize lighting control programs have the highest rate of adoption of daylighting and other controls. The data is based on an analysis of 1,730 surveyed sites.

[9] Installed stock is presented the U.S. DOE’s study “in terms of lighting systems (lamp(s), ballast and fixture are counted as one unit)” (DOE 2016).

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 and Other	0.1%	1.4%	2.9%	2.1%

Source: California Commercial Saturation, Iron.

Although the 2012 CBECS, 2016 U.S. DOE study, and the 2014 CSS survey found different levels of adoption of occupancy and daylighting controls, all studies demonstrate that occupancy sensors and daylighting controls have a low penetration rate across the U.S. and reveal an opportunity for energy savings by extending controls requirements to new spaces. However, the Statewide CASE Team is not proposing updates that will increase the prevalence in daylighting controls. Instead, the proposed updates realize energy savings due to requiring deeper dimming in spaces where daylighting controls are already required.

3.2 Technical Feasibility, Market Availability, and Current Practices

3.2.1 Technical Feasibility and Market Availability

To evaluate the technical feasibility and market availability of the proposed measure, an examination of the components of automatic daylighting control systems used to meet the current standard as compared to the proposed measure is useful. The typical components of automatic daylighting control systems are the:

- Photocell
- Daylighting logic controller
- Power controller
- Light source

Below is a discussion of each component of the daylighting control system and their ability to accommodate dimming to 10 percent and dimming plus OFF. According to staff interviewed at four lighting manufacturers and a certified lighting controls acceptance test provider, the majority of daylight controls and integrated fixtures with daylight controls have the option to be configured to dim to 10 percent or dim plus OFF.

The Statewide CASE Team conducted outreach to stakeholders to determine the market availability and current practices for daylight dimming controls. The Statewide CASE Team also gathered feedback on end-user acceptance of automatic daylighting controls with the OFF and 10 percent step. Specifically, the Statewide CASE Team spoke with stakeholders at the Strategies in Light Conference, held in February 2020, and also followed up with stakeholders to discuss. The Statewide CASE Team did not receive feedback that dim to 10 percent would be problematic. However, there was also feedback that daylighting controls are typically implemented to code solely for compliance.

3.2.1.1 Photocell

The photocell's function is to output a signal proportionate to the daylighting level in the space. The photocell equipment used to meet the current standard (dim to 35 percent) is sufficient to meet the proposed requirement (dim to 10 percent). The proposed code changes do not necessitate modifications to the type of equipment that is commonly used to meet the existing code requirements.

3.2.1.2 Daylighting Logic Controller

The daylighting logic controller's function is to receive an input signal from the photocell and output an appropriate control signal to the lamp power controller. The proposed code changes do not necessitate upgrades to the daylighting logic controller equipment. Equipment that is commonly used to meet the current requirements and is readily available in the marketplace is appropriate to use to comply with proposed code requirements.

The combination of a photocell and daylighting logic controller is referred to as the photosensor. The photosensor output determines the photocontrol.

As summarized in Table 8, there are three types of photocontrol products: wireless, wired, and wired stand-alone. All three types of photocontrols are widely available on the market. Wired products are most prevalent. Wireless controls are a popular choice in alterations as the increased cost of wireless systems often balances with reduced need for wiring or drywall and similar renovation tasks.

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 lighting 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

Daylight dimming control systems that use photosensors are typically configured using one of three options: open-loop, closed-loop, and hybrid systems employing both open and closed-loop system concepts. Each of these configurations are described below:

- **Open-loop systems** orient the photosensor to sense daylight only and adjust the electric light accordingly. An open-loop system would 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 are minimal.
- **Hybrid 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 Legrand’s WattStopper. Since these systems combine the algorithms of closed-loop and open-loop systems, they are less reactive to reflectance shift.

The photocontrols are integrated into system-level controls or LLLCs. Both system-level control options and LLLC solutions are available from multiple distribution channels. When first released, LLLCs were primarily marketed for office spaces. Applications have expanded to include warehouses and other spaces that typically use high bay luminaires. Additionally, some LLLCs are capable of connectivity with zonally controlled luminaires for customized granularity.

Dimming control strategies are summarized in Table 9. The control method used most frequently to control daylighting dimming controls is 0-10VDC, for which the average time delay before dimming is two to six minutes of continuous lumen input from lighting in the space. The most common strategies for daylight dimming controls are 0-10 Volt direct current (V_{DC}) and digital, including Digital Addressable Lighting Interface (DALI) due to the controls compatibility to dim fluorescent and LEDs without major flickering issues. Forward and reverse phase dimming is used for incandescent and fluorescent technology and can cause drop-out, flickering, and other lighting quality issues.

Table 9: Types of Dimming Control Strategies

Type of Photocontrol	Description
0-10 V_{DC}	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 for Electronic Low Voltage (ELV) transformers and common LED drivers.

3.2.1.3 Lamp Power Controller and Lamp

The market share of different lamp types has changed since the analysis for the current standard was performed. The daylighting requirements adopted into the current standard was conducted in 2011, based on T8 fluorescent lamp fixtures (California Utilities Statewide Codes and Standards Team 2011). At that time, T8 fluorescent lamps were approximately 45 percent of the commercial building market (Navigant Consulting, Inc. 2012). By 2021 LEDs are predicted to have 52 percent of the sales market (Pike Research 2019). Given that LEDs would have even more market share than T8 fluorescents had when they were used to justify an update to the Energy Code, it is judged appropriate to base the 2022 lamp power controller on LEDs.

3.2.2 Market Acceptance of Dimming Plus OFF

As discussed in Section 2.2, stakeholders have expressed concern about building occupant acceptance of daylight dimming plus OFF controls. To date, the Statewide CASE Team has not received substantive quantitative or qualitative findings. The Statewide team continues to reach out to stakeholders and encourages feedback.

While daylighting controls with the OFF step are not widely deployed in California, two large retail chains – Walmart and COSTCO – specified daylighting controls with the OFF step in their stores as a standard practice. Walmart 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. Walmart has over 1,000 stores with skylights and daylighting controls while COSTCO has over 250 stores with skylights and daylighting controls. As of 2019, Walmart is dimming to 50 percent, which does add energy costs but is expected to return to a dim plus OFF control strategy in the next year.

In July 2020, the Statewide CASE Team held a meeting with International Association of Lighting Designers (IALD) members to discuss the Daylighting CASE Report.[10] The Statewide CASE Team received no concerns on lowering the daylight dimming level to 10 percent.

3.3 Market Impacts and Economic Assessments

3.3.1 Impact on Builders

Builders of residential and commercial structures are directly affected by many of the measures proposed by the Statewide CASE Team for the 2022 code cycle. It is within the normal practices of these businesses to adjust their building practices to changes in building codes. When necessary, builders engage in continuing education and training in order to remain compliant with changes to design practices and building codes.

California's construction industry is comprised of about 80,000 business establishments and 860,000 employees (see Table 10).[11] In 2018, total payroll was $60 billion. Nearly 17,000 establishments and 344,000 employees focus on the commercial sector. The remainder of establishments and employees work in industrial, utilities, infrastructure, and other heavy construction (industrial sector).

[10] IALD is a global organization comprised of architectural lighting designers.

[11] Average total monthly employment in California in 2018 was 18.6 million; the construction industry represented 4.5 percent of 2018 employment.

Table 10: California Construction Industry, Establishments, Employment, and Payroll

Construction Sectors	Establishments	Employment	Annual Payroll (billions $)
Residential	**59,287**	**420,216**	**$23.3**
Residential Building Construction Contractors	22,676	115,777	$7.4
Foundation, Structure, & Building Exterior	6,623	75,220	$3.6
Building Equipment Contractors	14,444	105,441	$6.0
Building Finishing Contractors	15,544	123,778	$6.2
Commercial	**17,273**	**343,513**	**$27.8**
Commercial Building Construction	4,508	75,558	$6.9
Foundation, Structure, & Building Exterior	2,153	53,531	$3.7
Building Equipment Contractors	6,015	128,812	$10.9
Building Finishing Contractors	4,597	85,612	$6.2
Industrial, Utilities, Infrastructure, & Other	**4,103**	**96,550**	**$9.2**
Industrial Building Construction	299	5,864	$0.5
Utility System Construction	1,643	47,619	$4.3
Land Subdivision	952	7,584	$0.9
Highway, Street, and Bridge Construction	770	25,477	$2.4
Other Heavy Construction	439	10,006	$1.0

It is expected that builders would 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 changes 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.

Builders would need to invest in training and education to ensure the workforce, including designers, acceptance technicians, engineers, and contractions 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

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 daylight harvesting systems available on the market already include the capability to dim to 10 percent or turn the lighting OFF.

Adjusting design practices to comply with changing building codes practices is within the normal practices of building designers. Building codes (including the California Building Standards 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 needed to update design practices to comply with new building codes. As a whole, the measures the Statewide CASE Team is proposing for the 2022 code cycle aims 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.

Table 11: California Building Designer and Energy Consultant Sectors

Sector	Establishments	Employment	Annual Payroll (billion $)
Architectural Services [a]	3,704	29,611	$2.9
Building Inspection Services [b]	824	3,145	$0.2

Source: (State of California, Employment Development Department n.d.)

a. Architectural Services (NAICS 541310) comprises private-sector establishments primarily engaged in planning and designing residential, institutional, leisure, commercial, and industrial buildings and structures;

b. Building Inspection Services (NAICS 541350) comprises private-sector establishments primarily engaged in providing building (residential & nonresidential) inspection services encompassing all aspects of the building structure and component systems, including energy efficiency inspection services.

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 (Cal/OSHA). All existing health and safety rules would 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. Impact on Building Owners and Occupants

Building owners and occupants would 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.

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

The commercial building sector includes a wide array of building types, including offices, restaurants and lodging, retail, and mixed-use establishments, and warehouses (including refrigerated). Energy use by occupants of commercial buildings also varies considerably with electricity used primarily for lighting, space cooling and conditioning, and refrigeration. Natural gas consumed primarily for heating water and for space heating. According to information published in the 2019 California Energy Efficiency Action Plan, there is more than 7.5 billion square feet of commercial floor space in California and consumes 19 percent of California's total annual energy use. The diversity of building and business types within this sector creates a challenge for disseminating information on energy and water efficiency solutions, as does the variability in sophistication of building owners and the relationships between building owners and occupants.

The Statewide CASE Team interviewed manufacturers and concluded that the proposed changes would not significantly impact companies who manufacture, distribute, or sell lighting controls. Refer to Section 3.4.2 for more information.

3.3.5 Impact on Building Inspectors

The proposed code changes would have a minimal impact on the existing inspection application process. The Statewide CASE Team identified current lighting inspection forms and tables which would need to be updated in Section 7.6. Building inspectors and acceptance testers would need to be trained on the new control requirements as well as the field verified process through acceptance testing.

3.3.6 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.

Table 12 shows employment and payroll information for state and local government agencies in which many inspectors of residential and commercial buildings are employed. Building inspectors participate in continuing training to stay current on all aspects of building regulations, including energy efficiency. The Statewide CASE Team, therefore, anticipates the proposed change would have no impact on employment of building inspectors or the scope of their role conducting energy efficiency inspections.

Table 12: Employment in California State and Government Agencies with Building Inspectors

Sector	Govt.	Establishments	Employment	Annual Payroll (millions $)
Administration of Housing Programs [a]	State	17	283	$29.0
	Local	36	2,882	$205.7
Urban and Rural Development Admin [b]	State	35	552	$48.2
	Local	52	2,446	$186.6

Source: (State of California, Employment Development Department n.d.)

a. Administration of Housing Programs (NAICS 925110) comprises government establishments primarily engaged in the administration and planning of housing programs, including building codes and standards, housing authorities, and housing programs, planning, and development.

b. Urban and Rural Development Administration (NAICS 925120) comprises government establishments primarily engaged in the administration and planning of the development of urban and rural areas. Included in this industry are government zoning boards and commissions.

3.3.7 Impact on Statewide Employment

As described in Sections 3.3.1 through 3.3.6, the Statewide CASE Team does not anticipate significant employment or financial impacts to any particular sector of the California economy. This is not to say that the proposed change would not have modest impacts on employment in California. In Section 3.4, the Statewide CASE Team estimated the proposed change in daylight dimming to 10 percent would affect statewide employment and economic output directly and indirectly through its impact on builders, designers and energy consultants, and building inspectors. In addition, the Statewide CASE Team estimated how energy savings associated with the proposed change in daylight dimming to 10 percent would lead to modest ongoing financial savings for California residents, which would then be available for other economic activities.

3.4 Economic Impacts

For the 2022 code cycle, the Statewide CASE Team used the IMPLAN model software, along with economic information from published sources, and professional judgement to developed estimates of the economic impacts associated with each proposed code changes. While this is the first code cycle in which the Statewide CASE Team develops estimates of economic impacts using IMPLAN, it is important to note that the economic impacts developed for this report are only estimates and are based on limited and to some extent speculative information. In addition, the IMPLAN model provides a relatively simple representation of the California economy and, though the Statewide CASE Team is confident that direction and approximate magnitude of the estimated economic impacts are reasonable, it is important to understand that the IMPLAN model is a simplification of extremely complex actions and interactions of individual, businesses, and other organizations as they respond to changes in energy efficiency codes. In all aspect of this economic analysis, the CASE Authors rely on conservative assumptions regarding the likely economic benefits associated with the proposed code change. By following this approach, the Statewide CASE Team believes the economic impacts presented below represent lower bound estimates of the actual impacts associated with this proposed code change.

Adoption of this code change proposal would result in relatively modest economic impacts through the additional direct spending by architects, energy consultants, and building inspector in commercial building industry. The Statewide CASE Team does not anticipate that money saved by commercial building owners or other organizations affected by the proposed 2022 code cycle regulations would result in additional spending by those businesses.

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.[12] 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 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[13] 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 would result in a statewide first-year savings of 55.5 GWh, this measure would result in approximately 21.1 jobs created in the first year. See Table 22 for statewide savings estimates.

The daylighting proposal would have marginal impact on labor hours as daylighting controls are already required in most projects.

[12] 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."

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

3.4.2 Creation or Elimination of Businesses in California

As stated in Section 3.4.1, the Statewide CASE Team's proposed change would not result in economic disruption to any sector of the California economy. The proposed change represents a modest change to daylight dimming to 10 percent which would not excessively burden or competitively disadvantage California businesses – nor would it necessarily lead to a competitive advantage for California businesses. Therefore, the Statewide CASE Team does not foresee any new businesses being created, nor does the Statewide CASE Team think any existing businesses would be eliminated due to the proposed code changes.

3.4.3 Competitive Advantages or Disadvantages for Businesses in California

The proposed code changes would apply to all businesses incorporated in California, regardless of whether the business is incorporated inside or outside of the state.[14] Therefore, the Statewide CASE Team does not anticipate that these measures proposed for the 2022 code cycle regulation would have an adverse effect on the competitiveness of California businesses. Likewise, the Statewide CASE Team does not anticipate businesses located outside of California would be advantaged or disadvantaged.

3.4.4 Increase or Decrease of Investments in the State of California

The Statewide CASE Team analyzed national data on corporate profits and capital investment by businesses that expand a firm's capital stock (referred to as net private domestic investment, or NPDI).[15] As Table 13 shows, between 2015 and 2019, NPDI as a percentage of corporate profits ranged from 26 to 35 percent, with an average of 31 percent. While only an approximation of the proportion of business income used for net capital investment, the Statewide CASE Team believes it provides a reasonable estimate of the proportion of proprietor income that would be reinvested by business owners into expanding their capital stock.

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[14] Gov. Code, § 11346.3(c)(1)(C), 11346.3(a)(2); 1 CCR § 2003(a)(3) Competitive advantages or disadvantages for California businesses currently doing business in the state.

[15] Net private domestic investment is the total amount of investment in capital by the business sector that is used to expand the capital stock, rather than maintain or replace due to depreciation. Corporate profit is the money left after a corporation pays its expenses.

Table 13: Net Domestic Private Investment and Corporate Profits, U.S.

Year	Net domestic investment: Private: Domestic business, Billions of Dollars	Corporate Profits After Tax (without IVA and CCAdj), Billions of Dollars	Ratio of Net Private Investment to Corporate Profits
2000	536.9	513.2	105%
2001	341.4	518.9	66%
2002	256.8	627.9	41%
2003	253.6	756.4	34%
2004	348.0	979.2	36%
2005	415.6	1285.4	32%
2006	490.1	1413.7	35%
2007	506.3	1359.9	37%
2008	376.8	1123.2	34%
2009	-69.1	1263.3	-5%
2010	171.7	1561.5	11%
2011	269.3	1537.2	18%
2012	426.6	1821.2	23%
2013	495.3	1788.7	28%
2014	579.4	1857.2	31%
2015	609.2	1740.4	35%
2016	456.0	1739.8	26%
2017	509.3	1813.6	28%
2018	618.2	1843.7	34%
2019	580.9	1827.0	32%
Average 2015-2019			**31%**

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 2022 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 would 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.

3.4.6 Impacts on Specific Persons

While the objective of any of the Statewide CASE Team's proposal is to promote energy efficiency, the Statewide CASE Team recognizes that there is the potential that a proposed code change may result in unintended consequences. 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.

Lease holders would typically benefit from lower energy bills if they pay energy bills directly. These savings should more than offset any capital costs passed through from building owners. Lease holders who do not pay directly for energy costs may see some net savings depending on if and how building owners account for energy costs when determining rent prices.

4. Energy Savings

4.1 Key Assumptions for Energy Savings Analysis

To calculate energy savings, the Statewide CASE Team used building energy modeling software to simulate energy savings associated with dimming to 35 percent versus 10 percent in prototypical buildings. The next section describes the methodology in detail. The only key assumption is a change in the lighting power in dimmed conditions. Energy savings were modeled using the 2019 Title 24, Part 6 lighting power densities. The mandatory automatic daylighting control requirements apply to skylit and primary sidelit areas.

Table 14 details the total area of skylit, primary sidelit, and secondary sidelit daylit zones within each building prototype that was used in the analysis.

An energy and cost-effectiveness analysis using the methodology accepted by the Energy Commission in order to consider a code change proposal is not needed to move the prescriptive requirements for automatic daylighting controls in SDZs to the mandatory section. This submeasure was already proven to be cost effective in order to be added to the prescriptive requirements (California Utilities Statewide Codes and Standards Team 2011).

4.2 Energy Savings Methodology

4.2.1 Energy Savings Methodology per Prototypical Building

The Energy Commission directed the Statewide CASE Team to model the energy impacts using specific prototypical building models that represent typical building geometries for different types of buildings (California Energy Commission 2019b). The prototype buildings that the Statewide CASE Team used to develop per unit savings for new construction, Table 14. The proposed code change will apply to grocery stores, but the prototype for grocery stores does not include any daylit space which results in no measured savings. However, a percentage of grocery stores do have daylit spaces, which the savings were extrapolated from the Retail Stand Alone model and applied to an energy load of the grocery prototype.

Table 14: Prototype Buildings Used for Energy, Demand, Cost, and Environmental Impacts Analysis

Prototype Name	Number of Stories	Floor Area (ft^2)	Description	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 Total Building Area in Affected Daylit Zones	Total Affected Area of Daylit Zones (ft^2)
Assembly	1	34,007	5-zone assembly building DEER prototype model provided by SCE	Office Zones	0	9,834	7,229	28.90%	9,834
Small Hotel	4	42,554	4 story Hotel with 77 guest rooms. WWR-11%	Front Lounge, Offices and Meeting Rooms	0	2,023	2,023	4.80%	2,023
Office Large	12	498,589	12 story + 1 basement office building with 5 zones and a ceiling plenum on each floor. WWR-0.40	Perimeter Zones	0	24,706	19,660	5.00%	24,706
Office Medium	3	53,628	3 story office building with 5 zones and a ceiling plenum on each floor. WWR-0.33	Perimeter Zones	0	11,784	10,074	22.00%	11,784
Office Small	1	5,502	1 story, 5 zone office building with pitched roof and unconditioned attic. WWR-0.24	Perimeter Zones	0	2,022	1,520	34.80%	2,022
Restaurant FastFood	1	2,501	Fast food restaurant with a small kitchen and dining areas. 14% WWR. Pitched roof with an unconditioned attic.	Dining Area	0	566	396	38.40%	962
Retail Large	1	240,000	Big-box type Retail building with WWR - 12% and SRR-0.82%	Front Entry Area, Perimeter Zones	167,928	4,621	2,176	71.90%	172,549

Prototype Name	Number of Stories	Floor Area (ft^2)	Description	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 Total Building Area in Affected Daylit Zones	Total Affected Area of Daylit Zones (ft^2)
Retail MixedUse	1	9,375	Retail building with WWR -10%. Roof is adiabatic	Front Entry Area	0	995	1,000	10.60%	995
Retail StandAlone	1	24,563	Similar to a Target or Walgreens.7% WWR on the front façade, none on other sides. SRR of 2.1%.	Retail Areas, Point Sale	16,743	1,550	1,459	6.90%	16,743
Retail StripMall	1	9,375	Strip Mall building with WWR -10%	Front Entry Space	0	995	1,000	10.60%	995
School Primary	1	24,413	Elementary school with WWR of 0.36	Lobby, Corridor, Cafeteria	0	8,504	7,813	34.80%	8,504
School Secondary	2	210,866	High school with WWR of 35% and SRR 1.4%	All areas	34,551	33,340	30,952	32.20%	67,891
Warehouse	1	49,495	Single story high ceiling warehouse. Includes one office space. WWR- 0.7%, SRR-5%	All Areas	45,117	539	421	87,72%	45,656

The Statewide CASE Team estimated energy and demand impacts by simulating the proposed code change using EnergyPlus 9.01 and 2022 Research Version of the California Building Energy Code Compliance (CBECC) software for commercial buildings (CBECC-Com) (California Energy Commission 2020b). Since CBECC-Com does not allow for adjustment of the dimming fraction in daylighting controls, energy impacts were simulated by modifying the baseline EnergyPlus file generated by CBECC-Com and running the modified input file in EnergyPlus.

CBECC-Com generates two models based on user inputs: the Standard Design and the Proposed Design.[16] The Standard Design represents the geometry of the design that the builder would like to build and inserts a defined set of features that result in an energy budget that is minimally compliant with 2019 Title 24, Part 6 code requirements. Features used in the Standard Design are described in the 2019 Nonresidential ACM Reference Manual. The Proposed Design represents the same geometry as the Standard Design, but it assumes the energy features that the software user describes with user inputs. To develop savings estimates for the proposed code changes, the Statewide CASE Team created a Standard Design and Proposed Design for each prototypical building. There is an existing Title 24, Part 6 requirement that covers the building system in question and applies to both new construction and alterations, so the Standard Design is minimally compliant with the 2019 Title 24 requirements that specify the general lighting power shall reduce to 35 percent or less when illuminance in the space reaches 150 percent design illuminance.

The Proposed Design was identical to the Standard Design in all ways except for the revisions that represent the proposed changes to the code. Table 15 presents precisely which parameters were modified and what values were used in the Standard Design and Proposed Design. Specifically, the proposed conditions assume that the general lighting power is reduced to 10 percent instead of 35 percent in skylit and primary daylit areas. Continuous dimming controls have a fraction of rated power to fraction of rated light output that is a linear interpolation of the minimum power fraction at the minimum diming light fraction to rated power (power fraction = 1.0) at full light output (California Energy Commission 2019a).

Comparing the energy impacts of the Standard Design to the Proposed Design reveals the impacts of the proposed code change relative to a building that is minimally compliant with the 2019 Title 24, Part 6 requirements.

[16] CBECC-Res also creates a third model, the Reference Design, that represents a building similar to the Proposed Design, but with construction and equipment parameters that are minimally compliant with the 2006 International Energy Conservation Code (IECC). The Statewide CASE Team did not use the Reference Design for energy impacts evaluations.

Table 15: Modifications Made to Standard Design in Each Prototype to Simulate Proposed Code Change

Prototype ID	Climate Zone	Parameter Name	Standard Design Parameter Value	Proposed Design Parameter Value
All Prototypes	All	Minimum Input Power Fraction	0.35	0.10
All Prototypes	All	Minimum Light Output Fraction	0.35	0.10

CBECC-Com calculates whole-building energy consumption for every hour of the year measured in kilowatt-hours per year (kWh/yr) and therms per year (therms/yr). As part of this process, CBECC-Com calculates how much daylight is available for the prototypes in each climate zone and adjusts the amount of power (based on dimming in response to available daylight). Therefore, the whole-building energy consumption is based on both the amount of time the electric lighting is on and much the electric light is dimmed in response to available daylight. It then applies the 2022 time dependent valuation (TDV) factors to calculate annual energy use in kilo British thermal units per year (TDV kBtu/yr) and annual peak electricity demand reductions measured in kilowatts (kW). CBECC-Com also generates TDV energy cost savings values measured in 2023 present value dollars (2023 PV$) and nominal dollars.

The energy impacts of the proposed code change vary by climate zone. Statewide CASE Team simulated the energy impacts in every climate zone and applied the climate-zone specific TDV factors when calculating energy and energy cost impacts.

Per-unit energy impacts for nonresidential buildings are presented as savings per square foot of total building floor area. Annual energy and peak demand impacts for each prototype building were translated into impacts per square foot by dividing by the entire floor area of the prototype building.[17] This step allows for an easier comparison of savings across different building types and enables calculation of statewide savings using the construction forecast that is published in terms of floor area by building type.

Figure 4 shows the lighting power multiplier from daylight dimming to 35 percent versus dimming to 10 percent. It is important to note that not all areas in a building receive adequate daylight to dim to the code minimum and the dimming will be adjusted proportionally, as is seen below. Figure 4 depicts lighting power reductions as a result of daylight dimming in the in the medium office prototype, in the Southern Zone. This prototype consists of 3,096 square feet of primary sidelit space and 2,552 square feet of

[17] For the 2019 code cycle, the Statewide CASE Team presented savings per square foot of daylit space. For the 2022 code cycle, the Statewide CASE Team is presenting savings per square foot of total building floor area to be consistent with all other proposed changes for this code cycle.

secondary sidelit space. There is no skylit space. More details of this and all prototypes can be found in Table 14.

The data used in Figure 4 are the outputs of Energy Plus hourly modeling of the daylighting hourly multiplier when running the prototype energy models used to calculate energy savings. The definition of daylighting hourly multiplier is the amount by which the overhead electric lighting power in a zone is multiplied due to usage of daylighting to dim or switch the electric lighting. For example, if the multiplier is M and the electric power without dimming is P, then the electric power with dimming is M*P. The multiplier varies from 0.0, which corresponds to maximum dimming (zero electric lighting), to 1.0, which corresponds to no dimming.

As stated in the methodology, the two adjustments to the proposed models are the Minimum Input Power Fraction and Minimum Light Output Fraction. There were no adjustments made to the dimming curves or any other function of continuous dimming in the prototype. Therefore the rate of continuous dimming in the baseline and proposed models are merely the default functionality of the required prototypes.

Only during the hours from 4 to 6 pm are both primary and secondary zones fully daylit, that is the daylight illuminance is higher than default design illuminance. This is reflected in the Minimum Input Power Fraction and Minimum Light Output Fraction of 35% and 10% in the 2019 baseline model and the 2022 proposed measure case model, respectively. However during other hours of the day only the primary sidelit daylit zones are fully daylit and this is reflected in higher power multipliers than 35% and 10% for the baseline 2019 and proposed 2022 models respectively as these are weighted power reductions for the combination of primary and secondary sidelit daylit zones.

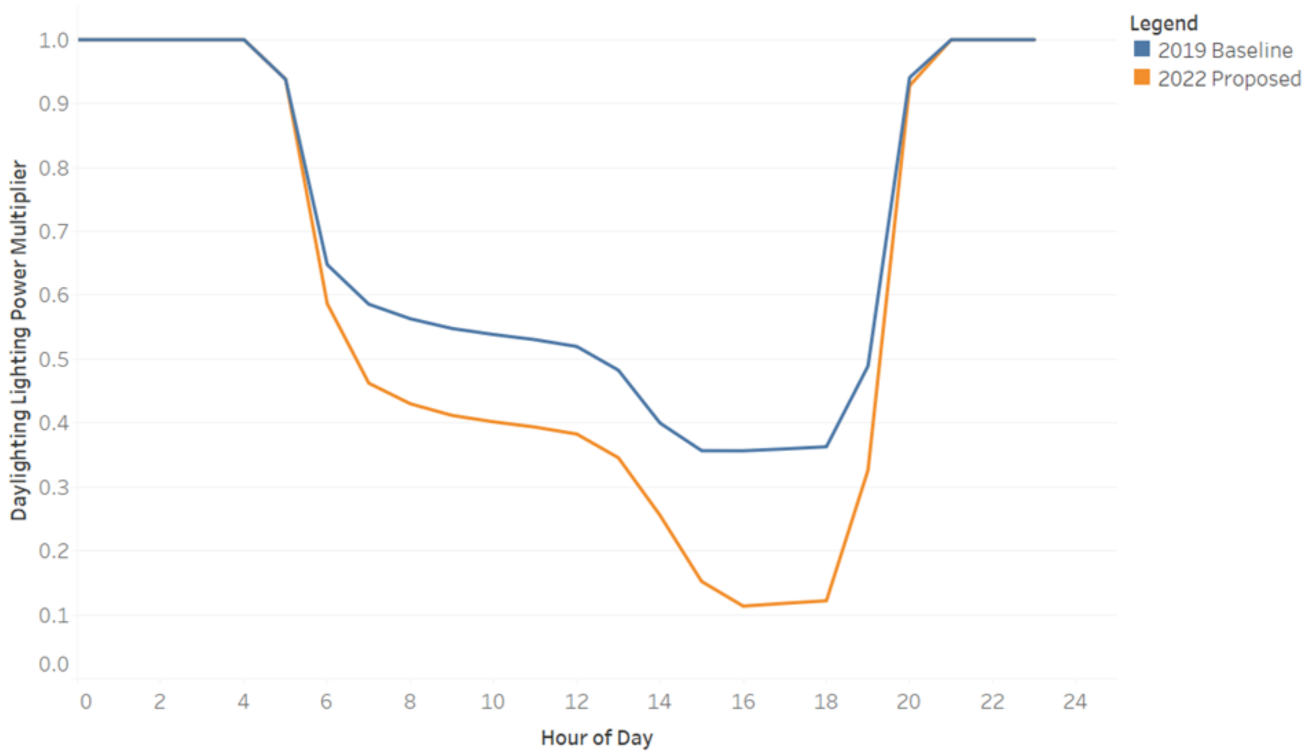


Figure 4: Medium Office, Southern Zone, June 21 Lighting Dimming Power by Hour

4.2.2 Statewide Energy Savings Methodology

The per-unit energy impacts were extrapolated to statewide impacts using the Statewide Construction Forecasts that the Energy Commission provided (California Energy Commission n.d.). The Statewide Construction Forecasts estimate new construction occurring in 2023, the first year that the 2022 Title 24, Part 6 requirements are in effect. It also estimates the size of the total existing building stock in 2023 that the Statewide CASE Team used to approximate savings from building alterations. The construction forecast provides construction (new construction and existing building stock) by building type and climate zone. The building types used in the construction forecast, Building Type ID, are not identical to the prototypical building types available in CBECC-Com. The Energy Commission provided guidance on which prototypical buildings to use for each Building Type ID when calculating statewide energy impacts. Table 16 presents the prototypical buildings and weighting factors that the Energy Commission requested the Statewide CASE Team use for each Building Type ID in the Statewide Construction Forecast.

Appendix A: presents additional information about the methodology and assumptions used to calculate statewide energy impacts.

Table 16: Nonresidential Building Types and Associated Prototype Weighting

Building Type ID from Statewide Construction Forecast	Building Prototype for Energy Modeling	Weighting Factors for Statewide Impacts Analysis
Small Office	OfficeSmall	100%
Large Office	OfficeMedium	50%
Large Office	OfficeLarge	50%
Restaurant	RestaurantFastFood	100%
Retail	RetailStandAlone	10%
Retail	RetailLarge	75%
Retail	RetailStripMall	5%
Retail	RetailMixedUse	10%
Grocery Store	Grocery	100%
Non-Refrigerated Warehouse	Warehouse	100%
Refrigerated Warehouse	RefrigWarehouse	N/A
Schools	SchoolPrimary	60%
Schools	SchoolSecondary	40%
Colleges	OfficeSmall	5%
Colleges	OfficeMedium	15%
Colleges	OfficeMediumLab	N/A
Colleges	PublicAssembly	5%
Colleges	SchoolSecondary	30%
Colleges	ApartmentHighRise	25%
Hospitals[a]	Hospital	100%
Hotel/Motels	HotelSmall	100%

4.3 Per-Unit Energy Impacts Results

Energy savings and peak demand reductions per square foot of total building floorspace are presented in Table 17 and represent savings from new construction and alterations/ additions. This table presents the average impacts across all prototypical buildings that were included in the analysis. See Appendix H: for results from each prototypical building independently. The per-unit energy savings figures do not account for naturally occurring market adoption or compliance rates. The average per-unit savings for the first-year electricity and peak demand reductions are expected to range from 0.07 to 0.11 kWh/yr depending on climate zone. Negative numbers are denoted in red with parenthesis. This measure will result in an increase in natural gas use, or a negative natural gas savings. Reduced lighting use will in turn reduce heat gains from lighting. The heating system will have to make up for this by delivering more heat to the space.

Table 17: First-Year Energy Impacts Per Square Foot – Construction Weighted Average of All Prototype Building

Climate Zone	Annual Electricity Savings (kWh/ft^2)	Peak Electricity Demand Reductions (W/ft^2)	Natural Gas Savings ($therms/ft^2$)	Annual TDV Energy Savings (TDV $kBtu/ft^2$)
1	0.07	0.00	(0.00)	0.99
2	0.08	0.00	(0.00)	1.63
3	0.07	0.00	(0.00)	1.40
4	0.08	0.00	(0.00)	1.71
5	0.08	0.00	(0.00)	1.44
6	0.09	0.00	(0.00)	1.69
7	0.09	0.00	(0.00)	1.82
8	0.09	0.00	(0.00)	1.87
9	0.09	0.00	(0.00)	2.29
10	0.10	0.00	(0.00)	2.37
11	0.09	0.00	(0.00)	1.85
12	0.09	0.00	(0.00)	1.77
13	0.10	0.00	(0.00)	2.16
14	0.10	0.00	(0.00)	2.08
15	0.11	0.00	(0.00)	2.50
16	0.09	0.00	(0.00)	1.31

5. Cost and Cost Effectiveness

5.1 Energy Cost Savings Methodology

The energy and cost analysis presented in this report used the TDV factors that are consistent with the TDV factors presented during the Energy Commission's March 27, 2020 workshop on compliance metrics (California Energy Commission 2019c). The electricity TDV factors include the 15 percent retail adder and the natural gas TDV factors include the impact of methane leakage on the building site. The electricity TDV factors used in the energy savings analyses were obtained from Energy and Environmental Economics, Inc. (E3), the contractor that is developing the 2022 TDV factors for the Energy Commission, in a spreadsheet titled "Electric TDVs 2022 - 15 pct Retail Adj Scaled by Avoided Costs.xlsx". The natural gas TDV factors used in the energy savings analyses were obtained from E3 in a spreadsheet titled "2022_TDV_Policy_Compliant_CH4Leak_FlatRtlAdd_20191210.xlsx". The electricity demand factors used in the energy savings analysis were obtained from E3 in a spreadsheet titled "2022 TDV Demand Factors.xlsx". The Energy Commission notified the Statewide CASE Team on April 21, 2020 that they were investigating further refinements to TDV factors using 20-year global warming potential (GWP) values instead of the 100-year GWP values that were used to derive the current TDV factors. It is anticipated that the 20-year GWP values will increase the TDV factors slightly. As a result, the TDV energy savings presented in this report are lower than the values that are expected if the final TDV use 20-year GWP values, and the proposed code changes will be more cost effective using the revised TDV. Energy savings presented in kWh and therms are not affected by TDV or demand factors.

Energy cost savings were calculated by applying the TDV energy cost factors to the energy savings estimates that were derived using the methodology described in Section 4. TDV is a normalized metric to calculate energy cost savings that accounts for the variable cost of electricity and natural gas for each hour of the year, along with how costs are expected to change over the period of analysis (30 years for residential measures and nonresidential envelope measures and 15 years for all other nonresidential measures). In this case, the period of analysis used is 15 years. The TDV cost impacts are presented in nominal dollars and in 2023 present value dollars and represent the energy cost savings realized over 15 years.

5.2 Energy Cost Savings Results

Per-unit energy cost savings for newly constructed buildings and alterations that are realized over the 15-year period of analysis are presented in 2023 present value dollars in Table 18: 2023 PV TDV Ener. This table presents the average impacts across all prototypical buildings that were included in the analysis. Negative numbers are denoted in red with parenthesis. This measure would have a very small increase in natural gas use, or a negative natural gas savings. See Appendix H: for results from each prototypical building independently. The TDV methodology allows peak electricity savings to be valued more than electricity savings during non-peak periods.

Table 18: 2023 PV TDV Energy Cost Savings Over 15-Year Period of Analysis – Per Square Foot – Construction-Weighted Average of All Prototype Building – New Construction and Alterations

Climate Zone	15-Year TDV Electricity Cost Savings (2023 PV$)	15-Year TDV Natural Gas Cost Savings (2023 PV$)	Total 15-Year TDV Energy Cost Savings (2023 PV$)
1	$0.13	($0.04)	$0.09
2	$0.17	($0.02)	$0.15
3	$0.14	($0.02)	$0.12
4	$0.17	($0.01)	$0.15
5	$0.14	($0.02)	$0.13
6	$0.16	($0.01)	$0.15
7	$0.17	($0.01)	$0.16
8	$0.17	($0.01)	$0.17
9	$0.21	($0.01)	$0.20
10	$0.22	($0.01)	$0.21
11	$0.19	($0.02)	$0.16
12	$0.18	($0.02)	$0.16
13	$0.21	($0.02)	$0.19
14	$0.21	($0.02)	$0.19
15	$0.23	($0.01)	$0.22
16	$0.16	($0.04)	$0.12

5.3 Incremental First Cost

To evaluate the incremental first cost of a proposed measure, the Statewide CASE Team first determined the daylighting control component costs for both the current code requirements and the proposed code requirements.

The components of a daylighting control system include:

- Photocell
- Daylighting logic controller
- Lamp power controller

The cost of the lamp is not included because the proposed code change does not impact the lamps or wattage requirements in the daylit space.

The photocell's function is to output a signal proportionate to the daylighting level in the space. The photocell equipment used to meet the current standard is also appropriate for the proposed measure. There is no increase in cost associated with the photocell for the proposed measure compared to the current standard.

The daylighting logic controller's function is to receive an input signal from the photocell and output an appropriate control signal to the lamp power controller. The daylighting logic controller equipment used to meet the current standard is also appropriate for the proposed measure. There is no increase in cost associated with the daylighting logic controller for the proposed measure compared to the current standard.

As discussed above in Section 3.2.1, LEDs would be a significant portion of the market when the 2022 standards take effect. As shown in Table 19 in the current code, LEDs are required to have dimming drivers that reduce lighting power to at least 10 percent of full power in the current standard. This means that the market would already be using lamp power controllers capable of dimming to 10 percent. Therefore, there is no cost increase for the lamp power controller for the proposed measure. Lamp power controllers that dim to 10 percent (i.e. dimming drivers for LEDs) would already have a market share greater than that used to justify the current standard, so requiring those controllers would not in general increase the cost of most projects.

Although the capability to dim to 10 percent from daylighting would be standard practice by the time the 2022 standards take effect, energy savings can still be claimed because the implementation of that capability is not a foregone conclusion without the adoption of the proposed requirement. Without a requirement to dim to 10 percent via daylighting controls, projects may choose to maintain higher levels of light in the space by dimming only to 35 percent, meeting the current requirements, even when there is sufficient daylight to dim to 10 percent and the multi-level controls capable of doing this are installed.

Although the change in lamp type is not included in the first cost of components, it may affect the technology used in the lamp power controller. The market share of different lamp types has changed since the analysis was performed for the 2019 California Energy Code. The daylighting requirements adopted into the current standard were based on T8 fluorescent lamp fixtures (California Utilities Statewide Codes and Standards Team 2011). The cost-effectiveness analysis supporting these requirements was done in 2011. At that time T8 fluorescent lamps were approximately 45 percent of the commercial building market (Navigant Consulting, Inc. 2012). By 2021 LEDs are predicted to have 52 percent of the sales market (Pike Research 2019). Given that LEDs would have even more market share than T8 fluorescents had when they were used to justify an update to the standard, and this measure would largely affect new construction, it is appropriate to base the 2022 lamp power controller on LEDs.

The lamp power controller technology used to dim LEDs is different than that used to dim fluorescents. Fluorescents use dimming ballasts while LEDs use drivers. There is a cost difference associated with these two technologies, but it is not needed in the cost effectiveness analysis because LEDs with the capability to dim to 10 percent would already be standard practice.

In summary, there are not incremental first costs for the following reasons:

- **Photocell:** there is no change in equipment from the current requirements.
- **Daylighting logic controllers:** there is no change in equipment from the current requirements.
- **Lamp power controllers:** lamp power controllers that dim to 10 percent is expected to be standard practice when the 2022 standards take effect.

The Statewide CASE Team reviewed this assumption with stakeholders during the utility-sponsored stakeholder meetings and heard no objections to this assumption.

Table 19: Table 130.1-A Multi-Level Lighting Controls and Uniformity Requirements

Luminaire Type	Minimum Required Control Steps (percent of full rated power[a])	Uniform level of illuminance shall be achieved by:
Line-voltage sockets except GU-24 Low-voltage incandescent systems LED luminaires and LED source systems GU-24 rated for LED	Continuous dimming 10-100%	Continuous dimming 10-100%
GU-24 sockets rated for fluorescent > 20 watts Pin-based compact fluorescent > 20 watts[b]	Continuous dimming 20-100%	Continuous dimming 20-100%
GU-24 sockets rated for fluorescent ≤ 20 watts Pin-based compact fluorescent ≤ 20 watts[b] Linear fluorescent and U-bent fluorescent ≤ 13 watts	Minimum one step between 30-70%	• Stepped dimming; or • Continuous dimming; or • Switching alternate lamps in a luminaire.

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

a. Full rated input power of ballast and lamp, corresponding to maximum ballast factor.

b. Includes only pin based lamps: twin tube, multiple twin tube, and spiral lamps

5.4 Incremental Maintenance and Replacement Costs

Incremental first cost is the initial cost to adopt more efficient equipment or building practices when compared to the cost of an equivalent baseline project. There are no incremental maintenance or replacement costs associated with this measure. A control system that is capable to reduce lighting power to 35 percent (current code) and 10 percent (proposed code) requires the same maintenance and replacements. As such, there are no incremental costs associated with the proposed code change.

The Statewide CASE Team reviewed this assumption with stakeholders during the utility-sponsored stakeholder meetings and heard no objections to this assumption.

5.5 Cost Effectiveness

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

The Energy Commission establishes the procedures for calculating 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. The incremental first cost and incremental maintenance costs over the 15-year period of analysis were included. The TDV energy cost savings were also included in the evaluation. Design costs were not included, nor were the incremental costs of code compliance verification.

According to the Energy Commission's definitions, a measure is cost effective if the benefit-to-cost (B/C) ratio is greater than 1.0. The B/C ratio is calculated by dividing the cost benefits realized over 15 years by the total incremental costs, which includes maintenance costs for 15 years. The B/C ratio was calculated using 2023 PV costs and cost savings.

As discussed above, there are no costs associated with the proposed code changes. Since reducing lighting power to 10 percent yields energy cost savings in all building types and climate zones, the proposed code change has an infinite B/C ratio in all climate zones. See the energy cost savings (benefit) of the proposed code change by building type and climate zone in Appendix H: .

6. First-Year Statewide Impacts

6.1 Statewide Energy and Energy Cost Savings

The Statewide CASE Team calculated the first-year statewide savings for new construction by multiplying the per-unit savings, which are presented in Section 4.3, by assumptions about the percentage of newly constructed buildings that would be impacted by the proposed code. The statewide new construction forecast for 2023 is presented in Appendix A: as are the Statewide CASE Team's assumptions about the percentage of new construction that would be impacted by the proposal (by climate zone and building type). It should be noted the 2019 CASE report assumed a smaller number of building types affected, in 2023 this was expanded to a be more accurate representation of true compliance which increased the overall statewide construction forecast and savings.

The Statewide CASE Team assumed that the alteration rate of luminaires in the existing building stock is ten percent per year. This assumption is based on the U.S. DOE's lighting market model, which "covers all upgrades/retrofits and renovations, regardless of their impetus, representing replacements that occur prior to the failure of the existing lighting fixture" (Department of Energy 2016).

The current energy code (2019 Title 24, Part 6, Section 141.0 I and J) offers three options to comply with the nonresidential lighting alteration requirements. Only one of the three available compliance options, referred to as "85-100 percent of LPD allowance" in this report, requires automatic daylighting controls.

The first-year energy impacts represent the first-year annual savings from all buildings that were completed in 2023. The 15-year energy cost savings represent the energy cost savings over the entire 15-year analysis period. The statewide savings estimates do not take naturally occurring market adoption or compliance rates into account.

Per-unit energy savings were normalized area, the results are scaled to the statewide affected floor stock of considered building types.

Table 20 presents the first-year statewide energy and energy cost savings from newly constructed buildings by climate zone.

Table 21 presents the first-year statewide energy and energy cost savings from alterations to buildings by climate zone.

Table 22 presents first-year statewide savings from new construction, additions, and alterations.

Table 20: Statewide Energy and Energy Cost Impacts – New Construction

Climate Zone	Statewide New Construction Impacted by Proposed Change in 2023 (million square feet)	First-Year[a] Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First-Year Natural Gas Savings (MMTherms)	15-Year Present Valued Energy Cost Savings (PV$ million in 2023)
1	0.60	0.04	0.00	(0.00)	$0.05
2	3.57	0.30	0.00	(0.00)	$0.52
3	16.96	1.25	0.02	(0.01)	$2.09
4	8.73	0.71	0.01	(0.01)	$1.33
5	1.69	0.14	0.00	(0.00)	$0.22
6	11.35	1.00	0.01	(0.00)	$1.68
7	8.66	0.76	0.01	(0.00)	$1.41
8	16.35	1.43	0.01	(0.00)	$2.68
9	27.23	2.37	0.05	(0.01)	$5.52
10	14.89	1.49	0.02	(0.01)	$3.13
11	3.25	0.29	0.00	(0.00)	$0.53
12	18.04	1.59	0.01	(0.01)	$2.85
13	6.33	0.61	0.01	(0.00)	$1.21
14	3.46	0.34	0.01	(0.00)	$0.64
15	2.10	0.23	0.00	(0.00)	$0.46
16	1.11	0.10	0.00	(0.00)	$0.13
TOTAL	**144.32**	**12.63**	**0.17**	**(0.08)**	**$24.43**

a. First-year savings from all buildings completed statewide in 2023.

Table 21: Statewide Energy and Energy Cost Impacts – Alterations

Climate Zone	Statewide New Construction Impacted by Proposed Change in 2023	First-Year[a] Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First-Year Natural Gas Savings (MMTherms)	15-Year Present Valued Energy Cost Savings (PV$ million in 2023)
1	1.94	0.14	0.00	(0.00)	$0.17
2	11.51	0.95	0.01	(0.01)	$1.68
3	53.87	3.99	0.07	(0.04)	$6.72
4	27.66	2.24	0.03	(0.02)	$4.20
5	5.46	0.44	0.01	(0.00)	$0.70
6	39.41	3.49	0.02	(0.01)	$5.94
7	29.61	2.58	0.05	(0.01)	$4.78
8	56.27	4.96	0.04	(0.02)	$9.38
9	91.60	8.10	0.16	(0.03)	$18.69
10	55.19	5.58	0.08	(0.03)	$11.68
11	10.84	0.96	0.02	(0.01)	$1.79
12	57.03	4.99	0.04	(0.04)	$8.94
13	21.05	2.03	0.03	(0.02)	$4.06
14	12.63	1.24	0.04	(0.01)	$2.35
15	7.57	0.84	0.02	(0.00)	$1.69
16	3.94	0.35	0.01	(0.01)	$0.46
TOTAL	**485.56**	**42.87**	**0.61**	**(0.26)**	**$83.21**

a. First-year savings from all buildings completed statewide in 2023.

Table 22: Statewide Energy and Energy Cost Impacts – New Construction, Alterations, and Additions

Construction Type	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First -Year Natural Gas Savings (MMTherms)	15-Year Present Valued Energy Cost Savings (PV$ million in 2023)
New Construction	12.6	0.2	(0.1)	$24.4
Additions and Alterations	42.9	0.6	(0.3)	$83.2
TOTAL	**55.5**	**0.8**	**(0.3)**	**$107.6**

a. First-year savings from all alterations completed statewide in 2023.

6.2 Statewide Greenhouse Gas (GHG) Emissions Reductions

The Statewide CASE Team calculated avoided GHG emissions assuming the emissions factors specified in the United States Environmental Protection Agency (U.S.

EPA) Emissions & Generation Resource Integrated Database (eGRID) for the Western Electricity Coordination Council California (WECC CAMX) subregion. Avoided GHG emissions from natural gas savings attributable to sources other than utility-scale electrical power generation are calculated using emissions factors specified in U.S. EPA's Compilation of Air Pollutant Emissions Factors (AP-42). See Appendix C: for additional details on the methodology used to calculate GHG emissions. In short, this analysis assumes an average electricity emission factor of 240.4 metric tons CO2e per GWh based on the average emission factors for the CACX EGRID subregion.

Table 23 presents the estimated first-year avoided GHG emissions of the proposed code change. During the first year, GHG emissions of 25,217 metric tons of carbon dioxide equivalents (Metric Tons CO2e) would be avoided.

Table 23: First-Year Statewide GHG Emissions Impacts

Measure	Electricity Savings[a] (GWh/yr)	Reduced GHG Emissions from Electricity Savings[a] (Metric Tons CO2e)	Natural Gas Savings[a] (MMTherms/yr)	Reduced GHG Emissions from Natural Gas Savings[a] (Metric Tons CO2e)	Total Reduced CO_2e Emissions[a,b] (Metric Tons CO2e)
Daylighting Dimming to 10%	55.5	13,340	(0.3)	(1,824)	11,516

a. First-year savings from all buildings completed statewide in 2023.

b. Assumes the following emission factors: 240.4 MTCO2e/GWh and 5,454.4 MTCO2e/MMTherms.

6.3 Statewide Water Use Impacts

The proposed code change would not result in on-site water savings. The reduction in electricity use would conserve water at thermoelectric power plants that use open loop systems for their water. These water savings are not yet considered pertinent for CASE proposals.

6.4 Statewide Material Impacts

As discussed in Section 3.2 the current and proposed code requirements require the same equipment to comply. The only change is the programming within controllers to enable dimming to 10 percent instead of 35 percent. Therefore, there is no expected change in material use.

6.5 Other Non-Energy Impacts

The Statewide CASE Team does not anticipate any other non-energy impacts.

7. Proposed Revisions to Code Language

7.1 Guide to Markup Language

The proposed changes to the standards, Reference Appendices, and the ACM Reference Manuals are provided below. Changes to the 2019 documents are marked with red underlining (new language) and ~~strikethroughs~~ (deletions).

7.2 Standards

SECTION 100.1 – DEFINITIONS AND RULES OF CONSTRUCTION

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

DAYLIT ZONE is the floor area under skylights or next to windows. Types of Daylit Zones include Primary Sidelit Daylit Zone, Secondary Sidelit Daylit Zone, and Skylit Daylit Zone.

SIDELIT DAYLIT ZONE, PRIMARY is the area in plan view 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.

SIDELIT DAYLIT ZONE, SECONDARY is the area in plan view 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.

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 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 located in an atrium, the skylit daylit zone shall include the floor area directly under the atrium, and the area of the top floor that is directly under the skylight, plus 0.7 times the average ceiling height of the top 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.

LIGHTING CONTROLS consist of the following:

Dimmer, Full-Range, or Continuous Dimmer, means a dimmer that varies the luminous flux of the electric lighting system over a continuous range from the device's maximum light output to the device's minimum light output without visually apparent abrupt changes in light level between the various steps.

Daylight Continuous Dimming Control means a Continuous Dimmer that varies luminous flux in response to available daylight.

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(f), in addition to the applicable requirements of Sections 110.9 and 130.0.

(sections omitted)

(d) **Automatic Daylighting Controls.** The general lighting in Sskylit Ddaylit Zzones, and Pprimary Ssidelit Ddaylit Zzones and Secondary Sidelit Daylit Zones, as well as the general lighting in the combined primary and secondary sidelit daylit zones in parking garages, shall be provided with controls that automatically adjust the power of the installed general lighting up and down to keep the total light level stable as the amount of incoming daylight changes. For skylights located in an atrium, the Sskylit Ddaylit Zzones definition shall apply to the floor area directly under the atrium and the top floor area directly adjacent to the atrium.

1. All skylit daylit zones, primary sidelit daylit zones, Secondary Sidelit Daylit Zones, and the combined primary and secondary sidelit daylit zones in parking garages shall be shown on the plans.

   NOTE: Parking areas on the roof of a parking structure are outdoor hardscape, not skylit daylit areas.

2. The automatic daylighting controls shall provide separate control for luminaires General Lighting in each type of daylit zone. Luminaires that fall in both a General Lighting in overlapping Sskylit Daylit Zone and a Primary or Secondary Ssidelit Ddaylit Zzone shall be controlled as part of the Sskylit Daylit Zone. General lighting in overlapping Primary and Secondary Sidelit Daylit Zones shall be controlled as part of the Primary Sidelit Daylit Zone.

   EXCEPTION to 130.1(d)2: Light emitting diodes (LEDs) and other solid state lighting (SSL) sources shall be treated as lamps in increments of 2 feet. General lighting LEDs or SSLs crossing across multiple daylit zones types or from daylit zone to non-daylit zone shall be segmented within 1 foot of the edge of each type of daylit zone and separately controlled based on the type of zone the segment is primarily located.

3. The automatic daylighting controls shall:

A. For spaces required to install multilevel controls under Section 130.1(b), adjust lighting via continuous dimming or the number of control steps provided by the multilevel controls;

B. For each space, ensure the combined illuminance from the controlled lighting and daylight is not less than the illuminance from controlled lighting when no daylight is available;

C. For areas other than parking garages, ensure that when the daylight illuminance is greater than 150 percent of the design illuminance received from the general lighting system at full power, the general lighting power in that daylight zone shall be reduced by a minimum of 90 ~~65~~ percent; and

D. For parking garages, ensure that 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 is zero.

4. When photosensors are located within the daylit zone, at least one photosensor shall be located so that they are not readily accessible to unauthorized personnel.
5. 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.

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

EXCEPTION 2 to Section 130.1(d): Areas adjacent to vertical glazing below an overhang, where the overhang covers the entire width of the vertical glazing, no vertical glazing is above the overhang, and the ratio of the overhang projection to the overhang rise is greater than 1.5 for South, East and West orientations or greater than 1 for North orientations.

EXCEPTION 3 to Section 130.1(d): Rooms in which the combined total installed general lighting power in the Skylit Daylit Zone and Primary Sidelit Daylit Zone is less than 120 Watts, or parking garage areas where the total combined general lighting power in the sidelit daylight zones is less than 60 watts.

EXCEPTION 4 to Section 130.1(d): Luminaires in Secondary Sidelit Daylit Zone(s) in an enclosed space in which the combined total general lighting power in Secondary Daylit Zone(s) is less than 120 watts, or where the combined total general lighting power in Primary and Secondary Daylit Zone(s) is less than 240 watts.

EXCEPTION ~~4~~ 5 to Section 130.1(d): Rooms that have a total glazing area of less than 24 square feet, or parking garage areas with a combined total of less than 36 square feet of glazing or opening.

EXCEPTION ~~5~~ 6 to Section 130.1(d): For parking garages, luminaires located in the daylight adaptation zone ~~and luminaires for only dedicated ramps~~. ~~Daylight adaptation zone and dedicated ramps are defined in Section 100.1.~~

EXCEPTION ~~6~~ 7 to Section 130.1(d): Luminaires in S~~s~~kylit D~~d~~aylit Z~~z~~ones in retail merchandise sales and wholesale showroom areas.

SECTION 140.6 – PRESCRIPTIVE REQUIREMENTS FOR INDOOR LIGHTING

(a) **Calculation of Adjusted Indoor Lighting Power.** The adjusted 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 4 of this subsection.

(section omitted)

2. **Reduction of wattage through controls.** In calculating Adjusted 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:

   A. An Installation Certificate is submitted in accordance with Section 130.4(b); and

   B. Luminaires and controls meet the applicable requirements of Section 110.9, and Sections 130.0 through 130.5; and

   C. The controlled lighting is permanently installed general lighting systems and the controls are permanently installed nonresidential-rated lighting controls.

   When used for determining PAFs for general lighting in offices, furniture mounted luminaires that comply with all of the following conditions shall qualify as permanently installed general lighting systems:

      i. The furniture mounted luminaires shall be permanently installed no later than the time of building permit inspection; and

      ii. The furniture mounted luminaires shall be permanently hardwired; and

      iii. The furniture mounted lighting system shall be designed to provide indirect general lighting; and

      iv. Before multiplying the installed watts of the furniture mounted luminaire by the applicable PAF, 0.3 watts per square foot of the area illuminated by the furniture mounted luminaires shall be subtracted from installed watts of the furniture mounted luminaires; and

      v. The lighting control for the furniture mounted luminaire complies with all other applicable requirements in Section 140.6(a)2.

   D. At least 50 percent of the light output of the controlled luminaire is within the applicable area listed in TABLE 140.6-A. Luminaires on lighting tracks shall be within the applicable area in order to qualify for a PAF.

   E. Only one PAF from TABLE 140.6-A may be used for each qualifying luminaire. PAFs shall not be added together unless allowed in TABLE 140.6-A.

F. Only lighting wattage directly controlled in accordance with Section 140.6(a)2 shall be used to reduce the installed watts as allowed by Section 140.6(a)2 for calculating the Adjusted Indoor Lighting Power. If only a portion of the wattage in a luminaire is controlled in accordance to Section 140.6(a)2, then only that portion of controlled wattage may be reduced in calculating Adjusted Indoor Lighting Power.

G. Lighting controls used to qualify for a PAF shall be designed and installed in addition to manual, multilevel, and automatic lighting controls required in Section 130.1, and in addition to any other lighting controls required by any provision of Part 6. PAFs shall not be available for lighting controls required by Part 6.

H. To qualify for the PAF for daylight continuous 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 the controls shall be continuous dimming 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 in the primary sidelit daylit zone, secondary sidelit daylit zone, and the skylit daylit zone~~.~~

(section omitted)

~~(d) **Automatic Daylighting Controls in Secondary Daylit Zones.** All luminaires providing general lighting that is in, or partially in a Secondary Sidelit Daylit Zone, 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); 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):** Luminaires in Secondary Sidelit Daylit Zone(s) in an enclosed space in which the combined total general lighting power in Secondary Daylit Zone(s) is less than 120 watts, or where the combined total general lighting power in Primary and Secondary Daylit Zone(s) is less than 240 watts.~~

~~**EXCEPTION 2 to Section 140.6(d):** Luminaires in parking garages complying with Section 130.1(d)3.~~

~~**EXCEPTION 3 to Section 140.6(d):** Areas adjacent to vertical glazing below an overhang, where there is no vertical glazing above the overhang and where the ratio of the overhang projection to the overhang rise is greater than 1.5 for South, East and West orientations, or where the ratio of the overhang projection to the overhang rise is greater than 1 for North orientations.~~

~~**EXCEPTION 4 to Section 140.6(d):** Rooms that have a total glazing area of less than 24 square feet, or parking garage areas with a combined total of less than 36 square feet of glazing or opening.~~

~~**EXCEPTION 5 to Section 140.6(d):** Luminaires in sidelit daylit zones in retail merchandise sales and wholesale showroom areas.~~

TABLE 140.6-A LIGHTING POWER ADJUSTMENT FACTORS (PAF)

<table>
<tr><th>TYPE OF CONTROL</th><th colspan="2">TYPE OF AREA</th><th>FACTOR</th></tr>
<tr><td colspan="4">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</td></tr>
<tr><td>1. Daylight Continuous Dimming plus OFF Control</td><td colspan="2">Luminaires in skylit daylit zone or primary sidelit daylit zone</td><td>0.10</td></tr>
<tr><td rowspan="3">2. Occupant Sensing Controls in Large Open Plan Offices</td><td rowspan="3">In open plan offices > 250 square feet: One sensor controlling an area that is:</td><td>No larger than 125 square feet</td><td>0.40</td></tr>
<tr><td>From 126 to 250 square feet</td><td>0.30</td></tr>
<tr><td>From 251 to 500 square feet</td><td>0.20</td></tr>
<tr><td rowspan="2">3. Institutional Tuning</td><td colspan="2">Luminaires in non-daylit areas.
Luminaires that qualify for other PAFs in this table may also qualify for this tuning PAF.</td><td>0.10</td></tr>
<tr><td colspan="2">Luminaires in daylit areas.
Luminaires that qualify for other PAFs in this table may also qualify for this tuning PAF.</td><td>0.05</td></tr>
<tr><td>4. Demand Responsive Control</td><td colspan="2">All building types of 10,000 square feet or smaller.
Luminaires that qualify for other PAFs in this table may also qualify for this demand responsive control PAF</td><td>0.05</td></tr>
<tr><td>5. Clerestory Fenestration</td><td colspan="2">Luminaires in daylit areas adjacent to the clerestory.
Luminaires that qualify for daylight dimming plus OFF control may also qualify for this PAF.</td><td>0.05</td></tr>
<tr><td>6. Horizontal Slats</td><td colspan="2">Luminaires in daylit areas adjacent to vertical fenestration with interior or exterior horizontal slats.
Luminaires that qualify for daylight dimming plus OFF control may also qualify for this PAF.</td><td>0.05</td></tr>
<tr><td>7. Light Shelves</td><td colspan="2">Luminaires in daylit areas adjacent to clerestory fenestration with interior or exterior light shelves. This PAF may be combined with the PAF for clerestory fenestration.
Luminaires that qualify for daylight dimming plus OFF control may also qualify for this PAF</td><td>0.10</td></tr>
</table>

7.3 Reference Appendices

Nonresidential Appendix NA7

Appendix NA7 – Installation and Acceptance Requirements for Nonresidential Buildings and Covered Processes

NA7.6 Indoor Lighting Control Acceptance Requirements

Lighting control acceptance testing shall be performed on:

(a) Automatic Daylighting Controls complying with Section 130.1(d) or Section 140.6(d).

(b) Shut-off ~~C~~controls complying with Section 130.1(c).

(c) Demand Responsive ~~C~~controls complying ~~in accordance~~ with Section 110.12 ~~130.1(e).~~

(d) Lighting controls installed to earn a power adjustment factor for institutional tuning in accordance with Section 140.6(a)2J.

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).~~

(a) The general lighting in skylit daylit zones, primary sidelit daylit zones and secondary sidelit daylit zones, or the general lighting in the combined primary and secondary sidelit daylit zones in parking garages, is controlled by automatic daylighting controls

(b) The daylit zones are shown on the plans.

(c) The automatic daylighting controls provide separate control for luminaires in each type of daylit zone. Luminaires that fall in both a skylit and primary sidelit daylit zone are controlled as part of the skylit zone.

(d) For photosensors located within a daylit zone, at least one photosensor is not readily accessible to unauthorized personnel, including inside a locked case or under a cover that requires a tool for access.

NA 7.6.1.2 Functional ~~t~~Testing

All photocontrols serving more than 5,000 ft² of daylit area shall undergo functional testing. Photocontrols that are serving smaller spaces may be sampled as follows:

For buildings with up to five (5) photocontrols, all photocontrols shall be tested. For buildings with more than five (5) photocontrols, sampling may be done on spaces with similar sensors and cardinal orientations of glazing; sampling shall include a minimum of one (1) photocontrol for each group of up to five (5) 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~~ test each group of lights controlled separately by the photocontrol according to the ~~following~~ protocol in NA 7.6.1.2.1 Continuous Dimming Control Systems or NA 7.6.1.2.2 Stepped Switching or Stepped Dimming Control Systems. In parking garages, the tests are conducted on daylighting controls that control together the combined area of the primary and secondary sidelit daylit zone. In all interior spaces other than parking garages, ~~a~~ separate tests shall be conducted for daylighting control of the primary sidelit daylit zone ~~separate from~~ and for daylighting control of the secondary sidelit daylit zone.

NA 7.6.1.2.1 Continuous Dimming Control Systems

This requirement is for daylighting control systems that have more than 10 levels of controlled light output in a given zone. Note: regardless of whether a light source is dimmable or dimmed by other controls, if the daylighting control has less than 10 steps of control, the daylighting control shall be tested in accordance with NA 7.6.1.2.2 Stepped Switching or Stepped Dimming Control Systems.

(a) **Reference Location.** Identify the minimum daylighting location in the controlled zone (Reference Location) for each daylit zone type (skylit, primary sidelit, and secondary sidelit) in the space. This can be identified using either the I~~i~~lluminance M~~m~~ethod or the D~~d~~istance M~~m~~ethod and will be used for illuminance measurements in subsequent tests. For parking garages, the reference location should always be the farthest edge of the secondary sidelit daylit zone away from the glazing or opening.

Illuminance Method

~~(b)~~.Turn off ~~OFF~~ controlled lighting and measure daylight illuminance within zones illuminated by controlled luminaires. ~~(c)~~. ~~Identify the~~ 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.~~ Turn the controlled lighting back on before proceeding to the no daylight test.

Distance Method

~~Identify the~~ The Reference Location is 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) ~~(d)~~ **No D~~d~~aylight T~~t~~est.** Simulate or provide conditions without daylight. Verify and document the following:

1. Automatic daylight control system turns on all controlled lighting to ~~provides appropriate control so that electric lighting system is providing~~

full light output unless otherwise specified by design documents or it has been documented that the continuous dimming luminaires have been intentionally tuned to less than full light output. Documentation includes NA7.7.5.2 for luminaires claiming the Power Adjustment Factor (PAF) for Institutional Tuning.

2. Document the Reference Illuminance ~~reference illuminance~~, which is the electric lighting illuminance level at the Reference Location ~~reference location~~ identified in NA 7.6.1.2.1(a) ~~Step1~~.

3. Light output is stable with no discernable flicker.

(c) ~~(e)~~ **Full Ddaylight Ttest.** ~~Simulate or provide~~ Provide bright conditions where the daylight illuminance is greater than 150 percent of the reference illuminance measured during the no daylight test, or provide simulated bright condtions including shining a bright light into the daylight sensor. Verify and document the following:

1. For parking garages the controlled lighting power is zero. For all other applications, ~~Lighting~~ lighting power reduction is at least 90 ~~65~~ percent under fully dimmed conditions and

2. ~~light~~ Light output is stable with no discernable flicker.

3. ~~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.

4. ~~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.

5. If a PAF 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 PAF for daylight dimming plus off controls.

(d) ~~(f)~~ **Partial Ddaylight Ttest.** Simulate or provide daylight conditions where illuminance (fc) provided only by ~~from~~ daylight only at the Reference Location is between 60 and 95 percent of Reference Illuminance (fc) measured during the no daylight test. ~~documented in Step (b)2;~~ Verify and document the following:

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

3. Light output is stable with no discernable flicker.

4. Only luminaires in daylit zones are affected by daylight control.

(e) **Alternate Partial Daylight Test.** Outdoor horizontal illuminance is at least 4,000 fc and where illuminance (fc) from daylight only at the Reference Location (Partial Daylight Illuminance) is no greater than 95 percent of Reference Illuminance (fc) measured at this location during the no daylight test. Verify and document the following:

1. Measure the Partial Daylight Illuminance (fc) at the Reference Location. This can be measured by turning the electric lighting off.

2. Measure that the combined daylight and controlled electric lighting illuminance (fc) at the Reference Location is no less than the Reference Illuminance (fc) measured at this location during the no daylight test

3. Measure that the combined illuminance of daylight and controlled electric lighting (fc) at the Reference Location is no greater than Partial Daylight Combined Illuminance Maximum, (PDCI Max).

   PDCI Max = Reference Illuminance + 0.40 x Daylight Illuminance

4. Light output is stable with no discernable flicker.

5. Only luminaires in daylit zones are affected by daylight control.

NA 7.6.1.2.2 Stepped Switching or Stepped Dimming Control Systems

This requirement is for systems that have no more than 10 discrete steps of control of light output.

~~If the control has 3 steps of control or less, conduct the following tests for all steps of control. If the control has more than 3 steps of control, testing 3 steps of control is sufficient for showing compliance.~~

(a) **Reference Location**. Identify the minimum daylighting location in the controlled zone (Reference Location) for each daylit zone type (skylit, primary sidelit, and secondary sidelit) in the space. This can be identified using either the illuminance method or the distance method and will be used for illuminance measurements in subsequent tests. For parking garages, the reference location should always be the farthest edge of the secondary sidelit daylit zone away from the glazing or opening.

Illuminance Method

~~1.~~ Turn off ~~OFF~~ controlled lighting and measure daylight illuminance within zones illuminated by controlled luminaires. ~~2.~~ ~~Identify the~~ 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 the controlled ~~lights~~ lighting back ~~ON~~ on before continuing with the other tests.

Distance Method

~~Identify the~~ The Reference Location is 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 D~~d~~aylight T~~t~~est.** 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 except for Verify Time Delay test NA 7.6.1.2.2(e).. ~~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 NA 7.6.1.2.2(a). ~~Step 1~~.

(c) **Full D~~d~~aylight T~~t~~est.** Simulate or provide bright conditions. Verify and document the following:

1. For parking garages, the controlled lighting power consumption is zero. For all other areas, ~~Lighting~~ power reduction of controlled luminaires is at least 90 ~~65~~ percent.
2. Only luminaires in daylit zones (toplit zone, primary sidelit zone and secondary sidelit zone) are affected by daylight control. If the daylighting controls control lighting outside of the daylight zones including those behind obstructions as described in Section 100.1(b) ~~130.1(d)1~~, the control system is not compliant.
3. Light output is stable with no discernable flicker.

(d) **Partial D~~d~~aylight T~~t~~est.** If the control system has one (1) to three (3) steps of control between on and off, test all control steps between on and off. If the control system has more than three (3) steps between on and off, testing three (3) control steps between on and off is sufficient to demonstrate compliance. If the control system has zero (0) steps between on and off, the partial daylight test is not necessary. For stepped switching control systems, steps in a controlled zone are achieved by turning some luminaires or groups of luminaires on or off without any steps between on and off. 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 or simulated illumination shall be no less than the ~~reference illuminance~~ Reference Illuminance measured at this location during the no daylight test ~~documented in Step 2.~~
   - B. The total measured or simulated illumination shall be no greater than 150 percent of the ~~reference illuminance~~ Reference Illuminance .
2. The control stage shall not cycle on and off or cycle between dim and undimmed while daylight illuminance remains constant.
3. Only luminaires in daylit zones (toplit zone, primary sidelit zone, and secondary sidelit zone) are affected by daylight control.

(e) **Verify time delay.**

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

7.4 ACM Reference Manual

5.4.5 Daylighting Control

This group of building descriptors is applicable for spaces that have daylighting controls or daylighting control requirements.

California prescribes a modified version of the split flux daylighting methods to be used for compliance. This is an *internal daylighting method* because the calculations are automatically performed by the simulation engine. For top-lighted or sidelit daylit areas, California compliance prescribes an internal daylighting model consistent with the split flux algorithms used in many simulation programs. With this method the simulation model has the capability to model the daylighting contribution for each hour of the simulation and make an adjustment to the lighting power for each hour, taking into account factors such as daylighting availability, geometry of the space, daylighting aperture, control type, and the lighting system. The assumption is that the geometry of the space, the reflectance of surfaces, the size and configuration of the daylight apertures, and the light transmission of the glazing are taken from other building descriptors.

For daylight control using a simplified geometry approach, daylight control for both the primary daylit zone ~~(mandatory)~~ and secondary daylit zone (~~prescriptive~~ mandatory) must be indicated on the compliance forms. If the simplified geometry approach is used and the visible transmittance of fenestration does not meet prescriptive requirements, the standard design lighting power is reduced by 20 percent as a penalty. See Interior Lighting.

Daylight Control Requirements	
Applicability	All spaces with exterior fenestration
Definition	The extent of daylighting controls in skylit and sidelit areas of the space
Units	List
Input Restrictions	When the installed general lighting power in the primary daylit zone exceeds 120W, daylighting controls are required, per the Title 24 mandatory requirements.
Standard Design	For nonresidential spaces, when the installed general lighting power in the skylit or primary sidelit daylit zone exceeds 120W, daylighting controls are required in the primary daylit zone, per the Title 24 mandatory requirements. For parking garages, when the installed general lighting power in the primary sidelit or secondary sidelit daylit zone exceeds 120W, daylighting controls are required, per the Title 24 mandatory requirements. Luminaires located in daylit transition zones or dedicated ramps are exempt from this requirement. For nonresidential spaces, daylighting controls are specified when the installed general lighting power in the skylit, primary sidelit, or secondary sidelit daylit zone(s) exceeds 120W. For parking garages, when the installed general lighting power in the primary sidelit or secondary sidelit daylit zone exceeds 120W, daylighting controls are required. Luminaires located in daylit transition zones or dedicated ramps are exempt from this requirement.
Standard Design: *Existing Buildings*	When lighting systems in an existing altered building are not modified as part of the alteration, daylighting controls are the same as the proposed design.

	When an alteration increases the area of a lighted space, increases lighting power in a space, or when luminaires are modified in a space where proposed design lighting power density is greater than 85 percent of the standard design LPD, daylighting control requirements are the same as for new construction.

Skylit, Primary, and Secondary Daylit Area	
Applicability	All daylit spaces
Definition	The floor area that is daylit. The skylit area is the portion of the floor area that gets daylighting from a skylight. Two types of sidelit daylit areas are recognized. The primary daylit area is the portion that is closest to the daylighting source and receives the most illumination. The secondary daylit area is an area farther from the daylighting source, which still receives useful daylight. The primary daylit area for side lighting is a band near the window with a depth equal to the distance from the floor to the top of the window and width equal to window width plus 0.5 times window head height wide on each side of the window opening. The secondary daylit area for side lighting is a band beyond the primary daylit area that extends a distance double the distance from the floor to the top of the window and width equal to window width plus 0.5 times window head height wide on each side of the window opening. Area beyond a permanent obstruction taller than 6 feet should not be included in the primary and secondary daylight area calculation. The skylit area is a band around the skylight well that has a depth equal to 70 percent of the ceiling height from the edge of the skylight well. The geometry of the skylit daylit area will be the same as the geometry of the skylight. Area beyond a permanent obstruction taller than 50 percent of the height of the skylight from the floor should not be included in the skylit area calculation. Double counting due to overlaps is not permitted. If there is an overlap between secondary and primary or skylit areas, the effective daylit area used for determining reference position shall be the area minus the overlap.
Units	ft^2
Input Restrictions	The daylit areas in a space are derived using other modeling inputs like dimensions of the fenestration and ceiling height of the space.
Standard Design	The daylit areas in the standard design are derived from other modeling inputs, including the dimensions of the fenestration and ceiling height of the space. Daylit area calculation in the standard design is done after window to wall ratio and skylight to roof ratio rules in Section 5.5.7 of this manual are applied.

Standard Design: Existing Buildings	Same as new construction when skylights are added/replaced and general lighting altered

Installed General Lighting Power in the Primary and Skylit Daylit Zone	
Applicability	All spaces
Definition	The installed lighting power of general lighting in the primary and skylit daylit zone. The primary and skylit daylit zone shall be defined on the plans, and be consistent with the definition of the primary and skylit daylit zone in the standards. Note that a separate building descriptor, fraction of controlled lighting, defines the fraction of the lighting power in the space that is controlled by daylighting.
Units	Watts
Input Restrictions	As designed
Standard Design	The installed lighting power for the standard design is the product of the primary daylit area and the LPD for general lighting in the space.
Standard Design: Existing Buildings	Same as new construction when skylights are added/replaced and general lights are altered

Installed General Lighting Power in the Secondary Daylit Zone	
Applicability	All spaces
Definition	The installed lighting power of general lighting in the secondary daylit zone. The secondary daylit zone shall be defined on the plans and be consistent with the definition of the secondary daylit zone in the standards. Note that a separate building descriptor, fraction of controlled lighting, defines the fraction of the lighting power in the space that is controlled by daylighting.
Units	W
Input Restrictions	As designed
Standard Design	The installed lighting power for the standard design is the product of the secondary daylit area and the LPD for general lighting in the space.
Standard Design: Existing Buildings	Same as new construction when skylights are added/replaced and general lights are altered

Reference Position for Illuminance Calculations

Applicability	All spaces or thermal zones, depending on which object is the primary container for daylighting controls
Definition	The position of the two daylight reference points within the daylit space. Lighting controls are simulated so that the illuminance at the reference position is always maintained at or above the illuminance setpoint. For step switching controls, the combined daylight illuminance plus uncontrolled electric light illuminance at the reference position must be greater than the setpoint illuminance before the controlled lighting can be dimmed or tuned off for stepped controls. Similarly, dimming controls will be dimmed so that the combination of the daylight illuminance plus the controlled lighting illuminance is equal to the setpoint illuminance. Preliminary reference points for primary and secondary daylit areas are located at the farthest end of the daylit area aligned with the center of each window. For skylit area, the preliminary reference point is located at the center of the edge of the skylit area closest to the centroid of the space. In each case, the Z – coordinate of the reference position (elevation) shall be located 2.5 feet above the floor. Up to two final reference positions can be selected from among the preliminary reference positions identified in for each space.
Units	Data structure
Input Restrictions	The user does not specify the reference position locations; reference positions are automatically calculated by the compliance software based on the procedure outlined below. Preliminary reference positions are each assigned a relative daylight potential (RDP) which estimates the available illuminance at each position, and the final reference position selection is made based on the RDP. **RDP:** An estimate of daylight potential at a specific reference position. This is NOT used directly in the energy simulation, but it used to determine precedence for selecting the final reference points. The relative daylight potential is calculated as a function of effective aperture, azimuth, illuminance setpoint and the type (skylit, primary sidelit, or secondary sidelit) of the associated daylit zone. RDP is defined as: $RDP = C_1 \times EA_{dz} + C_2 \times SO + C_3$ Where: C_1,C_2, and C_3 are selected from the following table.

	Skylit Daylit Zones			Primary Sidelit Daylit Zones			Secondary Sidelit Daylit Zones		
Illuminance Setpoint	C_1	C_2	C_3	C_1	C_2	C_3	C_1	C_2	C_3
≤ 200 lux	3927	0	3051	1805	-0.40	3506	7044	-3.32	1167
≤ 1000 lux	12046	0	-421	6897	-7.22	475	1512	-2.88	-22
> 1000 lux	5900	0	-516	884	-5.85	823	212	-0.93	57

Illuminance Setpoint: This is defined by the user, and is entered by the user, subject to the limits specified in Appendix 5.4A, determined from the space type.

	Source Orientation (SO): The angle of the outward facing normal of the daylight source's parent surface projected onto a horizontal plane, expressed as degrees from south. This is not a user input but is calculated from the geometry of the parent surface. For skylights, the source orientation is not applicable. For vertical fenestration, it is defined: $$SO = \|(180 - Azimuth)\|$$ Where: Azimuth is defined as the azimuth of the parent object containing the fenestration associated with the preliminary reference point. **Effective Aperture (EA):** For this calculation, effective aperture represents the effectiveness of all sources which illuminate a specific reference position in contributing to the daylight available to the associated daylit zone. In cases where daylit zones from multiple fenestration objects intersect, the effective aperture of an individual daylit zone is adjusted to account for those intersections according to the following rules: - For skylit and primary sidelit daylit zones, intersections with other skylit or primary sidelit daylit zones are considered. - For secondary sidelit daylit zones, intersections with any toplit or sidelit (primary or secondary) daylit zones are considered. Effective aperture is defined as follows: $$EA_{dz} = \left(VT_{fdz} \times A_{fdz} + \sum F_i \times VT_i \times A_i\right)/A_{dz}$$ Where: EA_{dz} Is the combined effective aperture of all daylight sources illuminating a specific daylit zone. VT_{fdz} Is the user specified visible transmittance of the fenestration object directly associated with the daylit zone. A_{fdz} Is the area of the fenestration object directly associated with the daylit zone. VT_i Is the user specified visible transmittance of the fenestration object associated with each intersecting daylit zone. A_i Is the area of the fenestration object directly associated with each intersecting daylit zone. F_i Is the fraction of intersecting area between the daylit zone in question and each intersecting daylit zone: $$F_i = A_{intersection}/A_{dzi}$$ A_{dzi} Is the area of each intersecting daylit zone (including area that might fall outside a space or exterior boundary). A_{dz} Is the area of the daylit zone (including area that might fall outside a space or exterior boundary).

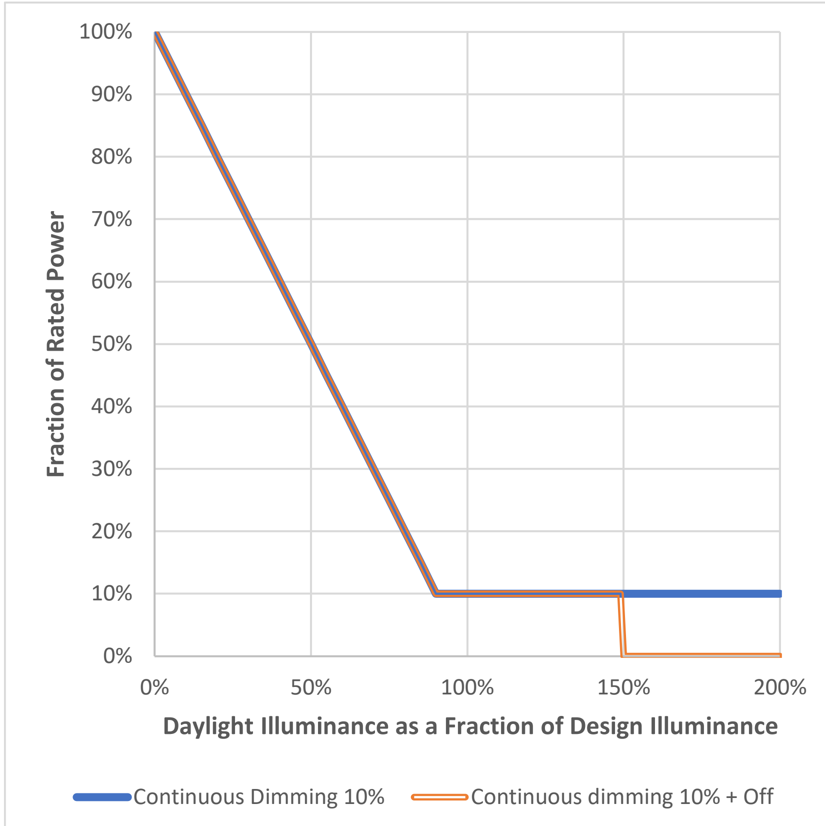
	First Reference Position: Select the preliminary reference point with the highest relative daylight potential (RDP) from among all preliminary reference points located within either top or primary sidelit daylit zones. If multiple reference points have identical RDPs, select the reference point geometrically closest to the centroid of the space. **Second Reference Position:** Select the preliminary reference point with the highest RDP from amongst all remaining preliminary reference points located within either top or primary sidelit daylit zones. If multiple reference points have identical RDPs, select the reference point geometrically closest to the centroid of the space.
Standard Design	Reference positions for the standard design shall be selected using the same procedure as those selected for the proposed design.
Standard Design: *Existing Buildings*	Additions or alternations of lighting in spaces trigger the daylighting control requirements whenever the total installed lighting in the daylit zone is 120 W or greater, and the reference positions shall be determined in the same manner as with new construction. This only applies when alterations or additions to the lighting in an existing building trigger daylighting control requirements.

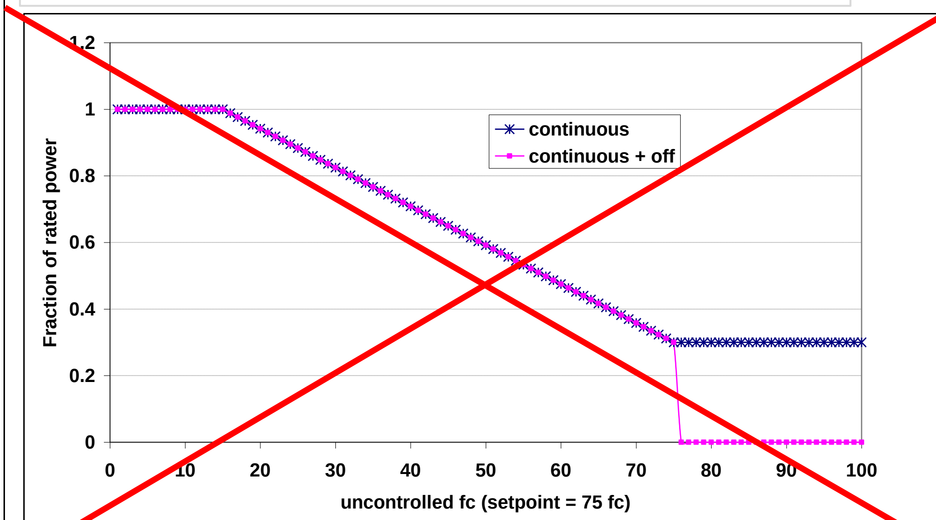
Illumination Adjustment Factor	
Applicability	All Daylighted Spaces
Definition	Recent studies have shown that the split flux interreflection component model used in many simulation programs overestimates the energy savings due to daylighting, particularly deep in the space. A set of two adjustment factors is provided, one for the primary daylit zone and one for the secondary daylit zone. For simulation purposes, the input daylight illuminance setpoint will be modified by the illuminance adjustment factor as follows: $LightSetpoint_{adj} = LightSetpoint \times Adjustment\ Factor$
Units	Unitless
Input Restrictions	Prescribed values for space type in Appendix 5.4A
Standard Design	The standard design illumination adjustment factors shall match the proposed
Standard Design: *Existing Buildings*	Same as new construction when skylights are added/replaced and general light is altered.

Fraction of Controlled Lighting	
Applicability	Daylighted Spaces

Definition	The fraction of the general lighting power in the primary and skylit daylit zone, or secondary sidelit daylit zone that is controlled by daylighting controls.
Units	Numeric: fraction for primary and skylit daylit zone, and fraction for secondary zone
Input Restrictions	As designed for secondary daylit areas. If the proposed design has no daylight controls in the secondary daylit area the value is set to 0 for the general lights in the secondary daylit area. Primary and skylit daylit area fraction of controlled general lighting shall be as designed when the daylight control requirements building descriptor indicates that they are not required, and shall be 1 when controls are required.
Standard Design	When daylight controls are required according to the daylight control requirements building descriptor in either the primary daylit and skylit zone, or the secondary daylit zone, or both, the fraction of controlled lighting shall be 1.
Standard Design: *Existing Buildings*	Same as for new construction when skylights are added/replaced, and general light is altered.

Daylighting Control Type	
Applicability	Daylighted Spaces
Definition	The type of control that is used to control the electric lighting in response to daylight available at the reference point. Options: • ~~Stepped switching controls vary the electric input power and lighting output power in discrete equally spaced steps. At each step, the fraction of light output is equal to the fraction of rated power.~~ • Continuous dimming controls have a fraction to rated power to fraction of rated output that is a linear interpolation of the minimum power fraction at the minimum diming light fraction to rated power (power fraction = 1.0) at full light output. See Figure 8: Example Continuous Dimming Control • Continuous dimming + off controls are the same as continuous dimming controls except that these controls can turn all the way off when none of the controlled light output is needed. The OFF stage of the control is not modelled unit daylight illuminance is 150% or above of design illuminance. See the example control chart below. Figure 8: Example of Lighting Power Fraction Continuous Dimming and Continuous Dimming Plus OFF Daylighting Controls

<table>
<tr><td></td><td>



~~Source: NORESCO for California Energy Commission~~</td></tr>
<tr><td>Units</td><td>List (see above)</td></tr>
<tr><td>Input Restrictions</td><td>~~As designed~~. <u>All controls meeting mandatory daylighting controls requirements are modeled as continuous dimming to 10%. All daylighting controls claiming Daylight Continuous Dimming plus OFF PAF are modeled as Continuous Dimming 10% + OFF. PAF is restricted to primary sidelit daylit zones and skylight zones (secondary sidelit daylit zone not allowed to claim credit)</u></td></tr>
</table>

Standard Design	Standard design uses continuous daylighting control.
Standard Design: *Existing Buildings*	Same as for new construction when skylights are added/replaced, and general light is altered.

Minimum Dimming Power Fraction	
Applicability	Daylit spaces
Definition	The minimum power fraction when controlled lighting is fully dimmed. Minimum power fraction = minimum power / full rated power.
Units	Numeric: fraction
Input Restrictions	~~As designed, specified from luminaire type~~ Proposed design is 0.1 (not a user input)
Standard Design	Standard design uses continuous dimming control with a minimum dimming power fraction of 0.1 ~~from Table 8: Standard Design Power/Light Output Fraction. Where the controlled luminaire type, input by the user, determines the minimum dimming power fraction.~~
Standard Design: Existing Buildings	Same as for new construction when skylights are added/replaced, and general light is altered.

Minimum Dimming Light Fraction	
Applicability	Daylighting and dimming controls
Definition	The minimum light output when controlled lighting is fully dimmed. Minimum light fraction = minimum light output / rated light output.
Units	Numeric: fraction
Input Restrictions	~~As designed.~~ The mandatory controls uses continuous dimming control with a minimum dimming light fraction of 0.1. Note Continuous dimming plus OFF controls has 10% minimum light fraction and 0 light output for the additional OFF control daylight illuminaces greater than 150% of design illuminance.
Standard Design	Standard design uses continuous dimming control with a minimum dimming light fraction of 0.1. ~~fromTable 8: Standard Design Power/Light Output Fraction. Where the controlled luminaire type, input by the user, determines the minimum dimming power fraction.~~
Standard Design: *Existing Buildings*	Same as for new construction when skylights are added/replaced, and general light is altered.

Table 8: Standard Design Power/Light Output Fraction

Light Source	Power Fraction	Light Output Fraction
LED	0.1	0.1
Linear Fluorescent	0.2	0.2
Mercury Vapor	0.3	0.2
Metal Halide	0.45	0.2
High Pressure Sodium	0.4	0.2
CFL	0.4	0.2
Incandescent	0.5	0.2

7.5 Compliance Manuals

Chapter 5.1.1 of the Nonresidential Compliance Manual would need to be revised. It would be updated to note that the minimum reduction of the general lighting power in daylight zones was adjusted from 65 percent to 90 percent. It would also note that automatic daylighting controls for SDZs are now mandatory instead of prescriptive.

Chapter 5.4.4 of the Nonresidential Compliance Manual would need to be revised. It would need to be updated to note that automatic daylighting controls for SDZs are mandatory and not prescriptive. This language would also need to move from Chapter 5.5.3 to Chapter 5.4.4.

Chapter 5.4 of the Nonresidential Compliance Manual would need to be revised. It would be updated to note that the minimum reduction of the general lighting power in daylight zones was adjusted from 65 percent to 90 percent. The specific changes would occur in Chapters 5.4.4.4 and 5.4.4.5.

Chapter 5.5 of the Nonresidential Compliance Manual would need to be revised. It would be updated to note that the minimum reduction of the general lighting power in daylight zones was adjusted from 65 percent to 90 percent. The specific change would occur in example 5-7.

Chapter 5.10 of the Nonresidential Compliance Manual would need to be revised. It would be updated to note that the minimum reduction of the general lighting power in daylight zones was adjusted from 65 percent to 90 percent. The specific change would occur in Chapter 5.10.3.3.

Chapter 13.4 of the Nonresidential Compliance Manual would need to be revised. It would be updated to note that the minimum reduction of the general lighting power in daylight zones was adjusted from 65 percent to 90 percent. The specific change would occur in Chapter 13.4.3.

7.6 Compliance Documents

Compliance documents that would need to be updated are listed as follows:

- NRCA-LTI-03 Automatic Daylighting Controls: Rated power should be 10 percent or less when the luminaire is dimmed
- NRCC-LTI-E
    - Section H Indoor Lighting Controls should specify for Daylight dimming to 10 percent
    - Section P revised with new PAF name for Daylight Dimming Plus OFF (PAF value remains the same)
    - Revise PAF allowance for secondary zones

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Appendix A: Statewide Savings Methodology

To calculate first-year statewide savings, the Statewide CASE Team multiplied the per-unit savings by statewide construction estimates for the first year the standards would be in effect (2023). The projected nonresidential new construction forecast that would be impacted by the proposed code change in 2023 is presented in Table 25 The projected nonresidential existing statewide building stock that would be impacted by the proposed code change as a result of additions and alterations in 2023 is presented in Table 26. This section describes how the Statewide CASE Team developed these estimates.

The Energy Commission Building Standards Office provided the nonresidential construction forecast, which is available for public review on the Energy Commission's website. This table also identifies the prototypical buildings that were used to model the energy use of the proposed code changes. This mapping was required because the building types the Energy Commission defined in the construction forecast are not identical to the prototypical building types that the Energy Commission requested that the Statewide CASE Team use to model energy use. This mapping is consistent with the mapping that the Energy Commission used in the Final Impacts Analysis for the 2019 code cycle (California Energy Commission 2018).

The Energy Commission's forecast allocated 19 percent of the total square footage of new construction in 2023 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 would 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 so that the percentage of building floorspace in each climate zone, net of the miscellaneous square footage, would remain constant. See Table 26 for a sample calculation for redistributing the miscellaneous square footage among the other building types.

After the miscellaneous floorspace was redistributed, the Statewide CASE Team made assumptions about the percentage of newly constructed floorspace that would be impacted by the proposed code change. Table 27 presents the assumed percentage of floorspace that would be impacted by the proposed code change by building type. If a proposed code change does not apply to a specific building type, it is assumed that zero percent of the floorspace would be impacted by the proposal. If the assumed percentage is non-zero, but less than 100 percent, it is an indication that no buildings would be impacted by the proposal. Table 28 presents percentage of floorspace assumed to be impacted by the proposed change by climate zone.

Table 24: Estimated Nonresidential Floorspace Impacted by Proposed Code Change in 2023 (New Construction), by Climate Zone and Building Type (Million Square Feet)

Climate Zone	Small Office	Large Office	Restaurant	Retail	Grocery Store	Non-Refrigerated Warehouse	Refrigerated Warehouse	Schools	Colleges	Hospitals	Hotel/ Motel	Total NR
1	0.04	0.15	0.00	0.11	0.01	0.10	0.00	0.06	0.03	0.05	0.05	0.60
2	0.26	0.86	0.03	0.63	0.05	0.58	0.00	0.37	0.20	0.27	0.31	3.57
3	0.94	4.84	0.12	2.89	0.22	3.00	0.00	1.49	0.87	1.17	1.43	16.96
4	0.47	2.54	0.06	1.48	0.11	1.54	0.00	0.75	0.44	0.59	0.74	8.73
5	0.10	0.45	0.01	0.30	0.02	0.29	0.00	0.16	0.09	0.12	0.14	1.69
6	0.68	3.35	0.12	2.04	0.16	2.29	0.00	0.81	0.45	0.60	0.85	11.35
7	0.94	1.89	0.08	1.44	0.14	1.35	0.00	0.87	0.40	0.66	0.91	8.66
8	0.89	5.03	0.17	2.93	0.23	3.29	0.00	1.11	0.64	0.88	1.18	16.35
9	1.43	9.30	0.28	4.55	0.35	5.23	0.00	1.49	1.21	1.59	1.80	27.23
10	1.24	1.90	0.21	2.84	0.25	4.34	0.00	1.58	0.62	0.88	1.03	14.89
11	0.33	0.40	0.03	0.58	0.06	0.79	0.00	0.41	0.17	0.27	0.20	3.25
12	1.73	3.95	0.13	3.10	0.25	3.91	0.00	1.72	0.79	1.27	1.19	18.04
13	0.72	0.62	0.06	1.22	0.13	1.37	0.00	0.91	0.34	0.57	0.39	6.33
14	0.24	0.65	0.04	0.67	0.06	0.93	0.00	0.32	0.13	0.19	0.22	3.46
15	0.23	0.20	0.02	0.38	0.04	0.67	0.00	0.22	0.06	0.11	0.17	2.10
16	0.10	0.17	0.01	0.21	0.02	0.28	0.00	0.12	0.05	0.08	0.07	1.11
TOTAL	**10.36**	**36.28**	**1.36**	**25.37**	**2.10**	**29.95**	**0.00**	**12.39**	**6.50**	**9.32**	**10.69**	**144.32**

Table 25: Estimated Nonresidential Floorspace Impacted by Proposed Code Change in 2023 (Alterations), by Climate Zone and Building Type (Million Square Feet)

Climate Zone	Small Office	Large Office	Restaurant	Retail	Grocery Store	Non-Refrigerated Warehouse	Refrigerated Warehouse	Schools	Colleges	Hospitals	Hotel/ Motel	Total NR
1	0.14	0.49	0.01	0.32	0.03	0.29	0.00	0.23	0.13	0.16	0.15	1.94
2	0.84	2.88	0.08	1.89	0.16	1.72	0.00	1.35	0.75	0.95	0.88	11.51
3	3.05	15.76	0.32	8.46	0.65	8.73	0.00	5.59	3.21	4.08	4.01	53.87
4	1.53	8.23	0.16	4.32	0.33	4.45	0.00	2.84	1.65	2.08	2.07	27.66
5	0.34	1.51	0.03	0.89	0.07	0.85	0.00	0.59	0.33	0.43	0.41	5.46
6	2.26	10.66	0.36	6.84	0.54	7.80	0.00	3.79	2.07	2.48	2.60	39.41
7	2.99	6.91	0.23	4.90	0.46	4.41	0.00	2.98	1.66	2.26	2.80	29.61
8	2.96	15.79	0.52	9.76	0.76	11.10	0.00	5.29	2.90	3.60	3.57	56.27
9	4.64	27.83	0.86	14.99	1.16	17.36	0.00	7.85	5.28	6.09	5.55	91.60
10	4.25	7.14	0.71	10.74	0.91	16.11	0.00	6.21	2.67	3.26	3.19	55.19
11	1.04	1.36	0.08	1.86	0.19	2.63	0.00	1.50	0.65	0.95	0.57	10.84
12	5.05	12.62	0.37	9.65	0.79	11.50	0.00	6.31	2.94	4.45	3.33	57.03
13	2.30	1.98	0.17	3.95	0.42	4.37	0.00	3.46	1.31	2.00	1.10	21.05
14	0.83	2.17	0.15	2.44	0.20	3.39	0.00	1.41	0.60	0.75	0.69	12.63
15	0.80	0.68	0.07	1.44	0.15	2.45	0.00	0.85	0.25	0.39	0.48	7.57
16	0.32	0.55	0.04	0.75	0.07	1.00	0.00	0.51	0.21	0.28	0.21	3.94
TOTAL	**33.36**	**116.58**	**4.18**	**83.21**	**6.90**	**98.16**	**0.00**	**50.75**	**26.60**	**34.21**	**31.62**	**485.56**

Table 26: Example of Redistribution of Miscellaneous Category - 2023 New Construction in Climate Zone 1

Building Type	**2020 Forecast (Million Square Feet) [A]**	**Distribution Excluding Miscellaneous Category [B]**	**Redistribution of Miscellaneous Category (Million Square Feet) [C] = B × [D = 0.145]**	**Revised 2020 Forecast (Million Square Feet) [E] = A + C**
Small Office	0.036	7%	0.010	0.046
Large Office	0.114	21%	0.031	0.144
Restaurant	0.015	3%	0.004	0.020
Retail	0.107	20%	0.029	0.136
Grocery Store	0.029	5%	0.008	0.036
Non-Refrigerated Warehouse	0.079	15%	0.021	0.101
Refrigerated Warehouse	0.006	1%	0.002	0.008
Schools	0.049	9%	0.013	0.062
Colleges	0.027	5%	0.007	0.034
Hospitals	0.036	7%	0.010	0.046
Hotel/Motels	0.043	8%	0.012	0.055
Miscellaneous **[D]**	0.145	N/A	N/A	N/A
TOTAL	0.686	100%	0.147	0.686

Table 27: Percent of Floorspace Impacted by Proposed Measure, by Building Type

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	N/A	100%	7%
Restaurant	N/A	25%	2%
Retail	N/A	80%	6%
Stand-Alone Retail	10%	25%	2%
Large Retail	75%	100%	7%
Strip Mall	5%	25%	2%
Mixed-Use Retail	10%	10%	1%
Food	N/A	25%	2%
Non-Refrigerated Warehouse	N/A	100%	7%
Refrigerated Warehouse	N/A	0%	0%
Schools	N/A	100%	7%
Small School	60%	100%	7%
Large School	40%	100%	7%
College	N/A	100%	7%
Small Office	5%	100%	7%
Medium Office	15%	100%	7%
Medium Office/Lab	20%	100%	7%
Public Assembly	5%	100%	7%
Large School	30%	100%	7%
High-Rise Apartment	25%	100%	7%
Hospital	100%	0%	0%
Hotel/Motel	100%	100%	7%
Offices	N/A	100%	7%
Medium Office	50%	100%	7%
Large Office	50%	100%	7%

a. Presents the assumed composition of the main building type category by the building subtypes. All 2022 CASE Reports assumed the same percentages of building subtypes.

b. When the building type is composed of multiple subtypes, the overall percentage for the main building category was calculated by weighing the contribution of each subtype.

c. Percent of existing floorspace that would be altered during the first year the 2022 standards are in effect.

Table 28: Percent of Floorspace Impacted by Proposed Measure, by Climate Zone

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 would be altered during the first year the 2022 standards are in effect.

Appendix B: Embedded Electricity in Water Methodology

The proposed code change would not result in on-site water savings. The reduction in electricity use would conserve water at thermoelectric power plants that use open loop systems for their water. These water savings are not yet considered pertinent for CASE proposals.

Appendix C: Environmental Impacts Methodology

Greenhouse Gas (GHG) Emissions Factors

As directed by Energy Commission staff, GHG emissions were calculated making use of the average emissions factors specified in the United States Environmental Protection Agency (U.S. EPA) Emissions & Generation Resource Integrated Database (eGRID) for the Western Electricity Coordination Council California (WECC CAMX) subregion (United States Environmental Protection Agency 2018). This ensures consistency between state and federal estimations of potential environmental impacts. The electricity emissions factor calculated from the eGRID data is 240.4 metric tons CO2e per GWh. The Summary Table from eGrid 2016 reports an average emission rate of 529.9 pounds CO2e/MWh for the WECC CAMX subregion. This value was converted to metric tons/GWh.

Avoided GHG emissions from natural gas savings attributable to sources other than utility-scale electrical power generation are calculated using emissions factors specified in Chapter 1.4 of the U.S. EPA's Compilation of Air Pollutant Emissions Factors (AP-42) (United States Environmental Protection Agency 1995). The U.S. EPA's estimates of GHG pollutants that are emitted during combustion of one million standard cubic feet of natural gas are: 120,000 pounds of CO_2 (Carbon Dioxide), 0.64 pounds of N_2O (Nitrous Oxide) and 2.3 pounds of CH_4 (Methane). The emission value for N_2O assumed that low NOx burners are used in accordance with California air pollution control requirements. The carbon equivalent values of N_2O and CH_4 were calculated by multiplying by the global warming potentials (GWP) that the California Air Resources Board used for the 2000-2016 GHG emission inventory, which are consistent with the 100-year GWPs that the Intergovernmental Panel on Climate Change used in the fourth assessment report (AR4). The GWP for N_2O and CH_4 are 298 and 25, respectively. Using a nominal value of 1,000 Btu per standard cubic foot of natural gas, the carbon equivalent emission factor for natural gas consumption is 5,454.4 metric tons per MMTherms.

GHG Emissions Monetization Methodology

The 2022 TDV energy cost factors used in the lifecycle cost-effectiveness analysis include the monetary value of avoided GHG emissions based on a proxy for permit costs (not social costs). To demonstrate the cost savings of avoided GHG emissions, the Statewide CASE Team disaggregated the value of avoided GHG emissions from the other economic impacts. The authors used the same monetary values that are used in the TDV factors – $106.20 per metric ton CO_2e.

Water Use and Water Quality Impacts Methodology

There are no water impacts from the proposed code change.

Appendix D: California Building Energy Code Compliance (CBECC) Software Specification

CBECC-Com software developers would use the information from this document to implement the proposed software change. Once the software change is implemented, the software would be tested and verified using the test procedure and reference results provided in the Simulation Engine Inputs section of this appendix.

The Energy Commission requires a beta version of CBECC software to be released at least one year prior to the effective date of the California Energy Code. The 2022 code would take effect January 1, 2023. Therefore, the beta version of the CBECC software must be released no later than January 1, 2022. The Statewide CASE Team would provide this appendix to the CBECC development teams at least 20 months prior to the anticipated effective date of the 2022 code to allow sufficient time for the development and testing of the software changes. Therefore, the Statewide CASE Team would provide this document to the CBECC development teams no later than May 1, 2021.

Introduction

The purpose of this appendix is to present proposed revisions to CBECC for commercial buildings (CBECC-Com) along with the supporting documentation that the Energy Commission staff, and the technical support contractors would need to approve and implement the software revisions.

Technical Basis for Software Change

Daylighting systems that dim to 10 percent are available and ready for the wide adoption as discussed in Section 3.2. Changing the Standard Design to have daylighting systems that dim to 10 percent would match the proposed mandatory requirement and ensure any penalties or credits that vary from this feature in the Proposed Design.

Description of Software Change

Background Information for Software Change

Daylighting systems lower the lighting system power in response to adequate daylight available from a space's fenestration. Daylighting is already a design feature in CBECC-Com and in particular the Standard Design follows the mandatory and prescriptive requirements for daylighting in Title 24, Part 6. Daylighting systems that dim to 10 percent are available and ready for wide adoption as discussed in Section 3.2. The Statewide CASE Team recommends that the Standard Design of CBECC-Com have daylighting systems that dim to 10 percent to match the proposed mandatory requirement. This ensures any energy penalties or credits that vary from this feature in the Proposed Design are applied.

Existing CBECC-Com Modeling Capabilities

The CBECC-Com values for minimum lighting power fraction and the minimum lighting fraction at that power are translated into EnergyPlus without modification and are used in EnergyPlus's split flux algorithm. The split flux algorithm first determines the level of daylight available. It then determines how much electric lighting is necessary to supplement the daylight such that the total lighting meets the illumination setpoint. If the illumination setpoint can be met by daylight alone, the minimum power fraction dictates a minimum amount of power the lighting system still uses. In practical terms, this lighting power represents the fact that electric lights are not completely off. For any electric lighting power in between full power and the minimum power fraction, the ACM has algorithms to determine the lighting power for both the Proposed and Standard Designs.

Currently, the Standard Design minimum lighting fraction is 0.20 at a power of 0.20. Note that this is different than the ACM which specifies that the Standard Design's minimum lighting and power fraction shall be determined by the luminaire type per the ACM's Table 8 and varies from 0.1 to 0.5. Both of these differ from the 0.35 minimum power fraction as listed in the mandatory daylighting requirements, Section 130.0(d)3.C of Title 24, Part 6.

For the Proposed Design, CBECC-Com determines the minimum lighting and power fraction by the luminaire type per the ACM's Table 8. This currently allows violation of the current mandatory requirement, allowing minimum dimming power fractions greater than 35 percent.

To match the proposed mandatory requirement, the Standard Design minimum lighting and power fraction would need to be reduced to 10 percent. In addition, the Proposed Design would need to be as-designed so that proper credits are applied where the Proposed Design is lower than the Standard Design. The Proposed Design can never have a minimum power fraction greater than the Standard Design as this would violate the proposed mandatory measure.

Currently CBECC-Com's Standard Design minimum lighting fraction is 0.20 at a power of 0.20. This is different than the ACM which specifies that the Standard Design's minimum lighting and power fraction shall be determined by the luminaire type per the ACM's Table 8 which varies from 0.1 to 0.5. Both of these differ from the 0.35 minimum power fraction as required by the mandatory daylighting requirements, Section 130.0(d)3.C of Title 24, Part 6.

For the Proposed Design, CBECC-Com determines the minimum lighting and power fraction by the luminaire type per the ACM's Table 8. This currently allows violation of the current mandatory requirement, allowing minimum dimming power fractions greater than 35 percent.

To match the proposed mandatory requirement the Standard Design minimum lighting and power fraction would need to be reduced to 10 percent. In addition, the Proposed Design would need to match the design so that proper credits are applied where the Proposed Design is lower than the Standard Design. The Proposed Design can never have a minimum power fraction greater than the proposed mandatory measure's 0.1.

Summary of Proposed Revisions to CBECC-Com

To correctly calculate credits or penalties from the as-designed minimum power fraction, it is proposed that the Standard Design minimum light and power fraction be reduced to 0.1 and 0.1, respectively. This follows the proposed measure's revisions to the mandatory daylighting controls. The ACM should also be revised as detailed in Section 7.4 to reflect this change and fix the current inconsistency between the ACM and CBECC-Com.

The Proposed Design's minimum lighting and power fraction should be the minimum lighting and power fraction as it is in the construction documents. This fixes the current inconsistency between the ACM and CBECC-Com and should be done whether or not the proposed measure's dimming to 10 percent is adopted.

The translation of the minimum lighting and power fraction into EnergyPlus would not change, nor would any additional inputs or outputs be required.

User Inputs to CBECC-Com

The user input fields necessary to implement this measure already exist in CBECC-Com, but they are not editable. Table 29 lists the necessary changes.

Table 29: Modified User Inputs Relevant to Daylight Dimming to 10 Percent

Input Screen	Variable Name	Data Type	Units	User Editable	Recommended Label
Luminaire Data	MinDimPwrFrac	Decimal	None	Yes	N/A
Luminaire Data	MinDimLtgFrac	Decimal	None	Yes	N/A

Simulation Engine Inputs

EnergyPlus

The existing algorithms for translation are sufficient for the proposed measure. No changes are needed.

Calculated Values, Fixed Values, and Limitations

The existing algorithms for calculations, fixed values and limitations are sufficient for the proposed measure. No changes are needed.

Simulation Engine Output Variables

The existing algorithms for calculations, fixed values and limitations are sufficient for the proposed measure. No changes are needed.

Compliance Report

The existing compliance reports are sufficient for the proposed measure. No changes are needed.

Compliance Verification

The existing compliance verification processes are sufficient for the proposed measure. No changes are needed.

Testing and Confirming CBECC-Com Modeling

The existing testing and confirmation process are sufficient for the proposed measure. No changes are needed.

Description of Changes to ACM Reference Manual

This information is available in Section 7.4.

Appendix E: Impacts of Compliance Process on Market Actors

This appendix discusses how the recommended compliance process, which is described in Section 2.5, could impact various market actors. Table 30 identifies the market actors who would play a role in complying with the proposed change, the tasks for which they would be responsible, their objectives in completing the tasks, how the proposed code change could impact their existing work flow, and ways negative impacts could be mitigated. The information contained in Table 30 is a summary of key feedback the Statewide CASE Team received when speaking to market actors about the compliance implications of the proposed code changes. Appendix F: summarizes the stakeholder engagement that the Statewide CASE Team conducted when developing and refining the code change proposal, including gathering information on the compliance process.

The compliance process would not need any significant change to the workflow. The proposed modification requires no new tasks. Currently market actors (e.g., designers, engineers, plan examiners) must include daylighting dimming that dims to at least 35 percent, exemptions excluded. The proposed measure involves identical workflow but to verify that the general lighting dims to 10 percent or lower.

ATTs would follow adjusted testing methods to verify the system is capable of dimming to 10 percent instead of 35 percent. Nothing else within the test procedure is expected to change.

Table 30: Roles of Market Actors in the Proposed Compliance Process

Market Actor	Task(s) In Compliance Process	Objective(s) in Completing Compliance Tasks	How Proposed Code Change Could Impact Work Flow	Opportunities to Minimize Negative Impacts of Compliance Requirement
Lighting Designer	• Identify relevant requirements and/or compliance path. • Perform required calculations by space to confirm compliance. • Coordinate design with other team members (Contractor/Installer/Engineers) • Complete compliance document for permit application. • Review submittals during construction. • Coordinate with commissioning agent/ATT as necessary.	Clearly communicate system requirements to constructors.	Should not significantly impact workflow.	Clear communication on sensor placement and operation to construction.
Installer	• Identify relevant requirements. • Confirm data on documents is compliant. • Confirm plans/specifications match data on documents. • Provide correction comments if necessary.	• Quickly and easily determine requirements based on scope. • Quickly and easily determine if data in documents meets requirements. • Quickly and easily	Should not significantly impact workflow.	Record compliance on documents in a way easily compared to plans.

		determine if plans/specs match documents. • Quickly and easily provide correction comments that would resolve issue.		
ATT	Identify photosensors function properly and lighting power reduces to 10 percent or more.	Verify photosensors work properly and lighting power reduces to 10 percent or more.	Should not significantly impact workflow.	Assessing plans and determine whether distance method or time-sensitive illuminance method is the appropriate depending on the project.

Appendix F: Summary of Stakeholder Engagement

Collaborating with stakeholders that might be impacted by proposed changes is a critical aspect of the Statewide CASE Team's efforts. The Statewide CASE Team aims to work with interested parties to identify and address issues associated with the proposed code changes so that the proposals presented to the Energy Commission in this CASE Report are generally supported. Stakeholders provided valuable feedback on draft analyses and helped to identify and address challenges to adoption including cost effectiveness, market barriers, technical barriers, compliance and enforcement challenges, or potential impacts on human health or the environment. Some stakeholders also provided data that the Statewide CASE Team used to support analyses.

Utility-Sponsored Stakeholder Meetings

Utility-sponsored stakeholder meetings provide an opportunity to learn about the Statewide CASE Team's role in the advocacy effort and to hear about specific code change proposals that the Statewide CASE Team is pursuing for the 2022 code cycle. The goal of stakeholder meetings is to solicit input on proposals from stakeholders early enough to ensure the proposals and the supporting analyses are vetted and have as few outstanding issues as possible. To provide transparency in what the Statewide CASE Team is considering for code change proposals, during these meetings the Statewide CASE Team asked for feedback on:

- Proposed code changes
- Draft code language
- Draft assumptions and results for analyses
- Data to support assumptions
- Compliance and enforcement, and
- Technical and market feasibility

The Statewide CASE Team hosted two stakeholder meetings for Daylighting via webinar which was part of the greater lighting stakeholder meeting.

Meeting Name	Meeting Date	Event Page from Title24stakeholders.com
First Round of Utility-Sponsored Stakeholder Meeting	Thursday, September 12, 2019	https://title24stakeholders.com/event/nonresidential-indoor-lighting-utility-sponsored-stakeholder-meeting/
Second Round of Utility-Sponsored Stakeholder Meeting	Tuesday, March 3, 2020	https://title24stakeholders.com/event/lighting-utility-sponsored-stakeholder-meeting-2/

The first round of utility-sponsored stakeholder meetings occurred from September to November 2019 and were important for providing transparency and an early forum for stakeholders to offer feedback on measures being pursued by the Statewide CASE Team. The Statewide CASE Team also presented initial draft code language for stakeholders to review.

The second round of utility-sponsored stakeholder meetings occurred from March to May 2020 and provided updated details on proposed code changes. The second round of meetings introduced early results of energy, cost-effectiveness, and incremental cost analyses, and solicited feedback on refined draft code language.

Utility-sponsored stakeholder meetings were open to the public. For each stakeholder meeting, two promotional emails were distributed from info@title24stakeholders.com One email was sent to the entire Title 24 Stakeholders listserv, totaling over 1,900 individuals, and a second email was sent to a targeted list of individuals on the listserv depending on their subscription preferences. The Title 24 Stakeholders' website listserv is an opt-in service and includes individuals from a wide variety of industries and trades, including manufacturers, advocacy groups, local government, and building and energy professionals. Each meeting was posted on the Title 24 Stakeholders' LinkedIn page[18] (and cross-promoted on the Energy Commission LinkedIn page) two weeks before each meeting to reach out to individuals and larger organizations and channels outside of the listserv. The Statewide CASE Team conducted extensive outreach to stakeholders identified in initial work plans who had not yet opted in to the listserv. Exported webinar meeting data captured attendance numbers and individual comments, and recorded outcomes of live attendee polls to evaluate stakeholder participation and support.

Statewide CASE Team Communications

The Statewide CASE Team held personal communications over email, phone, and in person at industry events with numerous stakeholders when developing this report. The Statewide CASE Team conducted outreach to manufacturers, contractors, designers, and ATTs). Specifically, the Statewide CASE Team asked over three dozen manufacturers, contractors, designers and other stakeholders for their feedback daylight harvesting[19] when attending LightFair 2019, Strategies in Light, Design Light Expo, and LightShow West. The Statewide CASE Team also worked with California Lighting Technology Center (CLTC) who conducted research and stakeholder outreach,

[18] Title 24 Stakeholders' Linkedin page can be found here https://www.linkedin.com/showcase/title-24-stakeholders/.

[19] Daylight harvesting refers to strategies for using daylighting to offset the amount of electric lighting needed. Daylight dimming plus OFF is an example of a daylight harvesting strategy.

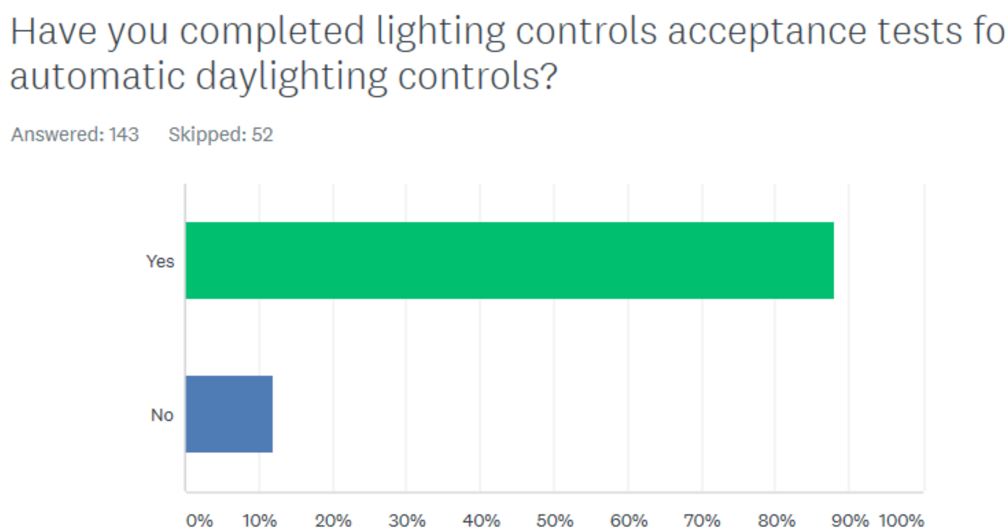
including discussions with the California Energy Alliance.[20] Finally, the Statewide CASE Team conducted a survey of ATTs, which is described below.

Survey

The Statewide CASE Team coordinated with the California Lighting Technology Center (CLTC) and the California Energy Alliance to develop and distribute a survey to ATTs that included questions on daylight dimming to 10 percent, along with other daylighting measures. The results of this survey are shown below.

Question 1

Have you completed lighting controls acceptance tests for automatic daylighting controls?



ANSWER CHOICES	RESPONSES	
Yes	88.11%	126
No	11.89%	17
Total Respondents: 143		

Figure 5: Daylighting Question 1 from ATT Survey.

Question 2

If the acceptance test procedure requires physical testing to verify and document the lighting power reduction of 90%, would it change the way in which you conduct the test?

[20] California Energy Alliance's website can be found here: https://caenergyalliance.org/.

For example, would it impact whether you used the illuminance method or distance method for completing the tests?

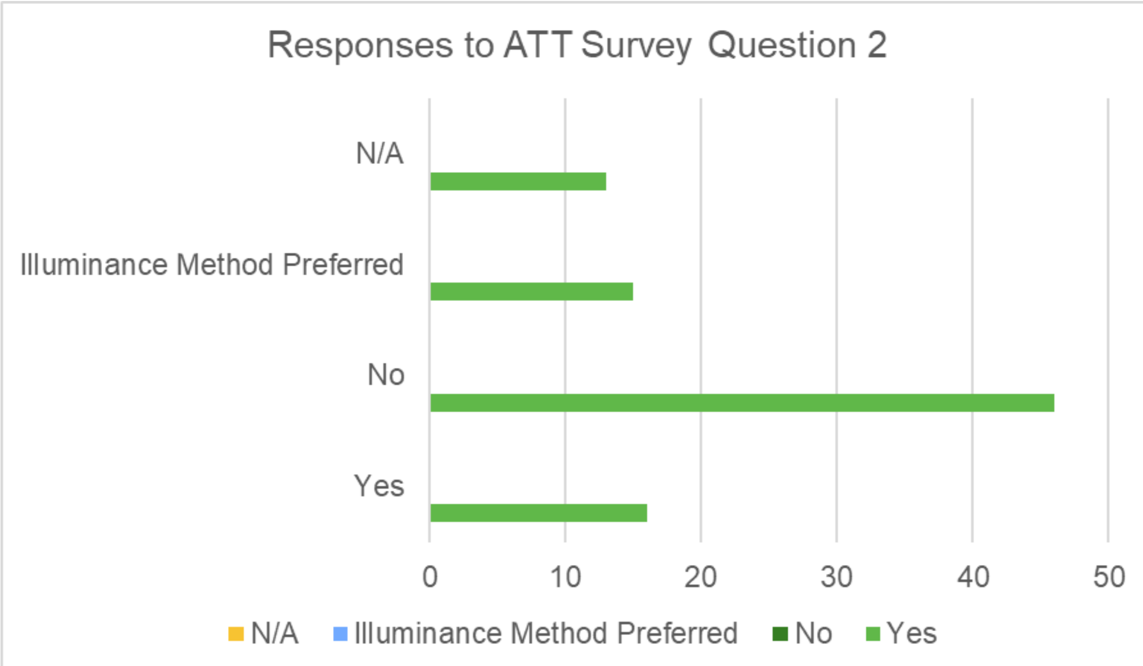


Figure 6: Response to ATT Survey Question 2.

Question 3

Is there any significant difference in time it takes to complete a daylighting controls acceptance test when using the illuminance test method as opposed to the distance method

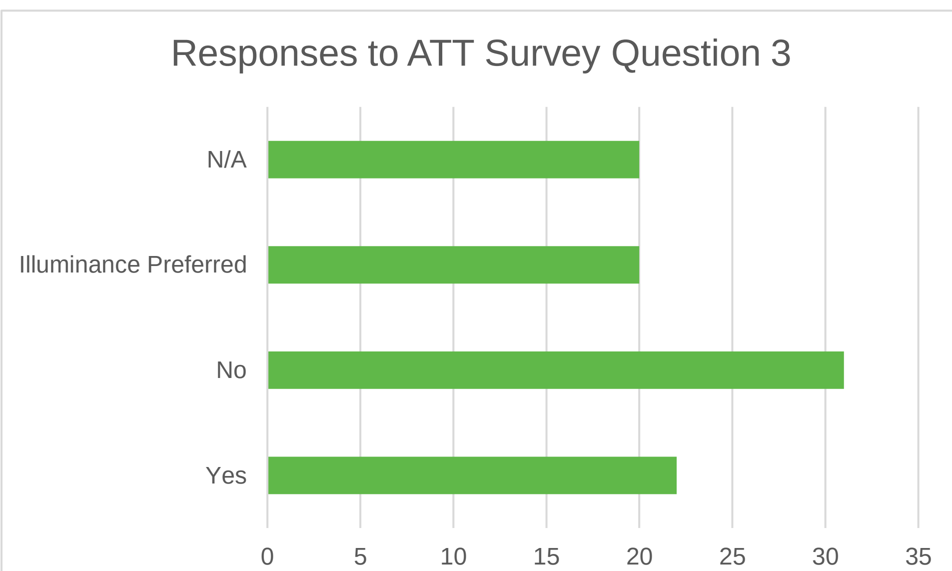


Figure 7: Response to Acceptance Test Technician survey question 3.

Appendix G: Nominal Savings Tables

In Section 5, the energy cost savings of the proposed code changes over the 15-year period of analysis are presented in 2023 present value dollars. This appendix presents energy cost savings in nominal dollars. Energy costs are escalating as in the TDV analysis but the time value of money is not included so the results are not discounted.

Table 31: Nominal TDV Energy Cost Savings Over 15-Year Period of Analysis – Per Square Foot – Construction-Weighted Average of All Prototype Building – New Construction and Alterations

Climate Zone	15-Year TDV Electricity Cost Savings (Nominal $)	15-Year TDV Natural Gas Cost Savings (Nominal $)	Total 15-Year TDV Energy Cost Savings (Nominal $)
1	$0.18	($0.05)	$0.12
2	$0.23	($0.03)	$0.20
3	$0.20	($0.02)	$0.18
4	$0.23	($0.02)	$0.21
5	$0.20	($0.02)	$0.18
6	$0.22	($0.01)	$0.21
7	$0.24	($0.01)	$0.23
8	$0.24	($0.01)	$0.23
9	$0.30	($0.01)	$0.29
10	$0.31	($0.02)	$0.30
11	$0.26	($0.03)	$0.23
12	$0.25	($0.03)	$0.22
13	$0.30	($0.02)	$0.27
14	$0.29	($0.03)	$0.26
15	$0.32	($0.01)	$0.31
16	$0.22	($0.06)	$0.16

Appendix H: Per Unit Energy and Cost Results by Prototypical Building

The tables below present energy savings per square foot for each prototypical building modeled and the 15-year energy cost savings associated with energy savings in 2023 present value dollars.

Table 32: Energy Impacts Per Square Foot and 15-Year Energy Cost Savings – Small Hotel Prototype Building

Climate Zone	Electricity Savings (kWh/ft²)	Peak Electricity Demand Reductions (kW/ft²)	Natural Gas Savings (therms/ft²)	TDV Energy Savings (TDV kBtu/ft²)	15-Year TDV Electricity Cost Savings (2023 PV$)	15-Year TDV Natural Gas Cost Savings (2023 PV$)	Total 15-Year TDV Energy Cost Savings (2023 PV$)
1	0.01	0.00	(0.00)	0.11	$0.01	$0.00	$0.01
2	0.01	0.00	(0.00)	0.18	$0.02	$0.00	$0.02
3	0.01	0.00	(0.00)	0.15	$0.02	$0.00	$0.01
4	0.01	0.00	(0.00)	0.20	$0.02	$0.00	$0.02
5	0.01	0.00	(0.00)	0.15	$0.01	$0.00	$0.01
6	0.01	0.00	(0.00)	0.23	$0.02	$0.00	$0.02
7	0.01	0.00	(0.00)	0.20	$0.02	$0.00	$0.02
8	0.01	0.00	(0.00)	0.26	$0.02	$0.00	$0.02
9	0.01	0.00	(0.00)	0.27	$0.02	$0.00	$0.02
10	0.01	0.00	(0.00)	0.26	$0.02	$0.00	$0.02
11	0.01	0.00	(0.00)	0.16	$0.02	$0.00	$0.01
12	0.01	0.00	(0.00)	0.19	$0.02	$0.00	$0.02
13	0.01	0.00	(0.00)	0.21	$0.02	$0.00	$0.02
14	0.01	0.00	(0.00)	0.21	$0.02	$0.00	$0.02
15	0.01	0.00	(0.00)	0.23	$0.02	$0.00	$0.02
16	0.01	0.00	(0.00)	0.14	$0.01	$0.00	$0.01

Table 33: Energy Impacts Per Square Foot and 15-Year Energy Cost Savings – Large Office

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	Natural Gas Savings (therms/ft2)	TDV Energy Savings (TDV kBtu/yr)	15-Year TDV Electricity Cost Savings (2023 PV$)	15-Year TDV Natural Gas Cost Savings (2023 PV$)	Total 15-Year TDV Energy Cost Savings (2023 PV$)
1	0.05	0.00	(0.00)	0.80	$0.08	-$0.01	$0.07
2	0.05	0.00	(0.00)	1.19	$0.11	-$0.00	$0.11
3	0.05	0.00	(0.00)	1.09	$0.10	-$0.00	$0.10
4	0.05	0.00	(0.00)	1.29	$0.11	-$0.00	$0.11
5	0.05	0.00	(0.00)	1.01	$0.09	-$0.00	$0.09
6	0.05	0.00	(0.00)	1.28	$0.11	-$0.00	$0.11
7	0.05	0.00	(0.00)	1.15	$0.10	-$0.00	$0.10
8	0.05	0.00	(0.00)	1.41	$0.12	-$0.00	$0.13
9	0.06	0.00	(0.00)	1.45	$0.13	-$0.00	$0.13
10	0.06	0.00	(0.00)	1.39	$0.12	-$0.00	$0.12
11	0.05	0.00	(0.00)	1.19	$0.11	-$0.00	$0.11
12	0.05	0.00	(0.00)	1.19	$0.11	-$0.00	$0.11
13	0.05	0.00	(0.00)	1.26	$0.11	-$0.00	$0.11
14	0.06	0.00	(0.00)	1.40	$0.13	-$0.00	$0.12
15	0.06	0.00	(0.00)	1.41	$0.12	-$0.00	$0.13
16	0.05	0.00	(0.00)	0.97	$0.09	-$0.01	$0.09

Table 34: Energy Impacts Per Square Foot and 15-Year Energy Cost Savings – Medium Office Prototype Building

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	Natural Gas Savings (therms/ft2)	TDV Energy Savings (TDV kBtu/yr)	15-Year TDV Electricity Cost Savings (2023 PV$)	15-Year TDV Natural Gas Cost Savings (2023 PV$)	Total 15-Year TDV Energy Cost Savings (2023 PV$)
1	0.07	0.00	(0.00)	1.02	$0.11	-$0.02	$0.09
2	0.08	0.00	(0.00)	1.68	$0.16	-$0.01	$0.15
3	0.07	0.00	(0.00)	1.51	$0.14	-$0.01	$0.13
4	0.08	0.00	(0.00)	1.78	$0.16	-$0.01	$0.16
5	0.08	0.00	(0.00)	1.41	$0.13	-$0.01	$0.13
6	0.08	0.00	(0.00)	1.91	$0.17	-$0.00	$0.17
7	0.08	0.00	(0.00)	1.72	$0.15	-$0.00	$0.15
8	0.08	0.00	(0.00)	2.08	$0.19	-$0.00	$0.19
9	0.08	0.00	(0.00)	2.12	$0.19	-$0.00	$0.19
10	0.08	0.00	(0.00)	2.00	$0.18	-$0.00	$0.18
11	0.08	0.00	(0.00)	1.76	$0.17	-$0.01	$0.16
12	0.08	0.00	(0.00)	1.70	$0.16	-$0.01	$0.15
13	0.08	0.00	(0.00)	1.89	$0.17	-$0.01	$0.17
14	0.08	0.00	(0.00)	2.17	$0.20	-$0.01	$0.19
15	0.09	0.00	(0.00)	2.12	$0.19	-$0.00	$0.19
16	0.07	0.00	(0.00)	1.28	$0.13	-$0.02	$0.11

Table 35: Energy Impacts Per Square Foot and 15-Year Energy Cost Savings – Small Office Prototype Building

Climate Zone	Electricity Savings (kWh/ft^2)	Peak Electricity Demand Reductions (kW/ft^2)	Natural Gas Savings ($therms/ft^2$)	TDV Energy Savings (TDV $kBtu/ft^2$)	15-Year TDV Electricity Cost Savings (2023 PV$)	15-Year TDV Natural Gas Cost Savings (2023 PV$)	Total 15-Year TDV Energy Cost Savings (2023 PV$)
1	0.11	0.00	(0.00)	1.86	$0.20	-$0.03	$0.17
2	0.12	0.00	(0.00)	2.57	$0.24	-$0.02	$0.23
3	0.12	0.00	(0.00)	2.60	$0.24	-$0.01	$0.23
4	0.12	0.00	(0.00)	2.75	$0.25	-$0.01	$0.24
5	0.12	0.00	(0.00)	2.49	$0.23	-$0.01	$0.22
6	0.12	0.00	(0.00)	2.87	$0.26	-$0.00	$0.26
7	0.12	0.00	(0.00)	2.72	$0.24	-$0.00	$0.24
8	0.14	0.00	(0.00)	3.52	$0.32	-$0.00	$0.31
9	0.13	0.00	(0.00)	3.31	$0.30	-$0.00	$0.29
10	0.12	0.00	(0.00)	3.02	$0.27	-$0.01	$0.27
11	0.12	0.00	(0.00)	2.54	$0.24	-$0.01	$0.23
12	0.12	0.00	(0.00)	2.57	$0.24	-$0.01	$0.23
13	0.12	0.00	(0.00)	2.84	$0.27	-$0.01	$0.25
14	0.13	0.00	(0.00)	3.18	$0.30	-$0.01	$0.28
15	0.14	0.00	(0.00)	3.53	$0.32	-$0.00	$0.31
16	0.11	0.00	(0.00)	2.04	$0.21	-$0.03	$0.18

Table 36: Energy Impacts Per Square Foot and 15-Year Energy Cost Savings – Fast Food Restaurant

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	Natural Gas Savings (therms/ft2)	TDV Energy Savings (TDV kBtu/yr)	15-Year TDV Electricity Cost Savings (2023 PV$)	15-Year TDV Natural Gas Cost Savings (2023 PV$)	Total 15-Year TDV Energy Cost Savings (2023 PV$)
1	0.13	0.00	(0.00)	1.71	$0.26	-$0.11	$0.15
2	0.15	0.00	(0.00)	3.28	$0.35	-$0.06	$0.29
3	0.15	0.00	(0.00)	2.87	$0.32	-$0.06	$0.26
4	0.16	0.00	(0.00)	3.66	$0.37	-$0.04	$0.33
5	0.15	0.00	(0.00)	2.80	$0.30	-$0.06	$0.25
6	0.16	0.00	(0.00)	3.63	$0.35	-$0.02	$0.32
7	0.16	0.00	(0.00)	3.37	$0.32	-$0.02	$0.30
8	0.16	0.00	(0.00)	4.15	$0.39	-$0.02	$0.37
9	0.17	0.00	(0.00)	4.09	$0.39	-$0.03	$0.36
10	0.16	0.00	(0.00)	3.91	$0.38	-$0.03	$0.35
11	0.16	0.00	(0.00)	3.62	$0.37	-$0.05	$0.32
12	0.16	0.00	(0.00)	3.59	$0.37	-$0.05	$0.32
13	0.16	0.00	(0.00)	3.84	$0.38	-$0.04	$0.34
14	0.17	0.00	(0.00)	3.98	$0.40	-$0.04	$0.35
15	0.17	0.00	(0.00)	4.35	$0.40	-$0.01	$0.39
16	0.16	0.00	(0.00)	2.62	$0.31	-$0.08	$0.23

Table 37: Energy Impacts Per Square Foot and 15-Year Energy Cost Savings – Large Retail

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	Natural Gas Savings (therms/ft2)	TDV Energy Savings (TDV kBtu/yr)	15-Year TDV Electricity Cost Savings (2023 PV$)	15-Year TDV Natural Gas Cost Savings (2023 PV$)	Total 15-Year TDV Energy Cost Savings (2023 PV$)
1	0.08	0.00	(0.00)	1.02	$0.13	-$0.04	$0.09
2	0.10	0.00	(0.00)	2.09	$0.20	-$0.01	$0.19
3	0.09	0.00	(0.00)	2.18	$0.21	-$0.01	$0.19
4	0.07	0.00	(0.00)	1.73	$0.16	-$0.01	$0.15
5	0.09	0.00	(0.00)	1.97	$0.19	-$0.01	$0.18
6	0.09	0.00	(0.00)	-0.67	-$0.05	-$0.00	-$0.06
7	0.12	0.00	(0.00)	2.41	$0.22	-$0.00	$0.21
8	0.09	0.00	(0.00)	1.16	$0.11	-$0.00	$0.10
9	0.11	0.00	(0.00)	2.11	$0.19	-$0.01	$0.19
10	0.12	0.00	(0.00)	3.34	$0.30	-$0.01	$0.30
11	0.11	0.00	(0.00)	3.23	$0.30	-$0.01	$0.29
12	0.08	0.00	(0.00)	1.68	$0.16	-$0.01	$0.15
13	0.09	0.00	(0.00)	2.13	$0.20	-$0.01	$0.19
14	0.09	0.00	(0.00)	2.32	$0.21	-$0.01	$0.21
15	0.10	0.00	(0.00)	2.49	$0.22	-$0.00	$0.22
16	0.09	0.00	(0.00)	1.51	$0.17	-$0.03	$0.13

Table 38: Energy Impacts Per Square Foot and 15-Year Energy Cost Savings – Mixed-use Retail

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	Natural Gas Savings (therms/ft2)	TDV Energy Savings (TDV kBtu/yr)	15-Year TDV Electricity Cost Savings (2023 PV$)	15-Year TDV Natural Gas Cost Savings (2023 PV$)	Total 15-Year TDV Energy Cost Savings (2023 PV$)
1	0.05	0.00	(0.00)	0.82	$0.09	-$0.01	$0.07
2	0.05	0.00	(0.00)	0.74	$0.07	-$0.01	$0.07
3	0.06	0.00	(0.00)	4.10	$0.37	-$0.01	$0.37
4	0.06	0.00	(0.00)	1.25	$0.12	-$0.00	$0.11
5	0.05	0.00	(0.00)	0.96	$0.09	-$0.00	$0.09
6	0.06	0.00	(0.00)	1.25	$0.11	-$0.00	$0.11
7	0.06	0.00	(0.00)	1.43	$0.13	-$0.00	$0.13
8	0.07	0.00	(0.00)	1.49	$0.13	-$0.00	$0.13
9	0.05	0.00	(0.00)	1.16	$0.11	-$0.00	$0.10
10	0.05	0.00	(0.00)	1.17	$0.11	-$0.00	$0.10
11	0.05	0.00	(0.00)	0.75	$0.07	-$0.01	$0.07
12	0.05	0.00	(0.00)	0.90	$0.09	-$0.01	$0.08
13	0.04	0.00	(0.00)	0.79	$0.08	-$0.01	$0.07
14	0.05	0.00	(0.00)	1.04	$0.10	-$0.01	$0.09
15	0.07	0.00	(0.00)	1.49	$0.13	$0.00	$0.13
16	0.04	0.00	(0.00)	0.63	$0.07	-$0.02	$0.06

Table 39: Energy Impacts Per Square Foot and 15-Year Energy Cost Savings – Stand Alone Retail

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	Natural Gas Savings (therms/ft2)	TDV Energy Savings (TDV kBtu/yr)	15-Year TDV Electricity Cost Savings (2023 PV$)	15-Year TDV Natural Gas Cost Savings (2023 PV$)	Total 15-Year TDV Energy Cost Savings (2023 PV$)
1	0.18	0.00	(0.00)	2.09	$0.28	-$0.09	$0.19
2	0.16	0.00	(0.00)	2.45	$0.24	-$0.03	$0.22
3	0.14	0.00	(0.00)	1.46	$0.15	-$0.02	$0.13
4	0.11	0.00	(0.00)	0.83	$0.09	-$0.02	$0.07
5	0.20	0.00	(0.00)	3.48	$0.34	-$0.03	$0.31
6	0.23	0.00	(0.00)	5.83	$0.53	-$0.01	$0.52
7	0.26	0.00	(0.00)	6.25	$0.57	-$0.01	$0.56
8	0.17	0.00	(0.00)	4.25	$0.39	-$0.01	$0.38
9	0.13	0.00	(0.00)	3.57	$0.33	-$0.01	$0.32
10	0.12	0.00	(0.00)	1.74	$0.17	-$0.02	$0.15
11	0.12	0.00	(0.00)	1.91	$0.19	-$0.02	$0.17
12	0.16	0.00	(0.00)	2.48	$0.24	-$0.02	$0.22
13	0.17	0.00	(0.00)	5.03	$0.46	-$0.02	$0.45
14	0.16	0.00	(0.00)	4.25	$0.40	-$0.02	$0.38
15	0.23	0.00	(0.00)	6.19	$0.56	-$0.00	$0.55
16	0.12	0.00	(0.00)	1.49	$0.19	-$0.06	$0.13

Table 40: Energy Impacts Per Square Foot and 15-Year Energy Cost Savings – Strip Mall Retail

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	Natural Gas Savings (therms/ft2)	TDV Energy Savings (TDV kBtu/yr)	15-Year TDV Electricity Cost Savings (2023 PV$)	15-Year TDV Natural Gas Cost Savings (2023 PV$)	Total 15-Year TDV Energy Cost Savings (2023 PV$)
1	0.05	0.00	(0.00)	0.69	$0.08	-$0.02	$0.06
2	0.04	0.00	(0.00)	0.55	$0.06	-$0.01	$0.05
3	0.05	0.00	(0.00)	0.88	$0.09	-$0.01	$0.08
4	0.05	0.00	(0.00)	0.85	$0.08	-$0.01	$0.08
5	0.06	0.00	(0.00)	0.98	$0.09	-$0.01	$0.09
6	0.05	0.00	(0.00)	0.99	$0.09	-$0.00	$0.09
7	0.06	0.00	(0.00)	1.80	$0.16	-$0.00	$0.16
8	0.05	0.00	(0.00)	1.18	$0.11	-$0.00	$0.10
9	0.04	0.00	(0.00)	0.77	$0.07	-$0.00	$0.07
10	0.03	0.00	(0.00)	1.32	$0.12	-$0.00	$0.12
11	0.05	0.00	(0.00)	0.97	$0.10	-$0.01	$0.09
12	0.05	0.00	(0.00)	0.77	$0.08	-$0.01	$0.07
13	0.06	0.00	(0.00)	1.25	$0.12	-$0.01	$0.11
14	0.05	0.00	(0.00)	1.03	$0.10	-$0.01	$0.09
15	0.05	0.00	(0.00)	1.05	$0.10	-$0.00	$0.09
16	0.04	0.00	(0.00)	0.56	$0.07	-$0.02	$0.05

Table 41: Energy Impacts Per Square Foot and 15-Year Energy Cost Savings – Primary School

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	Natural Gas Savings (therms/ft2)	TDV Energy Savings (TDV kBtu/yr)	15-Year TDV Electricity Cost Savings (2023 PV$)	15-Year TDV Natural Gas Cost Savings (2023 PV$)	Total 15-Year TDV Energy Cost Savings (2023 PV$)
1	0.13	0.00	(0.00)	1.93	$0.23	-$0.06	$0.17
2	0.17	0.00	(0.00)	3.71	$0.37	-$0.04	$0.33
3	0.18	0.00	(0.00)	3.80	$0.38	-$0.04	$0.34
4	0.15	0.00	(0.00)	3.39	$0.32	-$0.02	$0.30
5	0.15	0.00	(0.00)	2.95	$0.29	-$0.02	$0.26
6	0.16	0.00	(0.00)	3.59	$0.33	-$0.01	$0.32
7	0.16	0.00	(0.00)	3.44	$0.31	-$0.01	$0.31
8	0.16	0.00	(0.00)	3.74	$0.34	-$0.01	$0.33
9	0.16	0.00	(0.00)	3.97	$0.36	-$0.01	$0.35
10	0.16	0.00	(0.00)	3.69	$0.34	-$0.01	$0.33
11	0.15	0.00	(0.00)	3.35	$0.33	-$0.03	$0.30
12	0.15	0.00	(0.00)	3.13	$0.31	-$0.03	$0.28
13	0.16	0.00	(0.00)	3.61	$0.35	-$0.03	$0.32
14	0.16	0.00	(0.00)	3.90	$0.37	-$0.03	$0.35
15	0.17	0.00	(0.00)	4.26	$0.38	-$0.00	$0.38
16	0.15	0.00	(0.00)	2.53	$0.28	-$0.06	$0.22

Table 42: First-Year Energy Impacts Per Square Foot – Secondary School

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	Natural Gas Savings (therms/ft2)	TDV Energy Savings (TDV kBtu/yr)	15-Year TDV Electricity Cost Savings (2023 PV$)	15-Year TDV Natural Gas Cost Savings (2023 PV$)	Total 15-Year TDV Energy Cost Savings (2023 PV$)
1	0.08	0.00	(0.00)	1.08	$0.13	-$0.03	$0.10
2	0.08	0.00	(0.00)	1.68	$0.17	-$0.02	$0.15
3	0.08	0.00	(0.00)	1.49	$0.15	-$0.02	$0.13
4	0.08	0.00	(0.00)	1.68	$0.16	-$0.01	$0.15
5	0.09	0.00	(0.00)	1.45	$0.15	-$0.02	$0.13
6	0.09	0.00	(0.00)	1.91	$0.18	-$0.01	$0.17
7	0.09	0.00	(0.00)	1.73	$0.17	-$0.01	$0.15
8	0.09	0.00	(0.00)	2.16	$0.20	-$0.01	$0.19
9	0.09	0.00	(0.00)	2.22	$0.21	-$0.01	$0.20
10	0.09	0.00	(0.00)	2.08	$0.19	-$0.01	$0.19
11	0.09	0.00	(0.00)	1.72	$0.17	-$0.01	$0.15
12	0.09	0.00	(0.00)	1.70	$0.16	-$0.01	$0.15
13	0.11	0.00	(0.00)	2.28	$0.22	-$0.01	$0.20
14	0.09	0.00	(0.00)	2.19	$0.21	-$0.01	$0.20
15	0.10	0.00	(0.00)	2.22	$0.20	-$0.01	$0.20
16	0.08	0.00	(0.00)	1.29	$0.14	-$0.02	$0.11

Table 43: First-Year Energy Impacts Per Square Foot – Warehouse

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	Natural Gas Savings (therms/ft2)	TDV Energy Savings (TDV kBtu/yr)	15-Year TDV Electricity Cost Savings (2023 PV$)	15-Year TDV Natural Gas Cost Savings (2023 PV$)	Total 15-Year TDV Energy Cost Savings (2023 PV$)
1	0.14	0.00	(0.01)	1.31	$0.23	-$0.12	$0.12
2	0.14	0.00	(0.00)	2.49	$0.28	-$0.06	$0.22
3	0.14	0.00	(0.00)	2.20	$0.26	-$0.06	$0.20
4	0.14	0.00	(0.00)	2.67	$0.29	-$0.05	$0.24
5	0.14	0.00	(0.00)	2.19	$0.25	-$0.05	$0.20
6	0.14	0.00	(0.00)	2.77	$0.28	-$0.03	$0.25
7	0.14	0.00	(0.00)	2.56	$0.26	-$0.03	$0.23
8	0.14	0.00	(0.00)	3.19	$0.31	-$0.03	$0.28
9	0.14	0.00	(0.00)	3.23	$0.32	-$0.03	$0.29
10	0.14	0.00	(0.00)	3.02	$0.30	-$0.03	$0.27
11	0.14	0.00	(0.00)	2.48	$0.28	-$0.06	$0.22
12	0.14	0.00	(0.00)	2.63	$0.29	-$0.05	$0.23
13	0.14	0.00	(0.00)	2.70	$0.29	-$0.05	$0.24
14	0.15	0.00	(0.00)	3.08	$0.33	-$0.05	$0.27
15	0.15	0.00	(0.00)	3.18	$0.30	-$0.02	$0.28
16	0.14	0.00	(0.00)	1.70	$0.24	-$0.09	$0.15