CODES AND STANDARDS ENHANCEMENT INITIATIVE (CASE)

Nonresidential Lighting Controls: Partial-ON Occupancy Sensors

Measure Number: 2016-NR-LTG2-F

Nonresidential Lighting

2016 CALIFORNIA BUILDING ENERGY EFFICIENCY STANDARDS

California Utilities Statewide Codes and Standards Team

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September 2014

This report was prepared by the California Statewide Codes and Standards Enhancement (CASE) Program that is funded, in part, by California utility customers under the auspices of the California Public Utilities Commission.

TABLE OF CONTENTS

List of Tables

Document Information

Category: Codes and Standards

Keywords: Statewide Codes and Standards Team, Statewide CASE Team, Codes and Standards Enhancements, Title 24, 2016, efficiency, Partial-ON Occupancy Sensor, Vacancy Sensor, Delay Time.

EXECUTIVE SUMMARY

Introduction

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

The overall goal of this CASE Report is to propose a code change proposal for partial-ON occupancy sensors. The report contains pertinent information that justifies the code change including:

- Description of the code change proposal, the measure history, and existing standards (Section 2);
- Market analysis, including a description of the market structure for specific technologies, market availability, and how the proposed standard will impact building owners and occupants, builders, and equipment manufacturers, distributers, and sellers (Section 3);
- Methodology and assumption used in the analyses energy and electricity demand impacts, cost-effectiveness, and environmental impacts (Section 4);
- Results of energy and electricity demand impacts analysis, Cost-effectiveness Analysis, and environmental impacts analysis (Section 5); and
- Proposed code change language (Section 6).

Scope of Code Change Proposal

The Nonresidential Lighting – Partial -ON Occupancy Sensors measure will affect the following code documents listed in Table 1.

Table 1: Scope of Code Change Proposal

Standards Requirements (see note below)	Compliance Option	Appendix	Modeling Algorithms	Simulation Engine	Forms
M, Ps	No	No	No	No	Yes

Note: An (M) indicates mandatory requirements, (Ps) Prescriptive, (Pm) Performance.

Measure Description

This measure covers lighting controls modifications for nonresidential buildings. The partial-ON occupancy sensors requirement is focused on spaces that have an occupancy sensor currently, and meet the requirement to have multilevel lighting in the existing code. The Statewide CASE Team proposal is to require that these sensors operate as either a partial-ON sensor, or as a vacancy sensor, saving approximately 20 percent of the baseline energy in those spaces and to require a maximum delay time for all occupancy sensors which will reduce the amount of time that sensors are on while the space is unoccupied. Neither of these measures reduce connected load, but they will reduce the hours of operation and the actual load of the lighting when in a dimmed state, resulting in energy savings.

Section 2 of this report provides detailed information about the code change proposal including: ***Section 2.2 Summary of Changes to Code Documents (page 4)*** provides a section-by-section description of the proposed changes to the standards, appendices, alternative compliance manual and other documents that will be modified by the proposed code change. See the following tables for an inventory of sections of each document that will be modified:

- Table 4: Scope of Code Change Proposal (page 4)
- Table 5: Sections of Standards Impacted by Proposed Code Change (page 5)

Detailed proposed changes to the text of the building efficiency standards, the reference appendices, and are given in ***Section 6 Proposed Language*** of this report. This section proposes modifications to language with additions identified with underlined text and deletions identified with ~~struck-out~~ text.

Market Analysis and Regulatory Impact Assessment

There are no anticipated barriers to enforcement. The testing of the controls will readily identify a partial-ON controls approach during regular inspection and testing of the controls. While the compliance forms will require minor modifications, the testing will be comparable with current code requirements.

This measure is not dependent on emerging technology, and is possible with currently available technology and products. Since the lighting controls market has advanced rapidly, in both the sophistication of the controls schemes and the product availability to support this sophistication, the Statewide CASE Team expects that the hurdles to adoption are minimal.

This proposal is cost effective over the period of analysis. Overall this proposal increases the wealth of the State of California.

The expected impacts of the proposed code change on various stakeholders are summarized below:

- **Impact on builders:** The proposed measures will have little to no impact on builders.
- **Impact on building designers:** The proposed code change is not expected to significantly impact building designers. The controls requirements change will require a change in design practice details, but not methods of design. The specification of lighting controls in the affected spaces will be mostly unchanged from that done to meet the current code requirements.

- **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 California Division of Occupational Safety and Health. All existing health and safety rules will remain in place. Complying with the proposed code changes is not anticipated to have any impact on the safety or health occupants or those involved with the construction, commissioning, and ongoing maintenance of the building.
- **Impact on building owners and occupants:** Over the 15-year evaluation period the energy cost savings from this measure are higher than the incremental costs. The building owners and occupants who pay energy bills are expected to benefit from cost savings over the life of the building.
- **Impact on equipment retailers (including manufacturers and distributors):** No impact anticipated.
- **Impact on energy consultants:** The proposed code change is not expected to significantly impact energy consultants.
- **Impact on building inspectors:** As compared to the overall code enforcement effort, this measure has negligible impact on the effort required to enforce the building codes.
- **Statewide Employment Impacts:** The proposed changes to Title 24 are expected to result in positive job growth as noted below in Section 3.5. The particular measures proposed in this report are not expected to have an appreciable impact on employment in California.
- **Impacts on the creation or elimination of businesses in California:** The proposed measure is not expected to have an appreciable impact on California businesses.
- **Impacts on the potential advantages or disadvantages to California businesses:** In general California businesses would benefit from an overall reduction in energy costs. This could help California businesses gain competitive advantage over businesses operating in other states or countries and increase in investment in California. This particular measure is not expected to have an appreciable impact on any specific California business.
- **Impacts on the potential increase or decrease of investments in California:** As described in Section 3.5 of this report, the California Air Resources Board (CARB) economic analysis of greenhouse gas reduction strategies for the State of California indicates that higher levels of energy efficiency and 33 percent Renewable Portfolio Standard (RPS) will increase investment in California by about 3 percent in 2020 compared to 20% RPS and lower levels of energy efficiency. After reviewing the CARB analysis, the Statewide CASE Team concluded that the majority of the increased investment of the more aggressive strategy is attributed to the benefits of efficiency (CARB 2010b Figures 7a and 10a). The specific code change proposal presented in this report is not expected to have an appreciable impact on investments in California.
- **Impacts on incentives for innovations in products, materials or processes:** Updating Title 24 standards could encourage innovation through the adoption of new technologies to better manage energy usage and achieve energy savings. It is not anticipated that this measure will have a significant impact on innovation.

- **Impacts on the State General Fund, Special Funds and local government:** The proposed measure is not expected to have an appreciable impact on the State General Fund, Special Funds, or local government funds.
- **Cost of enforcement to State Government and local governments:** All revisions to Title 24 will result in changes to Title 24 compliance determinations. State and local code officials will be required to learn how buildings can comply with the new provisions included in the 2016 Standards, however the Statewide CASE Team anticipates that the cost of training is part of the regular training activates that occur every time the code is updated. These proposed changes would not affect the complexity of the code significantly. Therefore, on-going costs are not expected to change significantly.
- **Impacts on migrant workers; persons by age group, race, or religion:** This proposal and all measures adopted by CEC into Title 24, part 6 do not advantage or discriminate in regards to race, religion or age group.
- **Impact on Homeowners (including potential first time home owners):** The proposal does not impact residential buildings. There is no expected impact on homeowners.
- **Impact on Renters:** The energy cost savings from the proposed measures might be passed on to tenants.
- **Impact on Commuters:** This proposal and all measures adopted by CEC into Title 24, Part 6 are not expected to have an impact on commuters.

Statewide Energy Impacts

Table 2 shows the estimated energy savings over the first twelve months of implementation of the Partial-On Occupancy Sensors measure.

Table 2: Estimated First Year Energy Savings

	First Year Statewide Savings			TDV Dollar Savings ($ Millions)
	Electricity Savings (GWh)	Power Demand Reduction (MW)	Natural Gas Savings (MMtherms)	
TOTAL	14	5.4	N/A	31

Section 4.6.1 discusses the methodology and Section 5.1.1 shows the results for the per unit energy impact analysis.

Cost-effectiveness

The TDV Energy Costs Savings are the present valued energy cost savings over the 15-year period of analysis using CEC's TDV methodology. The Total Incremental Cost represents the incremental initial construction and maintenance costs of the proposed measure relative to existing conditions (current minimally compliant construction practice when there are existing Title 24 Standards). Costs incurred in the future (such as periodic maintenance costs or replacement costs) are discounted by a 3 percent real discount rate, per CEC's LCC

Methodology. The Benefit to Cost (B/C) Ratio is the incremental TDV Energy Costs Savings divided by the Total Incremental Costs. When the B/C ratio is greater than 1.0, the added cost of the measure is more than offset by the discounted energy cost savings and the measure is deemed to be cost effective. For a detailed description of the Cost-effectiveness Methodology see Section 4.7 of this report.

This measure does not incur incremental costs, and therefore is cost effective in all climate zones immediately.

Greenhouse Gas and Water Related Impacts

For more a detailed and extensive analysis of the possible environmental impacts from the implementation of the proposed measure, please refer to Section 5.3 of this report.

Greenhouse Gas Impacts

Table 3 presents the estimated avoided greenhouse gas (GHG) emissions of the proposed code change for the first year the Standards are in effect. Assumptions used in developing the GHG savings are provided in Section 4.8.1 on page 22 of this report.

Table 3: Estimated First Year Statewide Greenhouse Gas Emissions Impacts

	Avoided GHG Emissions ($MTCO_2e/yr$)
TOTAL	4,981

Section 4.8.1 discusses the methodology and Section 5.3.1 shows the results of the greenhouse gas emission impacts analysis.

Water Use 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.

Acceptance Testing

This measure will not require changes to acceptance testing procedures, but there will be changes to the forms to include the partial-ON and maximum delay time for sensors.

1. INTRODUCTION

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

The overall goal of this CASE Report is to propose a code change proposal for partial-ON occupancy sensors. The report contains pertinent information that justifies the code change.

Section 2 of this CASE Report provides a description of the measure, how the measure came about, and how the measure helps achieve the state's zero net energy (ZNE) goals. This section presents how the Statewide CASE Team envisions the proposed code change would be enforced and the expected compliance rates. This section also summarized key issues that were addressed during the CASE development process, including issues discussed during a public stakeholder meeting that the Statewide CASE Team hosted in May 2014.

Section 3 presents the market analysis, including a review of the current market structure, a discussion of product availability, and the useful life and persistence of the proposed measure. This section offers an overview of how the proposed Standard will impact various stakeholders including builders, building designers, building occupants, equipment retailers (including manufacturers and distributors), energy consultants, and building inspectors. Finally, this section presents estimates of how the proposed change will impact statewide employment.

Section 4 describes the methodology and approach the Statewide CASE Team used to estimate energy, demand, costs, and environmental impacts. Key assumptions used in the analyses can be also found in Section 4.

Results from the energy, demand, costs, and environmental impacts analysis are presented in Section 5. The Statewide CASE Team calculated energy, demand, and environmental impacts using two metrics: (1) per unit, and (2) statewide impacts during the first year buildings complying with the 2016 Title 24 Standards are in operation. Time Dependent Valuation (TDV) energy impacts, which accounts for the higher value of peak savings, are presented for the first year both per unit and statewide. The incremental costs, relative to existing conditions are presented as are present value of year TDV energy cost savings and the overall cost impacts over the year period of analysis.

The report concludes with specific recommendations for language for the Standards, Appendices, Alternate Calculation Method (ACM) Reference Manual and Compliance Forms.

2. MEASURE DESCRIPTION

2.1 Measure Overview

2.1.1 Measure Description

This measure covers lighting controls modifications for nonresidential buildings. The measure descriptions for each specific sub-measure are provided below.

Partial-ON Controls Requirements

The existing lighting controls in Title 24 do not require partial-ON lighting controls. There is an existing power adjustment factor (PAF) in Table 140.6-A that provides an adjustment to the lighting power (LPD) for spaces that include a partial-ON control approach (0.20 factor). There is a second PAF in Table 140.6-A that is intended for a combined Partial-ON and manual dimming control approach (0.25 factor).

The partial-ON requirement has now been employed in ASHRAE 90.1-2013 as a minimum required measure (in conjunction with a manual-ON option) for a select set of suitable space types in buildings. As a result, this approach has the general support of the design community.

The intent of this proposal is to remove the two PAF allowances and add language to Section 130.1(c)5 that will mandate the use of partial-ON occupancy sensors in applications listed in that section as appropriate. These include:

- Offices smaller than 250 square feet
- Multipurpose Rooms smaller than 1,000 square feet
- Classrooms of any size
- Conference Rooms of any size

Occupancy Sensor Maximum Delay Time Requirement

The current language in Sections 130.1 or 110.9 does not define a maximum delay time for programming occupancy sensors under normal circumstances. Section 1605.3(L)(2)(G)1 of Title 20 (the California Appliance Standards) defines the maximum delay time that is permitted to be available in an occupancy sensor device sold in California is 30 minutes, however, that should not be considered appropriate guidance for a delay time under normal design circumstances because most spaces are functionally adequate with much shorter delay times.

Further, without specific guidance in Title 24, a sensor is permitted to operate up to that 30 minute delay time, and the inspection cannot reject the device despite the excessively long delay time. A delay time of 30 minutes will result is considerable energy savings opportunities lost throughout the day and into the evening.

For this reason, and in keeping with the general recommendations that are also established in ASHRAE 90.1, the intent is to add a maximum delay time to Section 110.9(b)4 to limit the

delay time to a maximum of 20 minutes in all circumstances. This maximum will also be added to the acceptance testing process for occupancy sensors.

Note, however, that this is not a recommended change to the Title 20 Appliance Standards, which sets the maximum delay time for occupancy sensors at 30 minutes. The Title 20 Standards establishes the maximum time that the device is permitted to accommodate. This proposal establishes a maximum time for sensor programming in an installation. As a matter of course, it is possible for an owner to change the delay time up to 30 minutes under circumstances where this is a more appropriate delay time once the building has gained its occupancy permit.

2.1.2 Measure History

The current power adjustment factor (PAF) for partial-ON occupancy sensors was first introduced in the 2005 code revision cycle (although with somewhat different wording, so it was less obvious). Since then, it has remained in the code, but the language has changed as more of the PAFs for lighting controls have become mandatory requirements and the language has been narrowed to only include the specific type of control that is considered "partial-ON" in nature.

The primary reason this has not moved into the mandatory section until now has been the lack of broad availability of suitable sensor control systems that make this technology viable for widespread application, and the lack of a multi-level lighting system to achieve a level below full rated power available to apply.

The rapidly expanding availability of lighting controls at competitive pricing is changing this condition. This reduces the cost associated with adding controls, and in the case of partial-ON, the added cost is likely to be very small beyond the cost of the basic occupancy sensors that are currently required.

Second, the addition of the multi-level lighting requirement in the 2013 Title 24 revision cycle produces the catalyst to easily and cost-effectively enable this approach. This provides the intermediate level capabilities that are necessary to achieve partial-ON controls with little or no extra cost.

This measure is one of the last of the PAF allowances for occupancy sensor controls to be changed from a PAF into a mandatory requirement. As a result, there have been similar measures that have been considered in the past, but none that are specifically for this set of conditions. Since the multi-level lighting requirements have been adopted in 2013, the infrastructure required to implement this measure has changed considerably in a favorable direction.

There are no preemption concerns with this measure.

2.1.3 Existing Standards

In Title 24, the lighting controls are mostly required to be present, but there are a number of compliance options, of which motion sensors (Automatic-On) is one option.

Section 130.1(c)5 specifically requires that motion sensors be used in a select set of spaces (classrooms, offices, multipurpose rooms, etc.).

Section 130.1(c)6 requires Partial-Off lighting for certain applications in addition to the basic controls requirements of Section 130.1(c)1. Section 130.1(c)7 requires Partial-Off lighting controls for other applications instead of the requirements in Section 130.1(c)1.

2.1.4 Alignment with Zero Net Energy Goals

The Statewide CASE Team and CEC are committed to achieving California's zero-net-energy (ZNE) goal. This measure will help achieve ZNE goals by reducing the lighting load in nonresidential interior spaces to the minimum possible while still meeting current IES recommended design practices. This measure will also set the foundation for future code changes that will help ensure ZNE goals are achieved. In particular, this measure could lead directly to the following code changes in the 2019 and 2022 code change cycles:

Reductions in hours of operation will reduce the EUI of a given building. The reductions are amplified by reducing the HVAC load in warmer climate zones.

2.1.5 Relationship to Other Title 24 Measures

There are no other measures that focus on Section 130.1, however there is a measure that focuses on Non-Residential indoor lighting LPD values, which may have an impact on this measure (and vice-versa) when calculating combined Statewide Energy Impacts.

This measure has no other anticipated overlaps with any other measures. While the Indoor LPD measure adjusts available power for spaces, the impacted spaces in that measure do not overlap the limited spaces listed in this measure, so no interactive impacts are anticipated.

2.2 Summary of Changes to Code Documents

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

2.2.1 Catalogue of Proposed Changes

Scope

Table 4 identifies the scope of the code change proposal. This measure will impact the following areas (marked by a "Yes").

Table 4: Scope of Code Change Proposal

Mandatory	Prescriptive	Performance	Compliance Option	Trade-Off	Modeling Algorithms	Forms
Yes	Yes	No	No	No	No	Yes

Standards

The proposed code change will modify the sections of the California Building Energy Efficiency Standards (Title 24, Part 6) identified in Table 5.

Table 5: Sections of Standards Impacted by Proposed Code Change

Title 24, Part 6 Section Number	Section Title	Mandatory (M) Prescriptive (Ps) Performance (Pm)	Modify Existing (E) New Section (N)
130.1(c)5	Indoor Lighting Controls That Shall Be Installed	M and Ps	E

Appendices

The proposed code change will not modify the appendices of the Standards.

Nonresidential Alternative Calculation Method (ACM) Reference Manual

The proposed code change will not modify the sections of the Nonresidential Alternative Calculation Method References.

Simulation Engine Adaptations

The proposed code change can be modeled using the current simulation engine. Changes to the simulation engine are not necessary.

2.2.2 Standards Change Summary

This proposal would modify the following sections of the Building Energy Efficiency Standards as shown below. See ***Section 6.1 Standards*** of this report for the detailed proposed revisions to the Standards language.

Changes in Mandatory Requirements: The proposed code change will modify Section 130.1(c)5 of the Standards. The proposed language will modify existing language by adding a requirement that those spaces in Subsection 5 will be required to be either Partial-ON or Manual-ON controlled. Additionally, an exception will be added for spaces that do not meet the thresholds indicated in the multi-level lighting section, Section 130.1(b).

SECTION 110.9 – MANDATORY REQUIREMENTS FOR LIGHTING CONTROLS

Subsection 110.9(b)4: The change will add language to this subsection to limit the programmed sensor delay time to no greater than 20 minutes.

SECTION 130.1 – INDOOR LIGHTING CONTROLS THAT SHALL BE INSTALLED

Subsection 130.1(c)5: The change will add language to this subsection to require either a partial-ON sensor or a vacancy sensor for the applicable room types (multipurpose rooms less than 1,000 square feet, private offices less than 250 square feet, classrooms, conference rooms).

2.2.3 Compliance Forms Change Summary

The proposed code change will modify the following compliance forms listed below. Examples of the revised forms are presented in ***Section 6.5 Compliance Forms***.

- **Form NRCC-CXR-02-E** – Edits to section referring to Section 130.1(c)5 to include Partial-ON or Vacancy Sensor compliance options.

- **Form NRCI-LTO-02-E** – Edits to references to "Partial-ON" and the Title 20 documentation.

2.3 Code Implementation

2.3.1 Verifying Code Compliance

The existing code enforcement methods will remain in effect. No new compliance documents will be required, and no additional field verification or acceptance tests will be required, but minor modifications to the existing forms will be required.

2.3.2 Code Implementation

The code compliance methods currently employed by designers and builders will remain the same with this new measure. Title 24 is currently regulating controls requirements for buildings in a manner that is compatible with the changes intended with this measure. The building industry is accustomed to using the current controls requirements, and this change is limited to specific space types, so the changes will not cause confusion regarding whether they apply in most circumstances. The current system of controls requirements had been established in previous versions of Title 24, and this measure maintains this infrastructure.

This measure does not add significant expense to the design or construction process.

This measure makes no changes to the building inspection process.

There is no anticipated resistance to this measure from the building industry beyond the normal reluctance to lower LPD values.

2.3.3 Acceptance Testing

This measure does require specific acceptance testing to ensure optimum performance, but there will be a 20-minute check as part of the normal occupancy sensor tests to ensure the maximum relay time is not exceeded. The technology will benefit from a commissioning step in the same manner as all other controls. The level of commissioning will be no greater than other controls measures employing occupancy sensors.

The persistence of energy savings is dependent on maintenance of the lighting controls, comparable with all other lighting controls. Since controls were required in these spaces before, but not in a partial-ON-type manner, this should not require any additional maintenance than the incumbent code required products.

2.4 Issues Addressed During CASE Development Process

The Statewide CASE Team solicited feedback from a variety of stakeholders when developing the code change proposal presented in this report. In addition to personal outreach to key stakeholders, the Statewide CASE Team conducted a public stakeholder meeting to discuss the proposals. The issues that were addressed during development of the code change proposal are summarized below.

The question arose in the stakeholder meeting whether there was the possibility to broaden the measure to include requiring manual-ON for other controls requirements, including the lighting

controls associated with time-of-day scheduling devices. This approach is valid for some spaces types, but cannot be universally applied to spaces because of the variability of the geometry of the space and the need for flexibility to meet programming requirements.

Conversations with lighting controls representatives have confirmed that there will be no incremental cost to apply this measure because the multilevel lighting requirements in the 2013 Title 24 Standards create the infrastructure for this to be viable without added equipment.

3. MARKET ANALYSIS

The Statewide CASE Team performed a market analysis with the goals of identifying current technology availability, current product availability, and market trends. The Statewide CASE Team considered how the proposed Standard may impact the market in general and individual market players. The Statewide CASE Team gathered information about the incremental cost of complying with the proposed measure. Estimates of market size and measure applicability were identified through research and outreach with key stakeholders including utility program staff, CEC, and a wide range of industry players who were invited to participate in Statewide CASE Team's public stakeholder meetings held in 2014.

3.1 Market Structure

This measure does not impact the manufacturing or specification market in any substantial manner, so no impacts are expected based on the requirement for partial-ON sensor approach.

3.2 Market Availability and Current Practices

The scope of the partial-ON controls measure is limited to spaces that are required to employ an occupancy sensor in the current code, so the addition of the partial-ON or vacancy control part of the requirements is not a considerable additional set of requirements on these spaces.

The process and technology for implementing a partial-ON approach will be regularly applied to lighting systems as part of the multi-level lighting requirements in Section 130.1(b), however, the full implementation of the partial-ON approach may not be regularly done until this measure requires this approach.

The industry is able to supply the technology and the approach has been implemented in similar forms as part of the current PAF system, so there is no anticipated resistance from the controls community.

3.3 Useful Life, Persistence, and Maintenance

This measure makes no changes to the useful life of specified lighting equipment. The energy savings associated with a partial-ON lighting controls approach will persist over the life of the lighting equipment as long as the controls are adequately maintained. Since controls are already required, this level of maintenance is already needed in the existing code baseline to ensure persistence. There is no field verification, maintenance, or commissioning required to ensure that the savings are maintained.

The methodology the Statewide CASE Team used to determine the costs associated with incremental maintenance costs, relative to existing conditions, is presented in Section 4.7.1. The incremental maintenance costs of the proposed code change are presented in Section 5.2.1.

3.4 Market Impacts and Economic Assessments

There are no anticipated barriers to enforcement. The testing of the controls will readily identify a partial-ON controls approach during regular inspection. While the compliance forms will require minor modifications, the testing will be comparable with that previously performed.

This measure is not dependent on emerging technology, and is possible with currently available technology and products. Since the lighting controls market has advanced rapidly in both sophistication of the controls schemes and the product availability to support this sophistication, the barriers to adoption are minimal.

The equipment needed to meet the partial-ON controls requirement is required in all spaces where the measure is intended to apply (private offices under 250 square feet, multipurpose rooms under 1,000 square feet, conference rooms, and classrooms) as long as they exceed 0.5 watts per square foot. The maximum delay time limit is a reduction to a maximum setting on a sensor, and all sensors available can accommodate this capability currently.

3.4.1 Impact on Builders

The proposed measures will have little to no impact on builders.

3.4.2 Impact on Building Designers

No substantial impacts are anticipated. The controls requirements change will require a change in design practice details, but not methods of design. The specification of lighting controls in the affected spaces will be mostly unchanged from that done to meet the current code requirements.

The 20-minute maximum delay time should not require any changes in the design process. A general specification on the plans or in the specification is all required to place this in the design documents.

3.4.3 Impact on Occupational Safety and Health

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

3.4.4 Impact on Building Owners and Occupants

Over the 15-year evaluation period the energy cost savings from this measure are higher than the incremental costs. The building owners and occupants who pay energy bills are expected to benefit from cost savings over the life of the building.

3.4.5 Impact on Retailers (including manufacturers and distributors)

The proposed code change is not expected to have a significant impact on retailers.

3.4.6 Impact on Energy Consultants

The proposed code change is not expected to significantly impact energy consultants.

3.4.7 Impact on Building Inspectors

As compared to the overall code enforcement effort, this measure has negligible impact on the effort required to enforce the building codes.

3.4.8 Impact on Statewide Employment

The proposed changes to Title 24 are expected to result in positive job growth as noted below in Section 3.5. The particular measures proposed in this report are not expected to have an appreciable impact on employment in California.

3.5 Economic Impacts

The proposed Title 24 code changes, including this measure, are expected to increase job creation, income, and investment in California. As a result of the proposed code changes, it is anticipated that less money will be sent out of state to fund energy imports, and local spending is expected to increase due to higher disposable incomes due to reduced energy costs.[1]

These economic impacts of energy efficiency are documented in several resources including the California Air Resources Board's (CARB) Updated Economic Analysis of California's Climate Change Scoping Plan, which compares the economic impacts of several scenario cases (CARB, 2010b). CARB include one case (Case 1) with a 33% renewable portfolio standard (RPS) and higher levels of energy efficiency compared to an alternative case (Case 4) with a 20% RPS and lower levels of energy efficiency. Gross state production (GSP)[2], personal income, and labor demand were between 0.6% and 1.1% higher in the case with the higher RPS and more energy efficiency (CARB 2010b, Table 26). While CARB's analysis does not report the benefits of energy efficiency and the RPS separately, we expect that the benefits of the package of measures are primarily due to energy efficiency. Energy efficiency measures are expected to reduce costs by $2,133 million annually (CARB 2008, pC-117) whereas the RPS implementation is expected to cost $1,782 million annually, not including the benefits of GHG and air pollution reduction (CARB 2008, pC-130).

Macroeconomic analysis of past energy efficiency programs and forward-looking analysis of energy efficiency policies and investments similarly show the benefits to California's economy of investments in energy efficiency (Roland-Holst 2008; UC Berkeley 2011).

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[1] Energy efficiency measures may result in reduced power plant construction, both in-state and out-of-state. These plants tend to be highly capital-intensive and often rely on equipment produced out of state, thus we expect that displaced power plant spending will be more than off-set from job growth in other sectors in California.

[2] GSP is the sum of all value added by industries within the state plus taxes on production and imports.

This measure is not anticipated to have a large economic impact on the industry because it functions as a reduction in full load equivalent energy consumption. In most cases, the impacted areas are anticipated to use the same products and methods to comply with this proposed measure as the previous current controls requirements, so there is no anticipated economic impact.

3.5.1 Creation or Elimination of Jobs

CARB's economic analysis of higher levels of energy efficiency and 33% RPS implementation estimates that this scenario would result in a 1.1% increase in statewide labor demand in 2020 compared to 20% RPS and lower levels of energy efficiency (CARB 2010b, Tables 26 and 27). CARB's economic analysis also estimates a 1.3% increase in small business employment levels in 2020 (CARB 2010b, Table 32).

3.5.2 Creation or Elimination of Businesses within California

CARB's economic analysis of higher levels of energy efficiency and 33% RPS implementation (as described above) estimates that this scenario would result in 0.6% additional GSP in 2020 compared to 20% RPS and lower levels of energy efficiency (CARB 2010b, Table ES-2). We expect that higher GSP will drive additional business creation in California. In particular, local small businesses that spend a much larger proportion of revenue on energy than other businesses (CARB 2010b, Figures 13 and 14) should disproportionately benefit from lower energy costs due to energy efficiency standards. Increased labor demand, as noted earlier, is another indication of business creation.

Table 6 below shows California industries that are expected to receive the economic benefit of the proposed Title 24 code changes. It is anticipated that these industries will expand due to an increase in funding as a result of energy efficiency improvements. The list of industries is based on the industries that the University of California, Berkeley identified as being impacted by energy efficiency programs (UC Berkeley 2011 Table 3.8).[3]

This list provided below is not specific to one individual code change proposal; rather it is an approximation of the industries that may receive benefit from the 2016 Title 24 code changes.

[3] Table 3.8 of the UC Berkeley report includes industries that will receive benefits of a wide variety of efficiency interventions, including Title 24 Standards and efficiency programs. The authors of the UC Berkeley report did not know in 2011 which Title 24 measures would be considered for the 2016 adoption cycle, so the UC Berkeley report was likely conservative in their approximations of industries impacted by Title 24. The Statewide CASE Team believes that industries impacted by utilities efficiency programs is a more realistic and reasonable proxy for industries potentially affected by upcoming Title 24 Standards. Therefore, the table provided in this CASE Report includes the industries that are listed as benefiting from Title 24 and utility energy efficiency programs.

Table 6: Industries Receiving Energy Efficiency Related Investment, by North American Industry Classification System (NAICS) Code

Industry	NAICS Code
Residential Building Construction	2361
Nonresidential Building Construction	2362
Roofing Contractors	238160
Electrical Contractors	23821
Plumbing, Heating, and Air-Conditioning Contractors	23822
Boiler and Pipe Insulation Installation	23829
Insulation Contractors	23831
Window and Door Installation	23835
Asphalt Paving, Roofing, and Saturated Materials	32412
Manufacturing	32412
Other Nonmetallic Mineral Product Manufacturing	3279
Industrial Machinery Manufacturing	3332
Ventilation, Heating, Air-Conditioning, & Commercial Refrigeration Equipment Manufacturing	3334
Computer and Peripheral Equipment Manufacturing	3341
Communications Equipment Manufacturing	3342
Electric Lighting Equipment Manufacturing	3351
Household Appliance Manufacturing	3352
Other Major Household Appliance Manufacturing	335228
Used Household and Office Goods Moving	484210
Engineering Services	541330
Building Inspection Services	541350
Environmental Consulting Services	541620
Other Scientific and Technical Consulting Services	541690
Advertising and Related Services	5418
Corporate, Subsidiary, and Regional Managing Offices	551114
Office Administrative Services	5611
Commercial & Industrial Machinery & Equip. (exc. Auto. & Electronic) Repair & Maintenance	811310

3.5.3 Competitive Advantages or Disadvantages for Businesses within California

California businesses would benefit from an overall reduction in energy costs. This could help California businesses gain competitive advantage over businesses operating in other states or countries and an increase in investment in California, as noted below.

3.5.4 Increase or Decrease of Investments in the State of California

CARB's economic analysis indicate that higher levels of energy efficiency and 33% RPS will increase investment in California by about 3% in 2020 compared to 20% RPS and lower levels of energy efficiency (CARB 2010b Figures 7a and 10a).

3.5.5 Incentives for Innovation in Products, Materials, or Processes

Updating the Title 24 Standards will encourage innovation through the adoption of new technologies to better manage energy usage and achieve energy savings. Significant impact on product innovation is not expected through these proposed changes, as they are primarily clarifications to improve compliance.

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

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

3.5.6.1 Cost of Enforcement

There are no projected impediments to, or incentives for, innovation that would result from the proposed measures.

Cost to the State

State government already has budget for code development, education, and compliance enforcement. While state government will be allocating resources to update the Title 24 Standards, including updating education and compliance materials and responding to questions about the revised Standards, these activities are already covered by existing state budgets. The costs to state government are small when compared to the overall costs savings and policy benefits associated with the code change proposals.

Cost to Local Governments

All revisions to Title 24 will result in changes to Title 24 compliance determinations. Local governments will need to train permitting staff on the revised Title 24 Standards. While this re-training is an expense to local governments, it is not a new cost associated with the 2016 code change cycle. The building code is updated on a triennial basis, and local governments plan and budget for retraining every time the code is updated. There are numerous resources available to local governments to support compliance training that can help mitigate the cost of retraining. For example, utilities offer compliance training such as “Decoding” talks to provide training and materials to local permitting departments. As noted earlier, although retraining is a cost of the revised Standards, Title 24 Standards are expected to increase economic growth and income with positive impacts on local revenue.

3.5.6.2 Impacts on Specific Persons

The proposed changes to Title 24 are not expected to have a differential impact on any of the following groups relative to the state population as a whole:

- Migrant Workers
- Persons by age
- Persons by race

- Persons by religion
- Commuters
- Renters will typically benefit from lower energy bills if they pay energy bills directly.

4. METHODOLOGY

This section describes the methodology and approach the Statewide CASE Team used to estimate energy, demand, costs, and environmental impacts. The Statewide CASE Team calculated the impacts of the proposed code change by comparing existing conditions to the conditions if the proposed code change is adopted. This section of the CASE Report goes into more detail on the assumptions about the existing and proposed conditions, prototype buildings, and the methodology used to estimate energy, demand, cost, and environmental impacts.

4.1 Existing Conditions

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

There is an existing Title 24 Standard that covers the building system in question, so the existing conditions assume a building complies with the 2013 Title 24 Standards.

The existing lighting controls in Title 24 do not require partial-ON lighting controls. There is an existing power adjustment factor (PAF) in Table 140.6-A that provides an adjustment to the lighting power (LPD) for spaces that include a partial-ON control approach (0.20 factor). There is a second PAF in Table 140.6-A that is intended for a combined Partial-ON and manual dimming control approach (0.25 factor).

The current language in Sections 130.1 or 110.9 does not define a maximum delay time for programming occupancy sensors under normal circumstances. Section 1605.3(L)(2)(G)1 of Title 20 (the California Appliance Standards) defines the maximum delay time that is permitted to be available in an occupancy sensor device sold in California is 30 minutes.

Refer to Section 2.2 and 2.3 for more information on the standard practice of design in the industry.

4.2 Proposed Conditions

The proposed code change will change the method of turning ON lights to reduce energy consumption in the following spaces:

- Private offices under 250 square feet;
- Multipurpose rooms under 1,000 square feet;
- Classrooms (any size); and
- Conference rooms (any size).

The 20-minute maximum delay time setting for occupancy sensors is intended to apply to all occupancy sensor control devices and systems, including stand-alone devices and lighting controls systems (multiple devices designed to function in combination).

4.3 Prototype Building

This measure does not require whole building modeling to establish the savings estimates for each space and climate zone. The measure sets certain conditions for the requirements to apply to spaces in a building:

- Must be one of the listed space types (private offices under 250 square feet, conference rooms, multipurpose rooms under 1,000 square feet, classrooms); and
- Must have more than 0.5 watts per square foot lighting power density (and thus, must meet Section 130.1(b) requirements for multilevel lighting).

A space that meets these parameters will be required to employ a partial-ON or vacancy sensor approach. Our analysis used percentages of composite building spaces comprised of these space types.

4.4 Climate Dependent

This lighting measure is not climate dependent; however, the impacts are calculated by climate zone based on the construction forecasts.

4.5 Time Dependent Valuation

The TDV (Time Dependent Valuation) of savings is a normalized format for comparing electricity and natural gas savings that takes into account the cost of electricity and natural gas consumed during different times of the day and year. The TDV values are based on long term discounted costs (30 years for all residential measures and nonresidential envelope measures and 15 years for all other nonresidential measures). In this case, the period of analysis used is 15 years. The TDV energy estimates are based on present-valued cost savings but are normalized in terms of "TDV kBTUs" so that the savings are evaluated in terms of energy units and measures with different periods of analysis can be combined into a single value.

CEC derived the 2016 TDV values that were used in the analyses for this report (CEC 2014). The TDV energy impacts are presented in Section 5.1 of this report, and the statewide TDV cost impacts are presented in Section 5.2.

4.6 Energy Impacts Methodology

The Statewide CASE Team calculated per unit impacts and statewide impacts associated with all new construction during the first year buildings complying with the 2016 Title 24 Standards are in operation.

This is achieved by estimating the reduction in the hours of operation associated with the change in controls type, and then extrapolating this estimate to the entire state through CEC building construction forecasts.

4.6.1 Per Unit Energy Impacts Methodology

The Statewide CASE Team estimated the electricity savings associated with the proposed code change. The energy savings were calculated on a per square foot basis.

The energy savings for this measure come from reductions in annual energy consumption. The spreadsheet-based analysis took into account a variety of variables:

- Reductions in hours of operation for affected space types;
- Reductions in power requirements of lighting in a 'low' setting (50-70% of full power);
- Statistical breakdown of impacted space use types within various building types;
- Occupancy and use profiles for various building use types;
- Projections of new construction per building use type in California; and
- TDV calculations as required to provide a consistent analysis basis for cost-effectiveness.

Analysis Tools

The analysis is completed using percentages of composite building spaces comprised of impacted spaces, and predicted through the TDV calculation based on energy use profiles relying on occupancy profiles from the Title 24 Residential ACM manual for the appropriate building type in conjunction with the assumptions as listed below.

The energy modeling of the benefit of this controls approach may be done on a per square foot basis, and need not be done in specific spaces because there is no need to predict an incremental cost for this measure (since the equipment requirements do not change from the current code). As a result, the energy savings calculations are simplified.

Key Assumptions

In a study performed in 2011, California Lighting Technology Center (CLTC) produced percentages of time that the lighting systems in the study were at full power, low power, and OFF, compared to the baseline conditions (manual bi-level switching and occupancy sensor control conditions). The CLTC study provides information on the status of the tested lighting systems throughout the study period, which can be employed to predict the savings that a partial-ON and manual-ON occupancy system can deliver.

Table 7: Key assumptions for lighting full-load equivalent reductions

Control Method		While Occupied % Time at Off Setting	While Occupied % Time at Low Setting	While Occupied % Time at Full Setting
All ON Values		0%	0%	100%
Full ON + Bi-Level	BASELINE	19%	31%	50%
Partial-ON		17%	70%	13%
Manual-ON		30%	32%	38%

This produces a reduction in the lighting hours of operation and the connected load (depending on whether the Low setting is employed). The impact of this controls measures is dependent on

occupancy, which is variable space to space. As a result, the comparison is made as an average reduction in the full-load equivalent energy consumption, which produces average energy savings for the control measure, rather than specific, time-dependent savings that can be directly employed to inform demand information.

This measure calculates an approximate average savings for employing partial-ON or vacancy sensors in the impacted spaces at 20% below the current baseline of bi-level switching with an occupancy sensor. The range of savings, as shown in Table 8, is calculated from approximately 13% to 27% for partial-ON sensors and 16% to 18% for vacancy sensors when adjusting the variables of the High light power draw (whether task tuning is applied), the 'low' light power draw (within the permitted range of 50% to 70%), and presuming some variability of conditions other than those observed in the scope of the CLTC study.

More information on the modeling of the savings can be found in Appendix B.

Table 8: Anticipated Savings Range From Various Control Strategies

	Range of Savings Observed
Partial-ON Occupancy Sensor	13% to 27%
Manual-ON Occupancy Sensor	16% to 18%

The CEC has provided a number of key assumptions to be used in the energy impacts analysis. Some of the assumptions included in CEC's Lifecycle Cost Methodology Guidelines (LCC Methodology) include hours of operation (CEC 2011). Other key assumptions used in the per unit energy impacts analysis are presented in Table 9.

Table 9: Key assumptions for per unit Energy Impacts Analysis

Parameter	Assumption	Source	Notes
Energy reduction	An average of 20% reduction	Guided by published CLTC research into Partial-ON sensor savings	This is described in detail in Appendix B.

For this calculation, the presumed 20% reduction in demand is applied to the Title 24 ACM hourly occupancy profile to determine a kW reduction per square foot, associated with the weighted average of the impacted spaces in new construction. For most building types, this is 70% during the typical peak hours in the afternoon. For Retail and Hotel building types, this value is 90%. The 20% reduction is then applied to this lighting utilization level and then calculated statewide through weighted averages.

A table of construction square footage estimates for 2017 was used to determine the weighted average of the building types and impact on the state, and for the 'per unit' energy impact analysis.

Table 10 provides the assumptions of square footage of each space type within each building type, then provides an area weighted average reduction of the LPD. This information is combined with the percentage of each building type in the constructions forecast to provide a composite impact per square foot for the entire state in 2017.

Table 10: Key assumptions of affected space for per unit energy impacts of the measure

				Bulding Type											
Impacted Area Category	Baseline LPD	Modified LPD	LPD Delta	Hotel	Retail	Large Office	Small Office	Food (Grocery)	NR Warehouse	Ref. Warehouse	Restaurant	Schools	College	Other	Hospital
Private Office	0.75	0.6	0.15	0.03	0.03	0.17	0.25	0.03	0.01	0.01	0.03	0.05	0.05	0.05	
Conference Room	1.4	1.12	0.28	0.01		0.05	0.05					0.01	0.02	0.01	
Multipurpose Room	1.4	1.12	0.28	0.02	0.01	0.05	0.05	0.01	0.01	0.01	0.02	0.03	0.03	0.02	
Classroom	1.2	0.96	0.24									0.45	0.25		
Area Weighted Average LPD Savings				0.0129	0.0073	0.0535	0.0655	0.0073	0.0043	0.0043	0.0101	0.1267	0.0815	0.0159	0

4.6.2 Statewide Energy Impacts Methodology

First Year Statewide Impacts

The Statewide CASE Team calculated the statewide savings in 2017 (the first year the standards take effect) by multiplying the per unit savings, which are presented in Section 5.1.1, by the statewide new construction forecast for 2017.

The CEC Demand Analysis Office provided the Statewide CASE Team with the nonresidential new construction forecast for 2017, broken out by building type and forecast climate zones (FCZ). The Statewide CASE Team translated this data to building climate zones (BCZ) using the same weighting of FCZ to BCZ as the previous code update cycle (2013), as presented in Table 13. The projected nonresidential new construction forecast is presented in Table 14. Table 11 provides a more complete definition of the various space types used in the forecast, and Table 12 presents the assumed percent of new construction that would be impacted by the proposed code change.

This measure impacts any circumstance where the new construction code is triggered, and that will include renovations and alterations based on the criteria in Tables 141.0-E and 141.0-F.

Table 11: Description of Space Types used in the Nonresidential New Construction Forecast

OFF-SMALL	Offices less than 30,000 ft^2
OFF-LRG	Offices larger than 30,000 ft^2
REST	Any facility that serves food
RETAIL	Retail stores and shopping centers
FOOD	Any service facility that sells food and or liquor
NWHSE	Nonrefrigerated warehouses
RWHSE	Refrigerated Warehouses
SCHOOL	Schools K-12, not including colleges
COLLEGE	Colleges, universities, community colleges
HOSP	Hospitals and other health-related facilities
HOTEL	Hotels and motels
MISC	All other space types that do not fit another category

Table 12: Percent of New Construction Impacted by the Proposed Measure

Space Type	Percent of New Construction in 2017 Impacted by Proposed Code Change	Climate Zones Impacted by Proposed Code Change
OFF-SMALL	35%	Climate Zones 1 - 16
OFF-LRG	27%	Climate Zones 1 - 16
REST	5%	Climate Zones 1 - 16
RETAIL	4%	Climate Zones 1 - 16
FOOD	4%	Climate Zones 1 - 16
NWHSE	2%	Climate Zones 1 - 16
RWHSE	2%	Climate Zones 1 - 16
SCHOOL	54%	Climate Zones 1 - 16
COLLEGE	35%	Climate Zones 1 - 16
HOSP	0%	Climate Zones 1 - 16
HOTEL	6%	Climate Zones 1 - 16
MISC	8%	Climate Zones 1 - 16

Table 13. Translation from FCZ to BCZ

Source: CEC Demand Analysis Office

		Building Standards Climate Zones (BCZ)																
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Grand Total
Forecast Climate Zones (FCZ)	1	22.5%	20.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	9.8%	33.1%	0.2%	0.0%	0.0%	13.8%	100%
	2	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	22.0%	75.7%	0.0%	0.0%	0.0%	2.3%	100%
	3	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	21.0%	22.8%	54.5%	0.0%	0.0%	1.8%	100%
	4	0.2%	13.7%	8.4%	46.0%	8.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	22.8%	0.0%	0.0%	0.0%	0.0%	100%
	5	0.0%	4.2%	89.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	6.6%	0.0%	0.0%	0.0%	0.0%	100%
	6	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	100%
	7	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	75.8%	7.1%	0.0%	17.1%	100%
	8	0.0%	0.0%	0.0%	0.0%	0.0%	40.4%	0.0%	51.1%	8.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.5%	100%
	9	0.0%	0.0%	0.0%	0.0%	0.0%	7.0%	0.0%	24.5%	57.9%	0.0%	0.0%	0.0%	0.0%	6.7%	0.0%	4.0%	100%
	10	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	74.9%	0.0%	0.0%	0.0%	12.3%	7.9%	4.9%	100%
	11	0.0%	0.0%	0.0%	0.0%	0.0%	33.0%	0.0%	24.8%	42.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100%
	12	0.0%	0.0%	0.0%	0.0%	0.0%	0.9%	0.0%	20.2%	75.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	3.7%	100%
	13	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	69.6%	0.0%	0.0%	28.8%	0.0%	0.0%	0.0%	1.6%	0.1%	0.0%	100%
	14	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100%
	15	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	99.9%	0.0%	100%
	16	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100%
	17	3.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	97.1%	100%

Table 14: Estimated New Nonresidential Construction in 2017 by Climate Zone and Building Type (Million Square Feet)

Source: CEC Demand Analysis Office

Climate Zone	New Construction in 2017 (Million Square Feet)												
	OFF-SMALL	REST	RETAIL	FOOD	NWHSE	RWHSE	SCHOOL	COLLEGE	HOSP	HOTEL	MISC	OFF-LRG	TOTAL
1	0.058	0.016	0.041	0.014	0.040	0.002	0.046	0.018	0.028	0.031	0.094	0.069	0.457
2	0.227	0.088	0.630	0.163	0.327	0.031	0.244	0.163	0.200	0.350	0.742	1.140	4.306
3	0.728	0.408	2.913	0.677	2.518	0.183	1.000	0.625	0.729	1.400	3.894	4.952	20.026
4	0.484	0.190	1.586	0.413	0.595	0.071	0.541	0.408	0.490	0.890	1.641	2.935	10.245
5	0.094	0.037	0.308	0.080	0.116	0.014	0.105	0.079	0.095	0.173	0.319	0.570	1.990
6	0.811	0.825	3.072	0.756	2.649	0.122	0.659	0.649	0.508	0.571	4.144	2.264	17.030
7	0.959	0.300	1.635	0.502	1.004	0.013	0.772	0.448	0.325	1.059	3.077	1.253	11.347
8	1.078	1.106	4.241	1.034	3.588	0.162	0.856	0.931	0.773	0.872	5.860	3.186	23.686
9	0.971	0.916	3.975	0.937	3.287	0.119	0.600	1.095	1.127	1.329	5.376	5.675	25.408
10	1.372	0.707	2.995	0.839	2.630	0.074	0.883	0.580	0.528	1.056	8.010	1.496	21.170
11	0.333	0.088	0.770	0.268	0.875	0.089	0.504	0.156	0.239	0.197	0.737	0.629	4.885
12	1.710	0.502	3.656	1.014	3.157	0.202	1.687	0.678	1.048	1.480	3.637	4.721	23.493
13	0.668	0.205	1.606	0.544	1.706	0.286	1.401	0.390	0.520	0.359	1.884	0.817	10.387
14	0.224	0.138	0.609	0.162	0.527	0.025	0.156	0.128	0.115	0.185	1.472	0.431	4.171
15	0.349	0.096	0.675	0.238	0.761	0.022	0.192	0.098	0.133	0.204	1.123	0.289	4.180
16	0.199	0.106	0.506	0.142	0.449	0.042	0.205	0.122	0.125	0.144	0.931	0.394	3.367
TOTAL	10.264	5.729	29.218	7.784	24.228	1.457	9.852	6.570	6.983	10.301	42.941	30.821	186.148

4.7 Cost-effectiveness Methodology

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

CEC's procedures for calculating lifecycle cost-effectiveness are documented in LCC Methodology (CEC 2011). The Statewide CASE Team followed these guidelines when developing the Cost-effectiveness Analysis for this measure. CEC's guidance dictated which costs were included in the analysis. Incremental equipment and maintenance costs over the 15-year period of analysis were included. The TDV energy cost savings from electricity savings were considered. Each of these components is discussed in more detail below.

Design costs were not included.

Sources of cost data include:

- Distributor product pricing information;
- Manufacturers product cost and availability projections; and
- RS Means cost estimating guide for materials and labor needed to support the lighting or controls device installations.

Cost information for the lighting and controls devices are available through the normal sales representative and distribution network that supplies the devices to the contractors for installation.

In this circumstance, the conversations with the sales representatives were used to determine that no additional equipment or construction efforts beyond those needed in the current code (2013 Title 24 Standards) are required to enact this measure, and therefore no incremental costs will be incurred.

4.7.1 Incremental Cost Methodology

Incremental Construction Cost Methodology

As requested by CEC, the Statewide CASE Team estimated the Current Incremental Construction Costs and Post-adoption Incremental Construction Costs. The Current Incremental Construction Cost (ΔCI_C) represents the cost of the incremental cost of the measure if a building meeting the proposed Standard were built today. The Post-adoption Incremental Construction Cost (ΔCI_{PA}) represents the anticipated cost assuming full market penetration of the measure as a result of the new Standards, resulting in possible reduction in unit costs as manufacturing practices improve over time and with increased production volume of qualifying products the year the Standard becomes effective.

The Statewide CASE Team used data collected in Task 1 (data collection) to select appropriate assumptions for the cost analysis. Some of the key assumptions for this measure include:

- The cost of lighting controls has been reduced with increasing competition.
- The sophistication of the various lighting controls devices (in terms of programming capability) has increased.

The controls market is capable of meeting this measure without additional design and engineering development.

Key assumptions used to derive cost are presented in Table 15.

Table 15: Key Assumptions for per unit Incremental Construction Cost

Parameter	Assumption	Source	Notes
Construction Requirements	The partial-ON requirement does not add additional lighting controls equipment to impacted spaces	Interviews with controls manufacturers and sales representatives for system requirements suitable to meet the measure requirements.	This results in no incremental costs to the baseline system.

4.7.2 Cost Savings Methodology

Energy Cost Savings Methodology

This measure is not climate sensitive, so the energy cost savings were calculated using the population-weighted TDV values.

Other Cost Savings Methodology

This measure does not have any non-energy cost savings.

4.7.3 Cost-effectiveness Methodology

This measure incurs no incremental costs because the existing multilevel lighting code baseline requires the same equipment for compliance. Therefore, this is a change in how the equipment must be programmed or commissioned, and there is no impact on the cost of the system to comply.

As a result, the measure is instantaneously cost effective.

4.8 Environmental Impacts Methodology

4.8.1 Greenhouse Gas Emissions Impacts Methodology

Greenhouse Gas Emissions Impacts Methodology

The Statewide CASE Team calculated avoided GHG emissions assuming an emission factor of 353 metric tons of carbon dioxide equivalents ($MTCO_2e$) per gigawatt hour (GWh) of electricity savings. As described in more detail in Appendix A, the electricity emission factor represents savings from avoided electricity generation and accounts for the GHG impacts if the state meets the Renewable Portfolio Standard (RPS) goal of 33 percent renewable electricity generation by 2020. Avoided GHG emissions from natural gas savings were calculated using an emission factor of 5,303 $MTCO_2e$/million therms (U.S. EPA 2011).

4.8.2 Water Use Impacts Methodology

There are no impacts on water use or water quality.

4.8.3 Material Impacts Methodology (Optional)

The Statewide CASE Team did not develop estimates of material impacts.

4.8.4 Other Impacts Methodology

There are no other impacts from the proposed code change.

5. ANALYSIS AND RESULTS

Results from the energy, demand, cost, and environmental impacts analyses are presented in this section.

Energy savings are achieved through the reduction in the connected load during the period while the lights are dimmed back from full power (when employing a partial-ON design approach), or by reduced total hours of operation (when employing a vacancy sensor approach).

Additional savings will occur due to establishing a maximum delay time limit of 20 minutes, which will reduce annual hours of operation. As the number of opportunities for the sensor delay time to be triggered increases, the number of savings opportunities increases. However, we do not anticipate that the majority of design projects will be affected by the maximum delay time limit, as good design practice already has shorter delay times being specified on many projects.

This portion of the measure is primarily intended to address the laggard adopters who install a sensor because of the Code, but either do not commission it, or set the delay time to the maximum permitted in Title 20. Since Title 24 currently has no language on the maximum delay time, there has been no opportunity for a local inspector to reject a system that is functional, but contains a delay time as long as 30 minutes.

The measure proposes to establish a maximum delay time that is long enough to accommodate all of the normal applications that occur with occupancy sensors. However, establishing shorter delay times are still the prerogative of the designer, and it is expected that many will use shorter delay times.

5.1 Energy Impacts Results

5.1.1 Per Unit Energy Impacts Results

Per unit energy and demand impacts of the proposed measure are presented in Table 16. Per unit savings for the first year are expected to be 0.09 kilowatt-hours per year (kWh/yr) per square foot of newly constructed space.

It is estimated that the TDV savings over the 15-year period of analysis will be $ 0.20 per square foot. The TDV methodology allows peak electricity savings to be valued more than electricity savings during non-peak periods.

The demand reduction is not possible to directly establish based on the information presented in the research (CLTC), but this measure is not anticipated to be time-dependent in a manner that would focus on peak periods. The savings is anticipated to be maximized during the day and minimized at night, so a conservative peak demand savings is estimated to be equal to the average rate of energy savings, or 20 percent.

Table 16: Energy Impacts per Square Foot

Climate Zone	Per Unit First Year Savings[1]			Per Unit First Year TDV Savings[2]
	Electricity Savings[3] (kWh/yr)	Demand Savings (kW)	Natural Gas Savings (Therms/yr)	TDV Savings[4] (2017 $)
TOTAL	0.09	0.00021	N/A	0.19

1. Savings from one square foot of newly constructed space for the first year the building is in operation.
2. TDV energy savings for one square foot for the first year the building is in operation.
3. Site electricity savings. Does not include TDV of electricity savings.
4. Calculated using CEC's 2016 TDV factors and methodology. Includes savings from electricity.

5.1.2 Statewide Energy Impacts Results

First Year Statewide Energy Impacts

Using the projections for new construction in 2017 as provided by the CEC, the statewide energy impacts of the proposed measure are presented in Table 17. During the first year buildings complying with the 2016 Title 24 Standards are in operation, the proposed measure is expected to reduce annual statewide electricity use by 17 GWh and reduce demand by 6.6 megawatts (MW) from the baseline conditions.

Table 17: Statewide Energy Impacts

	First Year Statewide Savings[1]			TDV Savings[2]
	Electricity Savings[3] (GWh)	Power Demand Reduction (MW)	Natural Gas Savings (MMtherms)	TDV Dollar Savings[4] (Million $)
TOTAL	14	5.4	N/A	31

1. First year savings from all buildings built statewide during the first year the 2016 Standards are in effect.
2. First year TDV savings from all buildings built statewide during the first year the 2016 Standards are in effect.
3. Site electricity savings.
4. Calculated using CEC's 2016 TDV factors and methodology.

Assumptions and calculations used to derive per unit and statewide energy and demand savings are presented in Section 4.6 of this report.

5.2 Cost-effectiveness Results

5.2.1 Incremental Cost Results

The proposed measure does not incur any incremental costs because the baseline controls infrastructure requires the same equipment with different programming. Therefore, there are no additional costs associated with this measure.

Incremental Construction Cost Results

There will be no incremental construction costs incurred by this measure.

Incremental Maintenance Cost Results

There are no incremental maintenance costs associated with this measure.

5.2.2 Cost Savings Results

Energy Cost Savings Results

The per unit TDV energy cost savings over the 15-year period of analysis are presented in Table 17. This measure is not climate zone dependent.

Table 18: TDV Energy Cost Savings Over 15-year Period of Analysis - Per Square Foot

Climate Zone	TDV Electricity Cost Savings (2017 PV $)	TDV Natural Gas Cost Savings (2017 PV $)	Total TDV Energy Cost Savings (2017 PV $)
TOTAL	0.19	N/A	0.19

Given data regarding the new construction forecast for 2017, the Statewide CASE Team estimates that TDV energy cost savings (over 15 years) of all new buildings constructed during the first year the 2016 Standards are in effect will be $31 million.

Other Cost Savings Results

This measure does not have any non-energy cost savings.

5.2.3 Cost-effectiveness Results

This measure is cost effective and saves money over the 15-year calculation period. Since there is no incremental cost incurred by the measure, the payback is instantaneous.

Given data regarding the new construction forecast for 2017, the Statewide CASE Team estimates that that lifecycle cost savings (15-year) of all new buildings constructed during the first year the 2016 Standards are in effect will be $38 million.

5.3 Environmental Impacts Results

5.3.1 Greenhouse Gas Emissions Results

Table 19 presents the estimated first year avoided GHG emissions of the proposed code change. During the first year the 2016 Standards are in effect the proposed measure will result in avoided GHG emissions of 6,001 $MTCO_2e$.

Table 19: Statewide First Year Greenhouse Gas Emissions Impacts

	Avoided GHG Emissions[1] ($MTCO_2e$/yr)
TOTAL	4,981

1. First year savings from buildings built in 2017; assumes 353 $MTCO_2e$/GWh.

5.3.2 Water Use and Water Quality Impacts

Impacts on water use and water quality are presented in Table 20.

There are no impacts to water usage or quality associated with this measure.

Table 20: Impacts of Water Use and Water Quality

	On-Site Water Savings[1] (gallons/yr)	Embedded Energy Savings[2] (kWh/yr)	Impact on Water Quality Material Increase (I), Decrease (D), or No Change (NC) compared to existing conditions			
			Mineralization (calcium, boron, and salts)	Algae or Bacterial Buildup	Corrosives as a Result of PH Change	Others
Impact (I, D, or NC)	NC	NC	NC	NC	NC	NC
Per Unit Impacts	N/A	N/A	N/A	N/A	N/A	N/A
Statewide Impacts (first year)	N/A	N/A	N/A	N/A	N/A	N/A
Comment on reasons for your impact assessment	N/A	N/A	N/A	N/A	N/A	N/A

1. Does not include water savings at power plant
2. Assumes embedded energy factor of 10,045 kWh per million gallons of water.

5.3.3 Material Impacts Methodology (Optional)

The Statewide CASE Team did not develop estimates of material impacts.

5.3.4 Other Impacts Results

There are no other non-energy related impacts anticipated with this measure.

6. PROPOSED LANGUAGE

The proposed changes to the Standards, Reference Appendices, and the ACM Reference Manuals are provided below. Changes to the 2013 documents are marked with underlining (new language) and ~~strikethroughs~~ (deletions).

6.1 Standards

SECTION 130.1 – INDOOR LIGHTING CONTROLS THAT SHALL BE INSTALLED

Section 130.1(c)5 will be revised in the following manner:

5. **Areas where Occupant Sensing Controls are required to shut OFF All Lighting**. In offices 250 square feet or smaller, multipurpose rooms of less than 1,000 square feet, classrooms of any size, and conference rooms of any size, lighting shall be controlled with occupant sensing controls to automatically shut OFF all of the lighting when the room is unoccupied. The occupant sensing controls shall function either as a:

   A. Partial-On Occupant Sensor, with the automatic ON level set between 50-70 percent of full rated power, OR

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

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

   EXCEPTION to Section 130.1(c)5: Areas that do not meet the multi-level requirements of Section 130.1(b) shall operate using either Occupant Sensor or Vacancy Sensor control methods.

Section 130.1(c)6 will be revised in the following manner:

6. **Areas where partial ~~ON/~~OFF occupant sensing controls are required** in addition to complying with Section 130.1(c)1.

Section 130.1(c)7 will be revised in the following manner:

7. **Areas where partial ~~ON/~~OFF occupant sensing controls are required** instead of complying with Section 130.1(c)1.

SECTION 140.6 – PRESCRIPTIVE REQUIREMENTS FOR INDOOR LIGHTING

Section 140.6(A)2 will be revised in the following manner:

2. **Reduction of wattage through controls.** In calculating actual indoor Lighting Power Density, 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. (Thus, for example, portable lighting, portable lighting controls, and residential rated lighting controls shall not qualify for PAFs.)

      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 calculated actual indoor Lighting Power Densities as allowed by Section 140.6(a)2. 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 actual indoor Lighting Power Density.

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.

EXCEPTION to Section 140.6(a)2G: Lighting controls designed and installed for the sole purpose of compliance with Section 130.1(b)3 may be used to qualify for a PAF, provided the lighting controls are designed and installed in addition to all manual, and automatic lighting controls otherwise required in Section 130.1.

~~H. To qualify for the PAF for a Partial ON Occupant Sensing Control in TABLE 140.6-A, a Partial On Occupant Sensing Control shall meet all of the following requirements:~~

~~i. The control shall automatically deactivate all of the lighting power in the area within 30 minutes after the room has been vacated; and~~

~~ii. The first stage shall automatically activate between 30-70 percent of the lighting power in the area and may be a switching or dimming system; and~~

~~iii. The second stage shall require manual activation of the alternate set of lights, and this manual-ON requirements shall not be capable of conversion from manual-ON to automatic-ON functionality via manual switches or dip switches; and~~

~~iv. Switches shall be located in accordance with Section 130.1(a) and shall allow occupants to manually do all of the following regardless of the sensor status: activate the alternate set of lights in accordance with Item (iii); activate 100 percent of the lighting power; and deactivate all of the lights.~~

~~I~~H. To qualify for the PAF for an occupant sensing control controlling the general lighting in large open plan office areas above workstations, in accordance with TABLE 140.6-A, the following requirements shall be met:

i. The open plan office area shall be greater than 250 square feet; and

ii. This PAF shall be available only in office areas which contain workstations; and

iii. Controlled luminaires shall only be those that provide general lighting directly above the controlled area, or furniture mounted luminaires that comply with Section 140.6(a)2 and provide general lighting directly above the controlled area; and

iv. Qualifying luminaires shall be controlled by occupant sensing controls that meet all of the following requirements, as applicable:

a. Infrared sensors shall be equipped by the manufacturer, of fitted in the field by the installer, with lenses or shrouds to prevent them from being triggered by movement outside of the controlled area.

b. Ultrasonic sensors shall be tuned to reduce their sensitivity to prevent them from being triggered by movements outside of the controlled area.

c. All other sensors shall be installed and adjusted as necessary to prevent them from being triggered by movements outside of the controlled area.

~~J. To qualify for the PAF for a Manual Dimming System PAF or a Multiscene Programmable Dimming System PAF in TABLE 140.6-A, the lighting shall be controlled with a control that can be manually operated by the user.~~

~~K~~I. To qualify for the PAF for a Demand Responsive Control in TABLE 140.6-A, a Demand Responsive

Control shall meet all of the following requirements:

i. The building shall be 10,000 square feet or smaller; and

ii. The controlled lighting shall be capable of being automatically reduced in response to a demand response signal; and

iii. Lighting shall be reduced in a manner consistent with uniform level of illumination requirements in TABLE 130.1-A; and

iv. Spaces that are non-habitable shall not be used to comply with this requirement, and spaces with a lighting power density of less than 0.5 watts per square foot shall not be counted toward the building's total lighting power.

~~L. To qualify for the PAF for Combined Manual Dimming plus Partial ON Occupant Sensing Control in TABLE 140.6-A, (i) the lighting controls shall comply with the applicable requirements in Section 140.6(a)2J; and (ii) the lighting shall be controlled with a dimmer control that can be manually operated, or with a multi-scene programmable control that can be manually operated.~~

Table 140.6-A will be revised in the following manner:

TABLE 140.6-A LIGHTING POWER DENSITY ADJUSTMENT FACTORS (PAF)

TYPE OF CONTROL		TYPE OF AREA		FACTOR
a. To qualify for any of the Power Adjustment Factors in this table, the installation shall comply with the applicable requirements in Section 140.6(a)2 b. Only one PAF may be used for each qualifying luminaire unless combined below. c. Lighting controls that are required for compliance with Part 6 shall not be eligible for a PAF				
~~1. Partial ON Occupant Sensing Control~~		~~Any area ≤ 250 square feet enclosed by floor-to-ceiling partitions; any size classroom, conference or waiting room.~~		~~0.20~~
~~2~~1. Occupant Sensing Controls in Large Open Plan Offices		In open plan offices > 250 square feet: One sensor controlling an area that is:	No larger than 125 square feet	0.40
			From 126 to 250 square feet	0.30
			From 251 to 500 square feet	0.20
~~3. Dimming System~~	~~Manual Dimming~~	~~Hotels/motels, restaurants, auditoriums, theaters~~		~~0.10~~
	~~Multiscene Programmable~~			~~0.20~~
~~4~~2. Demand Responsive Control		All building types less than 10,000 square feet. Luminaires that qualify for other PAFs in this table may also qualify for this demand responsive control PAF		0.05
~~5. Combined Manual Dimming plus Partial ON Occupant Sensing Control~~		~~Any area ≤ 250 square feet enclosed by floor-to-ceiling partitions; any size classroom, conference or waiting room~~		~~0.25~~

Section 110.9(b)4 will be revised in the following manner:

4. **Occupant Sensing Controls:** Occupant, Motion, and Vacancy Sensor Controls shall meet the following requirements:

   A. **Occupant Sensors** shall meet all applicable requirements for Occupant Sensor Control devices in the Title 20 Appliance Efficiency Regulations.

   B**. Motion Sensors** shall meet all applicable requirements for Motion Sensor Controls devices in the Title 20 Appliance Efficiency Regulations.

   C. **Vacancy Sensors** shall meet all applicable requirements for Vacancy Sensor Controls devices in the Title 20 Appliance Efficiency Regulations.

   D. **Partial-ON Sensors** shall meet all applicable requirements for partial on sensing devices in the Title 20 Appliance Efficiency Regulations.

   E. **Partial-OFF Sensors** shall meet all applicable requirements for partial off sensing devices in the Title 20 Appliance Efficiency Regulations.

   F. All controls listed in 110.9(b)4 shall be programmed to turn off or reduce lighting power of controlled lighting equipment no longer than 20 minutes after the last occupant leaving the controlled zone, in accordance with the applicable controls requirements of Section 130.1(c).

   EXCEPTION to Section 110.9(b)4: Occupant Sensing Control systems may consist of a combination of single or multi-level Occupant, Motion, or Vacancy Sensor Controls, provided that components installed to comply with manual-on requirements shall not be capable of conversion by the user from manual-on to automatic-on functionality.

6.2 Reference Appendices

There are no proposed changes to the Reference Appendices.

6.3 ACM Reference Manual

Revise Section 5.4.4 of the ACM to reflect the removal of the PAF lighting control credits for manual dimming and dimming scene controls.

6.4 Compliance Manuals

Chapter 5.4.3 of the Nonresidential Compliance Manual will need to be revised to add the language for partial-ON or vacancy sensors in the affected spaces.

6.5 Compliance Forms

Forms NRCC-CXR-02-E and NRCC-LTI-02-E will need revision.

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APPENDIX A: ENVIRONMENTAL IMPACTS METHODOLOGY

Greenhouse Gas Emissions Impacts Methodology

The avoided GHG emissions were calculated assuming an emission factor of 353 metric tons of carbon dioxide equivalents ($MTCO_2e$) per GWh of electricity savings. The Statewide CASE Team calculated air quality impacts associated with the electricity savings from the proposed measure using emission factors that indicate emissions per GWh of electricity generated.[4] When evaluating the impact of increasing the Renewable Portfolio Standard (RPS) from 20 percent renewables by 2020 to 33 percent renewables by 2020, California Air Resources Board (CARB) published data on expected air pollution emissions for various future electricity generation scenarios (CARB 2010). The Statewide CASE Team used data from CARB's analysis to inform the air quality analysis presented in this report.

The GHG emissions factor is a projection for 2020 assuming the state will meet the 33 percent RPS goal. CARB calculated the emissions for two scenarios: (1) a high load scenario in which load continues at the same rate; and (2) a low load rate that assumes the state will successfully implement energy efficiency strategies outlined in the AB32 scoping plan thereby reducing overall electricity load in the state.

To be conservative, the Statewide CASE Team calculated the emissions factors of the incremental electricity between the low and high load scenarios. These emission factors are intended to provide a benchmark of emission reductions attributable to energy efficiency measures that could help achieve the low load scenario. The incremental emissions were calculated by dividing the difference between California emissions in the high and low generation forecasts by the difference between total electricity generated in those two scenarios. While emission rates may change over time, 2020 was considered a representative year for this measure.

Avoided GHG emissions from natural gas savings were calculated using an emission factor of 5,303 $MTCO_2e$/million therms (U.S. EPA 2011).

[4] California power plants are subject to a GHG cap and trade program and linked offset programs until 2020 and potentially beyond.

APPENDIX B: SAVINGS ESTIMATE CALCULATIONS

Estimating Savings for Partial-On Occupancy Sensors

The premise behind the partial-On occupancy sensor approach is that in many cases, the light level delivered by a lighting system at partial power (low power, around 50%) may be sufficient to meet the visual requirements of the occupant. This is increasingly true if a task light is available for the occupant to utilize, or if the space includes secondary or primary daylighting.

However, the daylighting variable is already part of the existing baseline, and a properly configured daylighting system will dim back the lights when 150% of the target illuminance is met, so the savings opportunity for those conditions are already partly covered in the baseline.

What is not covered is spaces that are marginally met with daylighting, non-daylighted spaces, and also occupants who have a lower appetite for lighting than intended in the lighting design for the space they occupy. In these circumstances, even with daylighting, there is an opportunity to keep the electric lighting at a lower level until there is a specific desire to increase the level to meet a visual task, or for another performance or aesthetic reason.

The question regarding whether a manual-ON (vacancy sensor) or partial-ON sensor is better at saving energy is not clearly resolved, because the answer depends on a number of variables, including:

- User preferences
- The power level of the 'low' setting
- The power level of the 'high' setting (whether there is task tuning employed)
- The amount of daylighting or availability of any daylighting
- The typical use of the space (office uses vs. conference room, for example)
- The volume of traffic in the space, and the traffic schedule

As a result, both approaches are considered viable, as both show savings beyond the baseline condition, which in this case is a space with an occupancy sensor and bi-level switches. If there is available daylight, it will have daylighting sensors and control as well.

A study performed by the CLTC in 2010 shows that given the circumstances they observed, a partial-ON system saved more energy than a vacancy sensor (CLTC 2010). However, modeling the two with other circumstances shows that the results can be reversed.

Table 21 below shows that the results can change if the various conditions of the lighting system are changed.

Table 21: Savings From Various Control Strategies on a Simple Office Condition

100	**Watts in room**

Using 85% Task Tune and 60% for Low setting

			While Occupied								
Control Method		**kWh/ Yr. in Test**	**% Time at Low Setting**	**Low Setting**	**% Time at Full Setting**	**Full Setting**	**Hours Occupied Per Year**	**Modeled Energy Consumption (kWh)**		**Modeled Demand (kW)**	
All ON Values		150	0%	60%	100%	85%	2000	170		0.085	
Full ON + Bi-Level	BASELINE	99	31%	60%	50%	85%	2000	122.2		0.0611	
Partial-ON		72	70%	60%	13%	85%	2000	106.1	87%	0.05305	87%
Manual-ON		81	32%	60%	38%	85%	2000	103	84%	0.0515	84%

Using 85% Task Tune and 50% for Low setting

			While Occupied								
Control Method		**kWh/ Yr. in Test**	**% Time at Low Setting**	**Low Setting**	**% Time at Full Setting**	**Full Setting**	**Hours Occupied Per Year**	**Modeled Energy Consumption (kWh)**		**Modeled Demand (kW)**	
All ON Values		150	0%	50%	100%	85%	2000	170		0.085	
Full ON + Bi-Level	BASELINE	99	31%	50%	50%	85%	2000	116		0.058	
Partial-ON		72	70%	50%	13%	85%	2000	92.1	79%	0.04605	79%
Manual-ON		81	32%	50%	38%	85%	2000	96.6	83%	0.0483	83%

Using 100% Task Tune (no Tuning) and 50% for Low setting

		While Occupied							
Control Method	**kWh/ Yr. in Test**	**% Time at Low Setting**	**Low Setting**	**% Time at Full Setting**	**Full Setting**	**Hours Occupied Per Year**	**Modeled Energy Consumption (kWh)**		**Modeled Demand (kW)**	
All ON Values	150	0%	50%	100%	100 %	2000	200		0.1	
Full ON + Bi-Level BASELINE	99	31%	50%	50%	100 %	2000	131		0.0655	
Partial-ON	72	70%	50%	13%	100 %	2000	96	73%	0.048	73 %
Manual-ON	81	32%	50%	38%	100 %	2000	108	82%	0.054	82 %

As a result of these, Table 22, below, shows the range of anticipated savings. The Partial-ON approach shows higher savings potential, but also lower minimum values, so the range is wider. The Manual-ON approach shows a much more narrow range, which averages out to be slightly lower than the values in the Partial-ON approach.

Table 22: Anticipated Savings Range From Various Control Strategies

	Range of Savings Observed
Partial-ON Occupancy Sensor	13% to 27%
Manual-ON Occupancy Sensor	16% to 18%

These results have been averaged to 20% savings beyond the baseline approach.

Note that the results of the CLTC study and the extrapolation of the results to different control setting conditions employs a fairly simplified hours of occupancy per year model, rather than a schedule of occupancy for the space based on use profiles. This can lead to differences in the results as well, especially when considering the TDV impacts of a measure of this nature.

When the statewide impacts were projected, the following use profile was employed, as it represents a reasonable profile for office environments, which is the primary anticipated building type that this measure will be employed within. This information is based on

applicable use profiles found in the 2008 ACM manual in Table N2-8. Note that the 2013 ACM document does not currently include this table, but the information is still considered valid by the CEC and may be employed. This table is the "combined dimming" segment, as the new requirements for multilevel lighting are likely to trigger at least two different modes of lighting reductions, including occupancy sensors, and possibly task tuning or daylighting.

Table 23, below, provides the use profile as employed for the calculations.

Table 23: Use Profile for Statewide Impacts Calculations

Measure Schedule - % lights on General NR			
Hour of day	MF	Saturday	Sunday
0	4%	4%	4%
1	4%	4%	4%
2	4%	4%	4%
3	4%	4%	4%
4	7%	4%	4%
5	14%	7%	7%
6	29%	11%	7%
7	53%	19%	11%
8	64%	20%	12%
9	70%	21%	12%
10	71%	21%	13%
11	71%	21%	13%
12	71%	21%	13%
13	71%	21%	13%
14	70%	16%	12%
15	68%	16%	12%
16	65%	15%	12%
17	60%	11%	8%
18	26%	7%	7%
19	7%	7%	7%
20	7%	7%	3%
21	7%	7%	3%
22	7%	7%	3%
23	7%	7%	3%