CODES AND STANDARDS ENHANCEMENT INITIATIVE (CASE)

Outdoor Lighting Controls

Measure Number: 2016-NR-LTG4-F

Nonresidential Lighting

2016 CALIFORNIA BUILDING ENERGY EFFICIENCY STANDARDS

California Utilities Statewide Codes and Standards Team September 2014

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TABLE OF CONTENTS

List of Tables

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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 measure name. 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 assumptions 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 Outdoor Lighting Controls CASE proposal 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	N/A	N/A	N/A	N/A	TBD

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

Measure Description

The Outdoor Lighting Controls measure is intended to modify current code language to make existing controls requirements more streamlined by removing the current exceptions from the controls requirements in Section 130.2(c), for Outdoor Sales Lots and Outdoor Sales Canopies. As a result, newly constructed Outdoor Sales Lot poles under 24 feet and Outdoor Sales Canopy lighting under 24 feet would be required to be controlled by motion sensors or other lighting control systems that automatically reduce lighting power in response to the area being vacated of occupants. The primary impact of these measures will be on fuel stations (the most common type of Outdoor Sales Canopy) and auto sales lots (the most common type of outdoor sales lot). Lastly, in response to stakeholder input, the CASE Team is proposing to lower the allowed wattage reduction during dimming to 90%, instead of the current 80% reduction limit.

Outdoor motion based lighting controls were introduced to the 2013 Title 24 Standards for most outdoor lighting area types, but with a number of exceptions in place. The exceptions may have been inserted into the code because these types of multi-level lighting controls installations were rare in sales lots and sales canopies, but in recent years they have started to occur more often, and have received positive reviews from occupants and building owners, so there has been renewed interest in the proposal concept.

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 5: Scope of Code Change Proposal
- Table 6: Sections of Standards Impacted by Proposed Code Change

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

Market Analysis and Regulatory Impact Assessment

The market for occupancy-based lighting controls in outdoor lighting design is well-established and many area types, including parking lots and outdoor hardscape. The market for these controls in fuel stations and car lots is smaller, but has grown in recent years. This energy savings measure was not being installed to a significant degree several years ago when CEC last set out to update the lighting Standards, so these space types were exempted from these requirements in the 2013 Title 24 code update. It was not clear whether there were technical feasibility concerns or other market barriers, as this type of installation had not been studied and there were few example projects. However, since then, accompanying the rise of light emitting diode fixtures (LEDs), a number of these exempted facilities have begun designing using this approach, both in California and throughout the United States. A similar proposal has also been submitted to the ASHRAE 90.1 Lighting Committee, and there is now momentum and interest in the energy savings potential from bi-level motion controlled lighting in fuel stations and car sales lots.

This proposal is cost effective over the period of analysis. Overall, this proposal increases the wealth of the State of California. California consumers and businesses save more money on energy than they do for financing the efficiency measure. As a result this leaves more money available for discretionary and investment purposes.

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

- **Impact on builders:** The proposed code change is not expected to have an impact on builders.
- **Impact on building designers:** Building designers will need to incorporate control design into the construction of sales canopies and sales lots.
- **Impact on occupational safety and health:** The proposed code change is not expected to have a negative impact on occupational safety and health. It has been suggested because light levels will instantly increase whenever motion is detected on the premises, the measure may in fact increase safety and awareness of occupants and workers in these facilities.
- **Impact on building owners and occupants:** Since this measure is cost effective, the building owners who pay their energy bills are reducing their energy costs more than their mortgage costs are increased as a result of this measure (i.e. they experience net cost savings). For building occupants that are paying for their energy bills, since the measure saves more energy cost on a monthly basis than the measure costs on the mortgage as experienced by the building owner, the pass-through of added mortgage costs into rental costs is less than the energy cost savings experienced by occupants.
- **Impact on equipment retailers (including manufacturers and distributors):** Equipment retailers will need to consider the increased demand for control systems due to this measure.
- **Impact on energy consultants:** Energy consultants will need to consider the new code baseline of lighting equipment in sales lots and sales canopies.
- **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 code change is not expected to have an impact on statewide employment.
- **Impacts on the creation or elimination of businesses in California:** The proposed code change is not expected to have an impact on the creation or elimination of businesses in California.
- **Impacts on the potential advantages or disadvantages to California businesses:** The proposed code change can offer energy savings for California businesses.
- **Impacts on the potential increase or decrease of investments in California**: The proposed code change is not expected to have an impact on the increase or decrease of investments in California.

- **Impacts on incentives for innovations in products, materials or processes:** The proposed code change is not expected to have an impact on incentives for innovations in products, materials or processes in California.
- **Impacts on the State General Fund, Special Funds and local government:** The proposed code change is not expected to have an impact on the State General Fund, Special Funds and the local government.
- **Cost of enforcement to State Government and local governments:** The proposed code change is not expected to have an impact on the cost of enforcement to State and local governments.
- **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 negative impact on homeowners; however, the measure may positively affect homeowners by reducing light trespass at night.
- **Impact on Renters:** This proposal is advantageous to renters of fuel station and car sales lot facilities, as it reduces the cost of utilities which are typically paid by renters. Since the measure saves more energy cost on a monthly basis than the measure costs on the mortgage as experiences by the landlord, the pass-through of added mortgage costs into rents is less than the energy cost savings experienced by renters.
- **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 this Outdoor Lighting Controls measure.

Table 2: Estimated First Year Energy Savings

	First Year Statewide Savings			First Year TDV Energy Savings (Million kBTU)
	Electricity Savings (GWh)	Peak Demand Savings (MW)	Natural Gas Savings (MMtherms)	
Sales Canopies	1.67	-	-	27.5
Outdoor Sales Lots	2.52	-	-	41.7
TOTAL	4.19	-		69.3

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

Cost-effectiveness

Results of per unit Cost-effectiveness Analyses are presented in Table 3. 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.

Because the measure is lighting related and not climate-dependent, cost-effectiveness was not calculated on a per climate zone basis. Rather, cost-effectiveness was calculated for each of the prototype facilities and scenarios modeled.

The Change in Lifecycle Cost values are negative in every prototype facility modeled by the Statewide CASE Team. This means that the proposed code change is cost effective, and the code change will result in cost savings relative to the existing conditions. While the measure is cost effective, the magnitude of cost-effectiveness varies from a high Planning B/C ratio of 10.25 in the auto sales lot prototype facility (with assumed higher wattage fixtures), to a low Planning B/C ratio of 1.21 in the 24-hour sales canopy prototype facility (with assumed lower wattage fixtures).

Table 3: Cost-effectiveness Summary

Prototype	Fixture Wattage	Benefit: TDV Energy Cost Savings (2017 PV $)	Cost: Total Incremental First Cost and Maintenance Cost (2017 PV $)	Change in Lifecycle Cost (2017 PV $)	Planned Benefit-to-Cost (B/C) Ratio
Prototype 1: Large 24-Hr Sales Canopy	122W	$ 6,470	$ 3,600	$ 2,870	1.80
	82W	$ 4,349	$ 3,600	$ 749	1.21
Prototype 2: Large 15-Hr Sales Canopy	122W	$ 11,170	$ 3,600	$ 7,570	3.10
	82W	$ 7,508	$ 3,600	$ 3,908	2.09
Prototype 3: Small 24-Hr Sales Canopy	122W	$ 2,876	$ 1,600	$ 1,276	1.80
	82W	$ 1,933	$ 1,600	$ 333	1.21
Prototype 4: Small 15-Hr Sales Canopy	122W	$ 4,964	$ 1,600	$ 3,364	3.10
	82W	$ 3,337	$ 1,600	$ 1,737	2.09
Prototype 5: Corner 12-Hr Outdoor Sales Lot	275W	$ 8,306	$ 810	$ 7,496	10.25
	126W	$ 3,805	$ 810	$ 2,995	4.70
Prototype 6: Large 12-Hr Outdoor Sales Lot	275W	$ 41,528	$ 4,050	$ 37,478	10.25
	126W	$ 19,027	$ 4,050	$ 14,977	4.70

Section 4.7 of this report discusses the methodology and Section 5.2 shows the results of the Cost-effectiveness Analysis.

Greenhouse Gas and Water Related Impacts

Please refer to Section 5.3 of this report for a more detailed and extensive analysis of the possible environmental impacts from the implementation of the proposed measures.

Greenhouse Gas Impacts

Table 4 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 of this report.

The monetary value of avoided GHG emissions is included in TDV cost factors (TDV $) and is thus included in the Cost-effectiveness Analysis prepared for this report.

Table 4: Estimated First Year Statewide Greenhouse Gas Emissions Impacts

	Avoided GHG Emissions ($MTCO_2e/yr$)
Sales Canopies	589
Outdoor Sales Lots	888
TOTAL	1,477

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

There are no new proposed acceptance testing requirements for the proposed measure.

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 that would impact the lighting controls requirements for Outdoor Sales Canopies and Outdoor Sales Lots. 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 summarizes key issues that the Statewide CASE Team 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 Manual (ACM) Reference Manual and Compliance Forms.

2. MEASURE DESCRIPTION

2.1 Measure Overview

2.1.1 Existing Standards

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

1. ensure that lights are turned off during daylight hours (photocontrol or astronomical time switch) (130.2(c)1)
2. ensure that outdoor luminaires can be controlled independently and be scheduled to be turned off during certain hours of the night (automatic scheduling control) (130.2(c) 2.)
3. ensure luminaires mounted under 24' automatically reduce power between 40 – 80%, in response to vacancy of the space (occupancy-based multi-level lighting control) (130.2(c)3)

This last item, a requirement for motion-based bi-level or dimming systems, includes several exceptions. Among those are exceptions for Outdoor Sales Canopies and Outdoor Sales Lots. These space types are instead required to meet the control requirements in a subsequent section (130.2(c) 4. This section requires luminaires in these space types to be equipped with *either* a motion-controlled, bi-level/dimming system OR a "Part-night Outdoor Lighting Control."

A "Part-Night Outdoor Lighting Control," is defined in Section 100.1 is a "time or occupancy-based lighting control device or system that is programmed to reduce or turn off the lighting power to an outdoor luminaire for a portion of the night."

In other words, Outdoor Sales Frontage and Outdoor Sales Canopies can comply with code by installing occupancy-based dimming controls or by installing a time-based control instead. However, the time-based control requirement may be duplicative with the automatic scheduling control, which is also able to turn off power to outdoor luminaires for part of the night. Section 2.1.3 below provides more detail about the differences between these two control options and the benefits of an occupancy-based, dimming control.

2.1.2 Measure History

Outdoor lighting controls requirements were introduced in the 2008 Title 24 code update (effective 1/1/2010) and expanded in the 2013 code (effective 7/1/2014). The 2008 code required outdoor lighting to have either a photocontrol system or an automatic scheduling control system; the 2013 code required both, and also added the motion control requirement. The proposal to add the motion-based control requirements in the 2013 code were being

developed in 2010-2011, and at that time exceptions were included for the bi-level motion-based control requirements in certain space types. The exceptions may have been inserted into the code because these types of motion-based, multi-level lighting controls installations were not being installed in sales lots and sales canopies, but in recent years they have started to occur more often.

The part-night control may have been envisioned as a stronger requirement than that automatic scheduling control because the part-night controls were intended to be mounted on the luminaires themselves, and therefore harder to manually override. However, this was not clearly defined and in the time since the code was adopted, many of these controls may now be controlled wirelessly, making them quite easy to override.

2.1.3 Measure Description

This measure would broaden the existing mandatory controls requirements by removing the exceptions from the occupancy-based bi-level/dimming controls requirements for Outdoor Sales Lots and Sales Canopies. These requirements, which are in Section 130.2(c), require control capability to dim the system to between 40% and 80% of full output wattage in response to vacancy, and to provide auto-on functionality in response to occupancy. The measure also proposes increasing the maximum allowable dimmed range to 90%. Other existing exemptions would remain unchanged, including those based on luminaire height and luminaire wattage.

Luminaires in Outdoor Sales Lots and Outdoor Sales Canopies are allowed to utilize a "Part-Night Outdoor Lighting Control," which, as defined in Section 100.1 is a "time or occupancy-based lighting control device or system that is programmed to reduce or turn off the lighting power to an outdoor luminaire for a portion of the night." By not requiring the installation of occupancy-based multi-level control systems a significant savings opportunity may be lost. Some, but not all, of the potential reasons for lost savings are provided here:

- The part-night control requirement does not specify how much power must be reduced, nor for what portion of the night, so even in facilities that are closed for much of the night, these controls could be programmed to provide very minimal power reduction while still complying with code.
- Many business owners may choose not to utilize (or to over-ride) part-night controls after business hours in order to ensure that lights are on at 100% in the event that anyone enters the property after hours.
- If a business changes hands, changes operating hours, or experiences other changes to normal operation, part-night controls may not be re-programmed to provide optimal savings (or they may be over-ridden if they're perceived to not fit the new operating practice).
- The part-night control is not likely to be utilized during business hours when lights are kept on for occupants, so they do not save energy in 24/7 facilities.

Occupancy-based multi-level controls ensure greater savings relative to these scenarios. They achieve savings regardless of whether a business is open or closed at night, so there is savings potential both in 24/7 facilities, facilities that operate for significant periods of time during the

night, and in facilities that are closed for much or all of the night but which often leave lighting on. In a business that operates at night but with only intermittent occupancy (such as fuel stations), bi-level motion controls will maintain lights at a low power state for much of the night, when no one is present, saving a considerable amount of energy. The controls will ramp up lighting to full power only when detecting motion, and then dim lights again in between customers. In facilities that are closed for most or all of the night, the measure will dim lights with the ability to ramp up should motion be detected, which can be a valuable safety feature for a facility like a sales lot, where increased light levels can draw attention to trespassers.

2.1.4 Alignment with Zero Net Energy Goals (ZNE)

The proposed code change will assist in California's nonresidential ZNE goals by reducing the electrical energy consumption of luminaires at the associated areas of non-residential buildings. Outdoor lighting represents a very significant amount of energy use in the state, consuming approximately 11,000-12,000GWh per year. This measure will assist with the State's goals established in Assembly Bill 1109, to reduce outdoor lighting energy consumption by 25%.

2.1.5 Relationship to Other Title 24 Measures

The proposed code change is related to the lighting power allowance (LPA) code change proposal being developed for nonresidential outdoor space types, including sales canopies and sales lots. The interaction of these two proposals has been considered through their development; this measure proposal, the energy impacts analysis, and the cost-effectiveness analysis presented in this report are based on the assumption that LPAs have been reduced to a primarily LED level.

2.2 Summary of Changes to Code Documents

The sections below provide a summary of how each Title 24 document 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 5 identifies the scope of the code change proposal. This measure will impact the following areas (marked by a "Yes").

Table 5: Scope of Code Change Proposal

Mandatory	Prescriptive	Performance	Compliance Option	Trade-Off	Modeling Algorithms	Forms
Yes						Yes

Standards

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

Table 6: 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)
130.2(c)	Outdoor Lighting Controls and Equipment	M	E

Appendices

The proposed code change will not modify any sections in the appendices.

Residential/Nonresidential Alternative Calculation Method (ACM) Reference Manual

The proposed code change will not modify the Residential or Nonresidential Alternative Calculation Method References.

Simulation Engine Adaptations

Because this is a mandatory measure, 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 of this report for the detailed proposed revisions to the standards language.

Changes in Mandatory Requirements

The proposed code change will remove the exceptions to the controls requirements for Outdoor Sales Lots and Outdoor Sales Canopies that currently exist in Section 130.2(c) of the current code. In response to stakeholder input, the proposed code language also extends the upper limit currently placed on the allowed wattage reduction from 80% to 90%.

SECTION 130.2- OUTDOOR LIGHTING CONTROLS AND EQUIPMENT

(c) Controls for Outdoor Lighting

EXCEPTION 1 to Subsection 130.2(c): The proposed code change will remove "Outdoor Sales Lots" and "Outdoor Sales Canopies" from this exception.

2.2.3 Standards Reference Appendices Change Summary

This proposal will not modify any sections of the Standards Appendices.

2.2.4 Nonresidential Alternative Calculation Method (ACM) Reference Manual Change Summary

This proposal would not modify the Alternative Calculation Method (ACM) Reference Manuals.

2.2.5 Compliance Forms Change Summary

The proposed code change will utilize the following compliance forms listed below. The proposed code change may require minor changes to the following Compliance Form:

- **NA7.8** – Outdoor Lighting Controls Installed to Comply with Section 130.2(c)

2.2.6 Simulation Engine Adaptations

Because this is a mandatory outdoor lighting measure, it does not need to be modeled by the building simulation engine.

2.2.7 Other Areas Affected

No other areas will be affected.

2.3 Code Implementation

2.3.1 Verifying Code Compliance

The proposed code change will utilize the same verification techniques defined in Nonresidential Appendix NA7.8 for Outdoor Lighting Controls Installed to Comply with Section 130.2(c).

2.3.2 Code Implementation

The proposed code change is a streamlining of the current code and it applies the current requirements to more space types. It represents a design strategy already very common in other space types, and code requirements that will be enforced in other space types effective 7/1/2014. It will not be any more difficult for building inspectors to verify compliance than the current 2013 code compliance verification process for other outdoor space types. Further, the industry will gain significant experience implementing these control strategies as a result of the 2013 code. However, the majority of new sales lots and sales canopy facilities do not currently employ this strategy (and are not required to do so under the 2013 code) so it will represent a change from the status quo in these space types. The measure also represents an added first cost, though not a significant expense relative to the overall project costs for new sales lots or fuel stations.

2.3.3 Acceptance Testing

The measure will need to utilize the existing Acceptance Testing located in Nonresidential Appendix NA7.8.1.2.

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.

- Design strategies: The Statewide CASE Team held discussions with manufacturers about the various design strategies that could be employed to comply with the motion control requirements, and the potential wiring set-up.

- Compliance costs: The Statewide CASE Team held discussions with manufacturers of products that would comply with standards and obtained estimates of incremental cost.
- Existing installations: The Statewide CASE Team held discussions with utility program managers around the country with experience running bi-level controls projects in car dealerships. The Statewide CASE Team has also communicated directly with facility managers who have implemented bi-level motion controlled lighting installations and obtained user feedback.
- Safety implications of reduced light levels: The Statewide CASE Team has communicated with multiple parties involved with completed bi-level controls projects at fuel stations and car lots (including manufacturers, facility managers, and utility program managers) and all have provided positive reviews of the projects and did not express concerns about safety associated with dimmed light levels. Rather, these individuals all indicated they expect to see these types of controls installed at more facilities. Furthermore, we have received feedback from manufacturers that the high uniformity of LED lighting offers significant visibility benefits, allowing for equal perceived brightness and clear security camera footage even with significant fixture dimming.
- Concerns about reduced light levels on facility marketing efforts: While this concern has not been raised directly by stakeholders in the development of this code proposal, it has been considered to be a possible point of concern in the past. The Statewide CASE Team believes these impacts to be minimal because in this proposal lights are not required to be turned off, but rather to be dimmed to at least 40% below full output (i.e. to 60%). Manufacturer contacts who have extensive experience on-site at sales canopies and/or sales lots have indicated that 40% dimming is not even detectable from the road. This stands to reason, because it is well understood in lighting design that as light levels are reduced, the relationship between perceived light levels and measured light levels is not linear. As the formula in the Illuminating Engineering Society 10th Edition Handbook explains, a light level reduction of 40% is only perceived as a 22.5% reduction in light. In other words, facility owners that wish to maintain illumination on the facility for marketing purposes will still be allowed to do so. The formula explaining the relation between measured light and perceived light is provide here (IESNA Lighting Handbook, 9th Edition, (New York; IESNA, 2000), 27-4):

$$\text{Formula: Perceived Light (\%)} = 100 \times \sqrt{\frac{\text{Measured Light (\%)}}{100}}$$

- Appropriateness of existing limits on dimmed levels: In the current code, automatic lighting controls are not allowed to reduce power by more than 80% of full power. The Statewide CASE Team discussed with stakeholders the appropriateness of this current maximum allowable dimmed level in the code, and explored rationale and options for updating that value to a higher number. The CASE team believes the initial intent of the maximum dimming requirement was simply to ensure that motion-controlled fixtures could in fact be dimmed, rather than only shut off completely. The outdoor lighting market has been rapidly shifting to LEDs and LED luminaires typically have very strong dimming performance and a wide dimming range. One of the results is that lower and

lower dimmed levels have become feasible in outdoor spaces and stakeholders commented that the 80% maximum dimmed limit was no longer appropriate. The CASE team has proposed to lower the maximum dimmed state from 80% to 90% to allow deeper dimming while still ensuring that fixtures are capable of providing multiple levels of light between fully on, and off. Note that even at 10% of full light output (a 90% dimmed state), one would still perceive the lighting to be at about 32% of full brightness, due to the previously explained non-linear relationship between perceived light levels and measured light levels.

- Definition of Automatic Scheduling Control: Section 130.2(c) 2 requires that new sales lots and sales canopy installations be "circuited and independently controlled from other electrical loads by an automatic scheduling control," but the term Automatic Scheduling Control does not currently have a formal definition. The CASE Team also received input that the current terms for Automatic Scheduling Control and Part-Night Outdoor Lighting Control could include some overlap—both are controls that allow fixtures to be turned off for certain parts of the night. The CASE Team has proposed a definition for Automatic Scheduling Control which should make it clear that many Part-Night Outdoor Lighting controls are in fact also Automatic Scheduling Controls. The new proposed definition can be found in Section 6 of this report.
- Removal of Section 130.2(c) 4: The CASE Team recommends that Section 130.2(c) 4 be removed to streamline the code, because it would be unnecessary if this measure and the proposed definition of Automatic Scheduling Controls are approved.
- Revised definition of Outdoor Sales Frontage: In the current proposal, Outdoor Sales Lots must comply with Section 130.2(c) 3 but Outdoor Sales Frontage will remain exempted, so it is important to clarify the distinction between these two space types. To ensure that sales lot owners claim a fair number of exempted luminaires, the CASE Team has proposed a revised definition of Outdoor Sales Frontage and an amendment to the Compliance Manual, both of which can be found in Section 6 of this report.
- Exemption of Commercial Fuel Station Sales Canopies: Pursuant to stakeholder feedback, the CASE Team recommends that Commercial Fuel Station Sales Canopies be exempted from Section 130.2(c) 3. The CASE Team believes that the savings potential is significantly lower for commercial fuel stations (those that primarily service large commercial vehicles such as tractor-trailers), because customers arrive more frequently at night and take longer to refuel. For the proposed definition of Commercial Fuel Station Sales Canopy, refer to Section 6 of this report.

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 a public stakeholder meeting that the Statewide CASE Team hosted in May 2014.

3.1 Market Structure

This measure proposes to require occupancy-based bi-level or continuous dimming lighting systems in fuel station canopy fixtures and auto sales lots. These types of systems are made up of two components: dimmable luminaires and occupancy control systems. Dimmable canopy luminaires and dimmable area (pole-mounted, wall-mounted etc.) fixtures are available from a wide array of lighting manufacturers, including Cree, General Electric, Lithonia, Acuity, Philips, LSI Industries, Leotek, MaxLite and many others. On the occupancy controls side, there are two typical controls configurations, circuit-controlled and fixture-integrated controls. Circuit-controlled outdoor occupancy control systems are commonly available from a variety of manufacturers, including Cooper, Hubbell, Wattstopper, Steinel, and Lumewave. Several of the aforementioned manufacturers now market fixture-integrated control systems as well, some of which offer wireless communication to optimize performance.

3.2 Market Availability and Current Practices

Though high intensity discharge (HID) fixtures have shown improvement in their dimming capabilities over the years, and occupancy control systems currently exist for a variety of outdoor lighting technologies including HID fixtures (primarily metal halide), this report assumes new fixtures will be LEDs. LEDs are much more easily and commonly dimmable than most lighting technologies – they are generally dimmable down to 10% of full light output, or lower. Outdoor fixture trends are moving to LED quickly as LED prices come down, and because LEDs offer much more customization for controls, deeper dimmability, quicker response, and linear power versus light characteristics (with neither efficacy nor light quality materially affected during dimming). The Outdoor Lighting LPA CASE Report is also proposing new lighting power requirements that will most likely be met by LED sources.

Occupancy-based control systems are frequently used in parking lots and other outdoor lighting systems and will be even more common after the 2013 standards become effective. Of the typical controls configurations, circuit controlled and fixture-integrated controls, both are commonly installed in many outdoor lighting new construction applications today. Expanding the existing Title 24 requirements to apply to fuel stations and car dealerships will slightly increase demand for these technologies, but it is not expected to create any supply issues, as this will be a relatively small incremental growth for this control strategy, and the Standards do not take effect until approximately two years after they are adopted.

Relevant product offerings with integrated-sensors include:

- Lumewave TOP900 Series Pole Fixtures with Wattstopper sensors mounted to each fixture
- Cree CPY Series Canopy and Soffit Luminaire
- Cree 304 Series Canopy
- LSI Crossover Gen 3 Canopy

- GE Evolve Canopy (to be released in October 2014)

In conjunction with other controls requirements already in place (e.g. photocells, timeclocks) controls strategies can be designed to optimize outdoor lighting efficiency. For example, controls can bring lights on to 70% shortly after sunset, then gradually to 100% as the night darkens, and then provide high/low operation of 100% to 50% based on the presence of people. After a certain hour, systems can be programmed to dim further when people are not present, for example dropping high/low operation to 100% and 30%. Another option is to design , install, tune, and commission fully autonomous motion sensor-coupled dimmable LED systems that solve safety issues assuring full light is there if activity is there. Longer range microwave sensors (Lumewave for example) are greatly expanding coverage eliminating overlap problems associated with PIR tech.

Most sensors are offered with a range of programmable response times (the length of vacancy before lights return to their dimmed state) and detection sensitivities. Most sensors offer a 1 minute or 30 second minimum response time, though some offer even shorter responses (e.g. 15 seconds). On the other end of the range, many sensors offer a 30 minute maximum response time.

3.3 Case Studies

3.3.1 Overview

The outreach efforts of the CASE Team have underscored the cost-effectiveness and feasibility of the proposed code change. The CASE Team has received responses from Hubbell, Cooper, Acuity, LSI, and GE indicating that there a number of sales lot or sales canopy installations that comply with the proposed code change and more will be installed in the near future. Through press releases and/or direct interviews, the CASE Team has been able to gather in-depth data on five specific sales lots or sales canopy installations that comply with the proposed measure, including two installations in the U.S.: a fuel station sales canopy installation at the Raley's in South Lake Tahoe, CA and a sales lot installation at the Mercedes-Benz dealership in Fort Mitchell, KY. Both U.S. installations were highly cost-effective projects that have been very well received. In addition to these installations in the U.S., the CASE Team has found case studies published by Philips and LSI Industries promoting sales canopy installations in Europe[1] and Malaysia.[2]

3.3.2 Raley's Fuel Sales Canopy in South Tahoe, CA

The motion controlled bi-level fuel station sales canopy lighting at the Raley's in South Lake Tahoe is part of a cost-effective and well received project using Cree LEDs with integrated motion sensors. The Raley's LED installation had a payback of less than one year according to

[1] http://www.lighting.philips.com/pwc_li/main/application_areas/assets/petrolstation/Philips_Petrolstations_Brochure.pdf

[2] http://www.lsi-industries.com/documents/case-studies/ShellDodo-casestudy.pdf

a case study of the Raley's published by Cree.[3] The CASE team visited this site in early August 2014 and interviewed two long-term nighttime employees who work at the Raley's fuel retail annex. The employees stated they like the lighting system, they have never received customer complaints about it, and they do not even notice a decrease in light levels when the lights dim. In a Cree press release,[4] Raley's Energy and Utility Manager Randy Walthers described the lighting system as:

> *"…high-quality Cree LED lighting equipped with a sophisticated control system for remarkable savings and light quality."*

3.3.3 Mercedes-Benz Dealership in Fort Mitchell, KY

The Mercedes-Benz dealership in Fort Mitchell, KY features bi-level LED lighting with motion controls that were installed as part of an impressively cost-effective and much applauded project.[5] According to Austin Ashe, Regional Sales Manager for GE Lighting, the payback for the addition of the controls was less than one year at the Fort Mitchell dealership. In promotional materials from GE,[6] Bernie Moreno, President of the Collection Auto Group, spoke effusively of the dealership's lighting system:

> *"The results from an aesthetic standpoint are unbelievable. It has been an amazing decision from a marketing perspective."*
>
> *"People are blown away when they come into the dealership and they see the amount of lighting and control of the lighting."*
>
> *"When Mercedes-Benz asked us to come into the Cincinnati, Northern Kentucky market, everybody who we talked to said this property really couldn't become a car dealership. Our first meeting we had, we invited all the neighbors, and there were about four or five concerns that they brought up: lights, lights, lights, lights, and then … lights. It was because of the benefits to the community of the dramatically reduced light pollution, and the neighbors buying into that, that allowed the project even to start, let alone finish. Then you fast forward and the comment is 'We can't believe how great the lights are, we're so happy with how the lights came out.'"*

A GE press release[7] highlighted how the motion controlled dimming at Mercedes-Benz promotes safety:

> *"For security, the lights instantly return to full brightness when motion sensors identify a vehicle entering the lot."*

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[3] https://www.creelink.com/exLink.asp?10950816OW16S78I30848498

[4] http://www.cree.com/News-and-Events/Cree-News/Press-Releases/2013/September/Raley-Install

[5] http://www.gelighting.com/LightingWeb/na/images/99642-GE-Retail-LED-Lighting-Fort-Mitchell-Case-Study_tcm201-65407.pdf

[6] https://www.youtube.com/watch?feature=player_embedded&v=SBnrqYbzZOQ

[7] http://www.genewscenter.com/Press-Releases/Auto-Dealer-Achieves-All-LED-Aspirations-with-GE-s-Collection-of-Lighting-Solutions-4469.aspx

Mr. Moreno announced plans to open more dealerships with similar motion controlled dimming LED lighting systems, a further endorsement of the lighting controls.

3.4 Useful Life, Persistence, and Maintenance

This measure is expected to have very high persistence of savings because it is occupancy based and does not depend on ongoing commissioning, for example if businesses change hands or change operating hours. Because systems will provide light whenever occupants are present, they are less likely to be over-ridden by building managers. Based on interviews with manufacturers, fixture and motion sensor lifetimes are assumed to approximate the period of analysis (15 years), so replacements will not be required within the period of analysis. There are also no assumed incremental maintenance costs for this measure.

3.5 Market Impacts and Economic Assessments

3.5.1 Impact on Builders

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

3.5.2 Impact on Building Designers

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

3.5.3 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 negative impact on the safety or health occupants or those involved with the construction, commissioning, and ongoing maintenance of the building. There has been some discussion with stakeholders about the potential implications for safety at the sites covered by this proposal. Stakeholders and manufacturer contacts have suggested that because light levels will instantly increase whenever motion is detected on the premises, the measure may increase safety and awareness of occupants and workers in these facilities.

3.5.4 Impact on Building Owners and Occupants

Since this measure is cost effective, the building owners are reducing their energy costs more than their mortgage costs are increased as a result of this measure (i.e. they experience net cost savings). For building occupants that are paying for their energy bills, since the measure saves more energy cost on a monthly basis than the measure costs on the mortgage as experienced by

the building owner, the pass-through of added mortgage costs into rents is less than the energy cost savings experienced by occupants.

3.5.5 Impact on Retailers (including manufacturers and distributors)

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

3.5.6 Impact on Energy Consultants

Energy consultants will need to consider the new code baseline of lighting equipment in sales lots and sales canopies.

3.5.7 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.

3.5.8 Impact on Statewide Employment

The proposed code change is not expected to have an impact on statewide employment.

3.6 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.[8] In addition, more dollars will be spent in state on improving the energy efficient of new buildings.

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)[9], 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

[8] 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.

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

RPS implementation is expected to cost $1,782 million annually, not including the benefits of GHG and air pollution reduction (CARB 2008, pC-130).

Macro-economic 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).

3.6.1 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).

3.6.2 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 7 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).[10] 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. A table listing total expected job creation by industry that is expected in 2015 and 2020 from all investments in California energy efficiency and renewable energy is presented in the

[10] 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. 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.

Appendix B: Job Creation by Industry of this CASE Report.

Table 7: 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 & Equipment (exc. Auto. & Electronic) Repair & Maintenance	811310

3.6.3 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.

3.6.4 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).

3.6.5 Incentives for Innovation in Products, Materials, or Processes

Updating Title 24 standards will encourage innovation through the adoption of new technologies to better manage energy usage and achieve energy savings. This particular proposal supports the adoption of innovative occupancy based multi-level lighting controls.

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

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

3.5.6.1 Cost of Enforcement

Cost to the State

State government already has budget for code development, education, and compliance enforcement. While state government will be allocating resources to update the Title 24 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 energy efficiency standards are expected to increase economic growth and income with positive impacts on local revenue.

This standard would revise an existing measure without significantly affecting the complexity of this measure. Therefore, on-going costs are not expected to change significantly.

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

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 (a requirement for part-night controls), however because the code does not require any specific operation of the part-night control, the energy use of such systems is unclear. The current proposed standard replaces the part-night control requirement with an occupancy-based dimming control requirement. For the purposes of the cost-effectiveness analysis, the existing condition is assumed to be a facility not utilizing or optimizing the part-night controls or the automatic scheduling controls, so lights are presumed to be on at night in the baseline facility. The baseline facility does have the other required time clock / photocell controls, so lights are therefore assumed to be turned off during all daylight hours.

The Statewide CASE Team conducted an analysis of different facility types, with different operating hours. Research conducted by the Statewide CASE Team found that 65% of fuel stations in California are open 24 hours a day, while the remaining 35% are open an average of 15 hours per day (~7:00 AM to ~10:00 PM). These values were derived based on a mix of rural, suburban, and urban stations, in both Northern California and Southern California, and including both big name chains and smaller independent operations. A similar survey of auto-dealerships found that almost all auto-dealerships are open for most of the day and closed at night. Typical operating hours for auto sales lots are 8:00 AM to 8:00 PM. This report therefore assumes the most common affected facility types are 24-hour fuel stations, 15-hour fuel stations (7:00 AM -10:00 PM), and 12-hour auto sales lots.

4.2 Proposed Conditions

The proposed conditions are defined as the design conditions that will comply with the proposed code change. Specifically, for this analysis, the proposed condition assumes that fixture-integrated occupancy-based control systems are installed in the covered area types. The proposed conditions assume that the controls ramp up lights to full power when occupants are present and then ramp down fixture power after vacancy is detected. Separate analyses were performed assuming different fixture wattages and different numbers of luminaires per facility to represent a range of savings potential. Detailed description of all assumptions and calculation methodology is available below in Section 4.6 of this report.

4.3 Prototype Buildings

CEC does not provide guidance on prototype building design for the outdoor lighting area types affected by this code proposal. The Statewide CASE Team has used the same prototype area types used in development of the 2013 Outdoor Lighting Standards, including a Large Outdoor Sales Canopy (8,682 square feet), a small Outdoor Sales Canopy (3,006 square feet), and a Small Corner Outdoor Sales Lot (13,156 square feet).

In addition, the Team has modeled a Large Outdoor Sales Lot (65,780 square feet) that is 5 times larger than the Small Corner Outdoor Sales Lot. The area of the Large Outdoor Sales Lot prototype site was influenced by stakeholder feedback indicating that there are a non-trivial number of Outdoor Sales Lots that are 5 to10 times larger than our Small Corner Outdoor Sales Lot prototype site as well as manufacturer interviews stating that sales lots 5 times larger than the small Outdoor Sales Lot prototype site are commonplace. In addition, the 2003 California Outdoor Lighting Baseline Assessment includes four case studies of outdoor auto sales lots that support the creation of a Large Outdoor Sales Lot prototype site (CEC 2003). The case studies in the 2003 Baseline Assessment list the site descriptions and Functional Use Areas of the four audited outdoor sales lots as: Modern Car Dealership, 191,796 square feet; Modern Car Dealership, 278,300 square feet; RV Sales, 1,219,766 square feet; and Auto Auction; 2,400 square feet. Except for the Auto Auction site, which is comparable in size to the Small Corner Outdoor Sales Lot prototype site, the Functional Use Areas of the sales lots surveyed in the 2003 Baseline Assessment are far larger than even the Large Outdoor Sales Lot prototype site, which suggests that the CASE Team has made conservative assumptions in modeling auto sales lot savings.

Table 8 presents the details of the prototype area types used in the analysis.

Table 8: Prototype Space Types used for Energy, Demand, Cost, and Environmental Impacts Analysis

	Occupancy Type	Area (square feet)	Number of Fixtures	Operating Hours
Prototype 1	Large Sales Canopy	8,682	36	24 hours
Prototype 2	Large Sales Canopy	8,682	36	7:00 AM – 10:00PM
Prototype 3	Small Sales Canopy	3,006	16	24 hours
Prototype 4	Small Sales Canopy	3,006	16	7:00 AM – 10:00 PM
Prototype 5	Small Corner Outdoor Sales Lot	13,156	10[1]	8:00 AM – 8:00 PM
Prototype 6	Large Outdoor Sales Lot	65,780	50[1]	8:00 AM – 8:00 PM

1. Does not include sales frontage fixtures

4.4 Climate Dependent

Since this measure is not climate sensitive, it is not necessary to model savings in every climate zone and statewide average TDV factors were used in the energy and cost analysis.

4.5 Time Dependent Valuation

The Time Dependent Valuation (TDV) 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 cost impacts are presented in 2017 present value dollars. 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 of this report.

4.6 Energy Impacts Methodology

The Statewide CASE Team calculated per unit impacts and statewide impacts associated with all new construction, alterations, and additions during the first year buildings complying with the 2016 Title 24 Standards are in operation. To calculate the measure impacts, the Statewide CASE Team has conducted research into these markets in order to develop an hourly savings model based on typical occupancy patterns and typical system design strategies. The following sections provide an explanation of the model used and the key assumptions used in the model.

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 both on a per fixture and per site basis.

Analysis Tools

The Statewide CASE Team utilized spreadsheet analysis to model the energy savings throughout each night of the year, in each prototype facility, under each facility's assumed operating hours.

Key Assumptions

The energy savings potential from an occupancy-based control measure is heavily dependent on the occupancy patterns of the space types in question, in terms of frequency and duration of occupancy, sensor response times, assumed fixture wattages, and assumed power levels when dimmed. The Statewide CASE Team conducted observations at both fuel stations and auto sales lot properties. The Statewide CASE Team has populated a model with a range of conservative assumptions and early observations for each prototype space type, to bind the savings potential and determines cost-effectiveness thresholds. The key assumptions used in the per unit energy impacts analysis that are not already included in the assumptions provided in the LCC Methodology are described below and then presented in Table 9.

Dimmed Levels

The current requirements for motion control outdoor lighting fixtures are that systems be able dim to between 40% and 80% of full output wattage in response to detection of occupancy; the CASE Team recommends that the maximum allowable dimming range be extended to 90%. The Statewide CASE Team has run simulations assuming a dimmed level in the middle of the proposed dimming range, or 65% below full power. This assumption is conservative in light of manufacturer feedback that installations employing motion controlled bi-level dimming typically dim 60-70% below full power for sales canopies and 70-80% below full power for Outdoor Sales Lots.

Fixture Wattages

The Statewide CASE Team modeled fuel station canopies using both 122W and 82W LED fixtures, both typical values for canopy fixtures. For the auto sales lot prototypes, the Statewide CASE Team modeled area fixtures at 275W and 126W. Manufacturer contacts indicated that 275W is a reasonable but conservative assumption for auto sales lot fixtures installed in 2017. The team modeled a 126W scenario to demonstrate its cost-effectiveness; however, such low fixture wattages are less common in auto sales lots.

Sensor Activation and Response Times

Outdoor sensors can generally be programmed to decrease power after 30 seconds to 30 minutes of vacancy, and common installations range from 2 minutes or less, up to 15 minutes. Historically, sensors installed with T8 or other fluorescent systems had longer response times to minimize rapid cycling of lamps and to avoid negative effects on lamp life. LED fixtures do not have such limitations and thus shorter response times are practical. Based on feedback from manufacturers the CASE Team has assumed a range in sensor response time between 4

and 6 minutes, which is equivalent to the amount of time spent in fuel stations by occupants at night.

The Statewide CASE Team has also made a conservative assumption about sensor activation, in that any time an occupant arrives in a facility, all sensors are assumed to be triggered and all fixtures are increased to full brightness. According to feedback from stakeholders who have designed these systems, this approach is particularly conservative for auto sales lots, because the vast majority of auto dealerships will not program their sales lot fixtures to dim and brighten all together at night, but rather will control their fixtures in multiple zones or even independently. Facility engineers at single canopy fuel stations are more likely to control all fixtures together, but for any such facilities that do allow the controls to operate independently or even in multiple zones, our current calculation methodology significantly underestimates how often the fixtures are dimmed and thus underestimates the true measure savings.

Fuel Station Occupancy Patterns for 24 Hour Facilities

For fuel stations and auto-dealerships that close for the majority of the night, the Statewide CASE Team assumed very little occupancy would happen in the middle of the night and sensors would not be triggered frequently (one occupant per hour during non-business hours). However, in the case of the 24-hour fuel stations, the Statewide CASE Team has conducted research to inform assumptions about length of time spent in fuel stations by customers at night and rates of customer visits at different hours of the night. Several sources were used to assess length of time spent in fuel stations.

- A study by All Over Media found fuel station visit times ranged from 3 to 5 minutes.[11]
- A study on urban refueling behavior (with a focus on common long lines at fuel stations in Beijing) found a range of time spent at fuel stations from 6 to 14 minutes, with the 6 minute trips occurring at night.[12]
- Statewide CASE Team's own monitoring of California fuel station duration times at night found an average of 3.8 minutes.
- Available data points were averaged for this study, resulting in an assumed length of night time fuel station occupancy of 4.5 minutes per visit/fueling event.

In terms of occupancy rates, various studies are available suggesting that the vast majority of consumers visit fuel stations during the day. In one recent survey with 20,000 respondents, fewer than 4% of respondents reported they regularly fill up their gas tanks between 10 PM and 5:00 AM.[13] The aforementioned study from Zhang et. al. found that about 16% of fuel station visits occurred between 10:00 PM and 5:00 AM and that the vast majority of fuel station fill-ups occurred between 9:00 AM – 12:00 PM and between 2:00 PM – 6:00 PM. The hours between 7:00 AM – 9:00 AM and between 6:00 – 8:00 PM represented a middle tier of occupancy, with significantly fewer fuel station visits than during the peak hours, but

[11] http://www.allovermedia.com/our-solutions/gas-pump/

[12] Fuzheng Zhang, David Wilkie, Yu Zheng, and Xing Xie; http://research.microsoft.com/apps/pubs/?id=196236

[13] http://www.gasbuddy.com/GB_Past_Polls.aspx?poll_id=195

significantly more visits than during the late night hours. Because this study only addresses night time hours, the Statewide CASE Team utilized these findings to define two distinct periods of night occupancy patterns:

- Higher occupancy night hours
  - From 7:00 AM to sunrise (only relevant in parts of the year when sunrise occurs after 7:00 AM)
  - From sunset to 8:00 PM (only relevant in parts of the year when sunset occurs before 8:00 PM)
- Lower occupancy night time hours
  - From 8:00 PM until 7:00 AM

The model has been developed to assume fuel stations that are open at night receive 15 customers per hour during the higher occupancy hours, and 6 customers per hour during the low occupancy hours. These are conservative values based on monitoring data that included some night time station occupancy patterns at a rate of only 1 customer per hour, and a maximum observed occupancy rate of 15 customers per hour.

Distribution of Night Occupancy Events

Given these parameters and an assumed average rate of occupants per hour, the Statewide CASE Team generated two complimentary models for determining the average amount of time lighting systems would actually be dimmed.

The Uniform Distribution Model assumes an average rate of occupants per hour (λ) and calculates what the actual dimming time would be if occupants arrived at regular intervals. For example, with the input of four occupants per hour ($\lambda = 4$), the Uniform Distribution Model assumes that one occupant arrives precisely every 15 minutes during that hour.

The Exponential Distribution Model employs the same rate of occupants (λ) but assumes that the times between one occupant leaving and the next arriving adhere to an exponential distribution. Under the Exponential Distribution Model, if there are assumed to be four occupants per hour ($\lambda = 4$), the *average* time between occupants is still 15 minutes, but the exponential distribution function allows us to assign a likelihood to shorter or longer times between occupant arrivals.

The statistical approach that underlies the Exponential Distribution Model is widely used for modeling waiting times or other similar events.[14] Roughly speaking, the time X before an event occurs has an exponential distribution if the probability that the event occurs during a certain time interval is proportional to the length of that time interval. This is true when the event is equally likely to happen at any given moment within the time period and if events occur independently of one another. The Exponential Distribution Model is predicated on the assumption that the next occupant in a space is equally likely to arrive at any given moment

[14] http://www.statlect.com/ucdexp1.htm

within a certain hour of the night (but allows for the rate of occupants per hour to vary between hours of the night).

Both the Uniform and Exponential Distribution Models have been programmed into the savings model used by the Statewide CASE Team to estimate measure savings throughout every night time hour of the year; however, for every simulated hour of occupancy we have only used the output of the model that most closely approximates the true savings. Because both models rely on conservative inputs and assumptions about occupancy patterns, both models underestimate the true savings value, providing two sets of lower bounds. To best approximate the true savings, we have selected for each hour of the year whichever model yields the higher lower bound for savings.

Peak Demand Reduction Factors

For both Outdoor Sales Lots and Sales Canopies, peak demand reductions were calculated by multiplying hourly electric savings by the CEC's 2016, 15-year, non-residential demand factors. Because the demand reduction for this measure is almost entirely off peak, the CASE Team has not noted any reduction in peak demand.

Table 9: Key assumptions for per unit Energy Impacts Analysis

Parameter	Assumption Used in Savings Model	Source	Notes
Dimmed Levels	Fixtures dimmed 65% below full output power	Based on proposed standards and supported by manufacturer interviews.	Derived as the midpoint between the proposed dimming capability requirements (40% and 90%)
Fixture Wattage	122W and 82W for Canopies, 275W and 126W for Sales Lots	Manufacturer interviews, fixture wattages of existing installations that would comply with the proposed code, spec sheets from major manufacturers, common wattage ranges, and consistent with Outdoor LPA CASE proposal which pushes market to LED	
Sensor Activation and Response Times	Response time: 4 minutes of continuous vacancy	Interviews with major manufacturers; Statewide CASE Team experience with similar project installations	Note that the current analysis assumes that all fixtures are activated (come to full brightness) any time anyone enters the space. In fact, in most sales lots and two-canopy sites and some single canopy sites, sensors may control sub-groups of luminaires (or individual luminaires) and only some of the sensors in a space may detect motion if an occupant passes through. Therefore not all fixtures will be brought to full power at each occupancy event.
Occupancy Patterns for 24 Hour Fuel Stations	6 occupants per hour during deep night hours, 15 occupants per hour in the evening and early morning	Statewide CASE Team analysis and site observations	
Occupancy Patterns for non 24 hour facilities	1 occupant per hour after business hours, and 15 occupants per hour during business hours (night)	Statewide CASE Team analysis and site observations	

4.6.2 Statewide Energy Impacts Methodology

First Year Statewide Impacts

The Statewide CASE Team estimated statewide impacts for the first year buildings comply with the 2016 Title 24 Standards by multiplying per unit savings estimates by statewide construction forecasts.

For Outdoor Sales Lots, the Statewide CASE Team assumed the vast majority of savings will come from new and retrofitted car dealerships. There are 7,392 licensed auto sales dealers in California.[15] The Statewide CASE Team estimates that approximately 70% of these (5,175) have pole or wall mounted luminaires below 24 feet high. Of these, the Statewide CASE Team estimates that 2% are new each year and 3% undergo major lighting retrofits, triggering code. The Statewide CASE Team therefore assumes that approximately 260 Outdoor Sales Lots will be required to meet the proposed requirements each year. Of those, the Team has assumed 75% would utilize luminaires with wattages typical of an LED sales lot luminaire (represented by 275W fixtures in this analysis). The assumption of 275 as a typical wattage was supported by manufacturer interviews and case studies of existing, code compliant installations. We conservatively assumed the remaining 25% of sites would utilize the less common, lower wattage area luminaires (represented by 126W fixtures in this analysis). As for the size of the modeled sales lots, manufacturer interviews suggest that there is great variability in the size of auto sales lots, ranging from 10 to over 150 non-frontage fixtures per lot, but 35 fixtures per lot was twice cited by manufacturer contacts as a reasonable average. The Statewide CASE Team has conservatively assumed that 75% of sales lots are small lots (represented by the Small Corner Outdoor Sales Lot with 10 poles) and 25% are large lots (represented by the Large Outdoor Sales Lot with 50 poles). The results of the 2003 California Outdoor Lighting Baseline Assessment further support that this is a conservative modeling approach. Of the four outdoor auto sales lots surveyed in the 2003 Baseline Assessment, three are significantly larger than the Large Outdoor Sales Lot prototype site, while the fourth surveyed site is comparable in size to the Small Corner Outdoor Sales Lot prototype site (CEC 2003).

For Outdoor Sales Canopies, the Statewide CASE Team identified approximately 10,000 fueling stations in California,[16] and based on research of fuel stations has determined that virtually all of these will have a sales canopy below 24 feet. Based on the Statewide CASE Team research, about 65% of these (6,500) are 24-hour facilities, while the remaining 35% (3,500) are open from about 7:00 AM to 10:00 PM (on average). Again, the Statewide CASE Team estimates that 2% are new each year and 3% undergo major lighting retrofits, triggering code, and about half utilize higher wattage luminaires (122W in our analysis) and the other half low wattage luminaires (82W in our analysis). Half of all Sales Canopy sites are assumed to be smaller sites (represented by the 16 fixture Small Sales Canopy prototypes) and half are assumed to be larger (represented by the 36 fixture Large Sales Canopy prototypes).

[15] Taxable Sales in California 2012, California State Board of Equalization

[16] Retail Fuel Outlet Survey, California Energy Commission Energy Almanac

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 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 nor were any incremental costs of verification.

4.7.1 Incremental Cost Methodology

The Statewide CASE Team conducted outreach to manufacturers to obtain estimated incremental costs for compliance with this measure. There are multiple ways to set up occupancy based control systems, some of which are more costly than others. Circuit based controls are generally the least expensive on a per fixture basis, though per fixture costs will depend on the number of fixtures installed to the fixture. Fixture-integrated controls are usually slightly more expensive, while wireless mesh networks are significantly more expensive per fixture. Assuming an LED base case by 2017, and assuming controls included at time of primary LED fixture purchase, incremental cost of occupancy control systems are below.

Key assumptions used to derive cost are presented in Table 10.

Table 10: Key Assumptions for per unit Incremental Construction Cost

Parameter	Assumption	Source
Circuit-Based OCS	$50-$100/ fixture	Manufacturer Interviews
Integrated OCS	$40-$105/fixture	Manufacturer Interviews
Wireless / Mesh OCS	$135-$200/fixture	Manufacturer Interviews

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 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. Some cost reductions may occur after adoption, as these technologies continue to develop and become more common. However, for the purposes of this analysis the team has not yet quantified the likely post-adoption incremental cost, and is using solely the current incremental cost in cost-effectiveness methodology.

Incremental Maintenance Cost Methodology

The Statewide CASE Team does not expect any incremental maintenance costs associated with this code change. If anything, dimming LED fixtures extends product life, so the consumer will see longer fixture life as a result of this measure in cases where LED lifetime limits fixture lifetime. The cost-effectiveness analysis does not take increased LED lifetime into account and is thus conservative in this respect.

4.7.2 Cost Savings Methodology

Energy Cost Savings Methodology

The present value of the energy savings were calculated using the method described in the LCC Methodology (CEC 2011). In short, the hourly energy savings estimates for the first year of building operation were multiplied by the 2016 TDV cost values to arrive at the PV of the cost savings over the period of analysis. This measure is not climate sensitive, so the energy cost savings were calculated using an average of the TDV values for all climate zones.

Other Cost Savings Methodology

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

4.7.3 Cost-effectiveness Methodology

The Statewide CASE Team calculated the cost-effectiveness using the LCC Methodology. According to CEC's definitions, a measure is cost effective if it reduces overall lifecycle cost from the current base case (existing conditions). The LCC Methodology clarifies that absolute lifecycle cost of the proposed measure does not need to be calculated. Rather, it is necessary to calculate the change in lifecycle cost from the existing conditions to the proposed conditions.

If the change in lifecycle cost is negative then the measure is cost effective, meaning that the present value of TDV energy savings is greater than the cost premium, or the proposed measure reduces the total lifecycle cost as compared to the existing conditions.

The Planning Benefit-to-Cost (B/C) Ratio is another metric that can be used to evaluate cost-effectiveness. The B/C Ratio is calculated by dividing the total present value TDV energy cost savings (the benefit) by the present value of the total incremental cost (the cost). If the B/C Ratio is greater than 1.0 (i.e. the present valued benefits are greater than the present valued costs over the period of analysis), then the measure is 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 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).

Greenhouse Gas Emissions Monetization Methodology

The 2016 TDV cost values include the monetary value of avoided GHG emissions, so the Cost-effectiveness Analysis presented in Section 5.2 of this report does include the cost savings from avoided GHG emissions. The monetization for the TDV values includes permit (retail) cost of avoided GHG emissions, but it does not include the social costs of avoided emissions. As evident in the results of the Cost-effectiveness Analysis, the value of avoided GHG emissions is aggregated into the total TDV cost savings and the contribution of GHG emissions is not easily discernible. To demonstrate the value of avoided GHG emissions, the Statewide CASE Team disaggregated the value of avoided GHG emissions from the overall TDV cost savings value.

4.8.2 Water Use and Water Quality Impacts Methodology

There are no impacts on water use or water quality resulting from this measure.

4.8.3 Material Impacts Methodology (Optional)

Material impacts were not calculated for this measure.

4.8.4 Other Impacts Methodology

No other impacts were quantified for this measure.

5. ANALYSIS AND RESULTS

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

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 11. Per unit savings for the first year are expected to range from 1,307 to 28,123 kilowatt-hours per year (kWh/yr), depending on facility type and scenario. These savings are based on a number of assumptions around system performance and occupancy patterns, many of which were designed to demonstrate a conservative savings scenario.

It is estimated that the per-site TDV electricity savings over the 15 year period of analysis will range from about 22,000 kBTU to about 465,000 kBTU. The TDV methodology allows peak electricity savings to be valued more than electricity savings during non-peak periods. Because this measure saves energy primarily at night (off peak), there are no peak savings attributed to this code change. Using the TDV method resulted in relatively low energy cost savings results compared to a measure that saves peak energy, based on the value given to peak energy in the TDV method.

Table 11: Energy Impacts per Prototype Facility [1]

Prototype	Fixture Wattage	Per Unit First Year Savings[2]			Per Unit First Year TDV Savings[3]	
		Electricity Savings[4]	Peak Demand Reduction[5]	Natural Gas Savings	TDV Electricity Savings[6]	TDV Natural Gas Savings[6]
		(kWh/yr)	(kW)	(Therms/yr)	(kBTU)	(kBTU)
Prototype 1: Large 24 Hour Sales Canopy	122W	4,376	-	NA	72,695	NA
	82W	2,941	-	NA	48,861	NA
Prototype 2: Large 15 Hour Sales Canopy	122W	7,671	-	NA	125,505	NA
	82W	5,156	-	NA	84,356	NA
Prototype 3: Small 24 Hour Sales Canopy	122W	1,945	-	NA	32,309	NA
	82W	1,307	-	NA	21,716	NA
Prototype 4: Small 15 Hour Sales Canopy	122W	3,409	-	NA	55,780	NA
	82W	2,291	-	NA	37,492	NA
Prototype 5: Corner Outdoor Sales Lot (12 Hours)	275W	5,625	-	NA	93,321	NA
	126W	2,577	-	NA	42,758	NA
Prototype 6: Large 12-Hr Outdoor Sales Lot	275W	28,123	-	NA	466,605	NA
	126W	12,885	-	NA	213,790	NA

1. Savings are shown on a per prototype building basis
2. Savings from one prototype building for the first year the building is in operation.
3. TDV energy savings for one prototype building for the first year the building is in operation.
4. Site electricity savings. Does not include TDV of electricity savings.
5. Calculated using CEC's 2016 15-year, non-residential demand factors and methodology.
6. 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

The statewide energy impacts of the proposed measure are presented in Table 12. 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 4.19 GWh.

Table 12: Statewide Energy Impacts

	First Year Statewide Savings[1]			TDV Savings[2]	
	Electricity Savings[3] (GWh)	Power Demand Reduction (MW)	Natural Gas Savings (MMtherms)	TDV Electricity Savings[4] (Million kBTU)	TDV Natural Gas Savings[4] (Million kBTU)
Sales Canopies	1.67	-	NA	27.5	NA
Sales Lots	2.52	-	NA	41.7	NA
TOTAL	4.19	-		69.3	

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.

All 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 incremental cost of the proposed measure, relative to existing conditions, is presented in Table 13. The total incremental cost includes the incremental cost during initial construction and the present value of the incremental maintenance cost over the 15-year period of analysis. Each of these components of the incremental cost is discussed below.

Table 13: Incremental Cost of Proposed Measure 2017 Present Value Dollars [1]

Condition	Incremental Initial Construction Cost		Incremental Present Value of Maintenance Cost[4]	Total Incremental Cost[5]
	Current[2]	Post Adoption[3]		
Incremental Measure Cost per Sales Canopy Fixture	$100	$100	$0	$100
Incremental Measure Cost per Outdoor Sales Lot Fixture	$81	$81	$0	$81
IMC Prototype 1 & 2	$3,600	$3,600	$0	$3,600
IMC Prototype 3 & 4	$1,600	$1,600	$0	$1,600
IMC Prototype 5	$810	$810	$0	$810
IMC Prototype 6	$4,050	$4,050	$0	$4,050

1. Incremental costs equal the difference between existing conditions and proposed conditions. Negative values indicate the Proposed Conditions are less expensive than Existing Conditions.
2. Initial construction cost using current prices; ΔCI_C
3. Initial construction cost using estimated prices after adoption; ΔCI_{PA}
4. Present value of maintenance costs over 15 year period of analysis; ΔCM.
5. Total costs equals incremental cost (post adoption) plus present value of maintenance costs; $\Delta CI_{PA} + \Delta CM$

Incremental Construction Cost Results

For the purposes of this analysis, the CASE Team has conservatively chosen $81 as the incremental cost for controls in Outdoor Sales Lots and $100 as the incremental cost of controls in Sales Canopies. The incremental cost assumption for sales lots reflects the maximum distributor price point ($50) consistently quoted by several major manufacturers, with a 35% markup, which manufacturer contacts agreed was a reasonable adder. The incremental cost assumption for sales canopies ($100) is a conservative median value between the price estimates for zone-based approaches ($50, $60, $100) and the higher cost of fixture integrated controls ($105 per fixture). The proposed measures may be significantly more cost effective if end users install lower cost circuit-based controls.

Incremental Maintenance Cost Results

The Statewide CASE Team does not expect any incremental maintenance costs associated with this code change. If anything, dimming LED fixtures extends product life, so there is some chance the consumer will see longer fixture life as a result of 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 14. The proposed measure results in cost savings in every climate zone (the measure is not climate specific) and in each of the prototype facilities developed.

Table 14: TDV Energy Cost Savings Over 15 Year Period of Analysis - Per Site

Prototype	Fixture Wattage	TDV Electricity Cost Savings	TDV Natural Gas Cost Savings	Total TDV Energy Cost Savings
		(2017 PV $)	(2017 PV $)	(2017 PV $)
Prototype 1: Large 24 Hour Sales Canopy	122W Fixtures	$6,470	NA	$6,470
	82W Fixtures	$4,349	NA	$4,349
Prototype 2: Large 15 Hour Sales Canopy	122W Fixtures	$11,170	NA	$11,170
	82W Fixtures	$7,508	NA	$7,508
Prototype 3: Small 24 Hour Sales Canopy	122W Fixtures	$2,876	NA	$2,876
	82W Fixtures	$1,933	NA	$1,933
Prototype 4: Small 15 Hour Sales Canopy	122W Fixtures	$4,964	NA	$4,964
	82W Fixtures	$3,337	NA	$3,337
Prototype 5: Corner Outdoor Sales Lot (12 hours)	275W Fixtures	$8,306	NA	$8,306
	126W Fixtures	$3,805	NA	$3,805
Prototype 6: Large Outdoor Sales Lot (12 hours)	275W Fixtures	$41,528	NA	$41,528
	126W Fixtures	$19,027	NA	$19,027

Other Cost Savings Results

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

5.2.3 Cost-effectiveness Results

Results per unit lifecycle Cost-effectiveness Analyses are presented in Table 15.

The proposed measure saves money over the 15-year period of analysis relative to the existing conditions. The proposed code change is cost-effective in each of the prototype space types modeled. As described in the methodology section, many of the assumptions that were made in the savings model and in the incremental cost analysis were conservative, in order to present a conservative assessment of cost-effectiveness. As more data becomes available, the actual cost-effectiveness analysis results may become even more favorable.

Table 15: Cost-effectiveness Summary [1]

Prototype Description	Fixture Wattage	Benefit: TDV Energy Cost Savings + Other Cost Savings[2] (2017 PV $)	Cost: Total Incremental Cost[3] (2017 PV $)	Change in Lifecycle Cost[4] (2017 PV $)	Benefit-to-Cost Ratio[5]
Prototype 1: Large 24-Hr Sales Canopy	122W Fixtures	$6,470	$3,600	-$2,870	1.8
	82W Fixtures	$4,349	$3,600	-$749	1.2
Prototype 2: Large 15-Hr Sales Canopy	122W Fixtures	$11,170	$3,600	-$7,570	3.1
	82W Fixtures	$7,508	$3,600	-$3,908	2.1
Prototype 3: Small 24-Hr Sales Canopy	122W Fixtures	$2,876	$1,600	-$1,276	1.8
	82W Fixtures	$1,933	$1,600	-$333	1.2
Prototype 4: Small 15-Hr Sales Canopy	122W Fixtures	$4,964	$1,600	-$3,364	3.1
	82W Fixtures	$3,337	$1,600	-$1,737	2.1
Prototype 5: Corner Outdoor 12-Hr Sales Lot	275W Fixtures	$8,306	$810	-$7,496	10.3
	126W Fixtures	$3,805	$810	-$2,995	4.7
Prototype 6: Large Outdoor 12-Hr Sales Lot	275W Fixtures	$41,528	$4,050	-$37,478	10.3
	126W Fixtures	$19,027	$4,050	-$14,977	4.7

1. Relative to existing conditions. All cost values presented in 2017 dollars.
2. Present value of TDV cost savings equals TDV electricity savings plus TDV natural gas savings; $\Delta TDV\$ = \Delta TDV\$E + \Delta TDV\$G$.
3. Total incremental cost equals incremental construction cost (post adoption) plus present value of incremental maintenance cost; $\Delta C = \Delta CI_{PA} + \Delta CM$.
4. Negative values indicate the measure is cost effective. Change in lifecycle cost equals cost premium minus TDV energy cost savings; $\Delta LCC = \Delta C - \Delta TDV\$$
5. The Benefit-to-Cost Ratio is the TDV energy costs savings divided by the total incremental costs; $B/C = \Delta TDV\$ \div \Delta C$. The measure is cost effective if the B/C ratio is greater than 1.0.

5.3 Environmental Impacts Results

5.3.1 Greenhouse Gas Emissions Results

Table 16 presents the estimated first year avoided GHG emissions of the proposed code change, during the first year the 2016 Standards are in effect. The monetary value of avoided GHG emissions is included in TDV cost factors (TDV $) for each hour of the year and is thus included in the Cost-effectiveness Analysis presented in this report.

Table 16: Estimated First Year Statewide Greenhouse Gas Emissions Impacts

	Avoided GHG Emissions[1] ($MTCO_2e$/yr)
Sales Canopies	589
Sales Lots	888
TOTAL	1477

1. First year savings from buildings built in 2017; assumes 353 $MTCO_2e$/GWh and 5,303 $MTCO_2e$/MMTherms.

5.3.2 Water Use and Water Quality Impacts

There are no projected impacts on water use or water quality, as shown in Table 17.

Table 17: 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 Results (Optional)

The impacts of the proposed code change on material use were not evaluated.

5.3.4 Other Impacts Results

Occupancy-based controls offer a potential safety feature of drawing attention to the arrival of an occupant to the space in the middle of the night. Also, operating LED fixtures in dimmed states for a significant amount of time is likely to extend the product lifetime.

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

Changes to Section 100.1 – Definitions and Rules of Construction

LIGHTING definitions:

Automatic Scheduling Control is a time-based lighting control device or system that is capable of being programmed to turn off the lighting power to an outdoor luminaire for a portion of the night, as determined by the user.

Outdoor Sales Frontage is the portion of the perimeter of an outdoor sales area immediately adjacent to a public street, road, highway, or ~~public~~ sidewalk.

Commercial Fuel Station Sales Canopy is the sales canopy of a fuel station intended to primarily serve customers operating commercial vehicles of 10,001 lb. or more, including tractor trailers and buses. Any fuel station sales canopy that has dual pumps and/or contains 50% or more of the pumps that are designed to dispense diesel fuel is considered a commercial fuel station sales canopy.

Dual Pump is a type of fuel station pumping system that provides fuel pumps on both sides of a vehicle such that drivers can fill both fuel tanks (one on each side of the vehicle) at once.

Changes to Section 130.2(c)

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

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

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

1. All installed outdoor lighting shall be controlled by a photocontrol or outdoor astronomical time-switch control that automatically turns OFF the outdoor lighting when daylight is available.

2. All installed outdoor lighting shall be circuited and independently controlled from other electrical loads by an automatic scheduling control.

3. All installed outdoor lighting, where the bottom of the luminaire is mounted 24 feet or less above the ground, shall be controlled with automatic lighting controls that meet all of the following requirements:

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

B. Shall be capable of automatically reducing the lighting power of each luminaire by at least 40 percent but not exceeding ~~80~~ 90 percent, or provide continuous dimming through a range that includes 40 percent through ~~80~~ 90 percent, and

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

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

EXCEPTION 1 to Section 130.2(c) 3: Lighting for Outdoor Sales Frontage and Commercial Fuel Station Sales Canopies.~~, Outdoor Sales Lots, and Outdoor Sales Canopies complying with Section 130.2(c) 4~~.

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

EXCEPTION 3to Section 130.2(c) 3: Outdoor lighting, where luminaire rated wattage is determined in accordance with Section 130.0(c), and which meet one of the following conditions:

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

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

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

EXCEPTION 4 to Section 130.2(c) 3: Applications listed as Exceptions to Section 140.7(a) shall not be required to meet the requirements of Section 130.2(c) 3.

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

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

~~B. Motion sensors capable of automatically reducing lighting power by at least 40 percent but not exceeding 80 90 percent, and which have auto-ON functionality.~~

6.2 Reference Appendices

There are no proposed changes to the Reference Appendices.

6.3 ACM Reference Manual

There are no proposed changes to the ACM Reference Manual

6.4 Compliance Manuals

The CASE Team proposes the following changes to Chapter 6 of the Nonresidential Compliance Manual in order to clarify the intended definition of sales frontage and to reflect that sales lot and sales canopy installations will no longer be exempted from motion-based multi-level controls requirements. The Team has also proposed edits to the section on outdoor lighting alterations to improve clarity around the alterations triggers.

6.3.3 Controls for Outdoor Lighting

D. Circuiting and Automatic Scheduling Control Requirements

§130.2(c) 2

All installed outdoor lighting shall be circuited and independently controlled from other electrical loads by an automatic scheduling control. An automatic scheduling control is a time-based lighting control device or system that is capable of being programmed to turn off the lighting power to an outdoor luminaire for a portion of the night, as determined by the user. Part-night outdoor lighting controls can be installed to meet this requirement, provided they meet this definition of Automatic Scheduling Control.

E. Mounting Specific Controls

§130.2(c) 3

All outdoor lighting, where the bottom of the luminaire is mounted 24 feet or less above the ground shall be controlled with automatic lighting controls that meet the following requirements:

- Shall be motion sensors or other lighting control systems that automatically controls lighting in response to the area being vacated of occupants.
- Shall be capable of automatically reducing the lighting power of each luminaire by at least 40 percent but not exceeding ~~80~~90 percent, or provide continuous dimming through a range that includes 40 percent through ~~80~~90 percent.
- Shall employ auto-ON functionality when the area becomes occupied.
- No more than 1,500 watts of lighting power shall be controlled together.

The following applications are not required to use controls for luminaires mounted less than 24 feet above the ground:

- Lighting for Outdoor Sales Frontage~~, Outdoor Sales Lots, and Outdoor Sales Canopies~~ The intent is to exempt one row of fixtures in the portion of the Sales Lot exterior perimeter that is immediately adjacent to a public street, road, highway, or sidewalk.
- Lighting for Building Facades, Ornamental Hardscape and Outdoor Dining
- Outdoor lighting, where luminaire rated wattage is determined in accordance with Section 130.0(c), and which meets one of the following conditions: pole mounted luminaires with a maximum rated wattage of 75 watts, non-pole mounted luminaires with a maximum rated wattage of 30 watts each, or linear lighting with a maximum wattage of 4 watts per linear foot of luminaire.
- Applications listed as Exceptions to Section 140.7(a) shall not be required to meet the requirements of Section 130.2(c) 3.

F. Application Specific Controls

~~§130.2(c) 4 &~~ §130.2(c) 5

~~For Outdoor Sales Frontage, Outdoor Sales Lots, and Outdoor Sales Canopies lighting, an automatic lighting control shall be installed that meets the following requirements:~~

- ~~A part-night outdoor lighting control as defined in Section 100.1, or~~
- ~~Motion sensors capable of automatically reducing lighting power by at least 40 percent but not exceeding 80 percent, and which have auto-ON functionality.~~

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

- A part-night outdoor lighting control as defined in section 100.1, or
- Motion sensors capable of automatically reducing lighting power by at least 40 percent but not exceeding ~~80~~90 percent, and which have auto-ON functionality, or
- A centralized time-based zone lighting control capable of automatically reducing lighting power by at least 50 percent.
- Note that outdoor wall mounted luminaires 'wall packs' where the bottom of the luminaire is mounted 24 feet or less above the ground must also be controlled by a motion sensor capable of shutting off between 40% and ~~80~~90% of the load, as required by Section 130.2(c) 3.

There are a number of options available to meet the requirements of this section. Automatic controls to reduce outdoor lighting by at least 40 percent but not exceeding ~~80~~90 percent are required with all of these strategies. Following are a few examples:

- Dimmable lighting systems can be used to meet the outdoor multi-level switching requirements. For HID luminaires, the high-low output approach (normally applied by switching capacitors in the ballast) capable of reducing the connected lighting power by 40 percent to ~~80~~90 percent may

be used. For HID and LED luminaires, stepped dimming is acceptable provided that steps are available within the 40 percent to ~~80~~90 percent range. LED continuous dimming strategies are acceptable as long as their dimming capacity encompasses the 40 percent to ~~80~~90 percent range.

- Equip the lighting systems with motion sensors and photoelectric switches. This option works well with fluorescent and LED sources. HID sources may employ the high-low strategy with motion sensors.
- Employ a part-night control system to set back the light level at a predetermined time after business hours.

6.5.1 Outdoor Lighting Additions and Alterations – Mandatory and Lighting Power Density Requirements

A. Mandatory Requirements

Additions ~~and~~ to existing outdoor lighting must meet all of the Standards mandatory measures for the added luminaires. Alterations to outdoor lighting as defined in Section 141.0(b) 2.J. must meet the following mandatory requirements:

- In alterations that increase the connected lighting load in a lighting application listed in TABLE 140.7-A or 140.7-B the entire lighting system in the altered lighting application shall meet the applicable controls and LPA requirements of Sections 130.0, 130.2, 130.4, and140.7;
- In alterations that replace 10 percent or more of the luminaires in a lighting application listed in TABLE 140.7-A or 140.7-B, just the altered luminaires are required to meet the applicable controls requirements of Sections 130.0, 130.2, 130.4; and
- In alterations that replace more than 50 percent of the luminaires in a lighting application listed in TABLE 140.7-A or 140.7-B, the entire lighting system in that application shall meet the applicable controls and LPA requirements of Sections 130.0, 130.2, 130.4, and 140.7.

The mandatory requirements include certification of any new lamps, light sources, ballasts and drivers that are installed if they are the type regulated by the Appliance Efficiency Regulations. Any new lighting controls must meet minimum performance requirements. In addition, control and circuiting requirements apply as follows:

- Motion sensing for incandescent luminaires rated over 100 watts
- BUG zonal lumen limits for luminaires rated greater than 150 watts
- Automatic controls to turn lighting OFF when daylight is available
- Separate circuiting and independently controlled from other electrical loads by an automatic scheduling control
- Motion sensing devices for luminaires mounted below 24 feet above ground that automatically ~~reducing~~ reduce the lighting power of each luminaire by at least 40 percent, but not greater than ~~80~~ 90 percent, auto-ON functionality when the area becomes occupied and no more than 1,500 watts of lighting power shall be controlled together.
    - Outdoor Sales Frontage is exempt from the motion sensing control requirement. The intent is to exempt one row of fixtures in the portion of the Sales Lot exterior perimeter that is immediately adjacent to a public street, road, highway, or sidewalk.
- ~~Outdoor Sales Frontage, Outdoor Sales Lot, and Outdoor Sales Canopies shall have a part-night control or motion sensors capable of automatically reducing lighting power by at least 40 percent but not exceeding 80 percent, along with auto-ON functionality.~~
- Building Façade, Ornamental Hardscape, and Outdoor Dining shall have a part-night control or motion sensors capable of automatically reducing lighting power by at least 40 percent but not exceeding ~~80~~ 90 percent, along with auto- ON functionality, or a centralized time-based zone lighting control capable of automatically reducing lighting power by 50 percent.
- All lighting controls must meet the requirements of §110.9.

6.5 Compliance Forms

Forms NRCC-LTO-02-E: Certificate of Compliance: Outdoor Lighting Controls may need to be revised slightly to reflect the application of code requirements to additional space types.

7. REFERENCES AND OTHER RESEARCH

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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.[17] 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).

Water Use and Water Quality Impacts Methodology

There are no impacts on water use and water quality for the proposed measure.

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

APPENDIX B: JOB CREATION BY INDUSTRY

Table 18 shows total job creation by industry that is expected from all investments in California energy efficiency and renewable energy (UC Berkeley 2010, Appendix D). While it is not specific to codes and standards, this data indicates the industries that generally will receive the greatest job growth from energy efficiency programs.

Table 18: Job Creation by Industry

NAICS	Industry Description	Direct Jobs	
		2015	2020
23822	Plumbing, Heating, and Air-Conditioning Contractors	8,695	13,243
2361	Residential Building Construction	5,072	7,104
2362	Nonresidential Building Construction	5,345	6,922
5611	Office Administrative Services	2,848	4,785
23821	Electrical Contractors	3,375	4,705
551114	Corporate, Subsidiary, and Regional Managing Offices	1,794	3,014
54133	Engineering Services	1,644	2,825
5418	Advertising and Related Services	1,232	2,070
334413	Semiconductor and Related Device Manufacturing	1,598	1,598
541690	Other Scientific and Technical Consulting Services	796	1,382
23831	Drywall and Insulation Contractors	943	1,331
3334	Ventilation, Heating, Air-Conditioning, & Commercial Refrigeration Equipment Manufacturing	453	792
3351	Electric Lighting Equipment Manufacturing	351	613
926130	Regulation and Administration of Communications, Electric, Gas, Other Utilities	322	319
23816	Roofing Contractors	275	277
54162	Environmental Consulting Services	151	261
484210	Used Household and Office Goods Moving	137	239
23835	Finish Carpentry Contractors	120	120
23829	Other Building Equipment Contractors	119	113
3352	Household Appliance Manufacturing	63	110
other	Other	454	547
	Total	**35,788**	**52,369**